5TH INTERNATIONAL CONFERENCE

ON

"Recent Trends in Science, Engineering & Technology" ICRTSET-2025

(28TH–29TH March, 2025)

ORGANIZED BY

Govindrao Wanjari College of Engineering & Technology Nagpur-441204

APPROVED BY

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ISBN NO: 978-81-971637-6-0

ABOUT NAGPUR

Named after the Nag River, Nagpur is also the third-largest city in Maharashtra and is renowned as the "city of oranges." While en route to the town, we discover that one of India's smart cities is frequently referred to as the state's secondary capital, following Mumbai. Its creation is credited to India's medieval Bhonsle kingdom. It is a quaint location with lakes, gardens, temples, and a rich cultural. Oranges are a major export from the city. Nagpur is also known as India's "Tiger Capital." The reason for this is the abundance of tiger reserves found within and near the city. The rate of literacy in the city is 90%. The river Nag, which flows through Nagpur, is the source of its name. Nagpur is also home to the regional office of the Nagpur Tiger Conservation Authority. Nagpur institution, the second-oldest in the state of Maharashtra, and the ninth-oldest institution in India. Nagpur, also called the Deekshabhoomi, is a pilgrimage place. Within its lovely grounds is the largest hollow stupa in the world. The largest producer of snacks and sweets is also Nagpur. The city is home to Asia's second-largest air maintenance workshop. India's busiest air traffic control room is located in Nagpur as well. The history of the city dates back over 3,000 years. Nagpur is surrounded by an abundance of natural beauties. Nagpur is located at an elevation of 310.5 meters above sea level on the Deccan plateau.

ABOUT CONFERENCE

This International Conference on Recent Trends in Science, Engineering & Technology (ICRTSET-2025) aims to provide an technical platform across the globe to exchange innovative ideas and research findings on contemporary issues for researchers from both industry and academia to participate,discuss the latest advancements and explore future directions in emerging areas of engineering. The participants will get benefit by experiencing knowledge on technical advancements and recent innovations in the field of science & Technology. Conference Will be conducted in Offline Mode. The focus area of the conference is global in nature and the meet is expected to be a good platform for academicians and practitioners to exchange ideas.

Swami Narayan Temple   Diksha Bhoomi   Orange City Sq   RBI

GOVINDRAO WANJARI COLLEGE OF ENGINEERING TECHNOLOGY

Govindrao Wanjari College of Engineering and Technology is affiliated to Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur & Dr Babasaheb Ambedkar Technological University, Lonere. It offers undergraduate programs in Engineering disciplines such as Computer Science & Engineering, Electronics & Communication Engineering, Electrical Engineering, Mechanical Engineering, Civil Engineering, Information Technology postgraduate programs in Management Studies and Diploma Programs in Civil, Electrical and Mechanical. GWCET has a strong focus on industry collaborations which helps the students gain practical knowledge through internships and projects with leading companies.

INSTITUTE VISION

"To emerge as a centre of excellence creating research, innovation and entrepreneurial attitude among the technocrats who in turn shall contribute to the development of society and mankind."

INSTITUTE MISSION

- To develop a culture of excellence in teaching and learning with accountability from all support activities.
- To promote new ideas leading to emergence of creators, innovators, leaders and entrepreneurs.
- To achieve excellence in application based research in technology to contribute to the development of the community.
- To imbibe the ethical values among the students to make them responsive citizens.

Any institute's faculty are its greatest asset, and the expansion of any institute is reliant on the faculty's growth. Keeping this in mind, the institute has put in place a number of programs that help faculty members meet the demands of contemporary society. The Soft Skills training classes for all branches and streams have begun at the institute. Exchange programs that give students the chance to connect with applicants from other prestigious universities are being implemented with great enthusiasm. Important clubs for language, oratory, and aptitude have been established to support students' total personality development.

MESSAGE FROM THE PRESIDENT

The 5th International conference on "Recent Trends In Science, Engineering & Technology" being organized by Govindrao Wanjari College of Engineering & Technology, Nagpur from dated 28 MARCH 2025 TO 29 MARCH 2025 will mark several exciting milestones for our organization. The conference highlights are important to mention because they demonstrate our contribution in the field of Engineering, Science and Management. The supportive and collaborative nature of the conference also builds on our mission to support learners in contexts of higher education. The contributions by the authors of the following proceedings reflect their dedication to learners in various settings and contexts. The proceedings not only build a legacy of scholarly contribution for the authors, but also for ICRTSET-2025. I would like to appreciate the editors for their hard work for preparing the proceeding of this conference. I would like to congratulate all the authors who presented their research at the conference.

Dr. Suhasini G Wanjari
President
Amar Sewa Mandal, Nagpur.

MESSAGE FROM THE SECRETARY

It is with great pleasure, I acknowledge the 5th International Conference on "Recent Trends in Science, Engineering & Technology" (ICRTSET-2025), organized by Govindrao Wanjari College of Engineering & Technology, Nagpur. I commend the organizing committee for their admirable efforts in ensuring the success of this conference and their commitment to presenting novel research findings and ideas. My best wishes to them for their ongoing efforts to disseminate the knowledge in their respective domain.

Adv. Abhijit G Wanjarri
MLC, Nagpur Constituency and Secretary
Amar Sewa Mandal, Nagpur

MESSAGE FROM THE TREASURER

Govindrao Wanjari College of Engineering & Technology, takes great pride in hosting the 5th International Conference on "Recent Trends in Science, Engineering and Technology (ICRTSET-2025). I would like to appreciate the entire team at GWCET for their unwavering efforts in bringing this significant event to fruition. This conference provides an excellent platform for students and young researchers to enhance their knowledge and gain a deeper understanding of the changing ideas and innovative methods in Technology. I am confident that this event will offer a valuable learning experience for all participants and provide an opportunity for them to share their expertise. I wish all the attendees a productive and fulfilling time ahead.

Dr. Smeetaa A. Wanjarri
Senate Member RTMNU and Treasurer
Amar Sewa Mandal, Nagpur

MESSAGE FROM THE PRINCIPAL & CONFERENCE CHAIR

It gives me great pride to announce that Govindrao Wanjari College of Engineering & Technology, organised the AICTE, ISTE Approved 5th International Conference on "Recent Trends in Science, Engineering and Technology (ICRTSET-2025) from 28 MARCH 2025 to 29 MARCH 2025. The conference will act as an excellent colloquium to develop a platform for the exchange of ideas towards scientific and technological innovations for the generations to come. I hope that the conference will deliberate on current issues of national and international relevance in the fields of Science and Technology, allowing academicians, researchers, and technocrats to share their thoughts and views on innovations in their respective fields. The conference will witness an unparalleled number of quality research articles being presented, paving the way for new paths to innovate in Science and Technology. I extend my heartfelt congratulations and appreciation to the entire team for their efforts in organizing this international conference and wish them great success in the successful conduct of the entire event.

Dr. Salim A. Chavan
Conference Chair (ICRTSET-2025) and Principal
Govindrao Wanjari College of Engineering & Technology, Nagpur

MESSAGE FROM KEYNOTE SPEAKER

It is a pleasure to note that Govindrao Wanjari College of Engineering & Technology is organizing the 5th International Conference. I would like to take this opportunity to thank you for your invitation and the excellent organized Conference. Conferences of this nature provide a platform to young researchers and faculty members to present their research and development work and get feedback and suggestions to improve their quality of work. The level of expertise and knowledge of the presenters are excellent. In addition, I appreciate their positive attitudes, willingness to explain concepts, clarity and opportunities to ask questions.

Dr. Mohan Kolhe
Professor,
Faculty of Engineering & Science,
University of Adger, Norway

MESSAGE FROM KEYNOTE SPEAKER

I am very glad to know that Govindrao Wanjari College of Engineering and Technology Nagpur is organising International Conference on Recent Trends in Science, Engineering & Technology (ICRTSET–25). I feel privileged to be part of this intellectual gathering and thankful to organizers for inviting me as key note speaker. This conference will provide broad forum to researchers to interact and collaborative. It will help to impact society with proposed innovative solutions.

Wishing you all a successful and fruitful conference.

Dr Latesh Malik
Associate Professor, Head of Department
Government College of Engineering Nagpur
Board of Studies Chairman (CSE/CT/IT/CE board)
RTM Nagpur University, Nagpur

MESSAGE FROM CONVENER

I sincerely thank the honorable Management and Principal of Institute for motivating us to organize AICTE, ISTE approved 5th International conference on "Recent Trends in Science, Engineering & Technology (ICRTSET-2025)" from 28 MARCH 2025 to 29 MARCH 2025. I wish the organizing team best of luck for further achievements, and hope for continued cooperation. I want to thank in advance the conference committee for extending their valuable time in organizing the program and all the authors, reviewers, and other contributors for their sparkling efforts and their belief in the excellence of ICRTSET-2025.

Dr. Rakesh G Shriwastava,
Professor,
Electrical Engineering Department,
Convener (ICRTSET-2025)
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International Conference on Recent Trends in Science, Engineering & Technology
(28ᵀᴴ–29ᵀᴴ MARCH, 2025)

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Acknowledgement

We present to you the proceeding for the AICTE, ISTE approved 5th International Conference on **"RECENT TRNEDS IN SCIENCE, ENGINEERING & TECHNOLOGY"** which was held from **28 MARCH 2025** to **29 MARCH 2025**.

We express our sincere thanks to Hon'ble Founder of Amar Sewa Mandal and our well-wisher **Dr. Suhasini. G. Wanjari,** for being a source of inspiration for all of us.

We would like to express sincere thanks to Hon'ble MLC and Secretary Amar Seva Mandal **Adv. Abhijit. G. Wanjarri** for giving the opportunity to organise such international conference and providing us necessary facilities .

We are very thankful to our Hon'ble Treasurer Amar Seva Mandal and Senate Member RTMNU, Nagpur **Dr. Smeetaa. A. Wanjarri.** She guided us for this conference and gave us valuable suggestion whenever and whereever required.

We feel very much delighted in expressing sense of gratitude to our Principal and Convener for this conference **Dr. Salim Chavan,** for his timely help during the conference and for his constant encouragement and valuable guidance. The successful execution of this conference would not have been possible without the firm support of our convener.

We would also like to express our sincere gratitude to **Dr. Karbhari Vishwanath Kale**, Vice-Chancellor, DBATU, **Dr Rajendra Kakde**, Pro-Vice-Chancellor, RTMNU, **Dr Manoj B. Daigawane**, Jt. Director, Technical Education, **Dr Dinesh K. Agrawal**, Add Director of Research, KIMSDU, Karad, **Dr Mohan Kolhe**, Professor, University of Agder, Norway, **Dr Latesh Malik**, BoS RTMNU for being involved in this International conference and sharing their views.

We wish to express our gratitude to all our faculty members who have helped us directly or indirectly in completing this conference

CO-CONVENER
Mr. Prashant Gumgaonkar
HoD IT Department
GWCET, Nagpur

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Development of IOT based Smart Safety System for Electric Vehicles application-A review paper

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ABSTRACT

Recently in domestic and industrial environments, Fire accidents are occurring frequently due to human negligence and unpredictable climatic changes. The proposed model is designed for avoid fire accidents by remote location and extinguish the fire. Also reducing the risk of fire fighters. The main objective of proposed research is cost effective design and automatic fire safety in automotive application. The flame/smoke sense by fire extinguisher fire areas which is inside vehicle for extinguishes the fire. There are many reasons for fire accidents in electric vehicle application due to battery used. In some incidents in which the cars caught fire and turned into ashes. It can improved the safety level for the vehicle & also minimize the financial loss in automatic fire extinguishing system

**KEYWORDS:** IOT Technology, Emergency Alert, Fire Situation, Controller, Battery Management System (BMS)

INTRODUCTION

In our country fire accident is the major issue. There is no modern technology to solve such problem in developing country. The fire problem can be overcome by fire brigade. Police and military has visited in firing spot to help. But it is not enough solution. The new safety challenges in the vehicle development process is Electric vehicle batteries. The testing of the minimal risk of fire is carried. Electrical system failures in some research, due to some causes of automobile related fires. [7]- [8]. The battery

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packs are problematic in all-electric and hybrid vehicle because quick start of fire. It is a big challenge in automotive industry to tackle. In every billion miles, car fires are a new problem in Indian roads for travelled. Automatic fire extinguishing system offer several gas jetting nozzles are arranged at desired locations and greater flexibility. In fire extinguishers, gas jetting nozzles are connected through a valve and a pipe with fire sensors. The valve is opened to cause fire-extinguishing gas to jet from the gas jetting nozzles into the region in fire signal from the fire sensors. Automatic fire extinguishing can be activated [9] The fire accidents are frequent occurs in domestic and industrial nowadays. The damage caused by fire and also the risk to human lives in future. The minimal solution to prevent small scale fire accidents in home of smart home automation system and to extinguish such fire hazard. The supporting factors for the fire cannot be controlled by the smart home automation system because it is spread out to the entire complex. A fire extinguishing vehicle is necessary to control the fire throughout the entire complex under such situation. [10]

In proposed system, a guided vehicle that can be installed in a domestic or industrial environment to alert the user at the time of fire accidents. The mobile phone control can be guided by the vehicle user to the intended location where the fire accident is occurring and water can be sprayed to extinguish the fire via mobile phone control. The user can be controlled velocity, volume and the direction of water while spraying. It can be observed in the screen of the mobile phone from far away to guide the motion of the vehicle. Thereby the user can communicate to effectively extinguish the fire. IoT (Internet of Things) enables the guided vehicle to organise, process data, analyse and allowing the user to make optimum decisions on a real-time basis.[11]. The damage that can be occurs by fire before the arrival of the fire extinguishing. The Squad can be drastically reduced the risk of involvement of fire extinguishing squad .it can also be minimised. The automatic door unlocking system can be reduced chance of life loss and / or injury in a normal automobile fire accident [12].The fire extinguishing squad's people are dedicated to stopping the fire even at the expense of their lives. The main targets of this research is to minimise human involvement to stop any fire accidents.

1. LITERATURE SURVEY

Research work related to Development of IOT based Smart Safety System for Electric Vehicles application were studied and reviewed.

- Khan et al. (2019), A BMS was suggested for electric vehicles,

employing a microcontroller, voltage and current sensors, and a GSM module for data transmission. The system's purpose was to oversee the battery's state of charge, health, and temperature, and to deliver real-time data and alerts to vehicle operators or fleet managers through SMS. The research determined that the proposed system significantly enhanced battery efficiency and reliability, offering valuable insights for vehicle operators.[1]

- Ghaffari et al. (2019), a BMS for an electric vehicle was proposed, integrating a current sensor, voltage sensor, temperature sensor, and microcontroller for data acquisition and analysis. The system aimed to monitor the battery's state of charge, temperature, and health, and to trigger a cooling system if the battery temperature surpassed a safe threshold. The research concluded that the implemented system effectively improved the battery's overall performance and safety while extending its lifespan.[2]

- Kasmi et al. (2019), A BMS was proposed for electric vehicles, utilizing a current sensor, voltage sensor, and a microcontroller for data acquisition and analysis. The system's objective was to monitor the battery's

state of charge, health, and temperature, while also triggering a cooling system if the battery temperature surpassed a safe threshold. The research concluded that the proposed system effectively regulated battery temperature and prolonged battery lifespan.[3]

- Liu et al. (2020), A BMS was proposed in electric vehicles integrating an Arduino microcontroller, voltage, and current sensors, along with a wireless communication module for data transmission. The system's primary objective was to monitor the battery's state of charge, health, and temperature, while also providing real-time data to drivers or fleet operators through a mobile application. The research concluded that the implemented system significantly enhanced battery efficiency and safety, while also offering valuable insights for vehicle operators.[4]

- Saha et al. (2020), the development of a BMS for an electric rickshaw was explored, incorporating voltage and current sensors, a microcontroller, and a temperature sensor. The primary purpose of this system was to monitor the battery's state of charge, temperature, and health, and to trigger

a cooling system if the battery temperature surpassed a safe limit. The research concluded that the implemented system significantly enhanced the battery's overall performance and reliability.[5]

- Zhang et al. (2021), A BMS was proposed for an electric vehicle, incorporating voltage and current sensors, along with a temperature sensor and a microcontroller for data acquisition and analysis. This system aimed to monitor the state of charge and temperature of the battery, activating a cooling system when the battery temperature surpassed a safe threshold. The research concluded that the implemented system effectively regulated the battery temperature, thereby enhancing the overall battery performance.[6]

2. PROBLEM STATEMENT

- Overcharging of Battery
- Battery electrolyte leakage-
- Electrical short circuit -
- Road crash-

3. RESEARCH OBJECTIVES

The objectives of the research are:

- To detect fire accidents

- To implement an automated system that activates a high-speed air fan when the temperature or fire is

detected, ensuring the battery temperature is minimized for safety.

Fig. 1: Buried EV Busses

- To develop an alert mechanism that triggers an alarm to notify the driver in case of heat or fire detection by the BMS

- An IOT module is integrated to the system

- To develop the experimental setup for the investigation.

-

4. EXISTING METHODS

Electric Vehicles (EVs) are increasingly becoming the preferred mode of transportation due to their eco-friendly nature. However, the safety of EV batteries remains a critical concern.

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Overheating, thermal runaway, and fire hazards pose significant risks to both passengers and vehicles. Current systems lack efficient, real-time monitoring and automated responses to such issues. Additionally, existing fire safety solutions are either manual or not specifically designed to address the unique challenges of EV battery management. This can result in delayed detection of potential hazards, inadequate cooling mechanisms, and increased risk of severe accidents. Moreover, there is limited integration of advanced technologies like IoT for remote monitoring and timely notifications, leaving drivers and passengers unaware of impending dangers until it is too late.

5. PROPOSED METHODOLOGY

The Smart Safety System for EVs using IoT addresses these challenges by integrating advanced sensors, real-time monitoring, and automated response mechanisms. The system continuously tracks critical parameters such as battery temperature, smoke, and potential fire hazards through temperature, smoke, and photoelectric sensors. When abnormal conditions are detected, the IoT-enabled microcontroller processes the data and triggers appropriate actions. These actions include activating high-speed cooling fans to manage overheating or fire suppression systems in case of fire.

The system is designed to monitor and manage the temperature of the battery inside an Electric Vehicle (EV) to prevent overheating and potential damage. It uses a combination of sensors, a microcontroller, and cooling mechanisms for efficient operation.

When the battery temperature rises, sensors such as a smoke sensor, photoelectric sensor, and temperature sensor detect the situation. The smoke sensor and photoelectric sensor monitor the presence of smoke, while the temperature sensor continuously measures the thermal condition of the battery. If any abnormalities are detected, the sensors send their readings to the Arduino microcontroller for processing.The microcontroller, programmed with specific logic, evaluates the data received from the sensors. Based on the input, it determines the appropriate response.

If smoke or signs of overheating are detected by the smoke or photoelectric sensor, the microcontroller activates a buzzer to alert nearby users, displays warnings on the LCD screen, and triggers the IoT module to send remote notifications to the system or user for immediate action.

In cases where the temperature sensor indicates overheating, the microcontroller initiates the high-speed DC fan in addition to the buzzer, IoT module, and LCD display. The DC fan starts operating at high speed to generate increased airflow around the battery, rapidly dissipating heat and reducing the

temperature to safer levels.

This system ensures real-time monitoring and rapid response to battery overheating. The IoT module facilitates remote tracking and alerts, allowing for timely interventions and improved safety and efficiency of the EV. The components used for IOT based Smart Safety System are Development Board, Relay Board,IOT Module Arduino Uno Controller,LCD Display,Buzzer,Power supply unit,Battery,DC Fan,Fire sensor, Temperature sensor,. Figure 2 shows proposed block diagram of IOT based Smart Safety System & Figure 3 shows Flow chart of working system
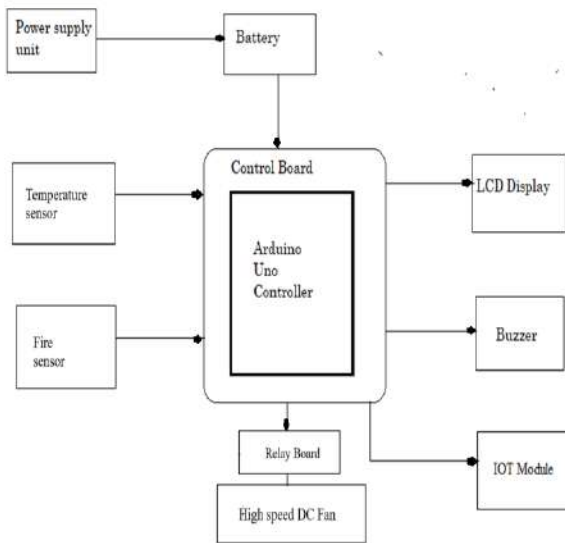
Fig.2. Block Diagram of IOT based Smart Safety System
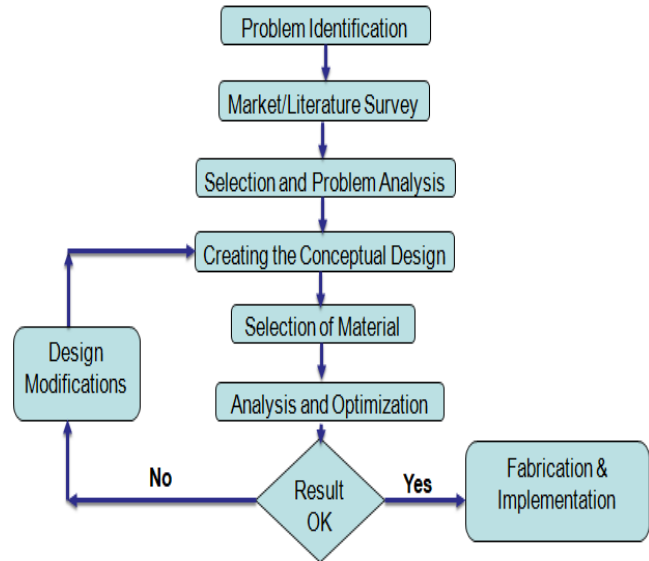
Fig.3.Flow chart of working system

6. ADVANTAGES

- **Real-time Monitoring:** Continuous monitoring of battery temperature ensures proactive detection of overheating issues.

- **Enhanced Safety:** Prevents potential hazards like thermal runaway, fire, or explosion in EV batteries.

- **Efficient Cooling:** High-speed DC fans effectively dissipate heat, maintaining battery health and extending its lifespan.

- **Remote Notification:** IoT integration allows users and maintenance teams to receive alerts in real-time, enabling swift action.

- **User-Friendly:** The LCD display provides clear information about the system's status, making it accessible to all users

- **Cost-Effective:** Prevents costly damage to the EV by ensuring timely interventions
- **Low Maintenance:** The system is robust, requiring minimal maintenance over time.

7. APPLICATION

- **Electric Vehicles:** Battery temperature management in EVs to ensure safety and performance.
- **Renewable Energy Systems:** Cooling batteries in solar or wind energy storage setups.
- **Data Centers:** Managing heat in battery backups for uninterrupted operations.
- **Portable Electronics:** Thermal regulation in high-capacity battery-powered devices.
- **Industrial Systems:** Monitoring and cooling batteries in automated machinery or robotics.
- **Aerospace:** Ensuring safe battery operations in drones, aircraft, and space applications.
-

8. CONCLUSION

The integration of a Smart Safety System for Electric Vehicles (EVs) using IoT is crucial for enhancing the safety, performance, and longevity of EV batteries. This innovative system monitors key battery parameters like temperature and smoke, providing real-time alerts through IoT connectivity. In case of overheating or potential fire hazards, the system automatically activates safety mechanisms such as high-speed cooling fans or extinguishing units, effectively preventing accidents. This system's simplicity ensures minimal maintenance, making it a practical and cost-effective solution. Its compact design allows seamless integration without causing any discomfort to drivers or passengers. IoT connectivity enables remote monitoring and instant notifications to users, ensuring prompt action.With continued research and development, this smart safety system could revolutionize EV safety, offering scalable solutions adaptable to various battery types and sizes. It represents a significant step forward in ensuring EV reliability and user confidence in modern transportation.

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Fault Impact Analysis of Parallel Feeder Based Distribution System using PSCAD Simulation

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ABSTRACT

Distribution system play very crucial role to deliver electrical power to consumer. For healthy operation of distribution system, it is important that fault analysis should be appropriate. Fault impact analysis is basic requirement to conduct power system analysis of any system. The fault analysis give information about to behavior of bus voltages, short circuit current at different fault such as (L-G, LL-G, LLL-G, and LL).

The work exposed in this paper consist of parallel feeder four bus system simulate in PSCAD/ EMTDC software. Observing source current (sending end) and load current (receiving end) at normal operating and faulty condition at different fault on time instant. And verify simulation, mathematical result before and after fault in case of LLL-G fault. Also check and studied the effect of solid state resistive fault current limiter on feeder 1 fault current magnitude in case of LLL-G fault in system

KEYWORDS: *parallel feeders, distribution system, fault current limiter.*

INTRODUCTION

Parallel feeders are two or more distribution feeders temporarily connected to share load [1]. This practice is used for maintenance, service restoration, and load balancing. It is especially useful for backing up de-energized feeders and distributing heavy loads. The goal is to improve system flexibility, efficiency, and reliability. However, paralleling feeders requires careful consideration of voltage differences and impedance. When feeders are paralleled, circulating currents can flow between them, affecting overall current flow and voltage distribution.These currents depend on voltage differences and loop impedance. Voltage angle differences are primarily influenced by the transmission system and are difficult for distribution personnel to change. In case of a fault, relay sense fault and circuit breakers open its contact, isolator isolate healthy and unhealthy part in system. Allowing the remaining feeders to continue supplying power to consumers.

DISTRIBUTION SYSTEM

A distribution system is a network that delivers electricity from power plants to homes and businesses [2]. It includes feeders, transformers, and distribution lines. Feeders carry electricity from substations to different areas, while transformers reduce the voltage for safe use. Distribution lines transport electricity through neighborhoods and commercial areas. The system is designed for reliable and efficient power delivery .Circuit breakers and protective devices prevent widespread outages. Load balancing ensures no single feeder or transformer is overloaded. Modern distribution systems use smart grid technologies for better monitoring and control [3]. This improves outage response and optimizes energy usage. Renewable energy (distributed generation) sources, like solar panels, are becoming more common and require advanced system management [4]. The distribution system is essential for a stable and continuous electricity supply.

SYSTEM ARCHITECTURE
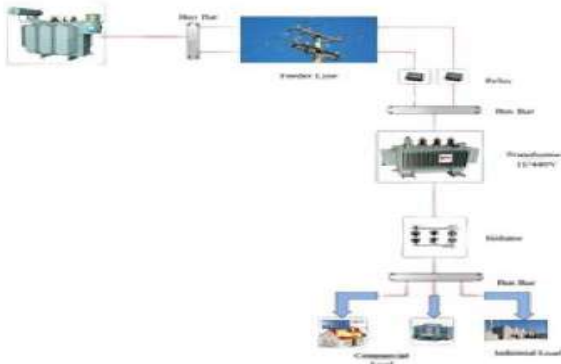
Fig.1 System Architecture

SINGLE LINE DIAGRAM

Single line diagram of parallel feeders based distribution system.
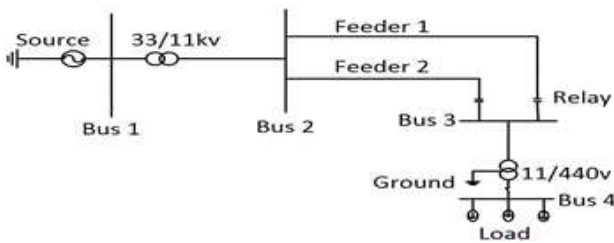
Fig.2 parallel feeder

SYSTEM UNDER STUDY

Fig.3 shows that simulation of four bus parallel feeders based distribution system in PSCAD [5]. Configuration of parallel feeder is given in Appendix. In this system source is connected to bus 1 and load is connected to bus 4.
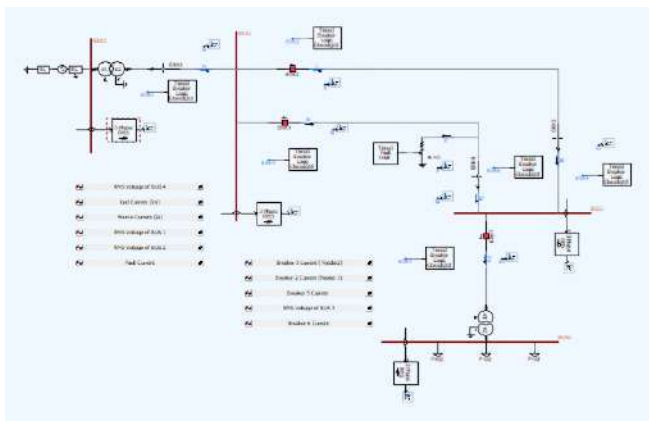
Fig.3 Simulation of four bus system in PSCAD

SIMULATION RESULT

The work presented in this paper consists of following cases.

Case I. Nature of load and source current at normal operating condition of parallel feeder based distribution system without fault. So load draws a load current form source that time total source current flowing equally in feeder 1and feeder 2. Fig. 4 represent the waveform of current supplied by source, current drawn by feeder 1 and feeder 2 and current drawn by load obtained from PSCAD simulation. The magnitude of load current is equal to source current which verify Kirchhoff's law.
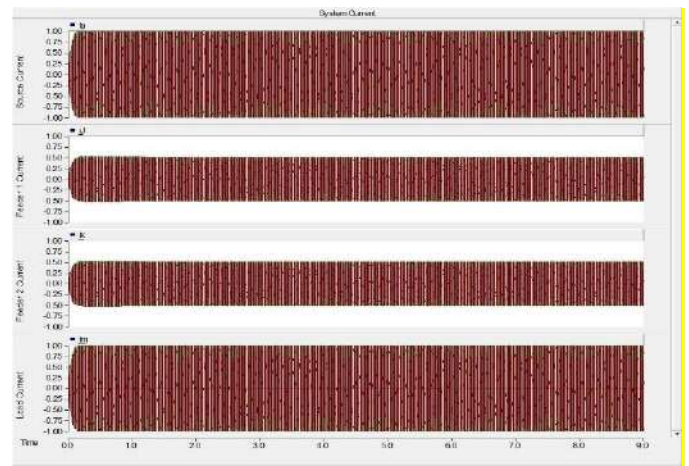
Fig. 4 System current waveform of parallel feeder based distribution system without fault.

Table-I
Case-I Source, Load and Feeder 1and Feeder 2 current

Case-I	Source current (kA)	Feeder 1 (Peak Valve in kA)	Feeder 1 (Peak Valve in kA)	Load Current (kA)
Normal operating condition (Without Fault)	1.0296	0.5148	0.5148	1.0296

Case II. Nature of all four bus voltages at normal operating condition of parallel feeder based distribution system without fault. Source is connected at bus1 due to that RMS voltage of that bus is highest. In between Bus 2 and 3 parallel feeders connected. At consumer side load is frequently change due to that more voltage drop at bus 4. Fig. 5 represent the waveform of RMS voltage of all four bus voltages obtained using PSCAD simulation.

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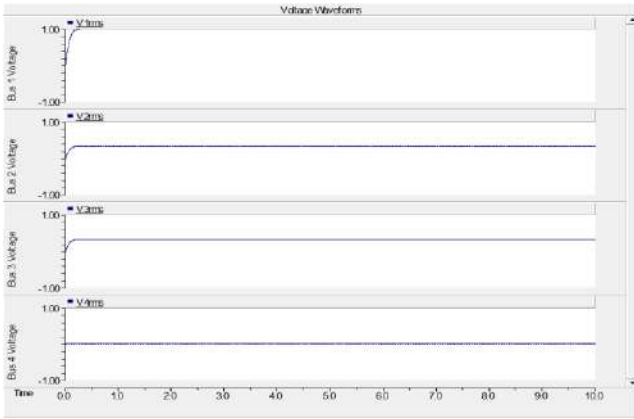
Fig. 5 System voltage waveform of parallel feeder based distribution system without fault.

Table-II
Case –II RMS voltages of buses

Case-II	RMS voltage of bus 1 (Vpu)	RMS voltage of bus 2 (Vpu)	RMS voltage of bus 3 (Vpu)	RMS voltage of bus 4 (Vpu)
Bus volatges (Without Fault)	0.9979	0.3322	0.3315	0.1020

Case III. In this case LL-G fault occur on feeder 1 at time instant 4 sec for duration of 2 sec. it observed that before fault in system at time instant 0 to 4 sec both feeder drawn same current trough source but after occurring fault at feeder 1 at time instant 4 sec feeder 1 breaker open its contact this current shift to healthy feeder 2 for the duration of 4 to 6 sec. The magnitude of feeder 1 and feeder 2 current before fault and after fault is same.Fig.6 represent the waveform of current supplied by source, current drawn by feeder 1 and feeder 2 and current drawn by load obtained from PSCAD simulation. The magnitude of load current is equal to source current which verify Kirchhoff's law.
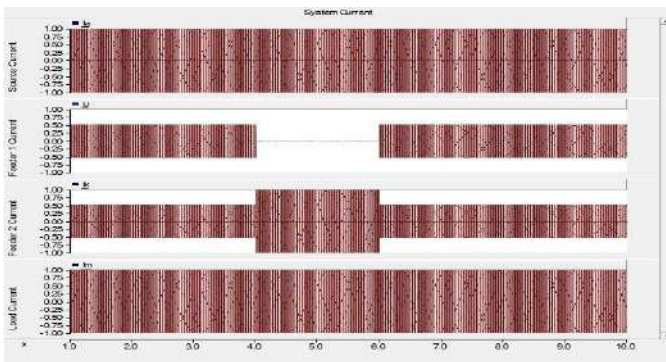
Fig. 6 System current waveform of parallel feeder based distribution system with LL-G fault at feeder 1.

Case IV. In this case LL-G fault occur on feeder 2 at time instant 4 sec for duration of 2 sec. it observed that before fault in system at time instant 0 to 4 sec both feeder drawn same current trough source but after occurring fault at feeder 2 at time instant 4 sec feeder 2 breaker open its contact this current shift to healthy feeder 1 for the duration of 4 to 6 sec. The magnitude of feeder 1 and feeder 2 current before fault and after fault is same.Fig.7 represent the waveform of current supplied by source, current drawn by feeder 1 and feeder 2 and current drawn by load obtained from PSCAD simulation. The magnitude of load current is equal to source current which verify Kirchhoff's law.
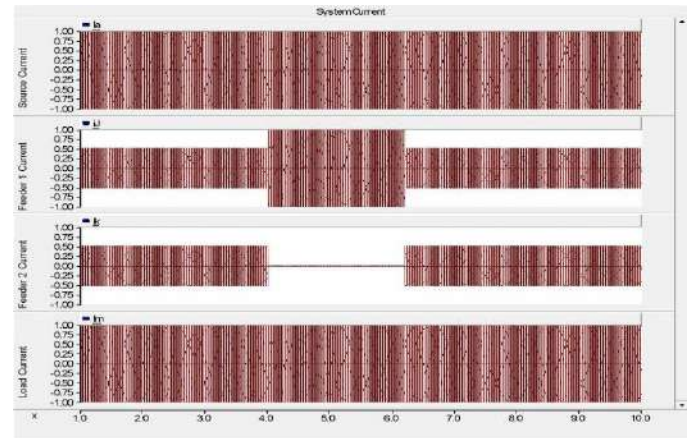
Fig. 7 System current waveform of parallel feeder based distribution system with LL-G fault at feeder 2.

Table-III
Source, Load and Feeder 1and Feeder 2 current in case of III and IV.

Case-III and Case VI	Source current (kA)	Feeder 1 current at (4 to 6) sec in kA	Feeder 2 current at (4 to 6) sec in kA	Load Current (kA)
LL-G Fault at Feeder 1	1.0321	0	1.0321	1.0421
LL-G Fault at Feeder 2	1.1031	1.1031	0	1.1031

Case V. In this case LLL-G fault occur on feeder 1 at time instant 4 sec for duration of 2 sec. it observed that before fault in system at time instant 0 to 4 sec both feeder drawn same current trough source but after occurring fault at feeder 1 at time instant 4 sec feeder 1 breaker open its contact this current shift to healthy feeder 2 for the duration of 4 to 6 sec. The magnitude of feeder 1 and feeder 2 current before fault and after fault is same. Fig.8 represent the waveform of current supplied by source, current drawn by feeder 1 and feeder 2 and current drawn by load obtained from PSCAD simulation. The magnitude of load current is equal to source current which verify Kirchhoff's law.

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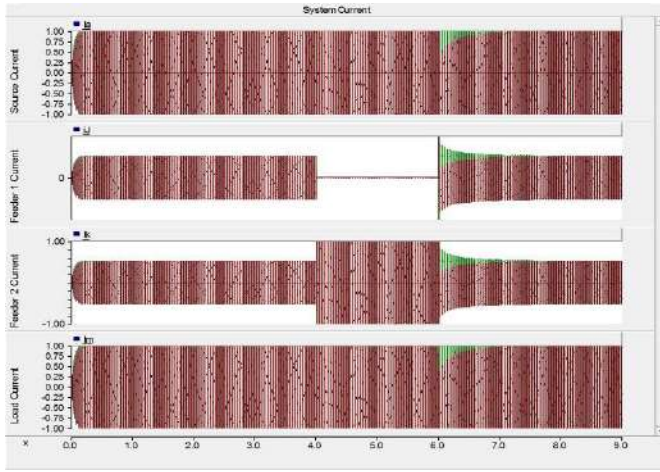
Fig. 8 System current waveform of parallel feeder based distribution system with LLL-G fault at feeder 1.

Case VI. In this case LLL-G fault occur on feeder 2 at time instant 4 sec for duration of 2 sec. it observed that before fault in system at time instant 0 to 4 sec both feeder drawn same current trough source but after occurring fault at feeder 2 at time instant 4 sec feeder 2 breaker open its contact this current shift to healthy feeder 1 for the duration of 4 to 6 sec. The magnitude of feeder 1 and feeder 2 current before fault and after fault is same.Fig.9 represent the waveform of current supplied by source, current drawn by feeder 1 and feeder 2 and current drawn by load obtained from PSCAD simulation. The magnitude of load current is equal to source current which verify Kirchhoff's law.
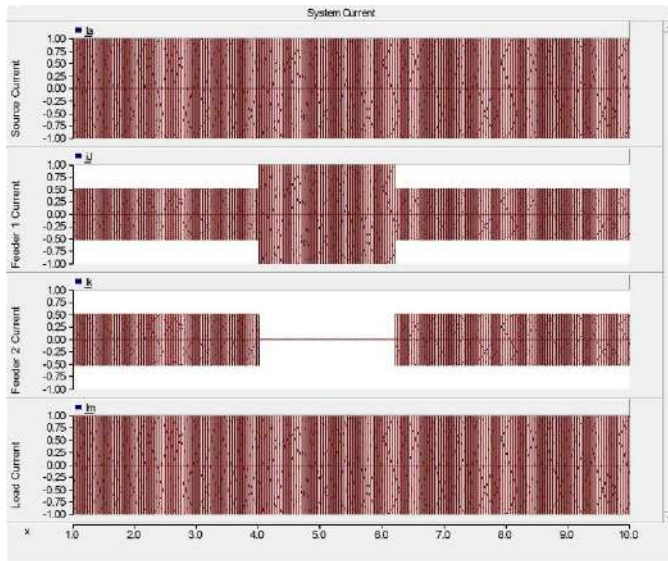
Fig. 9 System current waveform of parallel feeder based distribution system with LLL-G fault at feeder 2.

Table-VI
Source, Load and Feeder 1and Feeder 2 current in case of V and VI

Case-V and Case IV	Source current (kA)	Feeder 1 current at (4 to 6) sec in kA	Feeder 2 current at (4 to 6) sec in kA	Load Current (kA)
LLL-G Fault at Feeder 1	1.0380	0	1.0048	1.0402
LLL-G Fault at Feeder 2	1.0352	1.0441	0	1.0034

Comparison of feeder 1 fault current magnitude without fault current limiter and with resistive fault current limiter of 5 Ω. Under the influence of LL-G, LLL-G fault is shown in the below table.

Table-V
Comparison of feeder fault current in case IV and VI.

Types of Fault	Current in Previous Cases	
	Feeder 1 Fault Current without FCL (Peak Valve in KA)	Feeder 1 Fault Current with5 ohm FCL (Peak Valve in KA)
LL-G fault	1.1031	0.60
LLL-G fault	1.0441	0.54

MATHEMATICAL RESULT

To verify simulation and mathematical result before and after fault in a case of LLL-G. In this case first measure RMS voltage of all four buses using PSCAD simulation for that connect three phase RMS meter to particular bus. After that finding the bus impedance of all buses, calculate before fault current on time instant 0 to 4 sec, during fault instant 4 to 6 sec and after fault current on time instant 6 to 10 sec.

Case VII. Before fault calculation in case of LLL-G fault.

Bus 1 voltage = 1 PU (voltage at sending end)
Bus 2 voltage = 0.33 PU
Bus 3 voltage = 0.33 PU
Bus 4 voltage = 0.015 PU (voltage at receiving end)

Calculate Impendence Z for all buses.
   A) Impendence (Z_1) for Bus 1.

$$z_1 = \frac{v}{I} = \frac{1}{1} = 1\,pu$$

   B) Impendence (Z_2) & (Z_3) for bus 2 and 3.

$$z_4 = \frac{v}{I} = \frac{0.015}{1} = 0.015\,pu$$

   C) Impedance for bus 4.

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$$z_4 = \frac{v}{I} = \frac{0.015}{1} = 0.015\,pu$$

Total impedance (Z) of all buses (Simulation result in PSCAD Simulation)

$$Z_{total} = \frac{(Z_1)+(Z_2)+(Z_3)+(Z_4)}{4} = 0.583$$

Calculate Current (before fault in time instant 0 to 4 sec)

$$I_{calculate} = \frac{1}{(Z_3)+\frac{(Z_2)(Z_1+3*(Z_4))}{(Z_2)+2(3*Z_4)}} = 0.625$$

Calculated fault current (I_f) during fault instant (4 to 6 sec)

$$I_f = \frac{-3*\in_0*Z_2}{(Z_2*Z_1)+(Z_2*Z_0)(Z_0*Z_1)} = -1.13$$

Case VII. After fault calculation in case of LLL-G fault

Bus 1 voltage = 1 PU (voltage at sending end)
Bus 2 voltage = 0.30 PU
Bus 3 voltage = 0.299 PU
Bus 4 voltage = 0.015 PU (voltage at receiving end)

Calculate Impendence Z for all buses.

A) Impendence (Z_1) for Bus 1.

$$z_1 = \frac{v}{I} = \frac{1}{1} = 1\,pu$$

B) Impendence (Z_2) bus 2

$$z_2 = \frac{v}{I} = \frac{0.300}{0.50} = 0.60\,pu$$

C) Impendence (Z_3) bus 3

$$z_3 = \frac{v}{I} = \frac{0.299}{0.50} = 0.599\,pu$$

D) Impendence (Z_4) bus 4

$$z_4 = \frac{v}{I} = \frac{0.015}{1} = 0.015\,pu$$

Total impedance (Z) of all buses (Simulation result in PSCAD Simulation.

$$Z_{total} = \frac{(Z_1)+(Z_2)+(Z_3)+(Z_4)}{4} = 0.568$$

Calculate Current (After fault in time instant 6 to 10 sec)

$$I_{calculate} = \frac{1}{(Z_3)+\frac{(Z_2)(Z_1+3*(Z_4))}{(Z_2)+2(3*Z_4)}} = 0.625$$

Calculated fault current (I_f) during fault instant (4 to 6 sec)

$$I_f = \frac{-3*\in_0*Z_2}{(Z_2*Z_1)+(Z_2*Z_0)(Z_0*Z_1)} = -1.15$$

CONCLUSION

The work presented in this paper depicted that importance of parallel feeder during faulty condition in distribution system and giving uninterrupted power supply to consumer end. In LLL-G fault current value effect on parallel feeder operation and create a protection problems for solving these issue connect a solid state fault current in series with feeder 1. It is observed that after adding FCL in case of IV and VI fault current value decrease. The main advantages of the proposed FCL are limit the fault current value in predetermined level and maintain continuous power to consumer, reduced the risk of safety hazards. Also adding such type of FCL on system FCL has no effect on voltage utility and current at normal system operation and even after fault minimizing fault current to safe value .It observed that normal operating condition both feeder drawn same current value form source and given to load (consumer end) verified by Kirchhoff's law. Simulation and mathematical result also verified before and after in case of LLL-G fault.

APPENDIX

Configuration of system under study

Component	Rating
Three Phase Source	100MVA, 66 kV, 60Hz
Transformer ($\Delta - \Delta$)	100MVA, 66 kV /11 kV, 60Hz
Feeder line data	Feeder 1 Voltage = 11 kV No coaxial cable = 03 Feeder 2 Voltage = 11 kV Sending end Voltage = 66 kV Receiving end Voltage = 11 kV
Transformer ($\Delta - Y$)	100MVA, 11 kV /0.4 kV, 60Hz

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Analyses of a Photonic Band Gap in case of Multifaceted Photonic Crystals Utilizing Alumina Dielectric Rods in Vacuum

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ABSTRACT: The new technology utilized for producing electricity at the most affordable price has the name photovoltaic. Even though solar photovoltaics only makes up a small portion of the world's total power-generating capacity of 4800 GW from all sources, by 2040 they will provide electricity in more than 80 nations and are the power-generation technology with the quickest pace of growth. In this paper, a novel kind of photonic crystal is created and its uses are examined. Researchers will have a better understanding of photonic crystal design with the aid of the CST program. The paper also discusses the benefits and drawbacks of utilizing solar energy in day-to-day activities.

Keywords: Electricity, Power Generation Technology, Photonic Crystals

INTRODUCTION:

The use of photovoltaic cells, the essential part of a photovoltaic system, is the subject of photovoltaic, a novel and rapidly expanding technology. The energy is transformed from one form to another by the cells, which is completely different from other generating methods. For example, solar energy is converted into electricity. Currently in use is the cleanest generation approach. The first use of photovoltaic technology dates back to 1839[1], and it was first put to use in the early 1970s. The United States began utilizing photovoltaic technology in their space program at this time. By 1990's end, this technology was being used in both large and small markets for things like electric power applications and pocket calculators. As of 2010, solar photovoltaic technology is the power-generation technology with the quickest rate of growth worldwide, producing electricity in over 80 nations but still making up a very small portion of the 4800 GW [2] total capacity of power generation worldwide from all other sources. The most effective way to use solar cells to generate power is

using photovoltaic technology. The process by which light photons knock electrons down to a higher energy level and produce electricity is known as the photovoltaic effect [1]. Sunlight is converted by solar cells into a DC form of energy that may be used to power devices or recharge batteries. An inverter is then used to transform the DC form of energy into an AC form of electricity. Powering satellites and other spacecraft in orbit was the first practical use of photovoltaics [1]. One relatively recent and intriguing technology that presents many new potential for producing "green" electricity is the ability to generate electricity from sunlight. We refer to this method as solar photovoltaic. PV, often known as solar electric, is a clean, quiet, and renewable method of producing electricity. It generates electricity using the sun's abundant energy without emitting harmful emissions of $CO2$, the gas backing to climate change. It is a way in right direction towards green initiative, that is crucial to employ while combating global warming. Many nations are making efforts to progress photovoltaic technology through independent projects and useful applications. Numerous nations,

including Germany, Japan, the Netherlands, Norway, and the USA [3], have set up government investment programs in partnership with different businesses, resulting in the construction of thousands of solar-electric homes worldwide [3]. However, other nations, like Scotland and the United Kingdom [3], lack a sizable domestic market in which to showcase their proficiency in PV knowledge or the resources to further expand this area. This kind of technology is straightforward to maintain, easy to install, and dependable. It should be highlighted that, despite the level of competence found in some industrialized nations, it is odd that PV technology is so little employed and does not have a bigger impact on people's daily lives. This could be because PV-generated electricity is costly to compete with in European Countries [3] since fossil fuel, nuclear, and even wind generation are so cheap.

A squeaky semiconductor layer that functions as an electric field in solar cells has two appearances: a positive side and a negative side. These days, silicon—a unique kind of molten sand with more than 2 thin layers of semi-conductive material, mainly silicon—is used to make the majority of solar cells [3].There are various charges in these layers. Two opposing charges—one positive and one negative—are applied to the operation layers. Electrons traveling along the solar cell are knocked down by sunlight, which releases them from the confines of atoms in a semiconductor material. When two separate conductors are connected, one at the positive and the other at the negative side, an electric circuit is created, allowing electrons to be trapped and converted into electricity in the form of an electric current. A load, such a tool or light, can then be powered by this electricity. The PV cells that are utilized are often built as

Schottky barrier devices or pn junctions [4]. Electrons and holes pair when sunlight strikes a cell's surface. This process is brought about by the interaction of incident photons from the sun with the atoms already existing in the cell. The electrons and photons drift as a result, changing their region. Under Standard Test Conditions (STC), which include an irradiation of $1000W/m2$ and a cell temperature of 25°C, the electrical output of a solar cell is measured [3]. This allows for the calculation of the cell's maximal power delivery and fill factor (FF), or cell conversion efficiency. [4]

In many nations, PV technology is only used as a last resort by people, mainly in remote or hard-to-reach places where connecting to the grid is costly or impossible. These kinds of problems exist in rural parts of countries like Africa and India, but because there is an abundance of sunlight in these regions, photovoltaic technology can be helpful. Stand-alone systems are already proving to be financially feasible in certain areas. These systems don't rely on the grid, and any extra energy they generate is typically stored in batteries.

The dielectric constant, lattice topology, and spatial period are the three components that make up photonic crystals [6]. When important parameters related to these are taken into account, a breach can be established where electromagnetic radiation is banned. As result, a photonic gap forms. Three distinct dimension schemes—one, two, and three—can be used to build photonic crystals. Every derivative with relation to the z-coordinate disappear in two-dimensional photonic crystals [6]. One-dimensional photonic crystal is produced by using a layer with a variable dielectric constant.

CREATING PHOTOVOLTAIC CRYSTAL DESIGNS

This chapter discusses the design of the photovoltaic crystal. For the creation of cell software design tools like CST Microwave Studio. High frequency component 3D electromagnetic modelling is a well-known use for this type of software. Antennas, filters, couplers, planar and multi-layer structures, SI, and EMC effects are examples of high frequency (HF) devices that can be swiftly and precisely analyzed by the user with the help of CST MWS [5].
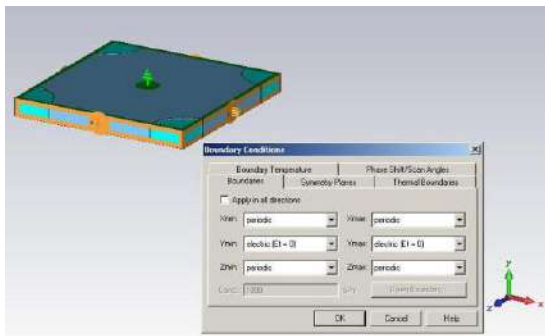
Alumina dielectric rods with an epsilon value of 9.8 [6] in a vacuum lattice are employed in this design method.

Figure: Creating and Establishing Boundaries in CST Software
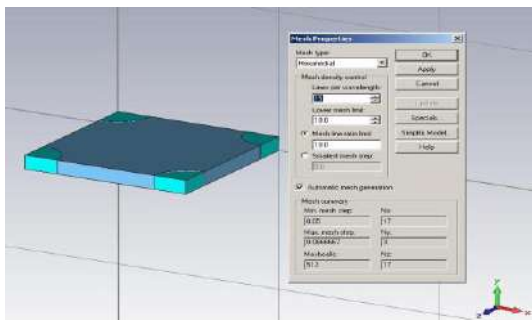
Figure: Applying Phase Shift on prepared cell using CST Software
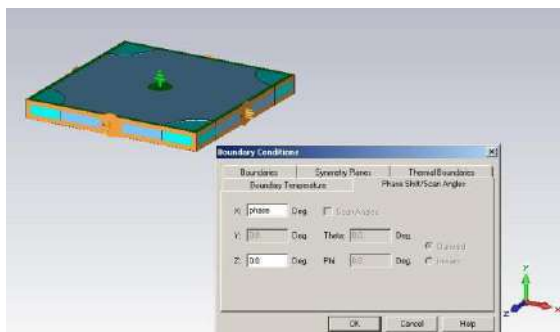
Figure: Setting the Mesh for prepared cell
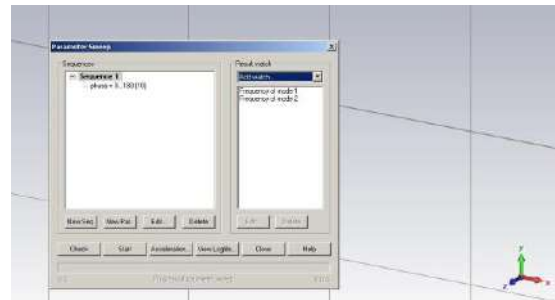
using CST Software

Figure:- Adding Frequency mode to cell using CST Software
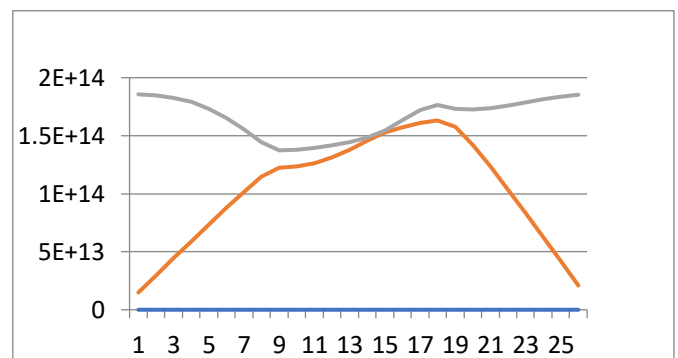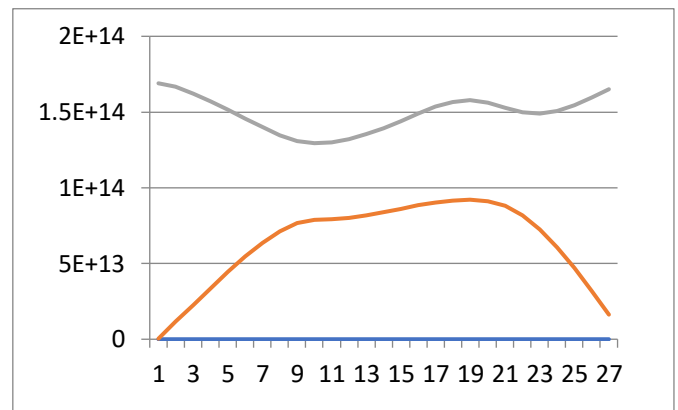
RESULTS:

Graphical Output: When Et = 0, output in frequency modes 1 and 2.

Graphical Output: When Ht = 0, output in frequency modes 1 and 2

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The developed photonic crystal's electrical and magnetic output properties are displayed above. Evidently, the photonic crystal employed in this experiment has a band gap that prevents photons at a particular energy level from passing through the crystal. Additionally, if the material is altered, the band gap will grow, and for higher values of epsilon, the band gap will increase as well. The employed material's refractive index rises as a result of this.

CONCLUSION:

Analysis therefore revealed that a band gap, which prevents photons within a specific energy range from propagating through it, may be generated by using different types of materials in the photonic crystal manufacturing process. Thus, it can be concluded that the crystal becomes increasingly likely to retain photons over extended periods of time. High epsilon value materials cause a rise in the band gap, which raises the used material's refractive index. However, using a material with a high epsilon value will not be practical as it could result in an increase in the crystal's manufacturing costs. In contrast to the practical approach employed by businesses, the CST program provides researchers with a very basic understanding of the designing of photonic crystals. Additionally, it aids in the design of various crystal types using various materials by the researchers.

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Development of Power Generation System using Solar-Wind-Piezo Energy

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ABSTRACT –

This project presents the development of a hybrid energy generation system that integrates solar, wind, and piezoelectric power sources to produce sustainable electricity. Designed to address the growing demand for renewable energy, the system combines photovoltaic panels and wind turbines to harness natural resources, while piezoelectric modules convert mechanical energy, such as footstep pressure, into electrical energy. The hybrid configuration ensures reliable power generation, particularly in remote or off-grid areas, by leveraging multiple renewable sources. It offers cost-effectiveness with a long lifespan and low maintenance requirements, despite higher initial investment costs. Additionally, the system reduces transmission losses and operational expenses by generating power locally. This approach supports energy independence, minimizes environmental impact, and caters to both domestic and industrial applications. By promoting clean energy adoption, the system contributes to achieving global sustainability goals.

KEYWORDS: Hybrid Energy System, Renewable Energy, Solar Power, Wind Energy, Piezoelectric Modules etc.

INTRODUCTION

The ever-increasing global demand for energy has posed significant challenges to traditional energy generation methods. Conventional power sources, such as coal, oil, and natural gas, have long been the backbone of energy supply worldwide. However, their continued use has severe implications for the environment, including the depletion of finite resources and the emission of greenhouse gases that contribute to climate change. These issues highlight the urgent need to transition to sustainable energy systems capable of meeting growing energy demands while minimizing environmental harm. Renewable energy sources, such as solar, wind, and piezoelectric power, have emerged as viable alternatives, offering clean, reliable, and eco-friendly solutions to global energy challenges.

A hybrid energy generation system combines multiple energy sources to maximize efficiency, reliability, and sustainability. By integrating solar, wind, and piezoelectric energy, these systems leverage the strengths of each source to overcome individual limitations, providing a comprehensive and innovative approach to energy generation. Solar energy, harnessed through photovoltaic panels, relies on sunlight as a limitless, clean resource. Wind energy, generated through turbines, converts the kinetic energy of wind into electricity, making it a complementary power source, particularly in areas with variable wind patterns. Piezoelectric energy, on the other hand, captures mechanical energy from pressure, such as footsteps, vibrations, or vehicle movement, and converts it into electricity.

The combination of these three energy sources in a hybrid system offers numerous advantages over traditional power generation methods. Solar energy production is highly dependent on weather conditions and daylight, resulting in fluctuating energy output. Similarly, wind energy is influenced by local wind patterns and speeds, making it an intermittent power source. Piezoelectric systems can supplement these sources by providing continuous energy generation from mechanical pressure, ensuring a stable energy supply even when solar or wind energy is unavailable. This synergy improves the overall efficiency and reliability of the system, making it particularly suitable for remote or off-grid areas where energy access is limited or inconsistent.

One of the key benefits of hybrid energy systems is their ability to reduce energy transmission losses. Traditional power systems often rely on centralized power plants that transmit electricity over long distances, leading to significant energy losses during transmission. In contrast, hybrid systems can be

installed locally, close to the point of use, minimizing transmission losses and ensuring efficient energy delivery. This localized approach also reduces the infrastructure and maintenance costs associated with large-scale energy grids, making hybrid systems a cost-effective and practical solution for a variety of applications, from domestic to industrial settings.

While the initial investment in hybrid energy systems may be higher than traditional systems, their long-term benefits far outweigh the upfront costs. These systems have low maintenance requirements, long operational lifespans, and minimal environmental impact. Furthermore, advancements in renewable energy technologies and decreasing costs of solar panels, wind turbines, and piezoelectric generators are making hybrid systems increasingly accessible and economically viable.

METHODOLOGY

Hybrid Power :

A hybrid power tool is a combination of two power sources used to power the load. Under other circumstances it may be summed up as "an strength device which is fruited are developed to extract electricity by the usage of two electricity sources, t's far called hybrid power system." The hybrid strength gadget has enough reliability, efficiency, low emissions, and low cost.

In this proposed gadget, solar and wind power are employed to generate electricity. Sun and wind strength have distinct advantages as compared to all other unconventional electricity sources. Each power asset is required in all areas. It desires a low fee. There is no need to identify a specific area to put in this gadget.

Solar Power :

Solar energy is power generated by the sun's radiation, which is constantly and readily available on the earth. It is freely accessible, does not emit pollutants, has minimal upkeep expenses, and is cost-effective. However, it has difficulty producing power in bad weather conditions. Solar energy is more efficient than conventional sources, requiring an upfront investment but having a longer lifespan and lower emissions.

Wind Power :

Wind power is generated from the wind utilizing a windmill, which is a sustainable energy source with minimal production and maintenance costs. Wind energy is accessible virtually 24 hours a day and produces little emissions. The starting cost is cheaper than for solar energy, and the amount of power produced is determined by the direction of the air flow.

The recommended Hybrid Energy System mixes solar and wind power to solve the short-term nature of individual renewable energy sources. This provides continuous power generation, increases dependability, and overcomes the limitations of individual sources. The system may be deployed in remote places, lowering gearbox costs while providing a dependable, low-emission, and cost-effective option providing continuous power delivery.

Hybrid energy generation systems that integrate solar, wind, and piezoelectric technologies represent a promising solution to the global energy crisis. By harnessing multiple renewable sources, these systems provide a sustainable, reliable, and efficient way to meet energy demands while reducing environmental impact. Their potential for widespread adoption can play a crucial role in achieving energy independence, reducing reliance on fossil fuels, and fostering a cleaner, greener future.

PROJECT DESCRIPTION
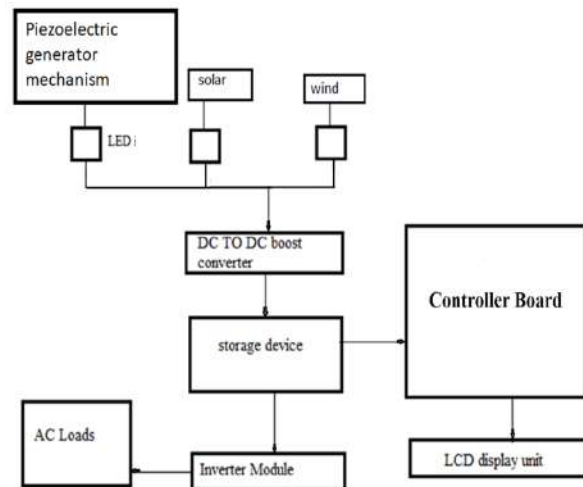
Fig.2. Block Diagram of system

- Hybrid energy is the combination of more than one energy source. Combination of solar and wind with piezo generator is better among all the other combination.
- Whenever force is applied on piezoelectric generator that force is converted to electrical energy which can be used to drive dc loads and that minute voltage which is stored in the lead acid battery. The battery is connected to the inverter.
- This inverter is used to convert the 12 volt D.C to the 230 volt A.C. This 230 volt A.C voltage is used to activate the loads.
- We are using conventional battery charging unit also for giving supply to the circuitry.
- Here we are using Charge Controller with display to show the amount of battery charged voltage.

- In this system wind turbine can be used to produce electricity when wind is available and solar energy panels are used when solar radiations are available. Power can be generated by both the sections at the same time also. The usage of batteries is to provide uninterrupted power supply.
- The microcontroller is used in the system to control the switching between the converters with the help of a driver circuit. A charge controller/converter is used to control the power supply of solar panels.

COMPONENTS SPECIFICATION

- *Solar Panel* **(12v25w)**

Solar energy is the energy that we receive from the sun in the form of radiation. It does not pollute and is infinitely renewable. It is accessible for free. A solar cell, sometimes called a photovoltaic cell, is a device that converts solar energy into electricity.

- **DC Generator (12v)**

A direct current generator, or DC generator, is a device whose principal job is converting mechanical power to electricity.

- **Piezoelectric sensor**

A piezoelectric sensor is a device that uses a piezoelectric effect to measure energy and convert them into an electrical signal. pressure, acceleration.
Challenge - Convert phase energy into electrical energy.
Solution - Using piezoelectric materials.
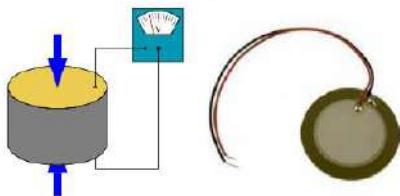
- **DC to DC boost Converter (Regulated 12v)**

A boost converter (or step-up converter) is a power converter from DC to DC that increases voltage while decreasing current from the input (supply) to the output

(load). It is a type of switched-mode power supplies (SMPS) that has a minimum of two semiconductor components (a diode and a transistor) along with at least a single energy storage element: a capacitor, an inductor, or both in combination.

- **Inverter (12v DC to 220v AC)**

As we all know, most electrical devices require AC power, thus the direct current (DC) power of the batteries is transformed into AC voltage using an inverter before being transmitted to the loads. The inverter has to be having excess voltage protection, the opposite polarity, as well as short circuit protection.

- **Battery (12V 5Ah)**

Batteries are used to store the power generated by piezoelectric and solar energy. The capacity of the battery might vary based on the dimension of the input power produced.

PROPOSED CALCULATIONS

Total energy generated by the system is the total energy generated by the solar PV panel and the power generated by the wind turbine. According to statistics, it can be represented by,

$$PT = NW * Pw + Ns * PS$$

There,

Total energy generated = PT

Power generated by wind turbines = PW

Energy produced by solar panels = PS

Wind turbine number = NW

Number of solar panels used = NS

A. Calculations for wind energy:

The energy produced by wind power is provided by,

Energy = (air density * swept area * cubed velocity) / 2

$PW = \frac{1}{2} . \rho (AW) (V) 3$

There,

P is the power in watts (W)

ρ air pressure per kilogram per cubic meter (kg / m³)

AW area of air per square meter (m²) V wind speed per meter (m / s).

B. Calculations for solar energy

To determine the size of the PV modules, the required power consumption should be measured. Therefore, power is calculated as

$PS = Ins (t) * AS * Eff (pv)$

There,

Ins (t) = separation at t (kw / m2)

AS = one PV panel area (m2)

Effpv = full efficiency of PV panels and dc / dc converters.

The overall efficiency is provided by,

$Eff (pv) = H * PR$

There,

H = Annual rate of solar radiation on oblique panels.

PR = Performance rate, loss coefficient.

C. Cost

The total cost of a solar-wind energy system depends on the total number of wind turbines used and the total number of solar panels used. The total cost is therefore provided as follows

Total Cost = (Wind Turbine Number * Cost of One Wind Turbine) + (Solar Panel Number * Cost of One Solar Panel) + (Number of Batteries Used in Battery Bank * Cost of One Battery)

$CT = (NW * CWT) + (NS * CSP) + (NB * CB)$

There,

CT is the total cost per Rs

CWT is the cost of a single wind turbine

CSP costs one day panel per Rs

CB One Battery Cost Rs

NW is the amount of wind turbine used

NS is the number of solar panels used

NB is the number of batteries used in the Battery Bank.

RESULTS AND DISCUSSION

The hybrid energy system integrating solar, wind, and piezoelectric power sources demonstrates significant potential in addressing global energy demands sustainably. The system ensures continuous and reliable electricity generation by leveraging the complementary characteristics of each energy source. Solar panels provide a steady energy output during daylight hours, while wind turbines contribute power under favorable wind conditions. The piezoelectric modules act as an additional energy source, converting mechanical pressure from movements or vibrations into electricity, particularly during periods of low solar and wind activity.

Experimental results highlight the system's improved efficiency and reliability compared to standalone renewable energy systems. Localized power generation reduces transmission losses, ensuring more efficient energy delivery. Additionally, the hybrid system's capability to operate in remote areas underscores its practicality for off-grid applications.

While the initial investment cost is higher, the system offers long-term economic benefits due to its low maintenance requirements, long operational lifespan, and reduced reliance on conventional energy infrastructure. However, challenges such as the need for efficient energy storage systems and integration of control mechanisms for optimal performance must be addressed.

This hybrid system effectively balances sustainability, reliability, and cost-efficiency, making it a promising solution for future energy generation and addressing global environmental concerns.

ADVANTAGES

• Increased Efficiency: Combines multiple renewable sources for continuous power generation.
• Environmentally Friendly: Produces no harmful emissions, reducing carbon footprint.
• Cost-Effective: Requires minimal maintenance with low operational costs after installation.
• Sustainability: Utilizes renewable resources, ensuring long-term power generation.
• Reliability: Provides consistent power, especially in remote or off-grid locations.
• Reduced Transmission Losses: Local power generation minimizes energy wastage during transmission.

DISADVANTAGES

1 The system is expensive compared to the current system.
2. Microcontroller programming is required, which increases software costs and makes prototyping difficult.
3. Solar panels need frequent cleaning.

APPLICATIONS

• Remote Areas: Provides power where traditional grids are unavailable.
• Industrial Use: Supports energy needs for factories and manufacturing units.
• Agricultural Applications: Powers irrigation systems, greenhouses, and farms.
• Rural Electrification: Supplies electricity to underserved rural communities.
• Standalone Systems: Suitable for off-grid or hybrid power setups.

SCOPE OF PROJECT

• It is the design method for maximum conversion efficiency of a turbine for delivering the maximum power to a load, battery in the case of a standalone solar-wind system.
• Saves space.
• It doesn't require fuel.

CONCLUSION

The hybrid energy system that combines solar, wind, and piezoelectric power generation provides an innovative and sustainable solution for electricity production. By integrating multiple renewable energy sources, the system maximizes energy generation efficiency and ensures a consistent and reliable power supply, even in remote or off-grid areas. Solar panels harness energy from the sun, while wind turbines capture kinetic energy from the wind, both of which are abundant and eco-friendly sources. Additionally, piezoelectric modules convert mechanical pressure, such as footsteps or vibrations, into electricity, further enhancing energy output and bridging gaps in energy availability during low solar or wind conditions.

This multi-source system significantly reduces dependency on conventional energy sources like coal and oil, thereby minimizing greenhouse gas emissions and mitigating climate change. While the initial investment for installation may be higher than traditional energy systems, the hybrid approach offers numerous long-term benefits, including a long lifespan, minimal maintenance, and reduced operational costs. Moreover, localized energy generation reduces transmission losses and infrastructure expenses, making it a cost-effective option.

Overall, the hybrid energy system offers a practical and efficient pathway to achieving energy sustainability. It addresses global energy challenges, promotes energy independence, and contributes to a cleaner environment, making it a promising solution for the future of renewable energy.

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Analysis of Electric Vehicles Under Different Driving Cycle Conditions Using MATLAB.

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ABSTRACT

Energy management systems (EMS) are crucial in optimising the performance and efficiency of hybrid electric vehicles (HEVs). This paper presents an analysis and comprehensive review of various EMS techniques and their applications in EVs. The study focuses on various energy sources, like batteries, supercapacitors (UCs), and fuel cells, to enhance system performance. The impact of vehicle dynamics on EMS performance, considering factors such as aerodynamic drag force, rolling resistance, and gradient hill force, is analysed. In this paper, the MATLAB simulation is done considering only the battery as an energy source, and the DC motor for transmission. The Drive cycle FTP 75 is considered a reference cycle for the simulation. The vehicle performance is analyzed for different drive cycle conditions such as acceleration, deceleration, normal running condition, and standstill condition.

Keywords—Electric Vehicle (EV), Battery, Energy management systems (EMS), State of Charge (SOC), Drive cycle.

INTRODUCTION

The importance of biofuel, electric energy, and other renewable energy in vehicle transportation systems is gaining demand nowadays. Various automotive companies are launching their vehicles in this section. The governments are also encouraging the companies and people who use these vehicles by giving them subsidies in different forms such as under the FAME scheme. [15,16,21].

The energy management system (EMS) is an important section of a hybrid electric vehicle (HEV). The main objective of EMS is to use two or more number of energy sources optimally and deliver the maximum output to the system. The various energy sources used in HEVs are Battery, Supercapacitor (or Ultracapacitor UC), Fuel cell (FC), Flywheel, and Solar panels. When it comes to the driving range of HEV, the specific energy of the source is considered and for acceleration, and efficiency improvement, the particular power of the energy source is considered. The EMS properly utilizes available energy sources to meet this demand. Many researchers work on performance improvement of EMS by implanting various advanced techniques some of which are listed in Table 1. During their research, the various systems, as well as energy source parameters, are taken into consideration some of them are mentioned in Table 1. The major function of EMS is to take a decision for energy consumption according to the voltage, current, and temperature data in real time and use it for cell balancing, thermal management, state of charge (SOC), state of health (SOH), of energy sources.

LITERATURE REVIEW

A review of different hybrid electric vehicles (HEV) and their challenges is done by Hannan et al. [5]. The different energy sources used for HEV are a Battery, A supercapacitor (or Ultracapacitor UC), a Fuel cell (FC) Solar cell, etc. The authors focus on the advantages and disadvantages of different energy storage devices, the dynamics of HEV, and the characteristics and types of HEV. This paper explain the details about HEV technologies and their shortcomings.The two-converter topology for the combined use of battery and supercapacitor is used by Khaled Alobeidli et al. [4]. The main objective is to enhance the overall system efficiency of the power management system of electric vehicles and to increase the battery life by decreasing its charging-discharging cycle. Two-stage artificial neural network (ANN)-based methods, called charge-sustaining ANN and charge-depleting ANN (CD-ANN), were created by the authors in [4].

The various parameters like battery state of charge

(SOC), vehicle velocity, and supercapacitor (or ultracapacitor (UC)) SOC are considered during complete work. The performance is validated using an ADVISOR-based simulation toolbox and MATLAB. The three different driving cycles are considered for evaluation purposes like the Japanese driving cycle (J1015), Indian Urban Driving cycle (IUDC), and Urban Dynamometer Driving Schedule (UDDS). thus, controlling the UC SOC reduces the battery energy throughput and operating temperature significantly. Along with the proposed technique, the rule base and fuzzy-based techniques are also studied. The suggested method lowers both the system's overall energy loss and battery energy throughput by about 20% each. Energy storage devices, which fall into three categories—passive, semi-active, and completely active—are typically utilized in electric vehicles (EVs) using four standard topologies. Q. Zhang et al. [1] employ the semi-active topology for battery and supercapacitor hybrid energy storage systems for research purposes. This type of topology uses a supercapacitor in conjunction with a DC/DC converter. The filtering and fuzzy logic controllers are the foundation of the author's real-time energy management control approach.

The author designed 5 membership functions for battery power and 3 membership functions for supercapacitor SOC. The result is evaluated with an experimental setup consisting of AVL emulator platform dSPACE based Auto box and lithium nickel manganese cobalt battery. The main outcome of this research is that the battery voltage is reduced when used in combination with UC the sole battery (i.e. hybrid energy storage system HESS). Also, battery peak current, battery energy capacity, and battery cost are reduced when used in HESS. The different driving cycles considered for the study are the highway driving cycle (HWDC), the new European driving cycle (NEDC), and IUDC.

Another method is an adaptive fuzzy logic-based energy management strategy (AFEMS) to calculate the power exchange between the battery bank and ultracapacitor (UC). This technique is used by H. Yin et al.[6]. Fuzzy logic controllers help handle complicated real-time control problems because they don't require prior knowledge of the driving cycle. This study presents an energy management plan for a battery/UC hybrid energy storage system. Due to their complementing features, UC and battery are paired in a parallel active topology. An EMS based on adaptive fuzzy logic is created to divide the power needs between batteries and UCs. The author covered the benefits and drawbacks of

lithium-ion batteries and supercapacitors [6]. Low power density, short cycle life, and other issues still plague lithium-ion batteries. In contrast to traditional batteries, UC has a low energy density but a high power density, extended cycle life, and fast dynamic response.

The comparative analysis of a few chosen research papers covering a range of significant topics taken into account when studying EMS is presented in Table 1. The parameters include the driving cycle being taken into consideration, the energy source used, the technique, the research's goal, and so on.

VEHICLE DYNAMIC

For any vehicle acceleration is important. The acceleration depends upon the traction unit's rating and all components' mass. The effort or force required to move the vehicle is the tractive effort. The total tractive force is the function of the mass in kg (M), velocity of vehicle(v), and slop angle (θ). The study of vehicle dynamics is important for studying different forces acting on vehicles. The total tractive force is important to calculate the power required by a vehicle. Figure 1 gives us an idea about the different forces acting on the vehicle. It mainly include the aerodynamic drag force (Fad), rolling resistance force (Frr), gradient hill force or climbing force (Fg) and velocity of the vehicle.
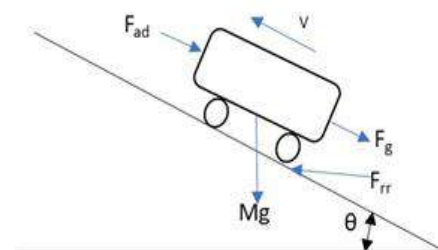
Figure 1. Vehicle dynamics

This total tractive force is given by

Fte =Fad +Frr+ Fg + Fla +Faa-----------(1)

The total power required is given by

Pte = Fte *V--------------------(2)

The effect of different forces on vehicles is examined by considering some reference parameters given in Table 2.

Table 2. Technical specifications for theoretical calculation

S. N.	Parameters	Value	S. N.	Parameters	Value
1	Radius of wheel (rw)	0.2768 m	6	Aerodynamic drag coefficient (cd)	0.5
2	Gear ratio (gr)	10.83	7	Grade angle	0º

3	Rolling resistance coefficient (μrr)	0.01	8	Acceleration due to gravity (g)	9.81 m/sec2
4	Air density(ρ)	1.22 Kg/m3	9	Mass	1177 kg
5	Frontal area (A)	2.48 m2			

The aerodynamic drag force is vital out of the total forces acting on the vehicle.it is the function of frontal area, shape of the vehicle, air density and the vehicle's velocity it is given by equation 3. The aerodynamic drag power is given by Equation 4

$$Fad = 0.5*\rho*cd*A*(V+ Vair)2 \quad ----------(3)$$

$$Pad = Fad *V--------------------------------(4)$$

Considering the various technical values of parameters in Table 2 the relationship between aerodynamic drag power and velocity of the vehicle is studied. Figure 2 give the relationship between velocity of vehicle and drag power. Figure 3 state the relationship between vehicle velocity and power required to overcome rolling resistance.
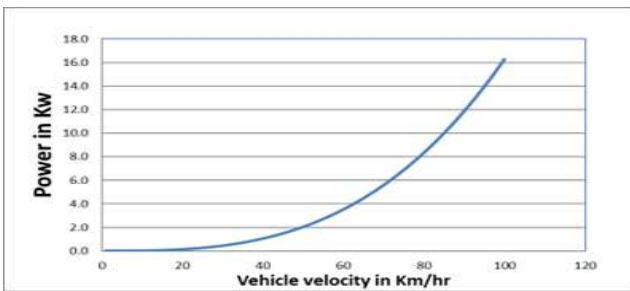
Figure 2. Velocity of a vehicle vs Pad
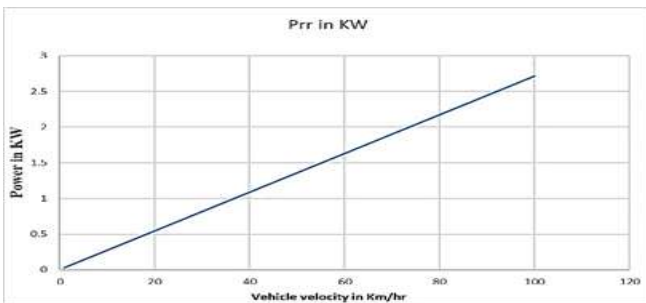
Figure 3. Velocity of a vehicle vs Prr

DRIVE CYCLE

The drive cycle is the graph between velocity on the Y-axis and time on the X-axis. For this simulation, we considered the FTP75 drive cycle.as shown in Figure 4 The drive cycle helps us to get the nature of the reference velocity
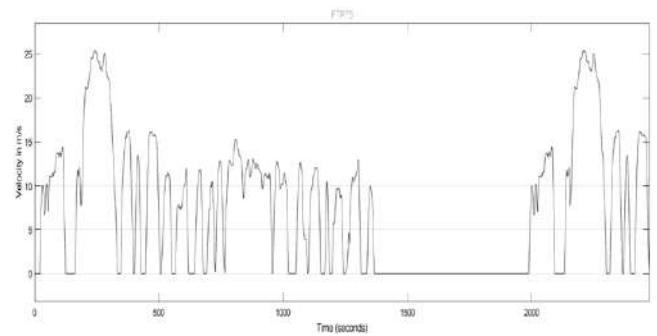
Figure 4. The drive cycle FTP75

METHODOLOGY: SIMULATION MODEL

Figure 5 represents the MATLAB model for EV. It contains different blocks, such as a longitudinal driver block for acceleration and braking conditions. The reference drive cycle, as well as the velocity feedback, is connected to this block. The other block is H bridge block, the main function of this block is the power flow management for both the condition, i.e. for motoring mode and breaking mode. The next block is the vehicle dynamics block All dynamics-related activities are done using it. In this model, the DC motor is used as a motoring option, and the lithium-ion battery is used as a source. The vehicle's performance is analysed for the reference drive cycle FTP 75 for 1000 sec. the main focus of the analysis is to study the behaviour of electric vehicles for various driving conditions such as acceleration mode, deacceleration mode and steady state condition mode of the vehicle.

For simulation, the following parameters are considered shown in table 3

Table:3

Lithium-ion battery	50 V, 280Ah	Frontal area (a)	2.48 m2
DC Motor	19 KW	Drag coefficient cd	0.5
Mass of Vehicle	1177 Kg	Air density	1.22 kg/m3
Gravitational acceleration	9.81 m/sec2	Arduous of wheel	0.2768 m
Rolling resistance	0.01	Grade angle	0 degree

RESULTS

Figure 6 represents the comparative graph of the behaviour of battery SOC with the Drive cycle. It has been observed that when an EV is in acceleration mode, the battery discharges, and when it is in deceleration mode. the actual reference drive

cycle is shown in Figure 7 The distance covered by

EV is shown in Figure 8

S.N.	Ref.	Energy sources used	Methods/ Techniques/ software used	Driving cycle	Parameters	Objective/ advantage or disadvantage
1	[1]	Battery and Supercapacitor	1. low pass filter and Fuzzy logic controller 2.DC-DC converter 3. Matlab	1. New European driving cycle (NEDC). 2. Highway Driving Cycle (HWDC). 3. Indian Urban Driving Cycle(IUDC)	1. State of Charge (SOC) of Battery. 2. State of Charge (SOC) of Supercapacitor	The battery life cycle could be effectively extended by combining the use of battery and supercapacitor. Battery size is reduce
2	[2]	Battery and Supercapacitor	1.PWM+Fuzzy logic controller 2.MatLab /Simulink platform	No driving cycle is used	1. Voltage 2.Current. 3. Temperature 4. SOC 5. Depth of Charge(DOC)	Improve the battery life and decreases the battery cost
3	[3]	Battery and internal combustion engine (ICE)	Pontryagins Minimum Principle(PMP) and discrete state space dynamic programming (PMP-DP)	FTP72 Urban driving cycle, NEDC 2000, Japan 1015	Vehicle velocity, Battery SOC, UC SOC	control of a hybrid electric car online. Compared to rule-based, FTP72 saves about 6.5% on battery electricity.
4	[6]	Battery and ultracapacitor (UC)	Adaptive fuzzy logic Energy management (AFEMS)	JC08 driving cycle, highway traffic situation (HWFET)	UC SOC, battery SOC, voltage of Battery and UC, current of battery and UC	System efficiency is increased while battery current fluctuation and UC SOC are minimized, and total energy loss is decreased by 20%.
5	[7]	Battery and ultracapacitor (UC)	dynamic programming (DP), Neural Network (NN), Rule based control strategy , MATLAB	NY_city Artemis, Manhattan, WVU, NEDC	battery SOC, UC SOC, load current, DC/DC convertor losses	The proposed solution for online EMS can extend battery life by over 60% when used as HESS compared to sole battery
6	[10]	Battery and ultracapacitor (UC)		NEDC, ECE-15	Temperature, power, vehicle velocity	The main objective is to study the effect of temperature on EMS. After research it is found total efficiency is decrease slightly with temp .
7	[8]	Battery and ultracapacitor (UC)	Genetic algorithm (GA)	Urban driving	Battery SOC, Supercapacitor SOC	The main objective is to reduce the daily operating cost of bus

Table 1 The comparative analysis

28
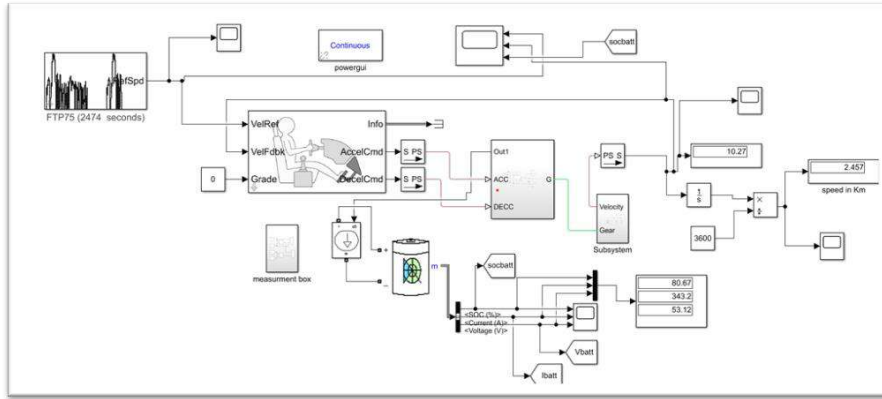
Figure 5. Matlab Model for simulation
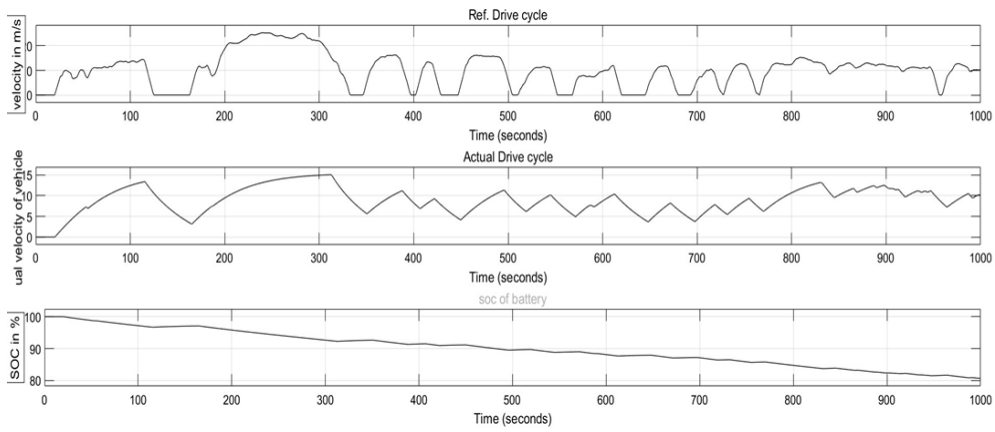
Figure 6. Comparative graph for reference drive cycle, actual drive cycle and SOC of battery
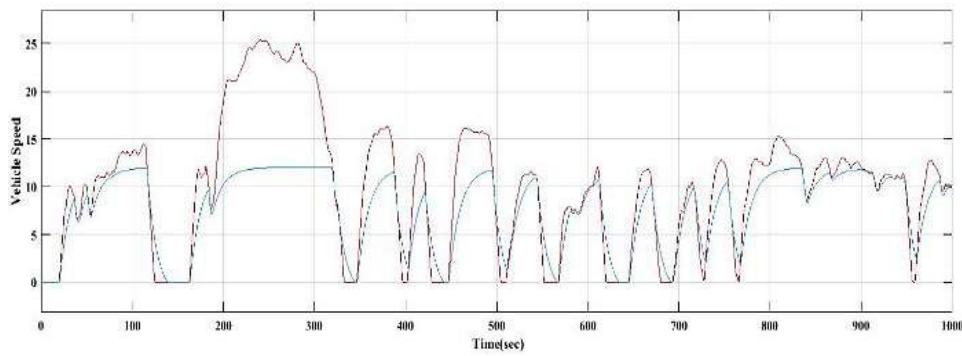
Figure 7. Graph for reference drive cycle, actual drive cycle
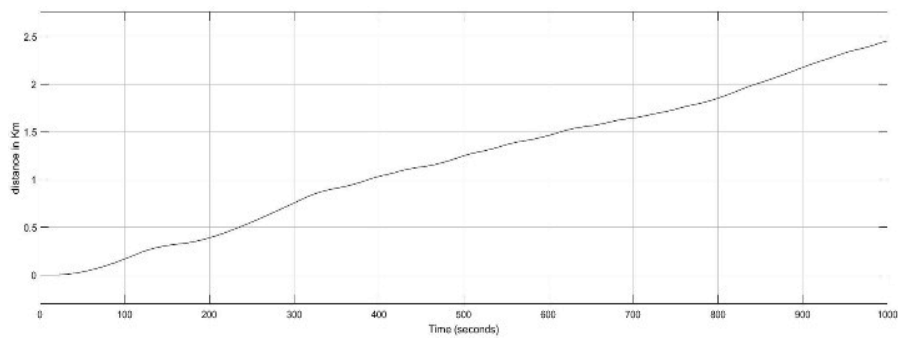
Figure 8. Distance covered in Km

CONCLUSION

This paper compares different EMS and analyzes EVs for different driving conditions. It also theoretically examines the effect of various forces acting on vehicles and discusses it with a graph. Changes in vehicle parameters, such as load and battery consumption, are also affected. The battery's SOC changes as per driving condition.

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Methods of Improving Transient Stability In Power System: A Comprehensive Review

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ABSTRACT

Modern electrical power system's complexity is increasing, posing challenges for system stability, particularly in transient stability. Transient stability is the ability of the power system which which regains its synchronism after having subjected to certain form of disturbances. Power system stability is crucial for secure operations, as past blackouts have been caused by instability due to the complex, interconnected nature of the power system. The transient stability phenomenon is found to be analysed by most of the researchers using various software tools such as PSIM, E-TAP, and MATLAB. MATLAB/Simulink simulations were used in most studies to demonstrate the effectiveness of STATCOM in improving voltage regulation and transient stability across a range of system configurations. In this review the role of STATCOM in mitigating voltage issues, damping oscillations, and improving system dynamics, especially under fault conditions are highlighted. The review also identifies key challenges such as system complexity, energy storage limitations, and control design complexities. The comprehensive review seems to provide a platform for future researchers to optimize the integration of STATCOM in modern power system.

Keywords : FACTs Devices, STATCOM, Reactive Power Compensation, Rotor angle stability, Voltage regulation

INTRODUCTION

Power system stability is crucial for ensuring the continuous and reliable operation of electrical grids, particularly during disturbances such as faults and fluctuating load conditions. Among the various methods for improving power system stability, the use of FACTs devices has emerged as an effective solution for enhancing transient stability. FACTs devices provide dynamic reactive power compensation by improving voltage regulation. Over the years, numerous studies have explored the integration of FACTs with advanced control strategies and optimization techniques to further enhance their performance. This paper reviews 27 studies published between 1993 and 2023, discussing the application of FACTs devices in various power systems, their effectiveness in improving transient stability, and the challenges associated with their implementation. The purpose of this literature review is to synthesize the findings, identify trends in the research, and suggest potential directions for future studies in this field

LITERATURE REVIEW :

The integration of STATCOM in power systems has been extensively studied, focusing on control strategies, optimization techniques, and system performance during fault conditions. The scholarly discourse surrounding the enhancement of transient stability via the implementation of STATCOM and various FACTS devices extends over several decades, underscoring a multitude of methodologies and technological advancements. Initial studies conducted by Morison et al. in 1993 [1], amalgamated analyses pertaining to both static and dynamic voltage stability. Patel et al. [2] investigated transient stability through the utilization of MATLAB/Simulink, whereas Wahad et al. ([3] accentuated the economic viability of STATCOM. Farrok et al. [4] and Hossain et al. [5] illustrated the efficacy of STATCOM in the enhancement of voltage regulation and the attenuation of oscillatory behaviour. Abraham et al. [6] elucidated the function of TCSC in oscillation damping, while Pahade et al. [7] examined the RVC control of STATCOM in relation to stability. Damor et al. [8] conducted a comparative analysis of FACTS devices, concluding that UPFC exhibited superior effectiveness, while Landry, Mukekwaet al. [9] corroborated its significance during substantial disturbances. Akhtar et al. [10] scrutinized the reactive current compensation capabilities of STATCOM, and Satyendra et al. [11] illustrated the potential of UPFC in two-area system configurations. Progressive control methodologies such as Fuzzy Logic Control (FLC) and Model Predictive Control

(MPC) were investigated by Rajalingam et al. [12], and optimization strategies were proposed by Vetoshkin et al. [13]. Research conducted by Mahmud et al. [14] and Kakaiya et al. [15] explored essential parameters and the reliability of STATCOM within modern power grids. Naeem et al. [16] drew attention to the advantages of STATCOM in comparison to Power System Stabilizers (PSS), while Khan et al. [17] examined the roles of MBPSS and STATCOM in the prevention of blackouts. Izumi et al. [18] presented innovative methodologies such as Superconducting Fault Current Limiters (SFCLs) and SOS programming aimed at enhancing transient stability. Varma et al. [19] proposed the BESS-STATCOM concept, underscoring the pivotal role of motor stabilization during disturbances, thereby a thorough investigation is carried out for enhancement of transient stability within power system. Table-1 presents a comprehensive review of some related approaches to tackle transient stability problems.

Table – 1: Comprehensive review of transient stability papers

Author	Year of publication	References	Brief of review	Key findings
G.K. Morison, P.Kundur	1993	[1]	This paper effectively combines static and dynamic methods to analyse voltage stability, providing valuable insights and explores better understanding of this critical aspect of power system.	Voltage stability analysis Static and dynamic methods of stability.
Ramnarayan Patel, T.S. Bhatti and D.P. Kothari	2002	[2]	The paper highlights Simulink's use in analysing transient stability of a 4-generator, 6-bus system. It demonstrates stability evaluation through rotor angle, speed, and voltage responses under faults, emphasizing Simulink's efficiency and flexibility for such studies.	Simplifications in modelling, better Component modelling, Utilized System size Solver and parameters Fault representations.
Noor Izzri Abdul Wahad, Norman Mariun, Azad Mohamed and Mohibullah Mohamad	2003	[3]	This paper conveys the cost-effectiveness of the D-STATCOM, Specify whether this based on installation, operational, or maintenance costs. The short duration of curtailment indicates efficient operation.	Focuses towards distribution static synchronous compensator (D-STATCOM)
O. Farrok, M.G. Rabbani, and M.R. Islam	2010	[4]	The paper presents the reactive power compensation and voltage regulation by using VSC-based STATCOM controller and demonstrates its effectiveness under dynamic conditions through improved transient stability and reduced voltage swings.	Complexity in realization, High computational efforts, Economic considerations.
Nikhil M. Abraham, Arun P Parameswaran	2011	[6]	In this paper, the TCSC demonstrates effective damping of both tie-line power and frequency oscillations. It performs well under sudden load disturbances in interconnected system.	Tie line power flow control technique is used based on utilization of TCSC
Javed Akhtar, Sinto george	2012	[10]	In this paper, dynamic performance under varying load conditions had been enhanced with effective reactive current compensation.	Tackled Increasing power quality issues due to non-linear loads
Arvind Pahade, Nitin Saxena	2012	[7]	In this research work, the use of STATCOM and a Reference Voltage Compensation control scheme to improve transient stability in power systems.	Reactive power demand, Damping characteristic are utilized to Control system complexity
S, Sujith.	2014	[20]	In this research, Three phase fault occurring between bus 7 and bus 4. STATCOM insight the best location to clear the fault in the system. To improve the transient stability of the MMPS at different fault condition the STATCOM is used.	Reactive power control with STATCOM for multi-bus system
Mr. Ketan, G. Damor, Mr. Vinesh Agrawal, Dr. Dipesh, M. Patel, Mr. Hirenkumar, G. Patel	2014	[8]	This paper present improvement of transient stability by using different types of facts devices. The simulation results reveals that Upfc is an effective facts device for improvement of transient stability than other facts device.	Comparision of FACTs devices. UPFC superiority. Challenges in power system

Author	Year	Ref	Description	Key Focus
Sohel Hossain, Atiqur Rahman Khan & Jannat-E-Noor	2014	[21]	This paper presents the STATCOM with or without power oscillation controller for different types of faulted conditions. It has been concluded that POC is more efficient controller for STATCOM to enhance the power system stability.	Development of power oscillation controller. Integration with STATCOM. Effictiveness of STATCOM with POC
Mohammad Ashraf Hossain Sadi, Mohd. Hasan Ali	2014	[5]	This paper explores methods for enhancing the transient stability of multi-machine power systems through the combined operation of Static Var Compensator (SVC).	Combined operation of circuit breaker and static SVC. Explored Simulation with 3-LG and LG fault.
Landry, Mukekwa	2016	[9]	This paper the system under study focus on integration of electric vehicles batteries with the power grid also explores the study regarding to integration of STATCOM with EVs batteries.	Integration of EVs with the grid and also with the STATCOM
Dr. A. Rajalingam, Dr. M. Ramkumar Prabhu,& K. Venkateswara Rao	2016	[12]	This paper provides that advanced control technologies like FLC and MPC are crucial for improving the stability of power systems equipped with STATCOM. The paper contributes the ongoing research in power system dynamics and control strategies.	Different STATCOM Control schemes. System voltage fluctuations.
M.A. Mahmud, M.J.Hossain, H.R Pota	2016	[14]	This paper explores the critical parameters of power system that affect the power system stability. The effectiveness is evaluated based on the damping of the dominant mode. The analysis reveals that the dynamic load has significant influence on the damping of the system.	Linearised modelling for dynamic load effects. Power oscillation damping controller PODC performance
Prashant Rajotia, Dr.Deepika Masand	2016	[22]	In this paper presents the effectiveness of STATCOM in enhancing the stability of MMPS under various fault conditions, it also suggests that the simulation work can be lengthened to analyse more complex MMPS and multiple fault scenarios.	Fault induced instability. STATCOM for stability enhancement. Optimal STATCOM placement.
G. B Jadhav, Dr.C.B.Bangal,	2017	[23]	The paper demonstrates tintegration of STATCOM with MBPSS provides substantial	Comparision of STATCOM and SVC
Dr.Sanjeet Kanungo			improvements in damping of oscillations in a MMPS and transient stability. The findings highlights the importance of selecting appropriate FACTS controllers and stabilizers to enhance the reliability and performance of power systems during disturbance.	for power system stability. Integration of PSS with SVC and STATCOM.
Vishwakarma Satyendra	2018	[11]	This paper presents two area power system with UPFC is having improvement of transient stability during large signal. UPFC converter can independently generate or absorb reactive power.	System behaviour without UPFC. Impact of on transient stability
Asad Naeem, Adnan Atif	2018	[16]	In this paper components, types and different methods for voltage regulation are discussed. PSS can clear the single phase fault but it can cannot control the low frequency oscillations and the system got unstable speed synchronisation loss problem which make the system unstable.	Limitations of generic PSS. Advantages of multiband PSS with generic PSS. Fault impacts
Shailesh U. Kakaiya, Dr.Bhupendra R. Parekh	2019	[15]	This paper provides valuable insights into the application of STATCOM for enhancing transient stability in power systems, supported by theoretical analysis and simulation results. The findings underscore the importance of FACTS devices in modern electrical networks, particularly as the demand for reliable electricity continues to grow.	Effectiveness of STATCOM in voltage stability. Power flow dynamics during faults. Rotor angle stability improvement.
Lavr Vetoshkin, Jan Votava, Jan Kyncl, and Zdeněk Müller	2019	[13]	The paper explores the transient stability improvement using STATCOM and optimization techniques, utilizing a MATLAB Simulink case study and future research.	Improvement of transient stability with STATCOM and optimal placement.
Daniel Ruk Tomas Asiah Daniel O&uh	2020	[24]	This research enhances reduced-order induction motor models for power system simulations. By using dynamic models that capture rapid frequency shifts and damping effects, as well as steady-state models for power flow analysis.	Development of reduced order models. Dynamic model characteristics
R. Jegedeesh Kumar,	2020	[25]	This paper shows the Simulation results show efficient power damping,	Power oscillation damping.

Dr. T. Rammoh an			particularly in internal faults. The bypass mode is optimal, avoiding impulse current and voltage. STATCOM properties on low-frequency oscillation and power compensation are compared.	Switching mode analysis. 3 phase fault impact.
Farhan khan	2020	[17]	In this paper the author explores the use of MBPSS and STATCOM to improve power system transient stability and highlighted their effectiveness in reducing peak overshoot and preventing blackouts.	Transient stability Complex network structure Damping of oscillations Device limitations Response time
Ruizhe Hu, Lei Chen, Hongkun Chen	2020	[26]	This paper explores the application of the modified flux- coupling-type SFCLs to improve the transient stability of a multi-machine power system . It is the research of an IEEE 9-bus system with the modified superconducting fault current limiter, it is concluded that the transient energy at fault clearance time is suppressed by the modified SFCLs and visibly reduce the generator rotor swing	Application of modified SFCL. Suppression of transient energy. Practical implication.

R. Jegedees h Kumar, Dr.T. Rmmoha n	2020	[25]	In this paper, transient stability of power systems, particularly in a multi-machine setup, using FACTS (flexible AC Transmission Systems) devices, specifically the STATCOM (Static Synchronous Compensator).	Power oscillation damping. Switching mode analysis. 3 phase fault impact.
Article, Original	2021	[27]	In this paper, In a single machine network connected to an infinite bus to designing the damping controller to improve the transient stability. STATCOM improved system stability was conducted in the MATLAB/ SIMULINK.	Optimizatio n based approach. Effictivenes s of STATCOM Rotor speed behaviour.
Rajiv K. Varma, Milad Ahmadi, Cristain Arpino	2023	[19]	In paper, clearly introduces the concept of BESS-STATCOM and its purpose. Provides a clear timeframe for the curtailment.	Stabilizatio n of critical loads Field demonstrati on. Integration with feeders.
Shinsaku Izumia, Hiroki Somekaw ab , Xin Xina Taiga Yamasak ia	2020	[18]	This paper represents the inertia constant and damping coefficient of generator are uncertain. To combining the polytopic representation and properties of SOS polynomials this method is proven that,To solves the analysis problem if the SOS programming problem is feasible.	Analysis of transient stability with parameter uncertainty.

CONCLUSION:

The evaluation of twenty-seven scholarly articles underscores that the Static Synchronous Compensator (STATCOM) represents one of the most effective FACTS devices for the improvement of transient stability in electrical power system, dynamic reactive power compensation, voltage regulation, and oscillation reduction. Sophisticated control methodologies, including Reactive Voltage Control (RVC), Power Oscillation Damping (POC), and combinations of Battery Energy Storage Systems (BESS) with STATCOM, in conjunction with contemporary techniques such as Fuzzy Logic Control, Model Predictive Control, and Multi-Band Power System Stabilizers, substantially bolster system stability by improving response times and mitigating oscillatory behaviour. Comparative evaluations indicate that STATCOM and Unified Power Flow Controllers (UPFC) surpass the performance of alternative devices such as Static

VAR Compensators (SVC), particularly when integrated with optimal reclosing methodologies. Nevertheless, challenges persist, including operational constraints, the complexity of control mechanisms, and significant computational and financial expenditures, alongside modeling limitations related to overly simplified configurations and inadequate fault representations. Simulation platforms, such as MATLAB/Simulink, exhibit efficacy for studies pertaining to transient stability, although comprehensive modelling is requisite for broader applicability. Hybrid methodologies, such as the integration of STATCOM with SVC or the utilization of BESS as compensatory devices, yield promising outcomes. Future investigations should prioritize the development of cost-effective solutions, sophisticated control algorithms, and an analysis of dynamic load influences to adequately meet the escalating demands posed by contemporary power systems.

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A Review paper on Generate Electricity by waste Materials

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ABSTRACT :

In order to achieve effective heating solutions, this paper focuses on the use of heating solar panels, which work on the principle of converting solar energy into thermal energy. Through its specialized surface, the heating solar panel absorbs sunlight and transforms it into heat energy, which is subsequently transferred to a working medium. This idea serves as the project's cornerstone and makes environmentally friendly and sustainable heating systems possible. The paper intends to reduce dependency on non-renewable energy sources and contribute to environmental sustainability by offering an energy-efficient substitute for traditional heating techniques by utilizing solar energy. The project's execution and operation show the potential of solar thermal technologies in a range of real-world uses.

Keywords - Thermal energy conversion, solar radiation absorption, solar thermal energy heating, and solar panels Eco-friendly heating options

INTRODUCTION : -

Innovations in solar energy technology have been spurred by the energy crisis and the increasing demand for renewable and sustainable energy sources. One such innovation is the use of solar panels for heating as well as electricity generation. The goal of this project is to provide an effective and environmentally responsible heating solution by harnessing the heat-collecting capabilities of solar panels. The system uses solar energy to heat air or water for use in homes, businesses, or industries.

LITERATURE SURVEY:-

One of the most promising renewable energy sources that can sustainably supply the world's energy needs is solar energy. In order to generate electricity, solar heating systems employ solar thermal or concentrated solar power (CSP) technologies to transform sunlight into heat. This review of the literature looks at current innovations, technologies, problems, and uses in this area.

The paper on "GENERATE ELECTRICITY BY USING WASTE MATERIAL" by Rohit Patil*1, Rushikesh Ghate*2published in International Research Journal of Modernization in Engineering Technology and Science Volume:04/Issue:12/December-2022 shows How to Generate Electricity by waste materials is successfully and how to control pollution by Pollution control filter ,

and they generate electrical energy from waste material with minimum pollution is about 50%. Because of this project 1250 hectares of land is save from storage of wastage. As compare to thermal power plant it generate less pollution is about 0-5%.

The paper by Shimpi Maheshwari on "Generate Electricity by Waste Materials" has proposed a Live working idea for generate Electricity by Plastic and Waste Materials, In This Project when electricity start storing that time output power supply off because of heating sensor so when electricity store perfect then heating sensor turn on the output power supply and LED bulb start glowing and we can show that time live working of g enerate electricity by waste material

PROBLEM STATEMENT :

The use of solar heating systems to generate electricity is still restricted despite the growing demand for renewable energy worldwide. This is because of issues like high capital costs, inefficient heat transfer, and reliance on favorable environmental conditions. The scalability and reliability of current technologies, such as hybrid photovoltaic-thermal (PV-T) systems and concentrated solar power (CSP), for continuous electricity generation are hampered by problems with thermal energy storage, land and water requirements, and intermittent solar radiation.

By creating an economical and effective solar heating system that can produce electricity with better thermal storage integration, increased efficiency, and less environmental impact, this paper seeks to address these issues. In order to develop a viable and sustainable solution for the production of renewable energy, the project will investigate cutting-edge materials, creative designs, and hybrid approaches.

OBJECTIVES OF THE PROJECT :

1. To Create a System for Effective Solar Heating:

2. Create a system that effectively harvests solar energy and transforms it into heat for the production of electricity.

3. Improve heat transfer systems to increase productivity and reduce losses.

4. Advanced Thermal Energy Storage (TES) Integration:

5. To enable continuous power generation even during non-sunny periods, use storage solutions like phase change materials or molten salts.

6. Boost the storage system's efficiency and energy density.

7. To lessen the impact on resources and the environment.

8. Investigate small and resource-efficient system designs to reduce the need for water and land.

9. Create eco-friendly materials and fluids for heat transfer.

10. To Make Things More Cost-Effective:

11. To increase the economic viability of solar heating technology, create a system with reduced startup and operating expenses.

12. For utility-scale and small-scale applications, investigate scalable solutions.

13. Create modular power generation systems that are appropriate for off-grid or decentralized systems.

14. To Perform a Feasibility Study.
15. Assess the suggested solar heating system's sustainability, affordability, and performance in various operational and environmental scenarios.
16. Conduct a comparison with current technologies.
17. To Encourage the Use of Renewable Energy.
18. Showcase the effectiveness and dependability of solar heating electricity generation to offer a competitive substitute for fossil fuels.
19. Increase knowledge of the possible uses of solar thermal systems in homes and businesses.

2) Existing Methods for Solar Heating Electricity Generation :

Solar heating generates electricity using a number of well-established techniques and technologies. Concentrated solar power (CSP) and hybrid solar systems are the main components of these techniques. This is a summary.:

1. Concentrated Solar Power (CSP) Systems

Through the use of mirrors or lenses, CSP technologies concentrate sunlight to produce heat, which powers a turbine or heat engine that is connected to a generator.

Parabolic Trough Collectors (PTC)

How it Works: Sunlight is focused by parabolic-shaped mirrors onto a receiver pipe that holds a heat transfer fluid (HTF), like molten salt or synthetic oil. Steam produced by the heated fluid powers a turbine..

Applications: utilized extensively in utility-scale power plants.

Examples: Andasol Plant (Spain), SEGS (USA).

b. Solar Power Towers

How it Works:-Sunlight is reflected onto a central receiver atop a tower by hundreds of heliostats, which are flat, movable mirrors. Steam is produced by transferring the heat to a working fluid, usually molten salt.

Advantages: high efficiency and the capacity to store energy.

Examples: Ivanpah Solar Electric Generating System (USA), Noor III (Morocco).

Solar Photovoltaic-Thermal (PV-T) Systems

How it Works: combines thermal collectors and photovoltaic (PV) panels. As the PV panels produce electricity, the extra heat is either stored or captured for use as heating.

Applications: Residential and small-scale installations.

Examples: Buildings with hybrid PV-T systems for both heating and power needs.

Thermal Energy Storage (TES) Systems

Combined with CSP to store extra heat for use at night or on overcast days. Typical TES technologies consist of

Molten Salt Storage: retains heat at elevated temperatures, usually ranging from 290°C to 565°C.

Phase Change Materials (PCMs): Utilize the latent heat of fusion to store energy in a small, effective package..

Emerging Technologies

Direct Steam Generation (DSG): s Synthetic heat transfer fluids are not necessary because sunlight heats water directly to create steam.

Nanofluid-Based Collectors: To increase thermal conductivity and heat transfer efficiency, add nanoparticles to fluids.

Limitations of Existing Methods

High Initial Cost: CSP systems demand a large infrastructure and material investment..

Water Use: Since many CSP plants require water to cool, they are not appropriate for **arid climates.**

Intermittency: Reliance on daylight and weather requires hybridization or effective storage.

Land Requirement: Large land areas are needed for CSP plants.

Proposed Methodology for Solar Heating Electricity Generation Project

This methodology describes how to create a solar heating electricity generation system that maximizes sustainability, cost-effectiveness, and efficiency while addressing the shortcomings of current **technologies.**

System Design and Conceptualization

Objective: Create a design that maximizes solar energy absorption, heat conversion, and electricity generation.

Steps: Create solar collectors that efficiently concentrate sunlight, such as solar power towers, linear Fresnels, or parabolic troughs.

To improve heat absorption and reduce losses, create a heat transfer system with cutting-edge materials or fluids (such as molten salts or nanofluids).

Incorporate thermal energy storage (TES) to store surplus heat and facilitate ongoing power production..

Selection of Materials and Components

Objective: Choose and employ materials that optimize cost-effectiveness, durability, and thermal efficiency.

StepsTo improve heat capture and reduce radiation losses, investigate and choose cutting-edge coatings for solar absorbers. Select or create high-performing, environmentally friendly heat transfer fluids (such as phase-change materials or molten salts). For highly optically efficient mirrors or lenses, use reflective materials.

Project Working Principle : Solar Heating via Solar Panels

Basic Principle of Solar Panels

The idea behind solar panels, also referred to as photovoltaic (PV) panels, is to use semiconductor materials—typically silicon—to directly convert sunlight into electrical energy. Electricity is produced when sunlight strikes the solar cells, exciting the electrons.

But we're not depending just on the solar panels' electrical output for this heating-focused project. The fundamental idea here is to take advantage of the solar panels' capacity to absorb solar radiation, which causes heat to be produced. When solar panels are exposed to sunlight, they produce heat that can be used for heating.

Heat Collection in Solar Panels

Sunlight is the main energy source that solar panels absorb and transform into thermal energy. The surface of the panels warms as a result of the absorbed sunlight. This project makes use of the thermal energy stored in the solar panels rather than the electrical energy they produce. Through pipes or channels that are connected to or integrated into the solar panel system, this thermal energy is transferred from the solar panels to a fluid (typically water or a heat-transfer fluid). After that, the heat is either used straight away for heating purposes or stored in a thermal tank.

Heat Transfer Mechanism

The system uses a heat exchanger or solar thermal collector to convert the heat that has been collected from the solar panel into a form that can be used. A closed-loop system circulates a heat transfer fluid (HTF), such as water, glycol, or antifreeze.

4. Heating Applications: Following transfer, the heat can be used in a variety of heating situations:

Heating water for domestic uses, such as cleaning, cooking, and bathing, is the most popular application.

Space Heating: To maintain a comfortable indoor temperature, the heated fluid can be circulated to air heating systems (such as forced-air heating systems, underfloor heating, or radiators).

Industrial Heating: Solar heating can be applied to industrial processes like pasteurization, drying, and agricultural applications that call for moderate heat.

In a nutshell, a heating panel produces electricity by letting photons—particles of heat or light—knock electrons out of atoms. In reality, heating panels are made up of numerous smaller components known as photovoltaic cells. (To put it simply, photovoltaic systems turn light or heat into electricity.)

The Operation of Heating Penal
A p-n junction is formed when p-type and n-type semiconductors are placed next to one another. With one fewer electron, the p-type pulls the extra electron from the n-type to stabilize itself. The electricity that results is what is called electricity because it is displaceable and creates an electron flow. An electron rises and is drawn to the n-type semiconductor when heat strikes the semiconductor. This results in a greater flow of electricity by producing more negatives in n-type semiconductors and more positives in p-type semiconductors. The photovoltaic effect is this.
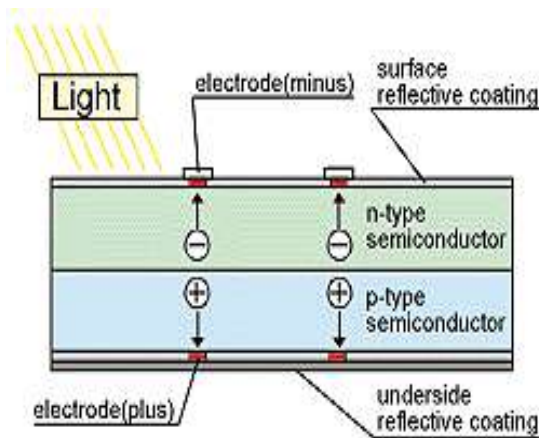
Advantages of Solar Heating Systems

1. Sustainable Energy Source: Solar heating uses the sun's free and abundant energy, reducing reliance on fossil fuels and lowering emissions of carbon.
2. Lower Operating Costs: Because sunlight is free and renewable, solar heating systems have low operating costs after they are installed.
3. Eco-Friendly: By offering a sustainable substitute for traditional heating techniques, solar heating systems aid in the reduction of greenhouse gas emissions and the mitigation of climate change.

4. Low Maintenance: Solar thermal systems require less maintenance than other heating systems, which over time makes them more affordable.
5. Energy Independence: Particularly in areas with plenty of sunlight, solar heating systems offer a certain amount of energy independence.

CHALLENGES AND LIMITATIONS

Initial Installation Cost: Solar panels and related equipment (like heat exchangers, storage tanks, and piping systems) can be expensive up front.

Weather Dependency: Due to their reliance on sunlight, solar heating systems may perform less well on overcast or wet days.

Space Requirements: Installing the required number of solar panels requires a substantial amount of ground or roof space, especially for large-scale heating applications.

Efficiency: In order to optimize efficiency and guarantee that heat is sufficiently stored and transferred, solar thermal systems typically need to be carefully designed.

CONCLUSION

Using solar panels, this project uses the principles of solar heating to provide an effective and sustainable way to heat water, air, and other fluids. By decreasing dependency on fossil fuels, the technology not only has major environmental benefits but also long-term economic benefits due to low operating costs and energy independence.

The long-term benefits of solar heating make it an appealing option for both residential and commercial applications,

even though the initial cost may be a deterrent for some.

FUTURE PROSPECTS:-

Because of continuous technological advancements, solar heating for electricity generation appears to have a bright future. Enhancing energy storage options, extending the life of solar panels, and lowering the price per watt of electricity generated are the main goals of research. Combining solar thermal and photovoltaic technologies to create hybrid systems could be a crucial step in increasing solar power generation efficiency.

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Analysis Of Effect Of Circuit Breaker Operation In An Interconnected Power System & Stability

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ABSTRACT –

In recent years, the demand for electricity by the utility industry has been increased continuously. To satisfy this increased demand for electricity, electric power systems are interconnected. As a consequence, some transmission lines gets heavily loaded & the issue of Transient instability & power imbalance arises. The Transient Stability plays a crucial role in maintaining the stable operating condition of power system during the events like large disturbances taking place. This paper investigates the stability and transient behaviour of a power system simulated in MATLAB Simulink, focusing on fault scenarios and the dynamic performance of synchronous generators. The analysis highlights the system's response to a line-to-ground (L-G) fault, where voltage dips and current surges were effectively mitigated through circuit breaker operations, demonstrating the system's fault tolerance and recovery capabilities. Additionally, the transient oscillations observed in the synchronous generator's rotor angle deviation underscore the need for enhanced damping mechanisms to improve system stability. The study concludes that the power system responds effectively to faults under different conditions, the implementation of appropriate damping strategies is essential for preventing transient instability and ensuring sustained system reliability. This work provides valuable insights into the role of damping mechanisms in enhancing transient stability in modern power systems.

Keywords : FACTs devices, Transient stability, Voltage regulation, Load angle, Rotor angle deviation

INTRODUCTION:

The demand for electricity in the utility industry has been steadily increasing in recent years, driving the need for interconnected electric power networks to share resources and meet rising energy demands. However, this expansion often leads to overloaded transmission lines, resulting in challenges related to transient voltage and power stability, particularly in transient stability [1]. Transient stability refers to the ability of a power system to maintain synchronism after being subjected to significant disturbances, such as faults or sudden load changes. To address these challenges, various methods and devices have been explored to improve transient stability, including power system stabilizers (PSS) and Flexible AC Transmission System (FACTS) devices, such as shunt controllers like Static VAR Compensators (SVC) and Static Synchronous Compensators (STATCOM) [2]. The advent of power electronics has introduced the use of FACTS devices in power systems, enabling fast and efficient control of network conditions. SVC and STATCOM, as members of the FACTS family, are connected in shunt with the system and provide critical support to bus voltages by injecting or absorbing reactive power [3]. MATLAB and Simulink are widely used for simulating electrical power systems, especially for studying dynamic behaviours like transient stability. Multimachine systems are more realistic representations of actual power grids, which typically involve many interconnected generators.[4] Stability in power systems depends on several factors, including initial operating conditions and the severity of disturbances. In this study, the focus is on analyzing the transient behaviour of the power system, particularly the load angle and rotor angle deviation, to understand their impact on system stability under fault conditions. The results contribute to a deeper understanding of transient stability and the dynamic behaviour of synchronous generators in power systems.

LITERATURE REVIEW:

The scholarly discourse surrounding the enhancement of transient stability via the implementation of STATCOM and various FACTS devices extends over several

decades, underscoring a multitude of methodologies and technological advancements. Initial studies conducted by Morison et al. in 1993[5] , amalgamated analyses pertaining to both static and dynamic voltage stability. Patel et al. [6] investigated transient stability through the utilization of MATLAB/Simulink, whereas [7] Hossain et al. accentuated the economic viability of STATCOM. illustrated the efficacy of STATCOM in the enhancement of voltage regulation and the attenuation of oscillatory behavior. Abraham et al. elucidated the function of TCSC in oscillation damping, while Pahade et al.[8] examined the RVC control of STATCOM in relation to stability. Damor et al.[6] conducted a comparative analysis of FACTS devices, concluding that UPFC exhibited superior effectiveness, while Landry, Mukekwaet al.[9] eloborated its significance during substantial disturbances. Akhtar et al.[10] scrutinized the reactive current compensation capabilities of STATCOM. The challenge of maintaining power system stability due to rising electricity demand and loaded transmission lines is explored in [10]. Using a four-bus system model, simulations show improved stability with STATCOM, supported by effective control strategies like synchronous reference frame theory [11]. S. Hossain et al. explored that STATCOM enhances power system stability with rapid reactive power control, while advanced strategies like the POC ensure faster and more efficient fault recovery, as confirmed by simulations[12]. M. Ashraf et al emphasizes how STATCOM can be used to solve problems with transient, dynamic, and steady state stability. STATCOM improves damping during oscillations, controls power flow, and improves voltage profiles. Its ability to increase transmission efficiency and stabilize systems under faults without the need for new infrastructure is confirmed by simulation studies and case analyses[13]

METHODOLOGY :

Case 1 – Healthy System Having Two Sources
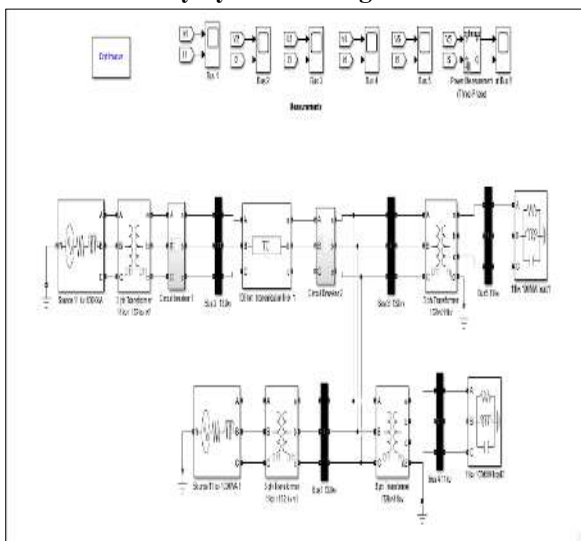
Figure 1: five bus healthy system with sources

The figure 1 represents a detailed power transmission and distribution system modeled in MATLAB Simulink. It includes two 11 kV, 100 kVA sources connected to step-up transformers, which increase the voltage to 132 kV for long-distance transmission. Circuit breakers are installed for switching and fault isolation, and the high-voltage transmission occurs over a 100 km line connecting Bus 2 and Bus 3. At the receiving end, step-down transformers reduce the voltage from 132 kV back to 11 kV for distribution. The system supplies two 100 MW loads at Buses 4 and 5. Each component, such as buses, transformers, and circuit breakers, is strategically placed to ensure efficient power flow and fault management. Measurement blocks at each bus monitor voltage, current, and power, enabling detailed analysis of system performance and stability under various operating conditions.
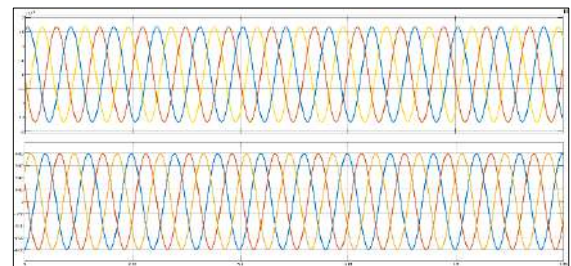
Figure 2: Voltage and Current Waveforms at Bus 5

The figure 2 displays the voltage and current waveforms at Bus 5 of the power system. The top plot shows the three-phase voltage, which is sinusoidal, balanced, and consistent in amplitude, with a 120-degree phase difference between phases, indicating proper voltage regulation and load distribution at this bus. The bottom plot represents the three-phase current, also sinusoidal and balanced, with its magnitude corresponding to the 100 MW load connected at Bus 5. Both waveforms demonstrate steady-state operation under balanced conditions, confirming the effective functioning of the step-down transformer, bus connections, and the load. The stability and periodicity of these waveforms validate the system's ability to deliver power efficiently without distortion or instability.

Case 2 – Two Sources System With L-G Fault
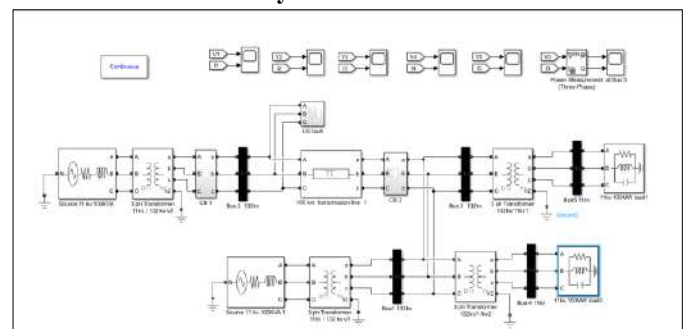
Figure 3: Five bus system with Line to Ground (L-G) fault

The figure 3 represents a MATLAB Simulink model of a power system, incorporating generation, transmission, and distribution, with a line-to-ground (LG) fault modelled in the transmission network. The system features two 11 kV, 100 kVA sources connected to step-up transformers, which increase the voltage to 132 kV for transmission over a 100 km line. Circuit breakers are included to control switching operations and isolate faults when needed. The 132 kV transmission line interconnects multiple buses (Bus 2 and Bus 3), facilitating high-voltage power transfer.

At the receiving end, step-down transformers reduce the voltage from 132 kV to 11 kV for distribution to two 100 MW loads connected at Buses 4 and 5. A **line-to-ground (LG) fault** is introduced on the transmission line to study its impact on system stability and performance. Measurement blocks are strategically placed across the buses to monitor voltage, current, and power, enabling an in-

depth analysis of fault conditions and system recovery. This setup is designed to analyze fault dynamics, ensure proper fault management, and validate the system's stability under abnormal conditions.
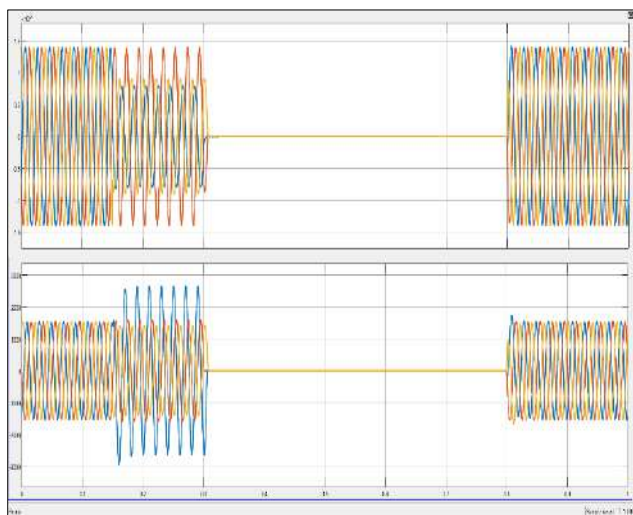
Figure 4: Voltage and Current Waveforms at Bus 2

The figure 4 shows the voltage and current waveforms at Bus 2 of the MATLAB Simulink model, highlighting the response to a line-to-ground (LG) fault. The fault occurs at **0.15 seconds**, causing a disturbance in the waveforms, evident from the abrupt drop in voltage and a corresponding rise in current. This marks the initiation of the fault condition on the transmission line.

At **0.3 seconds**, the circuit breaker operates to isolate the fault, resulting in the voltage and current waveforms stabilizing momentarily as the faulted line is disconnected. During this time, the system operates without the affected section, maintaining stability.

After the fault is cleared, the circuit breaker recloses at **0.8 seconds**, restoring the connection. Following the reclosing operation, the waveforms gradually return to their steady-state sinusoidal forms, indicating the system's recovery and resumption of normal operation. This simulation captures the dynamic behaviour of the system during the fault,

breaker operation, and reclosing, demonstrating its ability to manage and recover from transient disturbances effectively.
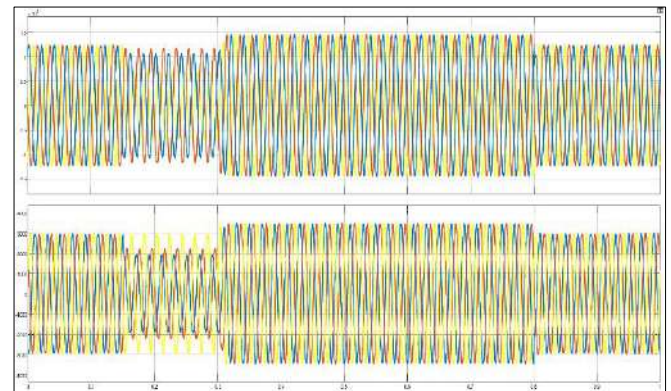
Figure 5 : Voltage and Current Waveforms at Bus 5

The above figure 5 represents the voltage and currents waveforms at the bus 5 . we can see that from 0 sec to 0.15 sec the waveforms were normal and at just 0.15 sec the L_G is occurred , therefore the disturbance in the voltage waveform is seen. And in incurrent waveform it observed that in during the fault time (0.15 sec to 0.7 sec) the waveform of yellow phase is increased in level it happens because when fault occues at that section more current draws from the faulty phase i.e. yellow phase. Then at 0.3 sec the circuit breaker operates and from 0.3 sec to 0.8 sec the circuit breaker were operated so the source 1 is totally disconnects from the system and only source 2 is in operation that's why the waveforms at bus 5 presents the increased voltage and current waveform increased. After clearing the fault the circuit breaker recloses, the the source 1 reconnects to the power system and starts operating normal as before fault were occurred.

Case 3 – Five Bus Healthy System Having Synchronous Generator
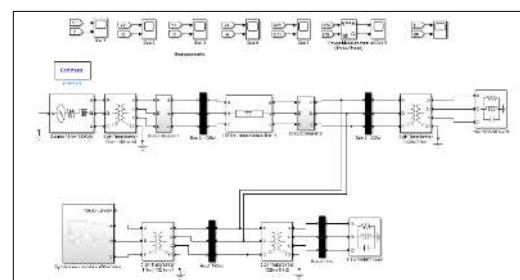
Figure 6: Five bus healthy system with synchronous Generator

Figure 6 shows the Simulink model represents a single-machine infinite bus (SMIB) system with a synchronous generator supplying power through a step-up transformer (11 kV to 132 kV) into a 100 km transmission line connecting buses. Circuit breakers (CB1 & CB2) manage power flow and fault isolation, Two step-down transformers (132 kV to 11 kV) feed 50 MW loads at Bus 4 and Bus 5. The above system is modelled as stable power system. The rotor angle deviation is monitored, showing gradual oscillations. While the load angle stabilizes, the increasing rotor angle deviation suggests potential poor damping, requiring further tuning for better transient stability.

Figure 7: Voltage and Current Waveforms at Bus 3

Figure 7 represents the waveform plot represents the voltage and current at Bus 3. Initially, both signals exhibit a steady-state sinusoidal waveform, indicating normal operation. The top plot shows the three-phase voltage, which is sinusoidal, balanced, and consistent in amplitude, with a 120-degree phase difference between phases, indicating proper voltage regulation and load distribution at this bus. The bottom plot represents the three-phase current, also sinusoidal and balanced, with its magnitude corresponding to the 100 MW load connected at Bus 5. Both waveforms demonstrate steady-state operation under balanced conditions, confirming the effective functioning of the step-down transformer, bus connections, and the load. The stability and periodicity of these waveforms validate the system's ability to deliver power efficiently without distortion or instability.

Figure 8: Load angle & Rotor angle deviation of above system

In the figure 8, the given plots illustrate the dynamic response of a synchronous generator by depicting the variation of load angle (δ) and rotor angle deviation ($\Delta\delta$) over time following a disturbance. The load angle initially oscillates before gradually stabilizing, indicating the presence of damping mechanisms that restore the system to steady-state operation. Similarly, the rotor angle deviation exhibits high initial oscillations, which diminish over time, ensuring that the generator maintains synchronism. This behaviour is crucial in assessing transient stability, as excessive oscillations could lead to instability. The damping observed in the response may be attributed to system inertia, inherent damping, or external stabilizing devices such as a STATCOM. If the response is without STATCOM, the level of damping can be analysed to determine the need for additional stabilization. Conversely, if the response includes STATCOM, it confirms its effectiveness in enhancing transient stability by improving damping characteristics. Overall, the results demonstrate that the synchronous

generator remains stable post-disturbance, emphasizing the importance of damping in transient stability analysis.

Case 4 – Five Bus System Having Synchronous Generator with L-G fault

Figure 9 : Five bus system having synchronous generator with LG-fault and circuit breaker operation

The given figure 9 represents a power system model in MATLAB Simulink, depicting a multi-bus transmission network with a synchronous generator (alternator), transformers, transmission lines, circuit breakers (CBs), and loads. The generator at Bus 1 supplies power through a step-up transformer (11 kV to 132 kV), connecting to Bus 2. A 100 km transmission line links Bus 2 to Bus 3, where another transformer steps down voltage for further distribution. A line-to-ground (LG) fault is applied in the middle of the transmission line, and circuit breakers (CB1 and CB2) are present to isolate the fault if needed. The system continues to Bus 5 and Bus 4, where loads are connected through step-down transformers (132 kV to 11 kV). Power and voltage measurements are implemented at various points to analyse system performance, stability, and transient responses under fault conditions. The setup is designed to study fault impact, stability, and protective measures in a power system.
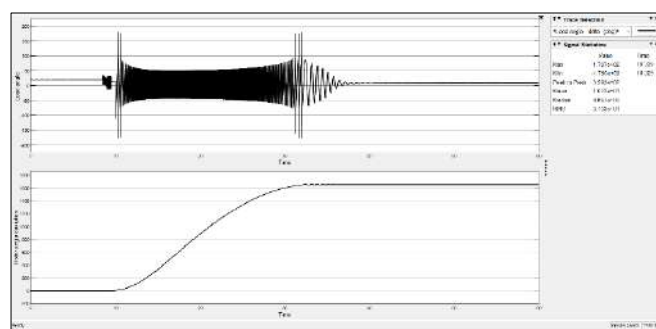
Figure 10 : Analysis of Load angle & Rotor angle deviation of above system

Figure 10 represents the analysis of Load Angle and Rotor Angle Deviation in the given System (fig. 9). The given simulation results illustrate the behaviour of the load angle (δ) and rotor angle deviation ($\Delta\theta$) when the circuit breaker (CB) opens at 8 sec and recloses at 10 sec, isolating the source while keeping the generator connected to the system. This leads to significant transient disturbances before the system eventually stabilizes.

1. Before CB Operation (0 - 8 sec) → Normal Steady-State

Before the CB operates at t = 8 sec, the system is in a stable operating condition. During this period, the load angle (δ) remains nearly constant, indicating steady power transfer between the generator and the system. Similarly, the rotor angle deviation (Δθ) is also stable, suggesting that the generator is well-synchronized with the system. This represents the normal steady-state operation of a synchronous generator under balanced load conditions.

2. CB Opens at 8 sec → Source Is Isolated

At t = 8 sec, the circuit breaker opens, disconnecting the source from the system while keeping the generator connected to the loads. As a result, the generator must now supply the entire system demand alone, leading to a sudden change in power balance.

This sudden loss of power support from the source causes a significant increase in electrical power output (Pe) from the generator, which, in turn, leads to a rapid change in the load angle (δ). As seen in the top graph, the load angle initially decreases but then exhibits high-frequency oscillations, indicating instability.

These oscillations occur because the generator is trying to adjust to the new operating condition, but due to the sudden nature of the event, the system enters a transiently unstable state where the rotor oscillates significantly before finding a new equilibrium.

3. CB Recloses at 10 sec → Source Reconnected

At t = 10 sec, the circuit breaker recloses, reconnecting the source to the system. However, by this time, the generator is already in a highly disturbed state, meaning its rotor position is out of phase with the source voltage. This phase mismatch leads to a large transient response in both the load angle (δ) and the rotor angle deviation (Δθ).

After reclosure, the load angle (δ) undergoes severe oscillations, as seen in the top graph, before gradually stabilizing. Meanwhile, the rotor angle deviation (Δθ) increases continuously without immediate stabilization, as observed in the bottom graph. This behaviour indicates that the generator is momentarily losing synchronism with the system before eventually resynchronizing.

4. Post-Reclosure Behaviour (10 sec - 30 sec)

Following reclosure, the load angle (δ) oscillations persist for nearly 20 seconds, as the generator attempts to resynchronize with the system. These oscillations gradually reduce due to damping effects within the system.

The rotor angle deviation (Δθ) continues to increase initially, suggesting that the generator is momentarily unstable before damping mechanisms bring it back to steady-state operation. Around t = 25 sec, the oscillations are sufficiently damped, and the system transitions into a new equilibrium state.

Ultimately, the final rotor angle is lower than before the disturbance, suggesting a redistribution of power flow in the system. This highlights the importance of stability studies in power system analysis, ensuring that transient disturbances do not lead to complete loss of synchronism.

RESULT ANALYSIS :

The MATLAB/Simulink model of the power system was analysed to study the effects of circuit breaker operation during faults. The system, consisting of two sources, multiple buses, transformers, and a 300 km transmission line, was analysed under balanced load conditions. During normal operation, the voltage and current waveforms across all buses remained stable and sinusoidal. A line-to-ground (L-G) fault was introduced at Bus 2 at 0.15 seconds, causing a significant disturbance, particularly in the yellow phase current, which showed an increase due to the fault. At 0.3 seconds, the circuit breaker operated, isolating the faulty section and disconnecting Source 1 from the system. During the disconnection (0.3–0.8 seconds), Source 2 maintained the power supply, leading to an increase in voltage and current waveforms at Bus 5 due to the redistribution of power flow. After the fault was cleared, the circuit breaker reclosed at 0.8 seconds, reconnecting Source 1 and restoring normal operation with balanced waveforms. The transformers (132 kV/11 kV) and the 300 km transmission line were modelled to reflect practical conditions, ensuring accurate voltage levels and fault analysis. The study demonstrated the effectiveness of circuit breakers in isolating faults, redistributing power, and maintaining system stability, highlighting their critical role in minimizing the impact of faults on the power system

The power system model in MATLAB Simulink was analysed under various scenarios to assess its stability and transient response. In the healthy two-source system, a five-bus setup with two 11 kV, 100 kVA sources was simulated, where voltage and current waveforms remained stable, ensuring efficient power flow to 100 MW loads at Buses 4 and 5. When a line-to-ground (L-G) fault was introduced, the system experienced a voltage dip and current rise in the affected phase. However, circuit breakers operated at 0.3 seconds to isolate the fault and reclosed at 0.8 seconds, restoring normal operation and demonstrating effective fault management. In the healthy system with a synchronous generator, power was supplied through transformers and transmission lines, but the rotor angle deviation showed oscillations, indicating transient effects. Though the system remained stable, improvements in damping were needed for enhanced transient stability. The addition of an L-G fault in the synchronous generator system led to rotor angle instability, with large oscillations occurring before the system resynchronized after circuit breakers opened at 8 seconds and reclosed at 10 seconds. These results highlighted the generator's transient behaviour and underscored the importance of proper damping mechanisms to prevent instability. Overall, the study concluded that while the system effectively handled faults with circuit breakers isolating and restoring power flow, the need for damping strategies, such as STATCOM, was

critical for improving stability and reducing transient oscillations.

CONCLUSION :

The analysis highlights the critical role of circuit breakers in ensuring the stability and reliability of power systems during fault conditions. The study demonstrated that circuit breakers effectively isolate the faulty section of the system, allowing the unaffected portions to operate without disruption. During the fault period, the redistribution of power was observed, particularly with increased voltage and current waveforms in specific areas. Upon fault clearance and circuit breaker reclosing, the system returned to normal operation, showcasing the circuit breaker's ability to restore stability. The overall analysis highlights the importance of system protection and stability measures. Fault occurrences and breaker operations significantly impact the generator's rotor angle stability. Properly coordinated reclosing strategies, damping mechanisms, and advanced control techniques are essential to ensure the system recovers smoothly from disturbances. Implementing stability-enhancing devices can help mitigate oscillations, improve damping, and maintain synchronism under dynamic operating conditions. This analysis reinforces the importance of incorporating properly designed circuit breakers to protect power systems from faults and maintain operational continuity.

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Load Flow Analysis and Optimization of Rural Distribution Feeders in India

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ABSTRACT

The increasing demand for reliable electricity in rural India necessitates the integration of renewable energy sources (RES) into distribution feeders. However, rural feeders often suffer from voltage instability, transformer overloading, and high power losses. This paper presents a comprehensive load flow analysis using the Newton-Raphson method, evaluating power losses, voltage stability, and transformer loading under different energy management scenarios. A case study in Solapur district illustrates the impact of distributed solar energy integration. The results indicate a 36.8% reduction in power losses and improved voltage stability (+6.8%), highlighting the need for optimal distributed generation (DG) placement and demand-side management strategies. Furthermore, an economic feasibility study using the Black-Scholes model demonstrates a 14.5% return on investment (ROI) over five years. The study underscores the importance of grid reinforcement, financial modeling, and smart optimization techniques for sustainable rural electrification.

KEYWORDS—*Load flow analysis, rural feeders, renewable energy, Newton-Raphson, power losses, voltage stability.*

INTRODUCTION

Rural distribution networks in India face significant challenges due to **long feeder lengths, high losses, and voltage fluctuations** [1]. With the increasing penetration of **renewable energy sources (RES)**, the complexity of power flow analysis has intensified. Traditional radial feeders lack the flexibility to handle **bidirectional power flow** introduced by **solar and wind energy** [2].

This study applies **load flow analysis** to evaluate feeder performance and suggests **optimization strategies** to enhance voltage stability and reduce losses. The Newton-Raphson method is employed for solving power flow equations, and a case study of Solapur's rural feeder is analyzed under different scenarios. Furthermore, a financial risk analysis using the Black-Scholes model is conducted to assess the viability of solar photovoltaic (PV) deployment.

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#Bale #Jam Mill
#Degaon #Navives
#Spare I A#Spare II

METHODOLOGY

2.1 Load Flow Analysis

Load flow analysis determines bus voltages, real/reactive power flows, and system losses. The power flow equations for an n-bus system are:

$$P_i = V_i \sum_{j=1}^{n} V_j (G_{ij} \cos \theta_{ij} + B_{ij} \sin \theta_{ij})$$

$$Q_i = V_i \sum_{j=1}^{n} V_j (G_{ij} \sin \theta_{ij} - B_{ij} \cos \theta_{ij})$$

where:
Pi, Qi = Active and reactive power at bus i.
• Vi, Vj = Voltage magnitudes.

Gij , Bij = Conductance and susceptance.

θ ij = Phase angle difference.

The **Newton-Raphson method** iteratively solves these nonlinear equations, using the Jacobian matrix:

$$\begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} = \begin{bmatrix} J_{11} & J_{12} \\ J_{21} & J_{22} \end{bmatrix} \begin{bmatrix} \Delta \theta \\ \Delta V \end{bmatrix}$$

where JJ is updated until the power mismatch falls below **0.0001 p.u.**

2.2 Case Study:
  Substation Details
  Degaon substation Solapur (MSEDCL)
  Substation Voltage Rating :
  132/110/33/11kV
  11 kV Feeders (Total :11 Feeders) :
  # Nehru Nagar AG feeder*
  #Solapur - I #Solapur – II
  #Solapur – III #Tikekarwadi
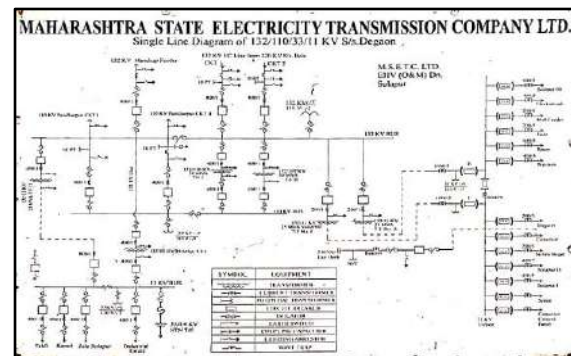
Fig 1 Single Line Diagram of Degaon Substation

A **5-bus rural feeder** in **Solapur, Maharashtra** is analyzed. The system parameters are:
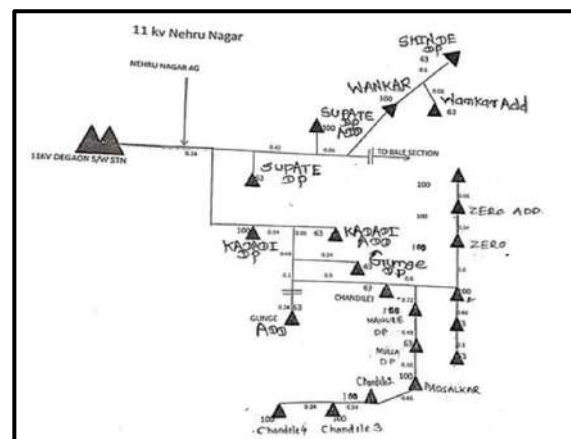
Fig 2 HT SLD of Nehru Nagar AG Feeder

Parameter	Value
Number of Buses	5
Number of Transformers	2(Chandele1,2)
Feeder Voltage	11 kV
Renewable Penetration	20% (solar PV)
Total Load	5 MW

Table 1 Feeder details

2

RESULTS AND DISCUSSION

3.1 Voltage Profile Comparison

Fig. 4 Voltage Profile comparison

Bus	Base Case Voltage (p.u.)	Optimized Case Voltage (p.u.)	Voltage Improvement (%)
1	1.00	1.00	0.00%
2	0.96	0.98	+2.08%
3	0.93	0.97	+4.30%
4	0.91	0.95	+4.40%
5	0.88	0.94	+6.80%

Table 2 Voltage profile comparison

3.2 Transformer Loading Analysis

Transformer	Base Case Loading (%)	Optimized Case Loading (%)	Reduction (%)
Chandele 2	85%	70%	-17.6%
Chandele 3	92%	78%	-15.2%

Table 3 Transformer Loading analysis
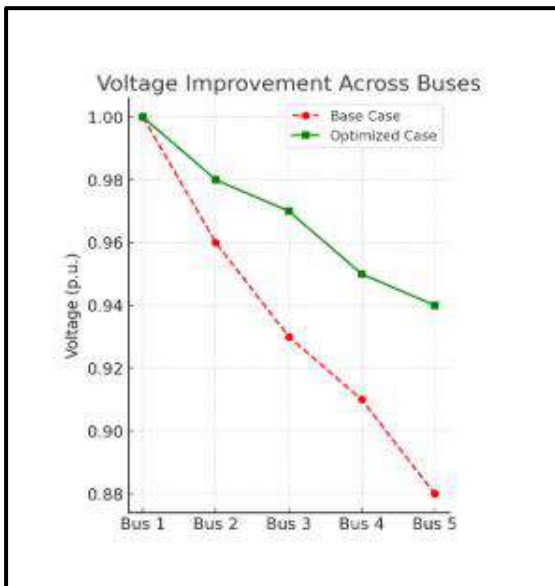
Fig. 3 Voltage improvement across buses
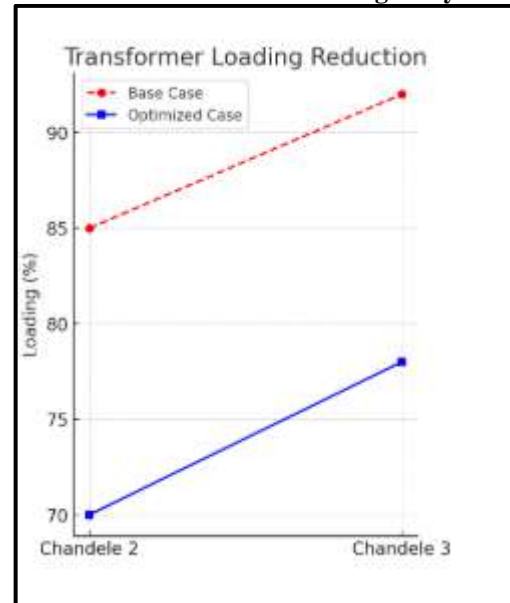
Fig. 5 Transformer Loading Reduction

Observations: Optimized energy management significantly improves voltage profiles, minimizing fluctuations and ensuring compliance with **grid standards (IEEE 1547)**.
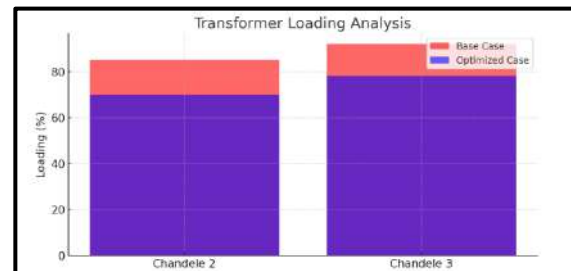
Fig.6 Transformer Loading Analysis

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Observations: Optimized case reduces transformer stress, improving **lifespan and reliability**.

3.3 Power Loss Reduction

Scenario	Total Losses (MW)	Reduction (%)
Base Case	0.38 MW	-
Optimized Case	0.24 MW	**-36.8%**

Table 4 Power Loss reduction

Fig. 7 Power Loss reduction

Observations: A **36.8% reduction in losses** is achieved with **optimized DG placement**.

FINANCIAL ANALYSIS USING BLACK-SCHOLES MODEL

Economic feasibility is assessed using:

$$C = S_0 N(d_1) - Xe^{-rt}N(d_2)$$

where:

- C= Renewable investment value.
- S0 = Initial investment cost.
- X = Future expected return.
- r = Risk-free interest rate.
- t = Investment time period.
- N(d1),N(d2) = Cumulative normal distributions.
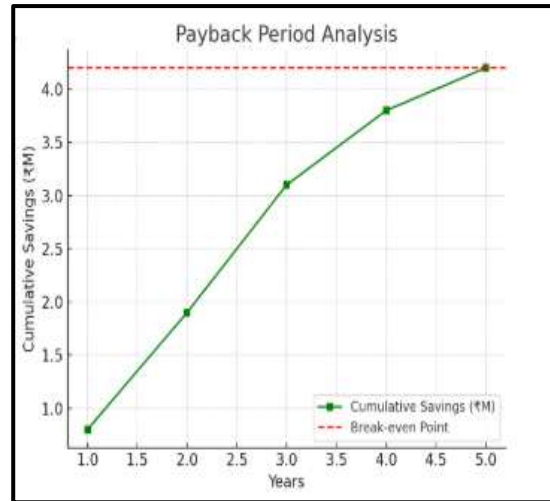
Fig8 Payback Period
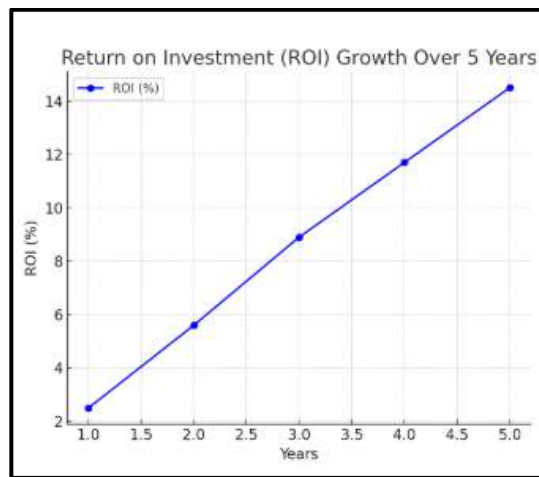
Fig. 9 ROI Graph

Results:

- **ROI = 14.5% over 5 years**
- **Payback period = 5.2 years**
- **Annual savings = ₹4.2M**

Observations: Renewable integration is **financially viable** under optimized conditions.

4

CONCLUSION AND FUTURE WORK

This study demonstrates that:
☑ **Load flow optimization improves voltage stability (+6.8%)**.
☑ **Transformer loading is reduced by 17.6%, preventing overload failures**.
☑ **Power losses are cut by 36.8%, increasing system efficiency**.
☑ **Solar integration is economically feasible (ROI = 14.5%)**.

Future work will explore:

- **Real-time AI-driven load forecasting**.
- **Machine learning-based optimal DG placement**.

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Review On Development of an Automated Solar Tracking System with Integrated Inverter Module for Enhanced Power Generation

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ABSTRACT— The renewable sources of energy are becoming one of the utmost priorities of the present day world due to their innumerous advantages. In particular, solar energy is progressing as a potential inexhaustible and non-polluting energy source to suffice our ever-increasing energy requirements. However, the solar panels which are the fundamental solar-energy conversion components are fixed at a certain angle and are not able to track the sunlight direction with diurnal and seasonal changes. This limits the area of exposure of sunlight on solar panels and efficiency of the solar tracking system involving solar panels. We have developed a solar tracking system using a combination of micro-controller, stepper motor and light dependent resistors (LDR's) with the primary aim of improving the power efficiency of the solar panels. The main component of this tracker is Arduino controller which is programmed to detect the sunlight with the help of LDRs and then actuate the stepper motor to position the solar panel in such a way so that it gets the maximum sunlight. Thus this system can achieve maximum illumination and can reduce the cost of electricity generation by requiring minimum number of solar panels with proper orientation with the sunlight.

Keywords— Solar tracker mechanism, LDRs, Stepper motor, Controller, Solar panel, Inverter , AC load etc.

INTRODUCTION

In the development of any nation, energy is the main driving factor in the world today. There is an extensive amount of energy that gets extracted, distributed, converted and consumed each and every day in the world today. Fossil fuels account for about 85 percent of energy that is produced. Fossil fuel resources are limited and also using them is known to cause global warming because of emission of greenhouse gases thereby leading to the need for alternate sources of energy.

Renewable energy is rapidly gaining momentum as an alternative source of energy since fossil fuel prices are varying every other day in the market. The most used renewable energies are solar, wind, gas and biomass but the most employed is solar energy.

The sun radiates energy in the form of electromagnetic energy and the amount of electromagnetic radiation that reaches the earth from the sun is referred to as solar radiation. Theoretically, solar energy levels reaches around 1366 W/ on the surface of the earth. This simply means that for every square meter of surface area on a solar collecting platform that faces the sun, the system will nearly be able to collect around 1 kW of solar energy(if it is 100% efficient) thus solar energy has impressive magnitude and provides more energy than present day human technology. Solar panels inarguably convert radiation from the sun into electrical energy. The panels are manufactured from semiconductor materials, such as silicon. Their efficiency is 24.5% on the higher side. Solar energy is being used as an alternative energy source due to the fact that it is readily available and environmentally friendly. It is hence critical for people to gain an understanding and appreciation of technologies associated with solar panels.

Solar energy is becoming increasingly lucrative with the increasing cost and continuous depletion of the non-renewable energy resources and the growing demand of other renewable energy sources such as solar wind, geothermal and ocean tidal wave. However, in spite of the multiple benefits of solar energy, solar panels which capture sunlight are stationary (solar array has a fixed orientation to the sky). These stationary as well as expensive solar panels are unable to extract the maximum solar energy as there is no stability of weather conditions. The power output of solar panels is maximum when it is oriented perpendicularly to the direction of sun rays as both the area of illumination of sunlight on solar panels and intensity of sun-rays is

maximum in this case. It has been found out that the efficiency of solar panels improve by 30-60 percent when we use a mobile solar tracking system instead of a stationary array of solar panels. The design and implementation of a power efficient solar tracker is therefore a challenge owing to the immobility of the solar panels.

The angle of inclination of sun-rays with the solar panels continuously changes due to the movement of the sun from east to west because of earth's rotation independent of the weather conditions. Moreover, during cloudy days the situation totally goes berserk. Additionally the revolution of the earth alters the distance between earth and sun which introduces change of pattern of incoming sun rays. All these factors should be kept in mind for designing the solar tracking electricity generation system to achieve maximum efficiency.

In this project, we have discussed about the solar tracking system that we have designed using some LDR's (light dependent resistances), Arduino controller, comparator using OPAMP's, a crystal oscillator, stepper motor and stepper motor driver , tracker Mechanism. The basic idea behind this work is that the intensity of light will be sensed by the LDR's separated by a certain angular distance, the comparators will compare the incident light intensity with the intensity of perpendicular incidence. The controller will rotate the stepper motor by the desired angle depending on the output of the comparators via a stepper motor driver circuit to maximize the efficiency. Owing to the change in the location where the device is placed and weather conditions, the intensity of sunlight changes, for which we have made a provision of changing the threshold value by using variable resistances.

PROBLEM IDENTIFICATION

- Fossil fuels dominate global electricity generation but pose environmental and accessibility challenges, especially in developing countries.
- Limited infrastructure often restricts electricity access, highlighting the need for sustainable alternatives like solar energy. However, conventional solar panels are inefficient due to their static design.
- This project develops a solar tracking system that increases energy capture by 30-40%. Using a control circuit, two stepper motors dynamically adjust the panel's orientation based on the sun's position, ensuring optimal sunlight exposure throughout the day.
- This innovative system enhances solar efficiency, making renewable energy more viable.
- By bridging the energy gap in underserved regions, it reduces reliance on fossil fuels and provides a cleaner, more reliable power source for communities.

A. Existing System

The existing solar power system primarily relies on fixed solar panels, which remain stationary throughout the day. These panels are positioned at a fixed tilt, optimized for average sunlight exposure but unable to track the sun's movement. As a result, energy capture is inefficient, especially during early morning and late afternoon hours. This limitation reduces overall power generation, requiring

larger panel installations to meet energy demands. Additionally, conventional systems often lack automation, relying on manual adjustments for seasonal optimization. In developing regions, these inefficiencies hinder widespread solar adoption, making it crucial to develop advanced solutions like solar tracking systems.

Fig.1. Existing System

B. Drawbacks

Fixed solar panel systems have several drawbacks, primarily due to their inability to track the sun's movement. This results in reduced energy efficiency, especially during morning and evening hours. They require larger installations to compensate for energy losses, increasing costs and space requirements. Seasonal adjustments must be done manually, adding inconvenience. Additionally, fixed systems generate lower power output, making them less viable in regions with inconsistent sunlight. These limitations hinder widespread solar adoption, especially in developing areas with energy shortages.

AIM AND OBJECTIVES

Aim : The aim of our projects is to utilize the maximum solar energy through solar panel. For this a digital based automatic sun tracking system is proposed.

The main objectives of the study are outlined below:
- To design a system that is able to control the position of solar panel in accordance with the position of the sun.
- To invent a more affordable solar tracker as opposed to commercial made solar trackers.
- To utilize this electric energy in AC loads using inverter module.

The solar panel tracks the sun from east to west automatically for maximum intensity of light.
Processes Involved are-:
i. To develop a Stepper dc motor control interfaced with driver circuit.
ii. To construct a model prototype solar cell movement system with a mechanical assemble to move the solar Panel.
iii. To design an electronic circuit to sense the intensity of light and to control dc stepper motor driver for the panel movement.

LITERATURE SURVEY

1) Shubhangi bhatambrekar et. al. 2022, This paper presents the design and construction of an 8051 microcontroller-based solar panel tracking system to enhance solar energy production. Solar trackers align panels perpendicular to the sun's rays throughout the day,

maximizing energy capture. Utilizing fuzzy control to position a DC motor, the system ensures optimal solar tracking. By following the sun's east-to-west movement, this innovative technology increases the efficiency of solar photovoltaic systems, providing a practical solution for sustainable energy generation.

2) Abhishek Shukla1 et. al. 2017, This study focuses on the development of an 8051 microcontroller-based solar tracking system designed to optimize solar energy harvesting. By continuously adjusting the orientation of solar panels to remain perpendicular to the sun's rays, the system enhances energy absorption throughout the day. Implementing a fuzzy control mechanism to regulate a DC motor, the tracker efficiently follows the sun's east-to-west trajectory. This advanced approach significantly boosts the performance of photovoltaic systems, offering an effective and sustainable solution for maximizing solar power generation.

3) Shreyasi Chakrabory et. al. 2021, This paper presents the design of a solar tracker system capable of dynamically aligning with the sun's movement using a microcontroller and stepper motor. The system operates effectively regardless of weather or location and includes adjustable threshold voltage settings to suit varying requirements. After sunset, the tracker resets its position, and the solar panel tilts toward the ground, protecting it from dust and enhancing its durability. While the prototype is limited to one-dimensional rotation and uses a small number of Light Dependent Resistors (LDRs), future enhancements will focus on increasing degrees of freedom and LDR coverage to improve performance.

4) Shivanshu Tiwari et. al. 2023, This research paper demonstrates an LDR-based solar tracking system designed to optimize energy capture. The prototype tracks the sun throughout the day using a comparator circuit, with noticeable improvements in voltage and current output compared to fixed panels. The tracker operates effectively regardless of weather, with an adjustable threshold voltage. Additionally, a reset mechanism repositions the panel to face east every morning. Although limited to one-dimensional tracking, future work will focus on enabling multi-dimensional movement for enhanced efficiency.

5) Karan Salgaonkar et. al. 2023, The aim of this paper is to present a novel design of an automated dual axis solar tracking system using a four quadrant light dependent resistor (L.D.R) and simple electronic circuit to provide a sinewy system performance. The proposed system uses the tracker to actively track the solar radiation and accordingly adjust the panel to maximize the power output. The project focuses on the simulation and implementation of the most efficient algorithm on the dual axis solar tracker which rotates in azimuth and elevation direction. This simulation positions the panel in a hemi spherical rotation absorbing maximum solar irradiation thus increasing the total electricity generation.

6) V Sundara Siva Kumar et. al. 2022, The aim of this paper is to present a solar energy collection technology by a photovoltaic cell. To present this efficient solar distributed generation system, a dual-axis solar tracker is designed. The tracker actively tracks the sun and changes its position accordingly to maximize the power output. The designed tracking system consists of sensors, microcontroller operated control circuits to drive DC motors and gear-bearing arrangements with supports and mountings. Two geared dc motors are used to move the solar panel so that sun's beam is able to remain aligned with the solar panel. With the rapid increase in population and economic development, the problems of the energy crisis and global warming effects are today a cause for increasing concern.

7) Errum Ali et. al. 2022, This paper deals with a microcontroller based solar panel tracking system. Solar tracking enables more energy to be generated because the solar panel is always able to maintain a perpendicular profile to the sun's rays. Development of solar panel tracking systems has been ongoing for several years now. As the sun moves across the sky during the day, it is advantageous to have the solar panels track the location of the sun, such that the panels are always perpendicular to the solar energy radiated by the sun.

8) Prof. Pooja K.et. al. 2019, This system can achieve the maximum illumination and energy concentration and cut the cost of electricity by requiring fewer solar panels, therefore, it has great significance for research and development. The main use of this report is to utilize the maximum power from the sun. Now a day we are in heavy need to use the solar power as in the coming days everything we use might depend on this kind of systems. If errors are found or the system needs to be improved or upgraded, the PCB must be redesigned. Adjusting and modifying the PCB is very inconvenient and increased the design cost and development period. This implementation has great future scope because the Sun is important source of energy which available in free of cost. As today's world need greater amount of energy it can be satisfy by our project use.

9) V Sundara Siva Kumar et. al. 2020, The aim of this paper is to present a solar energy collection technology by a photovoltaic cell. To present this efficient solar distributed generation system, a dual-axis solar tracker is designed. The tracker actively tracks the sun and changes its position accordingly to maximize the power output. The designed tracking system consists of sensors, microcontroller operated control circuits to drive DC motors and gear-bearing arrangements with supports and mountings. Two geared dc motors are used to move the solar panel so that sun's beam is able to remain aligned with the solar panel.

I. PROPOSED SYSTEM
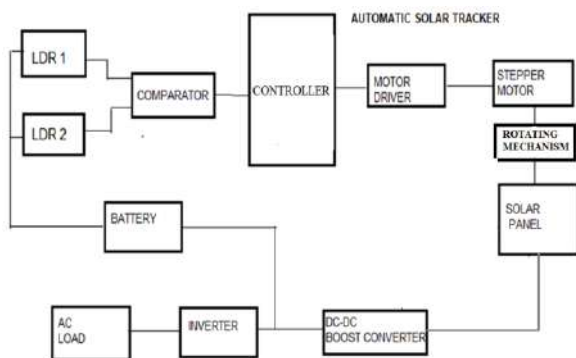
Fig. 1. Block Diagram of system

The solar tracking system is designed to maximize solar panel efficiency by continuously aligning the panel with the sun's position. The system uses Light Dependent Resistors (LDRs) to detect sunlight intensity and an Arduino Uno microcontroller to control the movement of a stepper motor.

To ensure accurate tracking, the LDRs are placed on the surface of a large curvature. This placement allows them to detect sunlight from various angles. At any given moment, only two adjacent LDRs remain active, which provides the microcontroller with precise directional information. The microcontroller processes this input and generates the required bit pattern to direct the stepper motor. The motor, in turn, rotates the solar panel mounted on its shaft to align it perpendicularly to the sun.

This continuous tracking ensures that the solar panel faces the sun throughout the day, optimizing the amount of sunlight captured. The energy generated by the solar panel is stored in a battery for later use. The stored energy is then utilized to power AC loads through an inverter module, making the system suitable for various applications, including household and commercial use.

The tracking mechanism significantly improves the efficiency of solar panels compared to fixed systems. By maintaining an optimal orientation, the system increases energy generation and ensures that the solar panel operates close to its standard working conditions. The design is flexible, allowing for easy adjustment of the LDR configuration or threshold settings. This ensures adaptability for different weather conditions and locations. The combination of efficient sunlight detection and precise motor control makes this solar tracking system a reliable and effective solution for enhancing solar energy utilization.

COMPONENTS USED

The main operating components of this system are:
- Photovoltaic Solar Panel
- Arduino controller
- Comparator LM324
- Gears Mechanism
- LDRs
- Motor driver IC L293D
- Stepper motor
- Inverter
- Battery
- AC Load
- Others.

Software Required:
- Arduino Compiler
- MC Programming Language: Embedded C.

II. ADVANTAGES

- Increased Efficiency: The solar tracking system ensures the panel is always optimally oriented toward the sun, leading to higher energy output compared to stationary systems.
- Versatility: The system can adapt to changing sunlight angles due to diurnal and seasonal shifts, maximizing power generation throughout the year.
- Automation: The use of an Arduino microcontroller and LDRs allows for automatic tracking, reducing the need for manual adjustments.
- Energy Storage: The inclusion of a battery enables energy storage, ensuring availability for later use or during non-sunny hours.
- Better Utilization of Space: Improved efficiency means more power can be generated from the same panel area.
- Durability: The system can reset the panel to a safe position, such as facing downward at night, protecting it from dust and environmental wear.
- Scalability: The design can be scaled up for larger solar installations.

CONCLUSION

In this project a solar tracker has been developed to increase the amount of power generated by the solar panel as the sun traverses across the sky. A controller was used to control the movement of the solar panel. The system is designed to be autonomous; such that energy generated by the solar panel would be used to charge two lead acid batteries. In this project some difficulties regarding the placement or the LDRs is faced, so that at a same time more than two LDR do not get activated. All the readings are taken very carefully during the project to eliminate the errors as many as possible. Solar Energy is one of the most popular renewable sources nowadays. It is being widely used also, and within some more years it will be very popular that it will be used for many purposes, in industries and household as well. So it is most important fact to utilize the maximum energy of the sun so that maximum power can be generated. The thought behind this project is also derived from this fact. In many places experiment is being done on this fact how it is possible to make full use of the day light. In many places application of this project can be seen also.

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Review On Development of Solar Panel Cleaning Robot

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ABSTRACT— Photovoltaic (PV) panels, which are grouped in several arrays inside a solar farm or solar energy system, are the primary source of solar power. Many nations with high levels of insolation favor solar as a possible source of clean energy, despite the variable efficiency of power generation from solar photovoltaic (PV) panels. However, even on a single panel in an array, the buildup of pollutants and dust reduces the level of energy produced by PV panels. Because of this condition, PV panels' surfaces need to be cleaned on a regular basis. The labor-intensive, time-, water-, and energy-intensive cleaning techniques used for photovoltaic arrays today lack automation. A completely automated system that may be used with or without water is suggested as a solution to this issue. Therefore, the development of a machine for automatic PV panel surface cleaning is discussed in this study. To regulate the robot's mobility while cleaning, the design makes use of an Arduino controlling system. Furthermore, it has a system for pumping water and two rough sponges that will be used to remove dust or dirt from PV panel surfaces. Prior to and following the cleaning procedure, the PV panels' efficiency is also noted. The outcome demonstrates that, once the dust of the photovoltaic panel is removed, the designed solar panel washing robot can efficiently clean the panel and restore 50% of the panel's maximum power and output current.

Keywords— Solar Panel Cleaning Robot, Photovoltaic (PV) Efficiency, Automated Cleaning System, Arduino-Based Control, Dust and Debris Removal etc.

INTRODUCTION

The primary source of electricity for all life on Earth is solar energy, which is also the foundation for all other energy sources except nuclear energy. However, solar electricity has not advanced to the level of conventional energy sources, and it faces numerous obstacles like high cost, unpredictable and erratic nature, low efficiency, and the need for storage. The goal of this project is to increase the efficiency of renewable energy sources by resolving the issue of dust accumulation on the surface regarding solar panels, which lowers the generated electricity and overall efficiency of the facility.It suggests creating a solar panel washing system that could regularly clear the dust buildup on the panel's surface and preserve the output of the solar power plant. Given the limited water supply in the areas where these plants are primarily found, the robotic system could move on its own across the tops of solar arrays using pneumatic equipment suction cups and clean them using dry techniques like a rotating cylindrical touch cleaning system. Because

cleaning solar panels exposes people to dangerous conditions in the blazing sun, this project also attempts to minimize the amount of human involvement involved in the process.

A robot is an instrument that can perform a sequence of tasks automatically based on input from its surroundings and an internal program. According to these guidelines, an autonomous robot can perform tasks and instructions with a high degree of precision on its own.

• Capable of obtaining concrete inputs from the surroundings; • Capable of carrying out tasks for extended periods of time without human intervention.

• Capable of moving around its workstation without assistance from humans.

• Unless specifically trained to do so, it is capable of avoiding circumstances that could endanger both humans and itself.

The robot that cleans.

Although cleaning is considered to be among the least desirable tasks, it is nevertheless a vital activity in human life. Cleaning can also be dangerous for people in some situations. Machines have thus been developed repeatedly

to help us with this essential evil of cleaning. The newest trend that has emerged in recent years is robotic cleaning. An autonomous robot that can turn around to disinfect surfaces using a variety of methods, including vacuuming, mopping, or just scouring with a rotating brush, is called a robotic cleaner.

Although it is intended for industrial cleaning in large-scale solar power facilities, the suggested solar panel clean system is classified as a cleaning robot. It is a robot with autonomy that uses vacuum suction cups to move across the sloped coating of the solar cells and a revolving cylindrical brush to clean the panels' surface. Every cycle begins with the robot traveling a certain distance parallel to the solar panel's base, after which the revolving brush moves from top to bottom perpendicular to the base. In order to maximize solar irradiance, the solar cells are attached at an angle toward the ground, depending on the latidunial position of the photovoltaic plants. However, because robotic cleaning systems must travel over a sloped surface, this benefit turns into a drawback. A typical wheel-based robot can't move on the sloping surface because it will slip and tumble to the ground. As a result, we have a pneumatic system with suction cups on the bottom. When these suction cups are activated by vacuum pumps, a suction force is produced that aids in the robot's attachment to and movement on its surface.

PROBLEM IDENTIFICATION

- Solar Technology Advancements: Solar panels, derived from solar cells, convert solar energy into electrical energy and are widely used in industries and households.
- Challenge in Maintenance: Maintaining solar panels is crucial to preserve efficiency, requiring effective cleaning methods.
- Impact of Dust: Dust accumulation is the primary factor reducing panel efficiency, with losses of up to 50%, depending on environmental conditions.
- Other Factors Affecting Efficiency: Shadow, snow, high temperatures, pollen, bird droppings, and sea salt also contribute to efficiency reduction.

Manual Cleaning Limitations:

- Commercial detergents are costly, time-consuming, and potentially hazardous to the environment.
- Frequent cleaning every few weeks is required, especially challenging for large arrays.
- Automated Cleaning Solutions:
- Robotics offers an economical, autonomous solution for cleaning large ground-based arrays.
- Eliminates human labor and supports efficient maintenance for systems with up to 22,000 panels.

Fig.1. solar panel cleaning

A. Existing System

The traditional method for cleaning solar panels involves manual labor, which is time-consuming, inefficient, and costly. Commercial cleaning detergents, although effective, pose environmental hazards and require frequent use to maintain panel efficiency. Large solar farms, consisting of thousands of panels, demand substantial human resources and water for regular maintenance. Additionally, factors like dust, bird droppings, and environmental pollutants accumulate on panel surfaces, reducing efficiency by up to 50%. Manual cleaning methods also expose workers to hazardous conditions, such as extreme heat and difficult terrain. Some semi-automated systems, such as water-based cleaning robots, exist but are limited by high water consumption and the inability to navigate slanted panel surfaces effectively. As solar farms expand, the inefficiencies of manual or semi-automated cleaning become more apparent, necessitating an advanced solution that enhances efficiency while reducing operational costs and human involvement.

B. Drawbacks

Despite its advantages, the automated solar panel cleaning system has several drawbacks.

The initial investment for robotic cleaning systems is high, making it less accessible for small-scale solar farms. The reliance on vacuum suction cups may lead to wear and tear over time, requiring regular maintenance. Additionally, the system may struggle with extremely rough or uneven panel surfaces. In regions with severe soiling, such as bird droppings or hardened debris, the dry cleaning method may not be as effective as water-based cleaning. Moreover, power consumption by the robot reduces the net energy gain, and extreme weather conditions may impact operational efficiency.

AIM AND OBJECTIVES

The main objectives of the project are comprehended as follows:

Aim : This Solar Panel Cleaning Robot aims to maintain the efficiency of Solar power production by making sure the Solar panels are kept clean without putting humans at risk.

Objectives :
• To develop smart cleaning robot for solar panels.
• To make wireless smartphone operation for cleaning robot using Bluetooth technology.
• To effectively clean dirt from solar panels using a roller brush and water sprayer.
• To enhance solar panel efficiency for both industrial and small-scale applications, including solar plants and rooftop panels.

LITERATURE SURVEY

Maghami et al. (2016) examine the effects of soiling on solar panels, analyzing how dust accumulation reduces sunlight absorption and subsequently lowers power output. Their study reviews various pollutants, such as soil, ash, and calcium carbonate, showing how each affects panel efficiency differently. They highlight the importance of regular maintenance and propose potential cleaning techniques to counteract dust impact on PV systems. The authors argue that managing soiling is crucial to sustaining optimal energy output, as daily energy loss due to dust can reach significant levels, especially in areas with prolonged dry spells.

Sayyah et al. (2014) explore how dust deposition on solar panels diminishes energy yield. They document how dust density and deposition rate correlate directly with power losses, noting variations based on geographic location and environmental conditions. The study evaluates multiple cleaning strategies, from manual to automated methods, highlighting the economic and operational impacts of each. Findings suggest that high-dust regions experience more frequent and severe energy yield losses, emphasizing the need for effective dust mitigation techniques to preserve energy efficiency, particularly for large-scale solar power systems.

Ilse et al. (2018) present an extensive review of techniques to mitigate soiling losses in PV systems, focusing on both preventive and active cleaning solutions. They assess passive coatings, robotic cleaners, and electrostatic methods, comparing their cost-effectiveness and suitability for different environments. The study shows that automated robotic systems provide efficient and scalable cleaning for commercial solar installations, reducing operational disruptions. By identifying the best strategies for soiling mitigation, this research provides valuable insights for developers and operators to improve PV panel longevity and output.

Bhushan et al. (2020) discuss power loss minimization by adopting various solar panel cleaning techniques. Their research evaluates manual, semi-automatic, and robotic cleaning options, analyzing each for cost, efficiency, and long-term effectiveness. They emphasize that automated systems, although costly upfront, offer consistent cleaning quality, enhancing panel performance and reducing maintenance intervals. Their findings support the integration of robotics in solar energy management, especially in areas with frequent dust accumulation, where they estimate power loss could reach up to 20% without regular cleaning.

Mani and Pillai (2012) investigate the influence of dust on PV performance, covering research developments and the challenges associated with dust accumulation. The authors review the varying degrees of power loss caused

by different dust types and recommend targeted cleaning solutions based on environmental conditions. They also highlight a need for economical, region-specific cleaning technologies to maintain PV efficiency, especially in arid and semi-arid climates. Their recommendations advocate for more research into automated cleaning solutions and coatings that prevent dust adherence, thereby preserving PV output and reducing operational costs.

Our research aims to construct a solar panel cleaning robot using Arduino and wireless technology. The objectives of the project are to design and implement a microcontroller-based dust cleaning system by using Arduino UNO as the main system, to optimise the performance of PV panel operation under dusty environment, and to improve the efficiency of the solar panel by keeping them clean.

PROPOSED SYSTEM
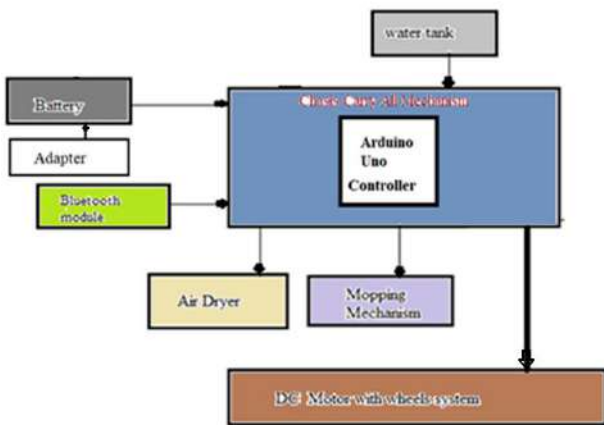
Fig. 1. Block Diagram of system

Their electric energy is stored in a battery when the adaptor is used. The machine's electrical switch board is powered by a 12v DC battery. SMPS and the air dryer receive their primary power from the electrical board, while the sighing process and SMPS receive DC power when they are operating. The DC motors, which are essential to the cleaning process, are operated by the moping process. One of the single D.C. motors rotates the mop to clean the central surface that the chassis covers. Compared to the brush motor, the DC motor that is used to rotate the mop has a higher torque. The front portion of the solar array is cleaned by another two DC motors with high RPM. The brushes are rotated by the DC motor via the shaft, which is fastened to the motor shaft by a nut and bolt. The arc on the left side of the chassis allows you to adjust the front mopping mechanism, which cleans the uneven particles that accumulate on the Solar's surface during the summer.

A spinning mop brings moisture as well as dust or dirt fragments into the central region of the chassis during the wet season, which slightly alters how the solar cleaning equipment operates. In order to gather more water in the center portion, the mopping heads rotate in the opposite directions, collecting the water and dirt mixture. For efficient cleanup, the mop is rotated by the third motor. A water sprayer pump is installed at the bottom for the water tank to supply fresh water for effective cleaning; the control valve sets the fresh water flow.

COMPONENTS USED

The manually operated Solar cleaning machine consist of various elements such as, DC motors, fresh water sprayer pump, mope, LED lights, chassis and fresh water tank. For converting the AC supply into DC the Switched mode power supply (SMPS) is used. The fresh water tank is used to stores the water in it. While doing wet cleaning it provides water as per the requirement. The switch board is fixed onto the handle. It is used to start and stop the machine as per operator's wish different buttons are provided to operate the different component. Chassis is a Main part of machine which holds all other parts on it. It is made up of mild steel because it satisfies all the required conditions. Water is stored in a chamber that has a opening controlled by a motor. By putting this motor to ON position water or cleaning liquid starts flowing from the tank. A connecting pipe connects it to a shower-style setup. There are several manually adjustable holes in the sprinkler system that are positioned in a consecutive fashion. When a mop is not needed, an arc is supplied to allow for positional adjustment.

- Battery
- Adapter
- Arduino Controller
- Motor Driver controller
- Relay Board
- Bluetooth Module
- Mop for cleaning

- DC Pump
- LCD Display
- Wheels

Software Required:
- Arduino Compiler
- MC Programming Language: Embedded C.

ADVANTAGES

1. Manual effort is reduced:
This solar cleaning machine has the electric work system that reduces the manual effort in the cleaning of surface.

2. Operating time is less:
As we are using the motorized brushes and mop in this machine this will reduce the operating time and cleaning work can be done faster.

3. It is possible to accomplish both cleaning and polishing simultaneously:
By using mop we can clean the dirt and dust and as well as at the same time solar polishing is also done with the help of mop.

4. Power consumption is less:
The power usage is lower because we are employing a low voltage electrical DC motor.

5. This machine requires low Maintenance cost.

6. In this machine Easy control of cleaning solution supply by controlling valve.

7. Other than rough surfaces, it can be employed in a variety of settings.

8. By further modification the drive or movement can be made automatic.

APPLICATIONS

Applications of Solar Panel Cleaning Robot:
- Industrial Solar Power Plants: Maintains efficiency of large-scale solar panels in dedicated solar power plants.
- Residential Rooftop Solar Panels: Cleans solar panels in homes, boosting power generation efficiency.
- Commercial Buildings: Enhances the performance of solar panels installed on office rooftops.
- Solar Farms: Regularly cleans solar arrays in vast solar farms to ensure maximum energy output.
- Hazardous Locations: Operates in areas where manual cleaning is risky or time-consuming, ensuring worker safety.
- Remote Solar Installations: Ideal for cleaning panels in isolated or difficult-to-reach areas.

CONCLUSION

Dust, dirt, pollen, sea salt, and bird droppings significantly impact solar panel efficiency, reducing peak power generation by 10-30%. Robotic cleaning methods effectively address this issue, enhancing power generation capacity while offering easy maintenance, low cost, and minimal power usage. The lightweight device, primarily made of aluminum, ensures affordability and efficiency, especially for large solar systems. Automatic cleaning proves more economical and less labor-intensive than manual methods, enabling frequent and consistent cleaning to maintain optimal panel transmittance. Innovative technology reduces human effort, encourages regular cleaning, and improves system performance. This advancement promotes sustainable energy solutions and supports India's progress by increasing solar efficiency, reducing costs, and fostering a cleaner, healthier environment for future generations.

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Comparative Review of Multilevel Inverter Topologies

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ABSTRACT

The three primary types of multilevel inverters—diode-clamped, flying-capacitor, and cascaded H-bridge multilevel inverters—as well as their variations for photovoltaic power systems are thoroughly reviewed in this work. Photovoltaic power systems typically create DC electricity. Therefore, it must be managed and transformed into a form that is beneficial. An inverter is a power electronic device that transforms DC power into AC power at the required output frequency and voltage. Because multilevel inverters may provide a staircase AC output voltage waveform without the need of a large passive filter, they have recently become an interesting subject of study in the field of electric power systems.

This paper presents multilayer inverter technology for photovoltaic power systems, which will be very beneficial in identifying the limitations of this field of study and, consequently, provide information to address current problems in the near future.

Keywords:*multilevel inverter, flying-capacitor, diode-clamped, cascaded H-bridge*

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INTRODUCTIN

Demand for clean energy is rising as more energy is produced from renewable resources like solar, wind, hydro, and so on [1]. The most significant renewable energy source in the world is the sun. Photovoltaic (PV) power systems use PV panels to turn sunlight into electricity. Solar panel-generated DC power must be managed and transformed into forms that can be used [2-4]. Authors have proposed a variety of power inverter types. Pulse-width modulated (PWM) multilevel inverters are becoming increasingly popular among them because of their numerous, dependable applications [5]. Because of their staircase output voltage's low total harmonic distortion (THD), large, costly, and passive filters are not necessary [6-8]. Diode-clamped, flying-capacitor, and cascaded H-bridge multilevel inverters are the three fundamental types of multilevel inverters [9]. The following sections cover the functioning, benefits, and drawbacks of diode-clamped, flying-capacitor, and cascaded H-bridge multilevel inverters. This is how the rest of the paper is designed.

DIODE-CLAMPED MULTILEVEL INVERTE

2.1 Working of Diode Clamped Inverter

Clamping diodes and cascaded dc capacitors are used in the diode-clamped multilevel to generate multi-level ac voltage waveforms. In general, the inverter can be set up with a three, four, or five-level topology; however, only the three-level High-power medium-voltage (MV) drives have made extensive use of inverters, also referred to as neutral-point clamped (NPC) inverters. When compared to a two-level inverter, the NPC inverter's primary characteristics include lower dv/dt and THD in its ac output voltages. Two cascaded dc capacitors typically split the inverter's dc input voltage, creating a floating neutral point.Additionally explained is how to manage the neutral-point voltage variation.Figure 2.1 shows the simplified circuit diagram of a three-level NPC inverter.The inverter leg A is composed of four active switches S_1 to S_4 with four antiparallel diodes D_1 to D_4. In practice, either IGBT or GCT can be employed as a switching device.
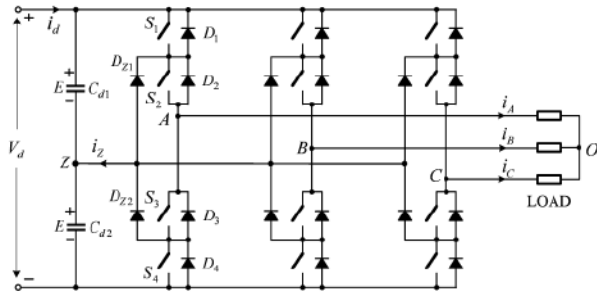
Fig2.1   Three Level NPC Inverter

The dc bus capacitor on the inverter's dc side is divided in half, creating a neutral point Z. The clamping diodes are D_{Z1} and D_{Z2}, which are connected to the neutral point. Upon activating switches S_2 and S_3, the inverter output terminal. One of the clamping diodes connects A to the neutral point. Each dc capacitor has a voltage of E across it, which is typically half of the total dc voltage Vd. Neutral current iZ can charge or discharge the capacitors when C_{d1} and C_{d2} have finite values, resulting in neutral-point voltage variation.

The switching states displayed in Table 1 shows the operational status of the switches in the NPC inverter.

Table 1: Switching States of three level (NPC) inverter

Switching States	Device Switching Status (Phase A)				Inverter Terminal Voltage
	S_1	S_2	S_3	S_4	V_{AZ}
P	On	On	Off	Off	E
O	Off	On	On	Off	0
N	Off	Off	On	On	–E

The upper two switches in leg A are in the "P" switching state, and the inverter terminal voltage V_{AZ}, while "N" denotes that the lower two switches conduct, resulting in $V_{AZ} = -E$, the voltage at terminal A with respect to the neutral point Z is +E. When the inner two switches, S_2 and S_3, are in the "O" switching state, the clamping diodes are clamping V_{AZ} to zero. Depending on the load's direction one of the two clamping diodes is activated by current iA. For example, terminal A is connected to the neutral point Z via the conduction of D_{Z1} and S_2, and D_{Z1} is forced to switch on by a positive load current ($i_A > 0$).

2.2 Commutation Circuit

Consider a switch from switching state [O] to [P] by turning S_3 off and S_1 on in order to examine the commutation of switching devices in the NPC inverter. The gate signals vg1 through vg4 for switches S_1 through S_4 are displayed in Figure 2.2.a, respectively. Comparable .The complementary switch

pair S_1 and S_3 must have a blanking time of ~ due to the gating configuration in the two-level inverter. The circuit layout for inverter leg A during commutation is displayed in Figures 2.2.b and 2.2.c. Each active switch has a parallel resistor for static voltage sharing. Based on the phase A load current iA's direction, the following two cases are looked into.
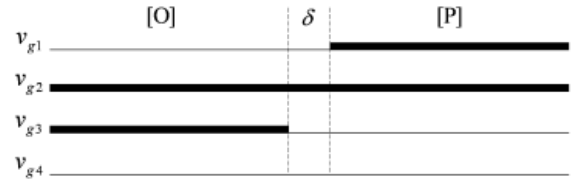
Fig.2.2.a Gate Signals

Case 1: Commutation with $i_A > 0$

It is assumed that (a) the inductive load causes the load current (i_A) to remain constant during commutation, and (b) the dc bus capacitors C_{d1} and C_{d2} are big enough so that all of the switches are in perfect condition and the voltage across each capacitor is maintained at E. Switches S_1 and S_4 are off in the switching state [O], whereas S_2 and S_3 are conducting.

The positive load current ($i_A > 0$) activates the clamping diode D_{Z1}. While the voltage on each of the off-state switches, S_1 and S_4, is equal to E, the voltages across the on-state switches, S_2 and S_3, are determined by $V_{S2} = V_{S3} = 0$. At δ interval S_3 is being turned off at this time. The i_A routes are unaltered. The static voltage sharing resistors R_3 and R_4 cause the voltages across S_3 and S_4 to become $V_{S3} = V_{S4} = E/2$ when S_3 is fully turned off. The top switch S_1 is gated on ($V_{S1} = 0$) in the switching state [P]. Because it is reverse-biased, the clamping diode D_{Z1} is off. From D_{Z1} to S_1, the load current iA is commutated. The voltage across S_3 and S_4 has already been in the off-state because $V_{S3} = V_{S4} = E$ is the result of dividing these two switches evenly by R_3 and R_4.
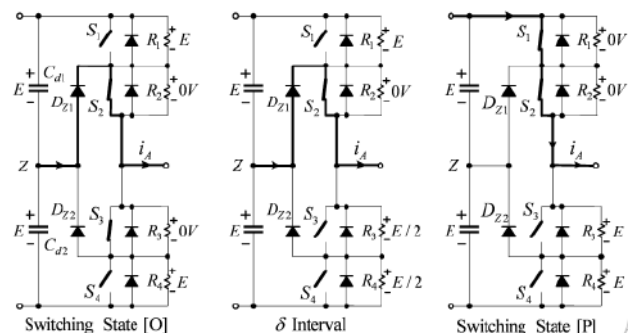
Fig. 2.2.b Commutation with iA>0

Case 2: Commutation with iA < 0
Fig. 2.2.c shows the commutation process with iA < 0. S_2 and S_3 conduct in the switching state [O], and the negative load current iA activates the clamping diode D_{Z2}. The off state voltage across $V_{S1} = V_{S4} = E$ for

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switches S_1 and S_4. At turn-off, S_3's resistance is always less than S_4's off-state resistance. As a result, V_{S4} remains at E while V_{S3} rises from zero to E. When S1 is in the switching state [P], the circuit's functionality is unaffected by its activation. Due to the conduction of D_1 and D_2, even when S_1 and S_2 are turned on, they do not carry the load current.
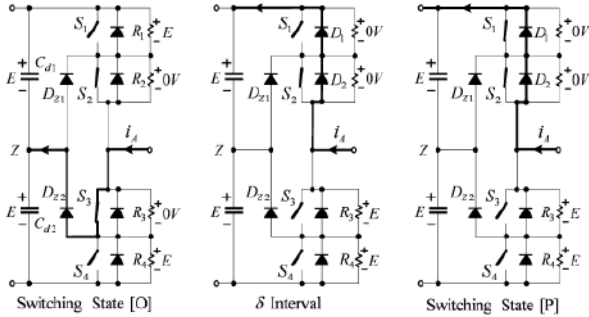
Fig. 2.2.c Commutation with iA<0

It may be inferred that during the transition from switching state [O] to [P], all of the switching components in the NPC inverter can only tolerate half of the dc bus voltage. Likewise, the commutation from [P] to [P] can be interpreted in the same way. [O], [N] to [O], or the other way around. As a result, there is no dynamic voltage sharing issue with the switches in the NPC inverter.

CASCADED H-BRIDGE MULTILEVEL INVERTERS

One of the common converter topologies utilized in high-power medium-voltage (MV) drives is the cascaded H-bridge (CHB) multilevel inverter [1–3]. It is made up of several single-phase H-bridge power cell modules. In order to achieve medium-voltage operation, the H-bridge cells are typically coupled in a cascade on their ac side. as well as minimal harmonic distortion. In reality, a CHB inverter's operational voltage and manufacturing cost mostly dictate how many power cells it has. An H-bridge power cell is fed by each of the several separate dc supply used by the CHB multilevel inverter.

The cascaded H-bridge multilevel inverter generates large ac voltages by connecting several H-bridge power cell units in a series chain, as the name implies. Fig. 3.1.1 depicts a typical five-level CHB inverter design.
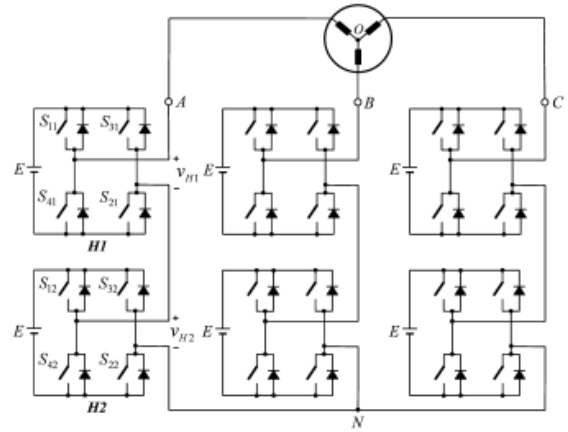
Fig 3.1.1 Five-level cascaded H-bridge inverter.

Two H-bridge cells driven by two separate dc sources with the same voltage E make up each phase leg. Multipulse diode rectifiers, which are typically used to get the dc supplies. Five voltages can be produced by the CHB inverter in Fig. 3.1.1. levels. The output voltage of the H bridge cells H1 and H2 is VH1 = VH2 = E when switches S11, S21, S12, and S22 are conducting. The resulting inverter phase voltage is VAN = VH1 + VH2 = 2E, which is the voltage at the inverter terminal A with respect to the inverter neutral N.

Similarly, VAN = –2E when S31, S41, S32, and S42 are turned on. Table 2 summarizes the several switching states that correspond to the other three voltage levels, which are E, 0 and -E. It is important to remember that the load phase voltage VAO, or the voltage at node A with respect to the load neutral O, may not always be equal to the inverter phase voltage VAN.

Table 2: Voltage Level and Switching State of the Five-Level CHB Inverter

Output Voltage VAN	Switching State				VH1	VH2
	S11	S31	S12	S32		
2E	1	0	1	0	E	E
E	1	0	1	1	E	0
	1	0	0	0	E	0
	1	1	1	0	0	E
	0	0	1	0	0	E
0	0	0	0	0	0	0
	0	0	1	1	0	0
	1	1	0	0	0	0
	1	1	1	1	0	0
-E	1	0	0	1	E	-E
	0	1	1	0	-E	E
	0	1	1	1	-E	0
	0	1	0	0	-E	0
2E	1	1	0	1	0	-E
	0	0	0	1	0	-E
	0	1	0	1	-E	-E

3.1 Modified Cascaded H-Bridge Multilevel Inverters

The Authors suggested a number of modified cascaded H-bridge multilevel inverters based on the Quasi-Z source concept in order to get rid of the constraints of the original design. A novel PV system topology is the quasi-Z source cascaded H-bridge multilevel inverter (QZS-CHB). Figure 3.2 explains the structure of PV system based on QZS-CHB multilevel inverter.
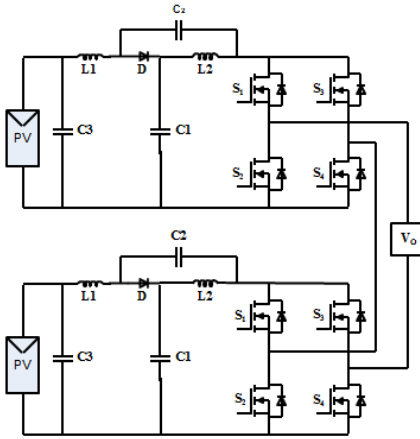
Fig 3.2. QZS-cascaded H-bridge multilevel inverter.

Two PV strings, three QZS H-bridge modules, filtering inductance, and the distribution grid make up this system. The total of all module output voltages is the QZS H-bridge multilevel inverter's output voltage. The output voltage waveform's number of levels often rose as the number of QZS H-bridge modules connected in series increased. This topology's primary benefit is its ability to successfully resolve the DC-link voltage imbalance issue. This system's shortcomings include the fact that it has many parts, making it expensive and complicated.

MULTILEVEL FLYING-CAPACITOR INVERTERS

A common five-level flying-capacitor inverter arrangement is depicted in Figure 4.1. By incorporating dc capacitors into the cascaded switches, it is an evolution of the two-level inverter. Each of the inverter legs contains four complementary switch pairs. Leg A's switch pairs, for instance, are (S1, S1')), (S2, S2'), (S3, S3'), and (S4, S4'). As a result, each inverter phase only needs four separate gate signals. Five different voltage levels can be produced by the flying-capacitor inverter shown in Fig. 4.1. When S1, S2, S3, and S4 switches are in the conducting state. The voltage at the inverter terminal A in relation to the negative dc bus N is 4E, which is

the phase voltage VAN. Likewise, VAN = 3E when S1, S2, and S3 are turned on. All of the voltage levels and the matching switching states are listed in Table 3. Noted that several switching states can be used to get different voltage levels. For example, six sets of distinct switching states can produce the voltage level 2E. Multilevel converters frequently experience switching state redundancy, which offers a great deal of flexibility in designing the switching pattern.
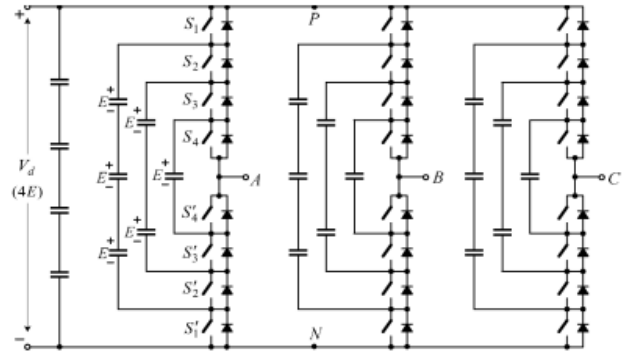
Fig 4.1 Five-level flying-capacitor inverter

Although the flying-capacitor inverter topology is based on the two-level inverter, it has some limitations. It is a multilevel inverter that produces voltage waveforms with reduced dv/dt and THD, and contains the same features as the two-level inverter, such as modular structure for the switching devices. Many dc capacitors with independent circuits for pre-charging. Several banks of large dc capacitors are needed by the inverter, and each one has its own pre-charge circuit. The working circumstances of the inverter typically affect the dc capacitor voltages. The voltages on the dc flying capacitors must be strictly regulated to prevent the issues brought on by the dc voltage deviation, which makes the control plan. Owing to the aforementioned limitations; the flying-capacitor inverter's practical application in the drive system appears to be restricted.

Table 3: Voltage Level and Switching State of a Five-Level Flying-Capacitor Inverter

Inverter Phase VAN	Switching State			
	S1	S2	S3	S4
4E	1	1	1	1
3E	1	1	1	0
	0	1	1	1
	1	0	1	1
	1	1	0	1
2E	1	1	0	0
	0	0	1	1
	1	0	0	1
	0	1	1	0

1E	1	0	1	0
	0	1	0	1
	1	0	0	0
	0	1	0	0
0	0	0	1	0
	0	0	0	1
	0	0	0	0

A COMPARISON OF THE ESSENTIAL MULTILEVEL INVERTER TYPES

This section presents a comparison of cascaded H-bridge multilevel inverters, diode-clamped inverters, and flying-capacitors. According to the comparison, the cascaded H-bridge multilevel inverter has become more popular because of a number of characteristics, including the fact that it doesn't require an excessive amount of clamping diodes and flying capacitors. The H-bridge can be added or removed to conveniently regulate the output voltage levels. It creates a multistep staircase voltage waveform that is almost sinusoidal by increasing the number of levels. The cascaded H-bridge multilevel inverter structure does not require a voltage balance circuit since it is made up of a cascaded connection of H-bridge units, each of which is fed with its own DC source. Only diode-clamped multilevel inverters require the clamping diode, while both diode-clamped and flying-capacitor multilevel inverters require the balancing capacitor. For the cascaded H-bridge multilevel inverter fewer components are needed. The H-bridge multilevel inverter topology has lately gained popularity in high AC power supplies and photovoltaic systems due to its reduced component count. Additionally, the likelihood of a system failure is reduced, and switch control is simple.

CONCLUSIONS

Basic multilevel inverter topologies and their modifications are thoroughly discussed in the study. Furthermore, the fundamental kinds of a variety of factors are used to compare multilayer inverters. Classical multilevel inverter structures have been examined, along with the benefits and drawbacks of each method. Multilevel inverters' primary benefit is that they address the issues of THD and dv/dt stress on switches. The explanation that follows leads to the conclusion that, in comparison to other multilevel inverter types, cascaded multilevel inverters require fewer components. Thus, it uses fewer semiconductor switches to generate a higher stepped output. Because there are fewer switches, the circuit's overall control is simpler and more compact.

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"Smart Municipal Solid Waste Management: A Review of Sustainable AI-Driven GIS Solutions for Urban Local Bodies in India"

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ABSTRACT

Municipal Solid Waste Management (MSWM) remains a critical challenge for Indian Urban Local Bodies (ULBs) due to rapid urbanization, population growth, and inefficient waste disposal mechanisms. The integration of Artificial Intelligence (AI) with Geographic Information Systems (GIS) offers a transformative approach to optimize waste collection, route planning, landfill site selection, and predictive analytics for waste generation patterns. This review-based study explores various AI-driven GIS applications in MSWM, comparing existing methodologies, case studies, and data-driven insights. The study aims to assess the effectiveness of AI and GIS technologies in addressing inefficiencies in waste management by analysing different models, such as machine learning-based waste segregation, route optimization using deep learning, and IoT-enabled real-time monitoring. The methodology involves a comparative analysis of global and Indian case studies, leveraging GIS-based spatial analysis, deep learning algorithms, and statistical visualization to highlight efficiency improvements.

Findings indicate that AI-integrated GIS solutions significantly enhance waste collection efficiency, reduce operational costs, and improve environmental sustainability. However, challenges such as data availability, technological adoption barriers, and infrastructural limitations in Indian ULBs must be mention. The study concludes by advocating for AI-GIS adoption in MSWM policies, proposing a strategic roadmap for scalable and cost-effective implementation.

KEYWORDS: *AI in Waste Management, GIS, Smart Cities, Urban Local Bodies, Machine Learning, Waste Collection Optimization.*

1. INTRODUCTION

1.1 Context of Urban India's MSWM

India's rapid urbanization has led to a significant increase in municipal solid waste (MSW) generation, with urban areas producing approximately 160,038 tonnes daily. Traditional waste management practices, such as manual collection and open dumping, have proven inadequate, resulting in environmental pollution and health hazards. To address these challenges, the Swachh Bharat Mission (SBM) was launched in 2014, emphasizing scientific MSW management and aligning with Sustainable Development Goal 11 to make cities inclusive, safe, resilient, and sustainable.

The integration of Geographic Information Systems (GIS) and Artificial Intelligence (AI) offers transformative solutions for MSW management. For instance, In india, a, GIS was utilized to optimize waste collection routes, leading to a 15%-28% reduction in operational costs and improved service efficiency. Additionally, AI-based forecasting models in New Delhi have demonstrated high accuracy in predicting waste generation, aiding in efficient resource planning. These technological interventions enhance waste collection efficiency, reduce operational costs, and promote

environmental sustainability.

India's rapid urbanization and population expansion have significantly escalated municipal solid waste (MSW) generation in urban areas. Currently, Indian cities produce approximately 160,038 tonnes of MSW daily, with projections estimating an increase to 165 million tonnes annually by 2031 and a staggering 436 million tonnes by 2050.
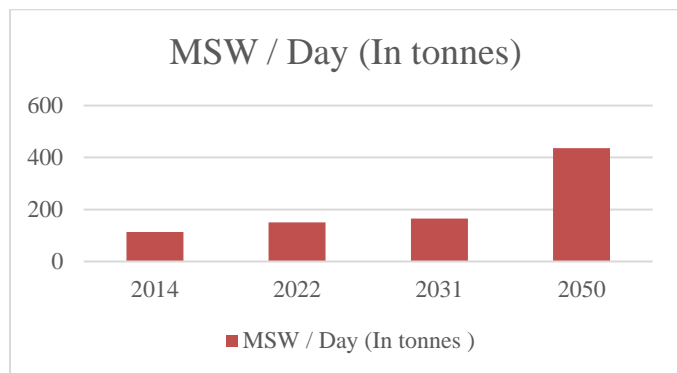
Figure No.1: Municipal (Urban) Solid waste generation per day Year wise data (in tonnes) projection in (2031, 2050)

The composition of MSW is diverse, with biodegradable waste constituting the largest share (42.51%), followed by paper (9.63%), plastics and rubber (10.11%), metals (0.63%), glass (0.96%), and inert materials (17%). However, the current waste management infrastructure in urban India struggles to cope with this growing waste burden, leading to inefficiencies in collection, segregation, treatment, and disposal.

Sr. No	Component of Urban SW	Percentage (%)
1	Biodegradable	42.51
2	Paper	9.63
3	Plastics/Rubber	10.11
4	Metal	0.63
5	Glass	0.96
6	Inert	17.00

Table No.1: Municipal (Urban) Solid waste components percentage (Inclusive National figure, 2018)

1.2 Challenges

One of the critical challenges in municipal solid waste management (MSWM) is **inefficient collection and segregation**. Despite a reported collection efficiency of 95.4%, a substantial portion of waste remains unsegregated at the source, making recycling and proper disposal difficult. The lack of a structured waste sorting mechanism at the household level exacerbates the problem, forcing waste management authorities to rely on inefficient post-collection segregation methods. Another pressing issue is **inadequate treatment and disposal**. A significant fraction of MSW is dumped in low-lying areas or open landfills without scientific treatment, leading to severe environmental pollution, groundwater contamination, and public health risks. Open dumping and unregulated landfills contribute to greenhouse gas emissions, particularly methane, further aggravating climate change concerns. Addressing these issues requires a paradigm shift toward sustainable waste management practices, leveraging modern technologies such as Artificial Intelligence (AI) and Geographic Information Systems (GIS) to optimize waste collection, improve segregation efficiency, and implement environmentally sound treatment and disposal methods.

1.2.1 Traditional vs. Modern Approach MSWM
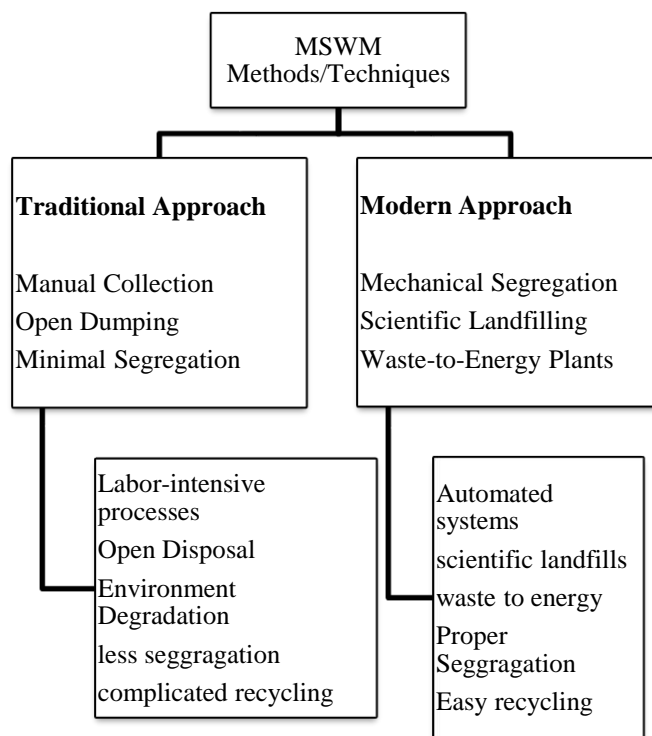
Figure No.2: MSWM Techniques- Traditional Vs Modern Approach

1.3 Swachh Bharat Mission (SBM) and Urban Sustainability Goals in India

SBM was Launched in 2014, the Swachh Bharat Mission aims to achieve universal sanitation and a clean environment. Under its urban component, SBM emphasizes scientific MSWM, promoting practices such as door-to-door collection, source segregation, and the establishment of composting and recycling facilities. These initiatives align with India's commitment to the Sustainable Development Goals (SDGs), particularly Goal 11, (11.1,11.2,11.3,11.4,11.5,11.6) which focuses on making cities inclusive, safe, resilient, and sustainable.
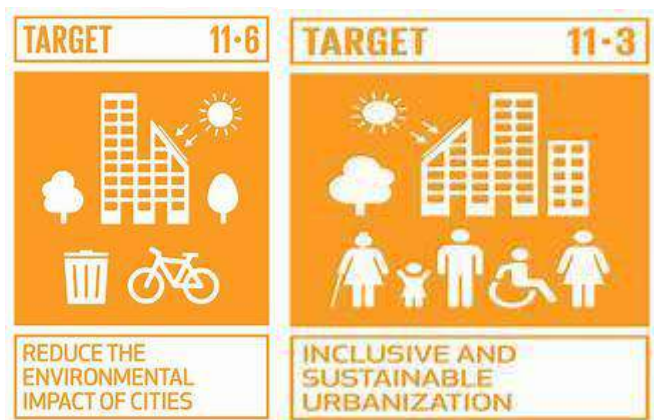
Figure No.3: SDG 11 Sustainability Goals

1.4 Integration of GIS and AI in Urban Solid Waste Management

In today's world modern Urban planners Engineers uses the convergence of Geographic Information Systems (GIS) and Artificial Intelligence (AI) which offers transformative solutions for MSWM.

Applications: It has following applications,

a) **Route Optimization:** AI algorithms analyze spatial data to determine efficient waste collection routes, reducing fuel consumption and operational costs
b) **Site Selection for Disposal:** GIS-based analysis assists in identifying suitable locations for waste disposal facilities, considering factors like population density, land use, and environmental impact

c) **Predictive Analytics:** Machine learning models forecast waste generation trends, enabling proactive planning and resource allocation

2 METHODOLOGY:

Following Methodology Adopted for the Review base understanding of MSWM GIS through AI application on Indian cities.

Step No.	Step Title	Description
1	Understanding Background of MSWM in Urban India	Analyze current MSWM status, challenges, and waste policies like **Swachh Bharat Mission (SBM) SDG** Goal.
2	Comparing Traditional vs. Modern MSWM Techniques	Evaluate manual collection; open dumping vs. AI-based **waste segregation, smart bins, WtE plants**.
3	Role of GIS in Solid Waste Management	Study how **GIS, AI, and RS optimize waste collection, segregation, landfill site selection, and decision-making**.
4	Comparing Case Studies of 4 Indian Cities (including metro)	Compare **Aurangabad, Hyderabad, Kolkata, Chandigarh**, on waste collection, cost savings, and efficiency.
5	Drawing Results & Framing Conclusion	Prove benefits of AI-GIS in **MSWM sustainability, cost reduction, and data-driven urban planning**.

Table No 2: Methodology Chart Shows 5 Step Involved in to the attempt of GIS MSWM Study for review paper.

2.1 AI-integrated Geographic Information System (GIS) framework Stages:

Approach to implementing an AI-integrated Geographic Information System (GIS) framework for **Municipal Solid Waste Management (MSWM)** in urban local bodies (ULBs) in India. The proposed system leverages **Artificial Intelligence (AI), Machine Learning (ML), Deep Learning (DL), Internet of Things (IoT), and Remote Sensing (RS)** technologies for efficient waste collection, transportation, segregation, treatment, and disposal.

Step 1: Data Collection & GIS Mapping
- **Satellite Images & Remote Sensing (RS)**
- **IoT Sensors in Waste Bins**
- GPS **Tracking of Waste Collection Vehicles**
- Public **Feedback & Surveys**
- Historical **Waste Generation Data**

Step 2: AI-Based Waste Generation Prediction and Route Optimization

A. Predictive Analytics using AI & ML
- **Machine Learning (ML)** models to predict future waste generation trends.
- **Deep learning models (CNN, LSTM) CCTV cameras** at LFS, DS.
- **AI-based forecasting tools** for resource allocation and infrastructure expansion.

B. Route Optimization using GIS and AI
- **Geospatial AI Model App**
- *Ai Algorithm App auto mechanism*
- **Real-time adjustments** & **IoT sensor alerts System**

Step 3: Smart Waste Segregation and Recycling Using AI & IoT
A.   AI-Based Waste Segregation:
- **AI-powered robotic arms equipped** with image recognition (CNN models) for waste sorting.
- **Smart conveyor belts use Deep Learning (YOLO, Faster R-CNN)** to detect and separate materials.
- **IoT sensors at Material Recovery Facilities (MRFs)** track the quantity and type of segregated waste.

B.   Automated Recycling Systems
- **Machine Learning algorithms :** Automation in swm scheme
- **Block chain for Waste Management :**

Step 4: Scientific Landfill Management and Waste-to-Energy Conversion
- GIS-Based Landfill Site Selection
- AI-Enabled Waste-to-Energy Plants

Step 5: AI-Powered Monitoring and Policy Decision Support (SI) & (RS)

- Real-Time Monitoring

- AI in Policy & Governance:
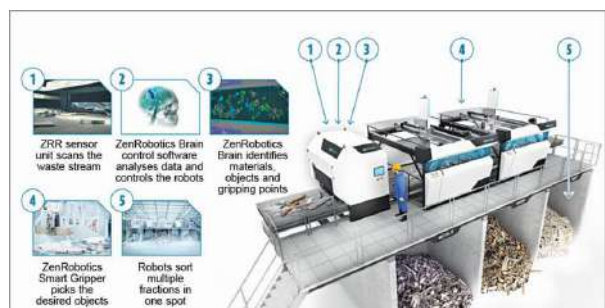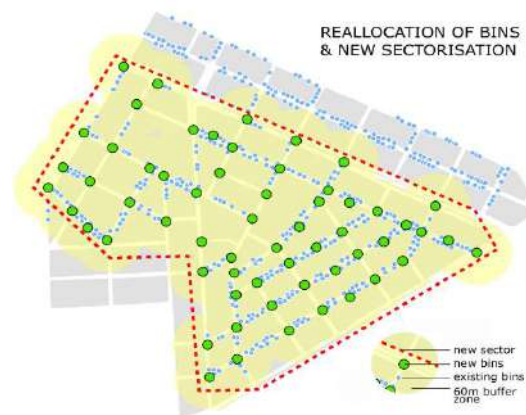
Fig No 4 : MSW Collection Routes Mapping, Waste Segregation, Landfill Management (Source: net images)

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3. AI-INTEGRATED (GIS) MSWM CASE STUDIES:

India's urban centers face significant challenges in managing municipal solid waste (MSW) due to rapid urbanization and population growth. The integration of Geographic Information Systems (GIS) and Artificial Intelligence (AI) has emerged as a transformative approach to enhance the efficiency and sustainability of solid waste management (SWM). This discussion presents case studies from four Indian cities - Aurangabad, Hyderabad, Kolkata, and Chandigarh—highlighting their adoption of GIS and AI technologies in SWM.

3.1 Case Study 1: Aurangabad

Aurangabad, located in Maharashtra, has implemented GIS-based models to optimize waste bin allocation and collection routes. Prior to this intervention, the city faced challenges with inefficient bin placement and irregular waste collection schedules. By analyzing spatial data, the municipal authorities reallocated waste bins and redesigned collection routes, leading to improved efficiency in waste collection and reduced operational costs. The GIS model facilitated better decision-making by providing a visual representation of waste generation patterns and collection logistics.

In Aurangabad, GIS was utilized to optimize waste collection routes, leading to a **15% reduction** in operational costs and improved service efficiency.

Technological Interventions:

- **Machine Learning (ML):** Enhances waste segregation processes by classifying waste types through image recognition.
- **Internet of Things (IoT):** Sensors monitor waste bin levels in real-time, facilitating timely collection and reducing overflow incidents.
- **Remote Sensing:** Assists in monitoring landfill sites and detecting unauthorized dumping through satellite imagery.

3.2 Case Study 2: Hyderabad

In Hyderabad, the integration of GIS, Management Information Systems (MIS), and Global Positioning Systems (GPS) has revolutionized SWM. The city developed a comprehensive GIS-MIS-GPS framework to monitor waste collection in real-time. This system enabled tracking of waste collection vehicles, ensuring adherence to designated routes and schedules. The implementation led to a significant increase in collection efficiency and a reduction in fuel consumption. The real-time data facilitated prompt decision-making and resource allocation, enhancing overall service delivery.

- **Increased Waste Collection Efficiency**: The city manages approximately 2,200 metric tonnes of solid waste daily, with 1,500 metric tonnes disposed of via landfilling and 700 metric tonnes utilized for power generation.
- Optimized **Resource Utilization**: The system's real-time tracking and route optimization have led to a reduction in fuel consumption and operational costs, though specific percentages are not detailed in the available sources.
- **Enhanced Service Delivery**: The implementation of the GIS-MIS-GPS framework has improved adherence to waste collection schedules and routes, resulting in more reliable and timely services.
- **Data-Driven Decision Making**: The integration of these technologies provides comprehensive data that supports informed decision-making and strategic planning for future waste management initiatives.

• 3.3 Case Study 3: Kolkata

Kolkata Municipal Corporation (KMC) employed GIS technology to optimize the placement of waste bins across the city. The traditional approach resulted in uneven distribution, leading to overflows in some areas and underutilization in others. By conducting a locational analysis using GIS, KMC identified optimal sites for bin placement, considering factors such as population density and waste generation rates. This strategic allocation improved waste collection efficiency and reduced instances of public littering.

Kolkata has implemented Geographic Information Systems (GIS) and Artificial Intelligence (AI) to enhance its Solid Waste Management System (SWMS). Key improvements include:

- **Optimized Waste Bin Placement**: A GIS-based study identified optimal locations for waste bins, considering factors like population density and waste generation rates. This strategic placement improved collection efficiency and reduced operational costs.

- **Increased Waste Collection Efficiency**: The city generates approximately 3,500 metric tonnes of solid waste daily. Implementing GIS and AI technologies has streamlined collection processes, leading to more timely and effective waste management.

- **Enhanced Resource Allocation**: By analyzing spatial data, authorities have optimized the deployment of collection vehicles and personnel, resulting in cost savings and improved service delivery.

- **Improved Waste Segregation**: The integration of AI has facilitated better sorting of waste at the source, increasing the percentage of segregated waste and promoting recycling efforts.

- **Data-Driven Decision Making**: The use of GIS and AI provides real-time data analytics, enabling informed decisions regarding route planning, resource allocation, and policy formulation.

- **3.4 Case Study 4: Kolkata**

Chandigarh implemented a GIS-based system to assess and enhance its MSW management. The city utilized spatial analysis to map waste generation sources and identify optimal routes for collection vehicles. This approach addressed previous challenges of route redundancy and uneven service distribution. Post-implementation, Chandigarh experienced improved waste collection coverage and a reduction in operational costs. The GIS application provided a platform for continuous monitoring and optimization of the SWM processes.

Chandigarh has significantly enhanced its Solid Waste Management System (SWMS) through the integration of Geographic Information Systems (GIS) and Artificial Intelligence (AI) technologies. Key improvements include:

- **Optimized Waste Collection Routes**: By utilizing GIS applications, Chandigarh has developed an integrated MSWM assessment model that optimizes collection and transport routes. This model aims to minimize costs, distances, and time associated with waste collection, leading to more efficient operations.

- **Cost Reduction in Waste Management**: Collection and transportation activities traditionally account for 60-70% of the total expenditure in municipal solid waste management. The implementation of GIS-based route optimization has significantly reduced these costs, though specific figures are not provided.

- **Enhanced Road Condition Monitoring**: The Municipal Corporation (MC) of Chandigarh has initiated a project employing AI and GIS tools to assess and monitor the condition of 200 km of roads. This initiative aims to identify potholes, uneven surfaces, and other maintenance needs in real-time, facilitating prompt repairs and improved infrastructure management.

- **Data-Driven Decision Making**: The integration of AI and GIS technologies provides comprehensive data that supports informed decision-making and strategic planning for future waste management and infrastructure maintenance initiatives.

4. RESULT AND FINDING

4.1 comparison of integrated technologies used in various Cities

Comparing the municipal solid waste management (MSWM) practices in Aurangabad, Hyderabad, Kolkata, and Chandigarh reveals diverse applications of Geographic Information Systems (GIS), Remote Sensing (RS), Artificial Intelligence (AI), Machine Learning (ML), and Deep Learning (DL) technologies. The table below summarizes the technologies employed by each city across various MSWM functions:

City	Waste Collection	Route Optimization	Waste Segregation	Recycling	Data Management	Future Waste Generation Prediction
Aurangabad	GIS-based system for monitoring and managing waste collection routes.	GIS utilized for optimizing collection routes, reducing travel distances and fuel consumption.	Efficiency increases from 28% to 67%	Application of DL, Ai tool manage to recycle 21% of recycling of daily waste	GIS employed for data collection and management related to waste collection activities.	AI integrated GIS Data
Hyderabad	Integration of GIS, MIS, and GPS for real-time monitoring of waste collection vehicles.	GIS and GPS technologies used to ensure adherence to designated routes and schedules.	Increased efficiency enormously double to the earlier readings	Optimizing different option related to recycling on trial models to find better suitability.	MIS serves as a centralized platform for data collection, storage, and analysis.	AI integrated GIS Data
Kolkata	GIS employed to determine optimal locations for waste bins, enhancing collection efficiency.	GPS and Real time technology adopted	Integrated technology of Ai sensor base two landfill sites design scientifically	Huge waste was treated recycling waste process through various ML, Sensor adoptive process	GIS aids in spatial analysis for strategic placement of waste collection infrastructure.	AI integrated GIS Data
Chandigarh	GIS-based models optimize waste collection routes, reducing travel distances and fuel consumption.	GIS utilized for route optimization, enhancing efficiency and reducing operational costs.	AI and ML models are playing on the demo status which results 83% success rate	Demo Level /Trial is working at spatial level scale upgrading	Integration of GIS and AI facilitates continuous monitoring and data management of waste collection activities.	AI-driven data analytics analyze waste generation patterns, supporting informed decision-making.

Table No 3: Comparison of Case Studies based on Waste Collection, Route Optimization, Segregation, Recycling, Data Management, Future Waste Generation Prediction parameter through Ai integrated GIS MSWM optimization used in these cities.

4.2 Findings of Case Studies about Integrated Ai Technology with GIS Application for MSWM.

Figure No 3: Graph Shows City wise % Percentage Cost Saving (reduction) In waste Collection Process after GIS base ai application Use.

% Cost Saving on Waste Collection Proces

■ % cost Saving
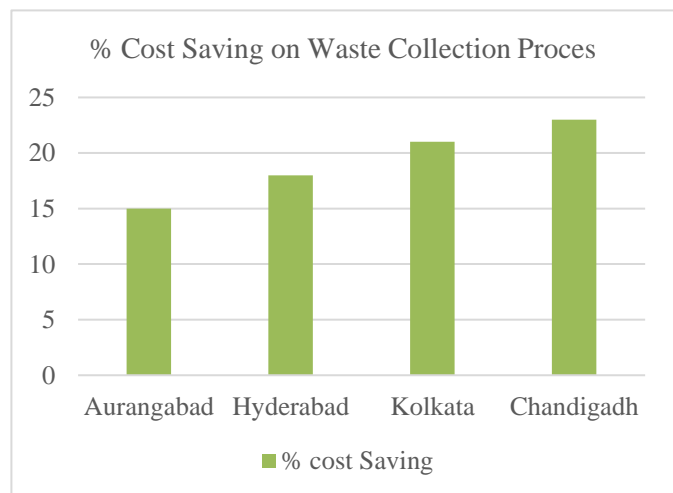
A. Improved Waste Collection Efficiency

- **Aurangabad**: Optimized waste collection **(680 MT)** routes led to a **15% reduction** in operational costs.

- **Hyderabad**: **18%** Increased efficiency in waste collection; manages **2,200 metric tonnes** daily, with **1,500 MT** landfilled and **700 MT** used for power generation.

- **Kolkata**: Waste collection efficiency increased **21%** due to GIS-based bin placement. Handles **3,500 metric tonnes** daily.

- **Chandigarh**: GIS-enabled route optimization led to **cost savings up to 23%** in collection and transport.
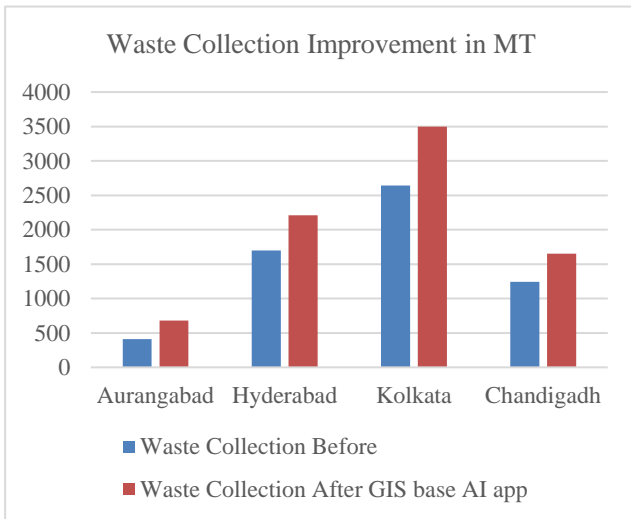
Figure No 4: Graph Shows City wise Improvement in waste Collection (before and after)use of GIS&AI

B. Route Optimization & Fuel Savings

•   **Aurangabad:** GIS models reallocated waste bins and optimized collection routes, 20%Fuel Saving, reducing travel distances average 40 minutes daily.

•   **Hyderabad:** Real-time GPS tracking decreased fuel consumption up to 19%,

•   **Kolkata**: Data-driven vehicle deployment minimized travel inefficiencies y 50%

•   **Chandigarh:** GIS Trial models optimized collection routes and reduced fuel consumption 15%, improving service coverage.
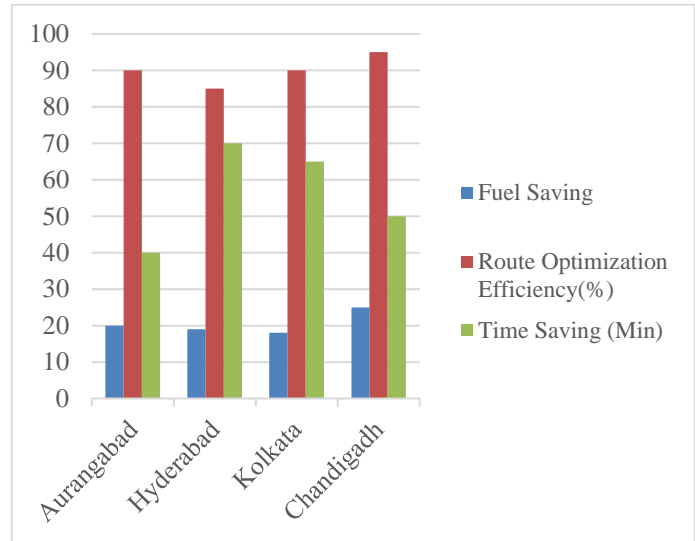
Figure No 5: Graph Shows City wise Improvement in Route Optimization, waste collection, time and fuel saving figures after GIS base AI integration Application.

C. Enhanced Waste Segregation & Recycling

•   **Aurangabad:** Machine Learning (ML) image recognition improved waste classification by 20% and recycle 30% gradually with saving time around 25% than usual one.

•   **Kolkata:** AI-enabled segregation waste recycling efforts by improving 25% efficiency and reduce human efforts from 10-30 % with waste segregation.

•   **Hyderabad:** AI Sensors segregation reduces waste recycling efforts by improving 21% efficiency Even 23% Improvement Observe in Segregation

•   **Chandigarh:** AI and GIS tools mapped waste sources and optimized recycling strategies with 18% improvement. Waste segregation raises up to 28% Helps in real time data for future prediction and site identification.

D. Cost Reduction in MSWM Operations

Aurangabad: GIS-led bin reallocation and optimized routes reduced expenses.

Hyderabad: Fuel cost savings due to GPS-tracked route optimization.

Chandigarh: Collection and transport cost savings; MSWM traditionally accounts for **60-70% of total municipal expenses,** Saved almost 1/3rd of total cost.

E. Better Data Management and Decision Making

Aurangabad: Remote Sensing (RS) identified unauthorized landfill sites.

Hyderabad: GIS-MIS-GPS integration facilitated **real-time monitoring** and resource planning integrated system

create a real time data of waste generation.

Kolkata: AI-driven data analytics helped authorities in **policy formulation and infrastructure planning** to cater huge density and expanded part of city.

Chandigarh: AI and GIS provided comprehensive data for **strategic decision-making** in waste management.

4.3 Finding Summary:

- GIS and AI have significantly improved MSWM efficiency **(optimized collection, transport, and waste disposal)**

- Cost-effectiveness and fuel savings **(Route optimization** and **tracking systems** reductions in **fuel consumption** and **operational costs**)

- Improved waste segregation and recycling efforts **(higher recycling rates** and **better waste processing**.)

- Data-driven decision-making enhances municipal planning **(GIS and AI** provide **real-time data and predictive analytics)**

- Sustainability and environmental benefits **(better recycling practices**, and **optimized landfill management cleaner and healthier urban environments)**

5. CONCLUSION

The integration of GIS, AI, ML, and Remote Sensing (RS) has significantly transformed municipal solid waste management (MSWM) in Indian urban areas, as demonstrated in the case studies of Aurangabad, Hyderabad, Kolkata, and Chandigarh. These cities have successfully utilized technology-driven solutions to optimize waste collection, improve route planning, enhance waste segregation, and enable data-driven decision-making. Aurangabad's GIS-based waste bin allocation and route optimization resulted in a **15% reduction in operational costs**, while Hyderabad's GIS-MIS-GPS framework streamlined real-time tracking, leading to improved efficiency and reduced fuel

consumption. Similarly, Kolkata's AI-enhanced waste segregation improved recycling rates, and Chandigarh's GIS-enabled route planning and monitoring led to **cost-effective and sustainable waste management solutions**.

The implementation of AI-powered predictive modeling has allowed municipalities to forecast future waste generation, ensuring better resource planning and infrastructure development. Additionally, IoT-based smart sensors have helped in monitoring waste bin levels in real-time, reducing overflow incidents and ensuring timely collection. These advancements contribute to India's **Swachh Bharat Mission (SBM)** and **urban sustainability goals**, addressing critical environmental and public health concerns. Despite these successes, challenges such as data integration, financial constraints, and public participation remain, requiring continuous policy support and technological innovation. Moving forward, scaling up AI-GIS applications across more urban centers and integrating waste-to-energy solutions can further strengthen India's efforts toward **sustainable and environmentally friendly waste management**.

The integration of GIS and AI in MSWM presents a promising avenue for urban local bodies in India to enhance efficiency, reduce costs, and promote environmental sustainability. Embracing these, technologies, supported by initiatives like the Swachh Bharat Mission, can significantly improve waste management practices, contributing to the broader urban sustainability goals of the nation.

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Solar Glass Road: The Innovation Step towards the Future Green India

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ABSTRACT

Solar energy is a crucial renewable energy source. Its vast availability makes it an attractive option for electricity generation. According to the International Energy Agency, Developing affordable, Inexhaustible, And clean solar energy technologies will yield significant long term benefits. India is among the leading countries in renewable energy production, With renewable sources contributing 21.22% of The Nations total utility electricity. The primary goal of the solar class roadway is to generate renewable energy on surface that can be walked or driven upon. This project has the potential to become a smart grid for the nation, Supplying energy to homes and businesses along its path. If implemented on a large scale, Solar roadways could produce substantial amount of renewable energy. It is also essential to continue supporting other forms of renewable energy.

Keywords- Solar Glass Road, Green India, Inexhaustible, Renewable Sources, Conventional Energy, Fossil Fuel, Modularity, Photovoltaic Cell

INTRODUCTION

In response to concerns about global warming and our dependence on fossil fuels, we explored the concept of replacing conventional or traditional wearing course with photovoltaic materials that can be driven on. This innovative idea involves Panels made of special formatted tempered glass, Capable of supporting the weight of semi-truck And providing a traction surface compared to asphalt. Imagine constructing a section of road from this material and incorporating LEDs to illuminate road lines from beneath, Enhancing nighttime Driving safety. Additionally, A heating element could be embedded in the surface to prevent snow and ice accumulation in colder climates. Such ideas lead to the inception of solar roadway project. Bharat is primary nation to establish a Authority dedicated to NCER, The Authority of new and renewable energy in (MNRE), In 1980. The SECOI, A public sector undertaking, Is responsible for Advancing the solar energy industry in the country. A solar roadway is a road surface that generates electricity using photovoltaic cells. In Netherlands, Efforts are underway to develop and commercially produce road panels made from recycled material that incorporates photovoltaic cells. Given India's extensive roadway network and abundant sunlight, The country Is well suited to implement this technology. When we talk about solar road, the idea seems to be a crazy one and looks difficult to implement. Definitely looking at the installation cost of solar roadways, which is 3X the conventional roads, seems to be difficult, but the additional benefit of generating clean, renewable energy from a self-sustaining structure makes it, worth a try. It really helpful to creates a job opportunities for the young youth in the different trends of the technical education and it seems like a 'Key' of the 'Global warming Lock' will certainly fulfil the requirement of the mission of 'Protect Environment'. The proposed work consist of the innovative step towards the green India Project of Solar Glass Road. The paper is organized into different sections, section 1 consist of the introduction of solar glass road, section 2 describes the working principle of this road, section 3 shows advantages and disadvantages of solar glass road and section 4 suggest the future scope of this world changing step with some suggestive measures in section 5. The growing concerns about global warming and heavy dependence on fossil fuels have driven researchers to explore alternative and sustainable energy sources. **Solar glass roads** offer an innovative solution by integrating photovoltaic (PV) cells within road infrastructure, enabling roads to generate electricity. These roads can potentially power streetlights, electric vehicle charging stations, and urban grids.

Key Features of Solar Glass Roads:

Tempered Glass Construction: Strong enough to withstand heavy vehicular loads.

Embedded LEDs: Illuminating lanes for improved nighttime visibility.

Heating Elements: Preventing snow and ice accumulation.

Energy Generation: Converting sunlight into electricity via embedded photovoltaic cells.

Integration with Piezoelectricity: Harnessing additional energy from vehicular movement.

In India, with vast road networks and high solar irradiance, solar roadways can contribute significantly to sustainable energy production. This paper evaluates the feasibility of implementing a 100-feet-long solar roadway in Jalgaon, Maharashtra, through design calculations, cost-benefit analysis, and a comparison of solar PV technology vs. piezoelectric energy generation.

WORKING PRINCIPLE

A solar roadway consist of a series of structurally engineered solar panels designed to be driven on. The concept involves replacing petroleum based asphalt roads, And driveways with Photovoltaic materials which collect energy for use by homes and businesses, With the potential to store access energy within or alongside the solar roadways. This renewable energy source can replace the fossil fuels currently used for electricity generation, Reducing greenhouse gas emission and promoting sustainable development. The panels are

intended for use in Driveways, And eventually highways. If solar roadway panels were installed across the entire interested highway system in United States , The generated electricity would exceed the nation's current consumption by many more than three times .(5) The Netherlands pioneered the construction of world first solar powered road . Photovoltaic Roads work on a technology that combines a transparent driving surface with underlying solar cells, electronics and sensors to act as a solar array with programmable capability [6].

A. Structural Composition
Solar roads are designed as modular panels with three primary layers:

1. **Transport-medium wearing course** – Composed of colourless, strong tempered mirror with an anti-slip texture.
2. **Electronics Layer** – Houses photovoltaic cells, LED components, and heating elements
3. **Base Plate Layer** – Supports load distribution and protects internal components.

B. Solar Energy Conversion Mechanism
The solar PV cells embedded in the panels absorb sunlight and convert it into electricity, which is stored in a connected energy grid. This electricity can be used for roadway lighting, traffic signals, and local energy supply.

C. Piezoelectric Energy Harvesting
Piezoelectric materials embedded within the road surface convert mechanical stress from vehicular movement into electrical energy. This system works alongside solar PV to enhance energy output, particularly in high-traffic areas.

Design Calculations for a 100-ft Solar Road in Jalgaon

A. Solar Power Generation Calculation
- **Total Road Length:** 100 ft (30.48 meters)
- **Width per Panel:** 10 ft (3.048 meters)
- **Total Area:** 100 ft × 10 ft = 1000 sq. ft (92.9 m²)
- **Solar Panel Efficiency:** 18%
- **Solar Irradiance in Maharashtra:** 5.5 kWh/m²/day
- **Power Output Calculation:**

  Where,
  - P = Power generated (kW)
  - A = Total solar panel area (92.9 m²)
  - S = Solar irradiance (5.5 kWh/m²/day)
  - η = Panel efficiency (18%)

  A **100-ft solar road** can generate approximately **92 kWh per day**, enough to power **15-20 households**.

B. Piezoelectric Energy Generation Calculation
- **Traffic Load:** 5000 vehicles per day (approx.)
- **Energy Generated per Vehicle:** 2-5 W
- **Total Piezoelectric Power Output:**

Piezoelectric technology can contribute an additional **15 kWh/day**, complementing solar PV generation.

Comparison: Solar PV vs. Piezoelectric Energy Generation

Feature	Solar PV Roadways	Piezoelectric Roads
Energy Source	Sunlight	Vehicular Stress
Efficiency	18-22%	2-5%
Energy Output	92 kWh/day	15 kWh/day
Installation Cost	High	Moderate
Maintenance Cost	Moderate	High
Scalability	Large-scale	Limited

Integration of both technologies can enhance overall energy output and efficiency.

Innovative Methodology for Solar Glass Road Construction
The construction of solar glass roads involves a combination of advanced materials, smart grid integration, and sustainable design principles. The methodology outlined below ensures efficiency, durability, and high energy output.

A. Smart Modular Design
1. **Precast Solar Panels:** The road surface is built using modular, prefabricated solar panels embedded with high-efficiency photovoltaic cells.
2. **Self-Healing Materials:** Use of smart materials that can repair minor cracks and damages, extending the life of the panels.
3. **Anti-Reflective Coating:** Special coatings enhance sunlight absorption and reduce glare for drivers.

B. Layered Road Construction
The road is constructed in multiple layers to ensure stability and efficient energy conversion:

1. **Surface Layer:** Made of high-strength tempered glass, ensuring durability and transparency.
2. **Energy Generation Layer:** Embedded with photovoltaic cells and LED indicators for smart traffic management.
3. **Sensor Layer:** Incorporating piezoelectric sensors to harvest kinetic energy from vehicles.
4. **Base Layer:** A sturdy, waterproof structure housing energy storage and distribution components.

C. Intelligent Traffic Integration
1. **Smart LED Road Markings:** Dynamic lane markings that adjust based on traffic conditions.
2. **Real-Time Data Collection:** Sensors monitor traffic, weather conditions, and road performance.
3. **Remote Monitoring System:** Integrated AI-driven analytics for predictive maintenance.

D. Hybrid Energy Utilization

1. **Dual-Energy System:** Combination of photovoltaic cells and piezoelectric technology enhances energy harvesting.
2. **On-Site Energy Storage:** Battery units store excess energy for nighttime and cloudy conditions.
3. **Grid Connectivity:** Excess electricity is fed into the local power grid, supporting nearby infrastructure
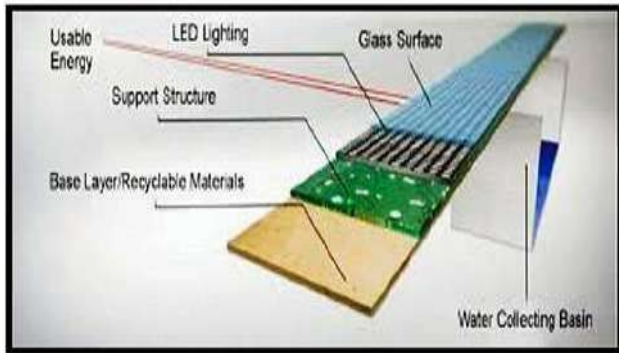
Fig.1 Construction of Solar Glass Road [7]

A. Transport-medium wearing course

Its course is colourless with strong body, providing sufficient tract force which also allows solar light to propagate through to embedded solar collector cells, LEDs, and heating elements. It must withstand current sudden heavy weights in adverse condition and be Water proof to protect the electronic course beneath.

B. Technological Electric Course

This layer is embedded with photovoltaic cells that capture solar energy. Additionally, it features a microprocessor board integrated with support circuits designed to monitor surface loads through sensors. It also regulates the heating element, helping to minimize or entirely prevent the accumulation of snow and ice. As *a* result, it aids in reducing the need for manual snow removal and helps prevent school and business closures caused by severe weather conditions.

C. Bass plate layer

This layer needs to be weather-resistant to safeguard the electronic layer positioned above it. The electronic layer is responsible for distributing power and transmitting signals to and from the panels [7]

ANALYSIS AND DISCUSSION

1. Benefits

❖ Nonconventional and Lifespan

Primary benefit in Photovoltaic roadway structure that isits use of renewable energy source to generate electricity, sustainably reducing dependence on the conventional sources like wood, coal, Petrol and earthen energy sources.

❖ Military and Emergency Response Support

During environmental crises or military emergencies, solar roadways can serve as a crucial power source when energy is in high demand. Since solar power is a renewable resource, it operates independently without relying on any external or artificial energy supply.

❖ Existing roadways

Another benefit of solar roadways is that they eliminate the need to develop unused land, which may be environmentally sensitive. This addresses a major concern associated with large-scale photovoltaic installations, particularly in the southern United States and other regions.

❖ Lighting up roads

By adding LEDs Beneath the transparent panels, Roads can be eliminated for safer nighttime travel and an aesthetic look. The led can be programme to display instructions such as "slow", "stop", "go", and "speed limit".

❖ Environmental advantages

Solar power production generates electricity with a limited environmental impact compared to other forms of electricity.

❖ Modularity and scalability

The size and generating capacity of the solar system depends on the number of installed solar modules, making the application of solar technology rapidly scalable and versatile.

❖ Accident prevention

Solar roadways can protect wildlife and motorist. The load cells in the solar panel can deflect if something is on the surface, Acting like a weighing machine.

❖ Electric vehicles

With the increasing availability of electric vehicles, More car manufacturers are offering electric options. If we can be recharged at conveniently located rest stops or parking lots, allowing owners to plug in and recharge while not driving.

❖ Snow/ Ice Management

The roads hit themselves with embedded hitting elements, Melting away snow and ice. [8]
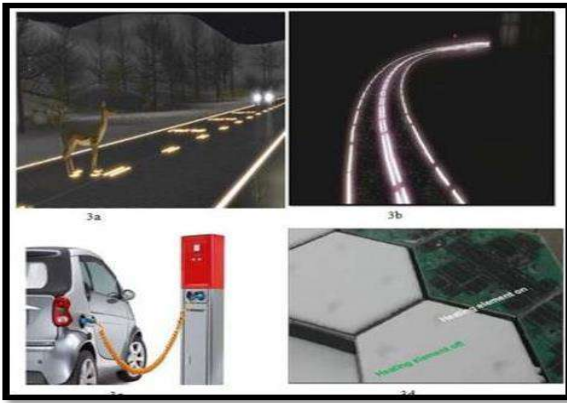
Fig.2 Advantages of Solar Glass Road [8]

2.Disadvantages

❖ **Seasonal efficiency**

While it will be less efficient in other seasons due to reduce so the radiation, This technique can be highly effective in countries where summer lasts for more than half of the year.

❖ **Needs town planning**

For these roads to be implemented town planning is crucial. Accurate orientation of buildings, Roads, Sanitary lines, Parking lots, Playgrounds, Etc., Is necessary.

FUTURE SCOPE

In the future the conventional roads can be replaced by solar roadways although a significant initial investment is required. The solar roadways alternative could be developed at a lower cost with energy return while gradually phasing out the old   system It can be also used at a high traffic area or high pedestrian way where the walking energy can also be utilized using piezoelectric technology to generate more energy with sunlight this integrated approach can be used in futuristic road.

1. **Hybrid Roads:** Combining solar PV and piezoelectric elements for optimal energy harvesting.
2. **Smart Traffic Management:** LEDs and sensors for real-time traffic updates.
3. **EV Charging Integration:** Using roadway-generated electricity for electric vehicle charging stations.
4. **Smart Cities:** Implementation in urban areas to power streetlights, signals, and public infrastructure.

CONCLUSION

It is common for people to focus on the limitations first. However, we can start with smaller changes that will lead to the dawn of new era. Therefore its time to upgrade our infrastructure, especially roads and power grids with 21st century technology. "Solar Glass Roadways". Solar glass roads present a revolutionary approach to infrastructure development in India. Compared to conventional asphalt roads, they offer clean energy generation, improved safety, and potential cost savings in the long run. Despite high initial investment costs, hybrid integration with

piezoelectric technology can optimize energy output and enhance economic feasibility. With proper policy implementation and funding, India can become a leader in sustainable road infrastructure, paving the way for a cleaner, greener future.

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ABSTRACT

The present study will employ standard WQI calculation techniques to analyze physicochemical and microbial parameters of raw water at JDCOEM campus. By comparing the obtained WQI values with national and international standards, the study will assess the suitability of water for human consumption and recommend appropriate treatment measures. The findings of this research will contribute to sustainable water resource management by identifying key contamination sources and proposing effective mitigation strategies. Furthermore, the study will serve as a foundation for establishing a long-term water quality monitoring framework for the JDCOEM campus and similar institutional settings.

KEYWORDS: Water quality index, remote sensing, Artificial intelligence, Physicochemical & biological parameters.

INTRODUCTION

" Water is one of the most critical natural resources for human survival, economic development, and ecological balance. The quality of water directly affects human health, agricultural productivity, industrial processes, and aquatic life. In its raw form, water from sources such as rivers, lakes, reservoirs, and groundwater is often subjected to contamination due to both natural processes and anthropogenic activities. Monitoring and assessing water quality is crucial for ensuring its suitability for drinking, irrigation, and industrial use. However, water quality is determined by multiple parameters, including physical, chemical, and biological factors, making its assessment complex. To simplify the interpretation of water quality data, the Water Quality Index (WQI) has been developed as a numerical representation of the overall status of a water body. WQI aggregates multiple water quality parameters into a single score, making it easier for policymakers, scientists, and the general public to understand and compare water quality across different locations and time periods. Various WQI models have been developed worldwide, with differences in parameter selection, weightage assignment, and calculation methods. This paper aims to review these methodologies and explore advancements in WQI computation, emphasizing its importance in sustainable water resource management.

LITERATURE REVIEW

Abdulazeez, A.M., Agada, J., Mohammed, S.A., Saidu, A., Amira, M.K., Idujagi, O.S., Adamu, S.U., Winner, L.Ransom, U.J., Joseph, I.B., Jamila, M.M.,(2025). This study examines the bacteriological quality of both raw and treated water at the Malali Water Works in Kaduna State, Nigeria. The primary objective was to assess the presence of harmful bacteria in the water samples and to compare the findings against standards established by the World Health Organization (WHO) and the Nigerian Standard for Drinking Water Quality (NSDWQ).

The analysis revealed that raw water sourced from the Kaduna River contained elevated levels of coliform bacteria, E. coli, Salmonella, and Pseudomonas. These bacteria serve as indicators of fecal contamination, stemming from human and animal waste entering the waterway, with higher concentrations noted particularly during the rainy season due to increased surface runoff.

In contrast, treated water from the Malali Water Works was found to be free of E. coli, Salmonella, and Pseudomonas, with only minimal levels of coliform bacteria detected, all of which fell well within the acceptable limits. This demonstrates the effectiveness of the treatment process at Malali Water Works in eliminating harmful pathogens, rendering the water safe for human consumption.

While the chemical parameters such as pH, temperature, and dissolved oxygen levels in the raw water were within safe ranges for aquatic life, the high bacterial content indicated it was unsafe for drinking without adequate treatment. The study highlights that the bacterial counts in raw water tend to be higher during the rainy season, emphasizing the ongoing risk for individuals relying on untreated water sources. Overall, the findings underscore the significant improvement in water quality achieved through the treatment processes at Malali Water Works.This study examines the bacteriological quality of both raw and treated water at the Malali Water Works in Kaduna State, Nigeria. The primary objective was to assess the presence of harmful bacteria in the water samples and to compare the findings against standards established by the World Health Organization (WHO) and the Nigerian Standard for Drinking Water Quality (NSDWQ).

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Dr. Zainab Bahaa Mohammed (June 2015) : The study evaluates the quality of raw and treated water from four water treatment plants in Baghdad (AlKarkh, Shark Dijla, Al-Wahhab, and Alkramh) using the Canadian Water Quality Index (CCME-WQI). The research, conducted from 2005 to 2013, analyzed various physical and chemical properties of water, including temperature, turbidity, pH, total hardness, magnesium, calcium, sulfate, iron, fluoride, nitrate, chloride, color, and conductivity. : The water quality index for raw water ranged from 51 to 57, classified as "bad" (Category IV), indicating the need for advanced treatment. Treated Water Quality: The water quality index for treated water was 86 for AlKarkh, 81 for Shark Dijla, and 80 for both AlWathba and Alkramh, classified as "good" (Category II). This shows significant improvement in water quality after treatment. Physical and Chemical Properties: Temperature and Color: Both raw and treated water met Iraqi specifications. Turbidity: Raw water turbidity ranged from 23 to 243 NTU, while treated water turbidity was between 1 and 4 NTU, within acceptable

limits.pH: Raw water was slightly alkaline (7.8 to 8.2), while treated water pH ranged from 7.4 to 7.8, within Iraqi standards. Electrical Conductivity: Ranged from 604 to 946 µs/cm for raw water and 601 to 998 µs/cm for treated water, within acceptable limits. Total Hardness: Ranged from 242 to 362 mg/l for raw water and 243 to 359 mg/l for treated water, within Iraqi standards. Calcium and Magnesium: Calcium levels in treated water sometimes exceeded Iraqi standards, while magnesium levels were within limits. Chloride and Sulfate: Chloride levels in treated water were slightly higher due to chlorine addition. Sulfate levels in treated water were higher due to alum addition, exceeding Iraqi standards in some plants. Iron, Fluoride, and Nitrate: Iron and nitrate levels were within acceptable limits, while fluoride levels were below the recommended range. The study concluded that the treated water from all four plants met the Iraqi standards for drinking water, with significant improvement in water quality after treatment. The water quality index improved from "bad" for raw water to "good" for treated water, indicating effective treatment processes. However, some parameters like calcium and sulfate levels in treated water occasionally exceeded the standards, suggesting areas for further improvement.

Goran Volf 1, Ivana Sušanj Čule 1 , Elvis Žic 1 and Sonja Zorko (13 September 2022) : The article "Water Quality Index Prediction for Improvement of Treatment Processes at Drinking Water Treatment Plant" by Goran Volf et al. focuses on predicting the Water Quality Index (WQI) to enhance treatment processes at a drinking water plant near the Butoniga Reservoir, Croatia. The study uses machine learning (ML) models to forecast WQI based on parameters like temperature, pH, and turbidity, utilizing data collected from 2011 to 2020. Four ML models, validated by 10-fold cross-validation, predict WQI one to fifteen days in advance, with the one-day model achieving the highest correlation coefficient (R = 0.93).

Additionally, the study by Sri U. Sudiarti et al. develops a performance index model for raw water infrastructure in Lombok and Sumbawa Islands, Indonesia, evaluating technical, non-technical, and environmental factors. Data were collected from 21 locations and through 160 questionnaires. The model includes a Technical Performance Index influenced by water source quantity and infrastructure condition, a Non-Technical Index considering socio-economic factors and policy compliance, and an Environmental Index focusing on ecological impacts. Model validation showed high accuracy (95.25%), providing a valuable tool for policymakers in maintaining sustainable water resources.

Rachmawati Sugihhartati Dj1 , Gina Salsabila1 (2024) : The present study examines the water quality of six rivers in West Java, namely Citarum, Cimanggu, Cibogo, Citonjong, Ciwayang, and Cigugur, with particular attention to their potential as sources of raw water for drinking. Amid escalating pollution levels in Indonesian rivers, the research evaluates critical water quality parameters including Dissolved Oxygen (DO), Total Suspended Solids (TSS), and total coliform bacteria. The findings are juxtaposed with the Indonesian Government Regulation No. 22 of 2021 (Class 1 standard).

Analysis Tools: The Water Quality Index (WQI) was computed using a Weighted Mathematical Model, and subsequent statistical analysis was conducted using SPSS software. The Kirkuk water treatment plant effectively processes water, rendering it suitable for consumption. The treated water consistently meets Iraqi drinking water standards and exhibits commendable WQI values across distribution sites. However, ongoing monitoring is essential to ensure sustained safety and to mitigate potential contamination risks.

RESEARCH OBJECTIVES

1. To evaluate the physicochemical and biological properties of raw water available at the JDCOEM campus by examining essential water quality parameters.

2. To calculate the Water Quality Index (WQI) using suitable mathematical models and standard methods for index calculation.

3. To compare the calculated WQI values with both national and international water quality standards (such as BIS and WHO) to assess the water's suitability for drinking and other applications.
    1. To identify the origins of contamination and the potential factors that could influence water quality on the campus.

2. To offer suggestions for water treatment and management strategies to enhance raw water quality if required.
3. To establish a framework for water quality monitoring to ensure ongoing evaluation and sustainability of water resources at JDCOEM.

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Study and Analysis Geotechnical Site Characterization using Artificial Intelligence (AI) and Computing Devices

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ABSTRACT

The present study investigates A key component of efficient civil engineering project planning, design, and execution is geotechnical site characterization. Integrating cutting-edge technology like artificial intelligence (AI) and the computing device has become a game-changing idea in the rapidly changing infrastructure construction scene, helping to increase the accuracy and productivity of geotechnical site characterization procedures. Using a wide variety of technologies, models, tools, and frameworks, this paper explores the joint use of AI and computing device in geotechnical site characterization. With the help of its machine learning algorithms, artificial intelligence (AI) can analyze large amounts of geological and geographical data, making it possible to identify subsurface conditions more precisely. Examining geological characteristics, forecasting soil behavior, and assessing possible dangers related to building projects are all made possible by neural networks and deep learning algorithms. Real-time monitoring and data collection at geotechnical sites are made possible by the integration of computing device technologies with AI. Geophysical data, such as soil moisture, temperature, and pressure, are collected by ground-embedded sensor networks, which provide a dynamic and ongoing knowledge of subsurface conditions. By feeding AI models with real-time data, a feedback loop is created that improves site characterization accuracy and forecast accuracy. The paper also presents a number of frameworks and technologies that make it easier to integrate AI and computing device in geotechnical engineering. Complex geological data is visualized and interpreted with the use of Geographic Information Systems (GIS) for spatial analysis. In order to promote a comprehensive approach to construction planning, Building Information Modelling (BIM) is being investigated as a way to include geotechnical data with the overall project design. Addressing the difficulties of contemporary infrastructure development and guaranteeing the sustainability and resilience of civil engineering projects in the future require embracing this technological activity.

KEYWORDS: *artificial intelligence, computing device, soil mechanics, geotechnical engineering, site characterization, soils and soil testing*

1. INTRODUCTION

IN civil engineering, geotechnical site characterization is essential because it provides vital information about the subsurface characteristics of building sites. The combination of artificial intelligence (AI) and the computing device has resulted in a revolutionary change as a result of the continuous advancement of technology. The precision, effectiveness, and breadth of geotechnical site studies are improved by this paradigm change. In order to provide a more sophisticated knowledge of subsurface conditions, this study explores a variety of models, tools, and frameworks at the cutting edge of these technologies. A new age in geotechnical engineering is being ushered in by the confluence of artificial intelligence (AI) and the computing device, which offers previously unheard-of capabilities for site characterization. Geotechnical studies are essential to building projects because they impact long-term structural integrity, construction techniques, and design. The combination of AI and computing device technology is already surpassing labor-intensive and time-consuming traditional techniques of site characterization, with the potential to revolutionize our understanding and engagement with the soil underneath structures[1].

The increasing need for more precise and effective geotechnical site characterization techniques is projected in this study. Conventional methods are useful, but managing the enormous volume of data produced during site studies presents difficulties. By offering intelligent data analysis, real-time monitoring, and predictive modeling, the combination of AI and computing device technologies aims to address these issues. This reduces the hazards connected with building projects by speeding up the site characterization process and improving the accuracy of the information gathered. The goal of this study is to provide a thorough analysis of how advanced AI and computing device technologies are revolutionizing the assessment of geotechnical sites. A wide variety of technologies, including sensor networks, data analytics tools, machine learning models, and integrated frameworks, are included in the scope. The study emphasizes each of these elements' unique contributions and synergies in improving the precision and effectiveness of geotechnical investigations by methodically examining them[2].
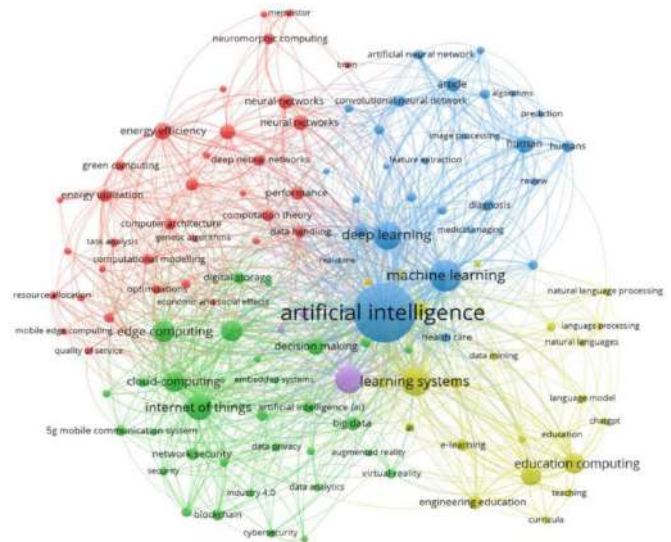
Figure 1: Keyword co-occurrence analysis in the Artificial Intelligent and Computing devices

Artificial intelligence is strong tools for data analysis, pattern recognition, and predictive modeling, has advanced significant . AI technologies are essential for processing and analyzing complicated subsurface data in the context of geotechnical site assessment. Neural networks, support vector machines, and decision trees are just a few examples of machine learning techniques that are excellent at identifying complex patterns in geotechnical data. By learning from past site data, these models make it possible to create prediction models that improve our comprehension of geological conditions and soil behavior. Subsurface imaging has potential for deep learning methods, especially convolutional neural networks (CNNs). Deep learning algorithms generate high-resolution, detailed pictures of subsurface structures by evaluating geophysical data from several sensors. This promotes safer building methods by enabling a more sophisticated knowledge of soil composition and possible risks. Potential geotechnical hazards may be identified and evaluated with the use of predictive analytics. To forecast difficulties during construction, AI systems examine past data, present circumstances, and other contributing variables. By taking a proactive stance, engineers may take preventative action and

reduce the possibility of unanticipated issues. The co-occurrence analysis of the terms in the literature ofin the artificial intelligent and computing devices is shown in Figure 1. Real-time monitoring has been transformed by the computing device, which gives engineers previously unheard-of access to data from distant sites [3]. computing device technology provide continuous monitoring capabilities that improve our comprehension of dynamic subsurface conditions in geotechnical site characterization. Real-time data collection from the site is mostly dependent on computing device-enabled sensor networks. From strain gauges to accelerometers, sensors provide information on things like ambient conditions, deformation, and ground movement. A more dynamic and flexible approach to site characterization is made possible by the constant flow of data. The smooth transfer of data from sensors to central monitoring systems is ensured by the inclusion of wireless communication technology. Engineers can make rapid decisions and use flexible building techniques because to this real-time connection, which provides them with instant data on subsurface conditions. In order to deal with data overload and latency issues, edge computing has become a practical solution. Edge computing eliminates the need to send massive amounts of data to central servers by processing data locally at the sensor level. This reduces the effect of transmission delays and improves the effectiveness of real-time monitoring. Integrated frameworks that incorporate the advantages of both paradigms are the most effective way to achieve the synergy between AI and computing device technologies [4]. These frameworks use computing device devices for continuous data gathering and real-time feedback, and they rely on machine learning algorithms for data analysis and interpretation. In geotechnical engineering, digital twins virtual copies of real assets have become more popular. Before building begins, engineers may evaluate hazards, create a digital duplicate of the site, and simulate scenarios to improve construction ideas. This improves the project's efficiency and helps create designs that are more durable and sustainable. Because cloud-based technologies provide a centralized repository for geotechnical data, they make collaborative analysis easier. In order to promote multidisciplinary cooperation and guarantee that site characterization benefits from a variety of skills, engineers, geologists, and stakeholders may access and contribute to the

data pool. AI algorithms are used by adaptive decision support systems to evaluate real-time data from computing device sensors and provide insights that may be put to use. By constantly modifying building plans in response to shifting subsurface conditions, these technologies guarantee that the project stays under budget and on time.

2. LITRATURE REVIEW
2.1 Artificial Intelligence in Geotechnical Engineering

Every day,we come into contact with and view consists of rocks and dirt. In the context of research, construction, and design, geotechnical engineering a subfield of civil engineering examines the characteristics and behavior of earth materials (soil, rock, and their derivatives). Two most often used geotechnical engineering materials, soil and rock, show a great range of behavior and properties . Apart from their homogeneity and isotropy of their fundamental structure, these materials also possess Diversity is linked to a great range of intricate and surprising transformations that lead to its birth. Popular engineering and construction materials with great homogeneity and isotropy include steel, bricks, stones, lime, and asphalt. This helps one to forecast and model their behavior. Geotechnical material design and serviceability investigations are complicated by this unpredictability and unexpected behavior. Moreover, certain difficult technical issues lack analytical theories, empirical equations, or models that could provide a solution. Lack of knowledge, inadequate quality, and a dearth of easily accessible information make many conventional treatments ineffective. The complexity of these design solutions, which transcends conventional methodologies, is being managed by computer-based modeling tools more and more. A computer-aided method of physics and mechanics is used in mathematics to replicate, examine, and graphically depict system performance and behavior. Recently, the "Artificial Intelligence (AI)" approach has been very well-known as a creative and original answer for geotechnical engineering design difficulties [5]. Artificial intelligence (AI) might therefore be expected to provide algorithms based on present empirical facts, hence guiding soil behavior. AI approaches may be used even in cases where the physical meaning or underlying correlations between variables are unclear, unlike most conventional statistical and empirical approaches

depending on physical traits. Given a sample of data similar to the data they are trying to anticipate, artificial intelligence systems may foresee future behaviors, structures, and patterns. This suggests that, instead of relying on underlying assumptions, artificial intelligence systems produce outputs based on maps produced only from the data they receive . Artificial intelligence systems do not have to understand basic presumptions or links in the data they come across. Given enough information, they can work it out on their own. An artificial intelligence system generates models by gathering data from many sources. These model outputs are produced until a function is developed that lessens the discrepancy between artificial intelligence model predictions and actual data. Unlike regression models, which can only address one answer at a time, AI methods have become very popular because of their great predictive strength and capacity to manage numerous replies at once (Park, 2011)[3]. Artificial intelligence models may use non-linear regression data even while the datasets themselves are not aware of their nonlinearity. Only if the kind of the nonlinearity is understood can one investigate non-linear statistical regression data. Using universal functions, neural networks (NNs) depict intricate mechanical behavior including resistance to missing data, generalization, approximation, and handling of many nonlinear variables for unknown interactions. This is why artificial intelligence (AI) technologies are not only a better choice than conventional methods, but also essential in cases where traditional approaches are unable or unable to handle the task.

2.2 Enharanced Geotechnical Engineering Using Artificial Intelligence

"Artificial intelligence" (AI) is the intelligence shown by other technological devices including computers. Many people worried about computers either "ruling the planet" or invading personal life. True, artificial intelligence is changing the planet; yet, nobody is complaining about. Many individuals now ask their "smart" phones for directions or instructions to a coffee shop, therefore using artificial intelligence in their daily life. Still, it wasn't until the early 2000s when everybody agreed that artificial intelligence (AI) had advancedments. One may find uses for artificial intelligence in many different fields. Artificial intelligence (AI) in computer science learns from its surroundings and acts to help it attain a

certain objective. In geological engineering, knowledge and a command of automated systems and neural network technologies are very crucial for issue solving. Long-term pavement performance may be predicted by artificial intelligence systems, which also examine rock fall or slope stability . Rock slope instability may cause both financial and functional losses as well as unsafe circumstances in various kinds of transportation. One must map the probability of rock slope collapse for both public and private use. Slope failure potential maps might be quickly and inexpensively produced using artificial intelligence (AI) technologies. The danger of gradient collapse may be found using the competency of professional specialists as well as their uncertainty of assessments. Artificial intelligence (AI) is evaluated using GIS data as a framework in order to predict slope instability. Geological and topographic data into a GIS database starts the process. To represent the complicated situation, the artificial intelligence system subsequently creates slope failure potential maps depending on the known correlations between the model variables. By giving follow-up operations top priority to reduce the issue, such as more thorough study and choosing suitable monitoring and early-warning systems, AI-generated maps displaying slope collapse potential also help in slope maintenance.

Artificial intelligence so greatly helps the subject of geotechnical engineering. Is it on its route to global domination? There is no chance! Still, geotechnical engineering gains much from artificial intelligence. More engineers will be needed as artificial intelligence develops to research, design, and test AI systems[9]. Engaging in the development of artificial intelligence is a great chance for the technological community to show its creativity and support its long-term viability simultaneously.

3. PROBLEM OF STATEMENT

This work aims to investigate the uses of artificial intelligence and internet computing devices used in geotechnical engineering, therefore addressing the major challenge. Every geotechnical engineering project starts with extensive study and classification of the characteristics of the subsurface. Geotechnical design nowadays mostly depends on methods for rock mass classification. Conversely, categories based on subjective or semi-quantitative assessments are more and more sought for doing the necessary lab analysis

and soil tests might be time-consuming and costly. The latest study examines subsurface conditions using many supervised machine learning models. Rising machine processing capability over the last several decades has made advanced analytics like AI feasible. Given the inherent uncertainty in geotechnical engineering, artificial intelligence might be a useful technique for creating consistent predictive models of many soil and foundation engineering traits. Geotechnical design parameters are often computed utilizing correlations determined by means of regression fitting of a dataset rather than depending on direct measurements from lab and in-situ testing.

4. METHODOLOGY

The study uses a rigorous approach, focusing mostly on bibliometric analysis and a review of the literature. Finding important databases for literature retrieval was the first step. In order to guarantee thorough coverage of papers covering engineering, computer science, and geotechnical investigations, databases such as IEEE Xplore, ScienceDirect, PubMed, and Google Scholar were used. Using relevant terms like "geotechnical site characterization," "artificial intelligence," "computing device," and its variants, a methodical search approach was developed. To weed out research that weren't relevant, criteria were developed. Only papers presented at respectable conferences or published in peer-reviewed publications were taken into account. The literature up to the research's current date was included in the temporal scope. For further analysis, pertinent information was methodically gathered from selected papers, such as the author or authors, the year of publication, the methodology, the main conclusions, and the technical interventions covered. Utilizing specialist tools like VOSviewer, bibliometric analysis was carried out. These programs visualized and analyzed citation networks by importing selected bibliographic datasets. The structure of the academic environment was shown via the visualization of co-authorship and citation networks. To comprehend patterns of collaboration and information flow, clusters and influential nodes were found. By combining these approaches, the study seeks to identify research gaps, provide a thorough picture of the status of AI and computing device technologies in geotechnical site characterization, and suggest ideas for further studies. The computing device and artificial intelligence (AI) technologies for improved geotechnical site characterization are shown in Figure 2.
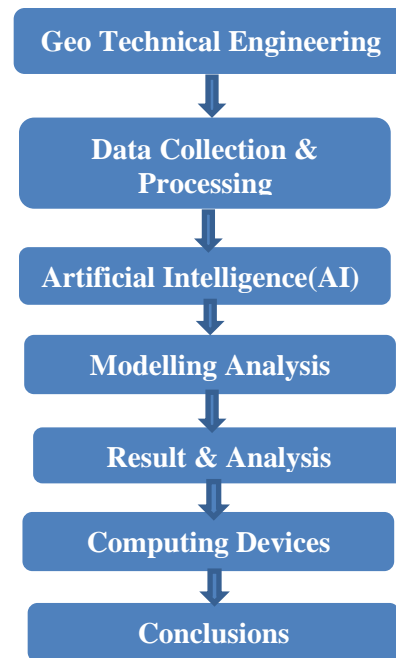
Figure 2: Methodology for Geo tech engineering using computing device and artificial intelligence

5. RESULT & ANALYSIS

The results of this extensive study show how artificial intelligence (AI) has a big impact on geotechnical engineering. In several applications, AI models have shown remarkable accuracy and efficiency in a variety of applications and computing devices are prediction, and predictive modeling. By providing more reliable and data-driven solutions, these results have the potential to revolutionize the field. The use of artificial intelligence (AI) to geotechnical site characterization has revolutionized the field by bringing advanced models and technologies that improve the accuracy, effectiveness, and security of site assessments & geotechnical site characterization.

● **Reinforcement optimization using AI**
Geotechnical site studies are optimized by reinforcement learning. Given variables like cost and uncertainty, AI models may be trained to suggest the most informative sites for soil sample. This adaptive method maximizes the quality of the information while reducing the number of samples needed [6].

- **Using Deep Learning to Characterize Geotechnical Sites**

Multiple-layer neural networks (deep neural networks) are used in deep learning, a branch of machine learning. These networks are appropriate for geotechnical applications because of their exceptional ability to handle intricate, non-linear interactions within data.

- **CNNs for Geotechnical Sites**

CNNs are excellent at understanding spatial data, which makes them useful for processing pictures such as geophysical surveys and drill logs. They help evaluate soil characteristics and subsurface structures by spotting patterns in these photos.

- RNNs, or recurrent neural networks:

When it comes to evaluating time-series data, such sensor readings over time, RNNs are very good [58–63]. RNNs provide a dynamic knowledge of subsurface conditions by modeling the temporal fluctuations of soil parameters in geotechnical site characterization.

- **GANs, or Generative Adversarial Networks:**

GANs help enhance datasets by producing synthetic samples that closely resemble actual soil data [7]. This improves the generalization and resilience of geotechnical AI models, which is particularly useful in situations when gathering vast quantities of labeled data is difficult.

- **Technologies related to geography:**

Artificial intelligence (AI) expanding their capabilities, geospatial technologies—such as Geographic Information Systems (GIS) and remote sensing—have become essential to geotechnical site characterization [8].

- **Integration of GIS and AI**

AI-powered integrated GIS solutions provide thorough geospatial studies of a location. When geological and geophysical data layers are analyzed by AI algorithms, patterns and correlations that are not visible using conventional techniques are revealed.

- **AI and Remote Sensing**

In order to help detect surface characteristics, land use patterns, and possible geohazards, artificial intelligence (AI) algorithms—particularly image recognition and classification models—extract useful information from satellite data and aerial surveys.

- **Quantification of Uncertainty and Probabilistic Models**

subsurface conditions vary, classification of geotechnical sites is necessarily ambiguous. Probabilistic models driven by AI quantify this uncertainty and provide more accurate and trustworthy evaluations.

- **Simulations using Monte Carlo**

AI-powered Monte Carlo simulations evaluate the range of potential outcomes for geotechnical parameters, helping to clarify underlying uncertainty and direct risk-reduction tactics.

- **Bayesian Networks**

For a more accurate depiction of subsurface conditions, Bayesian networks capture dependencies and uncertainties by modeling probabilistic interactions between geotechnical variables.

- **Combining data and integrating many sensors &**

AI-like technologies enable the merging of data from many sources and sensors to improve accuracy and completeness. The following formulas illustrate basic ideas and commonly used methods in artificial intelligence: Linear Regression Equation

$$y = mx + \text{b}$$

Where,

y Dependent variable

mx Independent variable Slope of the regression line

b Y-intercept of the regression line

- **Computing Devices to characterize geotechnical sites**

Geotechnical engineers may improve monitoring capabilities, get real-time data, and gain a deeper knowledge of the entire dynamics of a site by integrating computing device technology. This section examines the state-of-the-art uses of computing device in geotechnical site characterization, exploring a range of tools, models, technologies, and frameworks that are essential to determining the direction of this subject.

Using computing device Technologies to Characterize Geotechnical Sites:

● **Technologies for Sensors**

In order to collect data from the real world, computing device mostly relies on sensor technologie. Sensors keep an eye on variables including soil moisture, temperature, pressure, and seismic activity while characterizing geotechnical sites. Sophisticated sensors that provide comprehensive information about site conditions include strain gauges, tilt meters, and accelerometers.

● **Protocols for Wireless Communication**

In computing device applications, effective communication is essential. Data communication between sensors and central monitoring systems is made easy by wireless protocols such as NB-computing device, LoRa, and Zigbee [9]. Real-time data collecting is made possible by such methods, which minimize human involvement and guarantee prompt reaction to site condition changes.

● **Computing at the Edge**

By processing data closer to the source, edge computing lowers latency and speeds up reaction times. Edge computing may locally evaluate sensor data in geotechnical site characterization, transmitting only pertinent information to central servers. This guarantees speedier decision-making and reduces bandwidth use.

● **Cloud computing**

For the massive amounts of data produced by computing device devices, cloud systems provide scalable processing and storage capabilities. Cloud computing enables geotechnical engineers to store, process, and display data, enabling thorough site monitoring at the same time. For computing device applications, platforms such as AWS, Azure, and Google Cloud provide reliable solutions.

● **Combining computing device and AI to improve geotechnical site characterisation**

In the end, the integration of AI and computing device has improved the overall performance and safety of infrastructure projects by introducing more accurate, effective, and economical techniques for site characterization.

● **Integration and Fusion of Data:** When AI and computing device are combined, data from several sources is combined to get a complete picture of site conditions. This includes information from geological surveys, satellite photography, historical data, and ground sensor data. AI systems are excellent at combining various information to provide a comprehensive picture of geotechnical conditions.

● **Analytics for Prediction:** By examining data trends, AI programs forecast possible problems. For example, using historical data and real-time sensor inputs, machine learning models may predict geotechnical factors such as slope stability and soil settlement. By proactively addressing possible issues, engineers may improve overall safety and efficiency thanks to this predictive capabilities.

● **Risk Evaluation and Reduction:** AI is able to evaluate and quantify the dangers related to geotechnical conditions by processing data from computing device sensors. Finding regions vulnerable to landslides, soil erosion, or other dangers is part of this. To lower hazards and improve overall safety on building sites, engineers may then put specific mitigation measures into practice.

● **Automated Alerts and Monitoring:** Systems with AI capabilities can automate monitoring, continually analyze incoming data, and provide warnings in real time. This expedites the reaction to important occurrences and lessens the need for human monitoring. Construction crews may take immediate action by using automated notifications to notify them of possible problems like unstable ground.

● **Construction Process Optimization:** Using real-time data, AI systems may enhance building operations. AI can suggest the best times for certain building tasks by examining weather patterns and soil conditions, lessening the effect of unfavorable circumstances on project schedules. Cost reductions and more effective use of resources are the results of this optimization.

● **Astute Foundations:** computing device sensors

buried in the ground continually check soil conditions in a project where foundation stability is essential. In order to anticipate any settling problems, AI systems evaluate the data and automatically notify construction management to take preventative action.

- **Evaluation of Slope Stability:** computing device sensors are positioned strategically to monitor variables like temperature, seismic activity, and soil moisture in projects that include mountainous terrain. In order to enable prompt evacuation and stabilization efforts, AI algorithms evaluate this data to forecast slope stability and possible landslides.

- **Optimization of Tunnel Construction:** computing device sensors installed within the tunnel track ground conditions, such as rock stress and deformation, throughout tunnel building operations. AI-like systems minimize risk by optimizing the timetable based on this data [10].

6. CONCLUSIONS

At present era of accuracy, efficiency, and dependability in site characterization has been brought about in the area of geotechnical engineering by the merging of state-of-the-art Artificial Intelligence (AI) and computing device technology. Traditional methods for characterizing geotechnical sites have been redefined by the combination of AI and computing device. Sensor-equipped computing device devices make it easier to gather data in real time from the field. These instruments, which include seismometers, inclinometers, moisture sensors, and geophysical sensors, provide a wealth of data on the stability, composition, and environmental conditions of soil. AI systems analyze this huge data, exposing important patterns, connections, and insights that were previously elusive. The use of machine learning models is essential to AI in geotechnical site characterization. These models, which range from basic regression models to complex neural networks, use past data to forecast the behavior of soil in the future. Support vector machines and random forest algorithms, for instance, forecast settlement and deformation patterns based on prior site activity. This predictive capacity helps decision-making processes, enabling engineers to proactively address future difficulties and reduce risks. Deep learning methods

are very effective in subsurface imaging in the field of geophysics. To produce precise and in-depth subsurface pictures, convolutional neural networks (CNNs) and recurrent neural networks (RNNs) evaluate geophysical data, including seismic profiles and ground-penetrating radar scans. These pictures help engineers accurately characterize a location by giving them a thorough grasp of fault lines, soil layers, and other risks. In geotechnical engineering, the idea of digital twins—which replicate real infrastructure in a virtual setting—has grown in popularity. Digital twins provide a dynamic depiction of a site's current condition by fusing AI analytics with computing device data. This makes it possible to simulate and continuously monitor geotechnical conditions, which promotes proactive decision-making and improves maintenance plans. By serving as a link between the actual and virtual worlds, digital twins provide a comprehensive method for managing and characterizing sites. By giving gathered data a geographical context, Geographic Information Systems (GIS) are essential to the characterisation of geotechnical sites. Engineers may find geographical patterns, correlations, and anomalies in geotechnical data by using spatial analysis made possible by AI algorithms connected with GIS frameworks. The accuracy of site characterization is improved by this spatial intelligence, especially in large-scale infrastructure projects where engineering choices may be greatly impacted by geographical differences. The combination of AI and computing device is a lighthouse in this age of rapid technological development, pointing the way toward a day when geotechnical engineering will be associated with accuracy, flexibility, and creativity.

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Analysis the Design of An Efficient and Sustainable Septic Tank System for Wastewater Treatment to Reduce Environmental Risks

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ABSTRACT

A study was conducted to evaluate the treatment efficiency of septic tanks (STs) for wastewater treatment. Poorly designed septic tanks can contaminate groundwater, overflow, and cause serious environmental, health, and structural problems. If the system is not properly constructed, it may fail to treat wastewater, resulting in pollution, health risks, and costly repairs. The aim to investigate the possibility of increasing removal efficiency at the household level, thereby reduce costs and minimizing environmental risks. In this study accurate data collection is required to design an efficient septic tank system for the Govindrao Wanjari College of Engineering and Technology (GWCET). The research entails gathering wastewater generation rates, soil permeability data, and material analysis to ensure that the system runs efficiently and meets environmental standards.The goal of this case study is to compare the theoretical design parameters of a septic tank to actual installations at the GWCET facility. This analysis find to identify gaps between theoretical models and real-world performance by evaluating structural integrity, treatment efficiency, and compliance with relevant standards.The findings suggest that a well-engineered septic tank system can significantly enhance wastewater treatment efficiency and sustainability, thereby reducing

pollution and protecting groundwater resources.

1. INTRODUCTION

The disposal of domestic wastewater through conventional septic tank systems often leads to environmental contamination, primarily due to inadequate treatment and leakage. In many regions, outdated or improperly maintained septic systems contribute to groundwater pollution, posing serious health risks and ecological concerns. As populations grow and urban expansion continues, the need for improved wastewater management strategies becomes increasingly urgent. A well-designed septic tank system can play a crucial role in treating wastewater efficiently, reducing harmful discharges, and protecting water bodies from contamination. Sustainability in wastewater treatment is an essential aspect of modern environmental engineering. Traditional septic tank designs often rely on passive treatment processes that may not be sufficient to handle increasing wastewater loads. To address these challenges, researchers and engineers have been exploring innovative septic tank designs that integrate advanced treatment technologies and eco-friendly solutions. This paper aims to analyze the principles of septic tank system design and evaluate sustainable approaches that improve wastewater treatment efficiency while minimizing negative environmental impacts.

A sewage disposal tank, also called a septic tank, is an important part of home wastewater treatment. It is used in places where there are no big city sewage systems. The septic tank helps clean and manage wastewater from homes in a simple and low-cost way. This helps keep the environment clean and protects people's health. The main job of a septic tank is to separate solid waste, liquid, and grease. Inside the tank, bacteria naturally break down the waste. The cleaner water then flows out into the drain field or soak pit, where the soil further cleans it before it returns to nature. Role of septic tanks in rural and urban Sewage disposal tank Septic tanks play a crucial role in managing wastewater in both rural and urban areas, especially where centralized sewage systems are limited or unavailable. They provide an effective, low-cost solution for treating household

wastewater and preventing environmental pollution. The scope of this study includes an assessment of material selection, tank capacity, designing parameters, and sludge management strategies. Additionally, we will explore case studies of successful implementations of sustainable septic systems. By understanding these design improvements, policymakers, engineers, and homeowners can make informed decisions to enhance wastewater treatment and environmental protection.

2. PROBLEM OF STATEMENT

Problem of statement define with poorly designed septic tanks (e.g., groundwater contamination, overflow). A poorly designed septic tank can lead to serious environmental, health, and structural problems. If the system is not built correctly, it may fail to treat wastewater properly, causing pollution, health risks, and expensive repairs.

3. OBJECTIVES OF THE STUDY

The primary objective of this study is to design an efficient and sustainable septic tank system that ensures proper wastewater treatment while minimizing environmental risks. The specific objectives are as follows.
1. To Design an Efficient Septic Tank System to reduced cost-effectively and ensure treatment of waste water.
2. To Analyze the Impact of Different Materials and Shapes.
3. To Assess the environmental impact and sustainability of septic tanks.

4. METHODOLOGY
4.1 Research Approach for Govindrao Wanjari College of Engineering and Technology (GWCET): The research approach for designing a septic tank system for GWCET involves a combination of theoretical analysis, practical experimentation, and field surveys. This approach ensures that the system is efficient, environmentally sustainable, and suitable for the specific site conditions of the college.

4.1.1 Theoretical and Practical Methods Used

The study follows a structured methodology that includes both analytical calculations and real-world assessments.

A. Theoretical Methods

1. Literature Review:
- Review of BIS 2470, EPA regulations, WHO guidelines, and previous research on septic tank design.
- Study of fluid dynamics, soil absorption capacity, and bacterial decomposition in wastewater treatment.

2. Septic Tank Design Calculations:
- Determination of wastewater flow rate based on the number of students, faculty, and staff.
- Sizing of the tank considering retention time, sludge storage, and peak flow conditions.
- Hydraulic and structural design, including inlet/outlet pipes, baffles, and ventilation systems.
- Material selection analysis to compare concrete, plastic, and fiberglass septic tanks.

B. Practical Methods

✧ Site Assessment & Soil Testing:
- Soil permeability test to determine the suitability of the drain field.
- Groundwater level measurement to prevent contamination risks.

✧ Data Collection from Existing Systems:

☐ Evaluation of current wastewater management at GWCET.

☐ Identification of issues in the existing septic system

✧ Environmental Impact Analysis:
- Assessment of effluent quality to ensure compliance with environmental standards.
- Proposal of alternative treatment methods if necessary (e.g., biofilters, reed bed systems).

4.1.2 Field Survey or Experimental Setup

- To validate the theoretical design, a field survey or small-scale experimental setup may be conducted.
- Field Survey at GWCET Campus
- Measurement of wastewater generation rates from classrooms, and canteens.
- Interviews with maintenance staff to understand desludging frequency and common problems.
- Collection of historical wastewater management records.
- Experimental Setup (If Feasible)
- A prototype septic system may be constructed to test effluent quality under different conditions.
- BOD (Biochemical Oxygen Demand) and COD (Chemical Oxygen Demand) tests will be performed on wastewater samples.
- Comparison of different filtration media (gravel, sand, biochar) for effluent treatment.

4.2 Data Collection

To design an efficient septic tank system for Govindrao Wanjari College of Engineering and Technology (GWCET), accurate data collection is essential. The study involves gathering wastewater generation rates, soil permeability data, and material analysis to ensure the system functions efficiently and complies with environmental standards.

4.2.1 College Wastewater Generation Rates

Determining the daily wastewater generation is crucial for sizing the septic tank. The data is collected based on:
- Total number of users: Students, faculty, staff.
- Water usage patterns: Classrooms, toilets, canteens, laboratories.
- Standard wastewater production rates:

☐ According to BIS 1172-1993, the average wastewater generation is:

    1. Day scholars and staff: 45–50 LPCD

    2. Canteen wastewater: 7–10 liters per meal served

    3. Laboratories & Miscellaneous: Variable, depending on activity

☐ Estimation Formula:

$Q = P \times W$

Where:

☐ Q = Total wastewater flow (liters per day)

☐ P = Population (number of users)

☐ W = Average wastewater generation per person (LPCD)

For example, if 1,500 students and staff generate 50 LPCD (Institutional and Commercial Water Demand), the total daily wastewater flow would be:

$Q = 1,500 \times 50 = 75,000$ liters/day (75 m³/day)

This data helps in determining septic tank capacity and drain field requirements.

4.2.2 Soil Permeability Tests for Leach Fields

The effluent disposal system (leach field/soak pit) depends on the soil's ability to absorb and filter wastewater. A percolation test (P-test) is conducted to determine soil permeability.

Testing Procedure:

1. Dig a test pit (30 cm wide × 30 cm deep) at the proposed leach field location.

2. Fill the pit with water and allow it to drain completely.

3.Refill the pit with 6 inches of water and measure the time taken for the water to drop by 1 inch.
4.The percolation rate (minutes per inch) determines soil suitability.

Table 1: Standard Permeability Values

Soil Type	Percolation Rate (min/inch)	Suitability for Leach Field
Sandy Soil	**<15**	Excellent, high drainage
Loamy Soil	**15–30**	Good, moderate drainage
Clay Soil	**>30**	Poor, may require alternative treatment

4.2.3 Tank Material Analysis

The septic tank material must be durable, watertight, and resistant to corrosion. The study compares different construction materials for efficiency and cost-effectiveness.

Table 2: Common Septic Tank Materials

Material	Advantages	Disadvantages
Reinforced Concrete (RCC)	Durable, long lifespan, high strength	Prone to cracks if not waterproofed
Precast Concrete	Faster installation, uniform quality	Heavy, requires crane for placement
Brick Masonry	Low cost, easy to construct	Less watertight, needs lining
Plastic (HDPE/Fib erglass)	Lightweight, corrosion-resistant, leak-proof	Expensive, may deform under soil pressure

Structural Design Considerations:
- RCC with reinforcement (M20 or M25 grade concrete) is preferred for large institutional tanks.
- Thickness of walls and base slab calculated to withstand earth pressure and effluent load.
- Waterproofing layers applied to prevent seepage.
- Corrosion-resistant coatings on reinforcement bars ensure durability.

5. DESIGN AND ANALYSIS
5.1 Septic Tank Design Parameters
Tank dimensions (Length, width, depth)
Length = 7.62 m
Breath = 4.572 m
Depth = 3.048 m
 Volume of tank = 7.62 * 4.572 *3.048 = 106.18 cum
Convert Cum to liter =106.18 *1000 = 1,06,180 Liter.

✧ **Step-by-Step Calculation:**
1. Water Intake Per Toilet
- Each student flushes the toilet 3 times a day.
- Total flushes per day by all students & Staff = 1756 students × 3 flushes = 5268 flushes per day.
- Since there are 6 toilets, the total flushes per toilet = 5268 flushes ÷ 6 toilets = 878 flushes per toilet per day.
- Water used per flush = 6 liters.
- Total water used per toilet per day= 878 flushes × 6 liters = 5727 liters per toilet per day.
 2. Water Intake Per Student
- Each student uses the toilet 3 times a day, with each flush using 6 liters of water.

- Water used per student per day = 3 flushes × 6 liters = *18 liters per student per day*.
● Summary:
- *Water intake per toilet per day =878 liters.
- *Water intake per student per day =18 liters.
☐Inlet and outlet pipe positioning for efficient flow.
-UPVC or HDPE = 110 mm dia.

5.2 Computational and Software Modeling
AutoCAD drawings of the tank
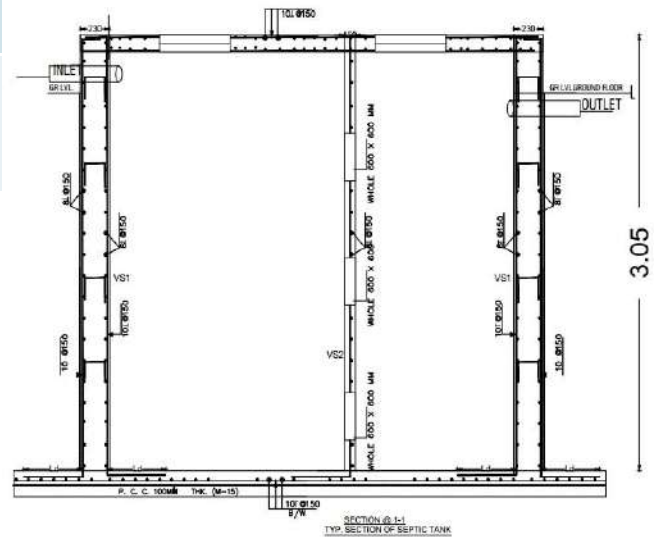
Figure 1: Section of Septic Tank
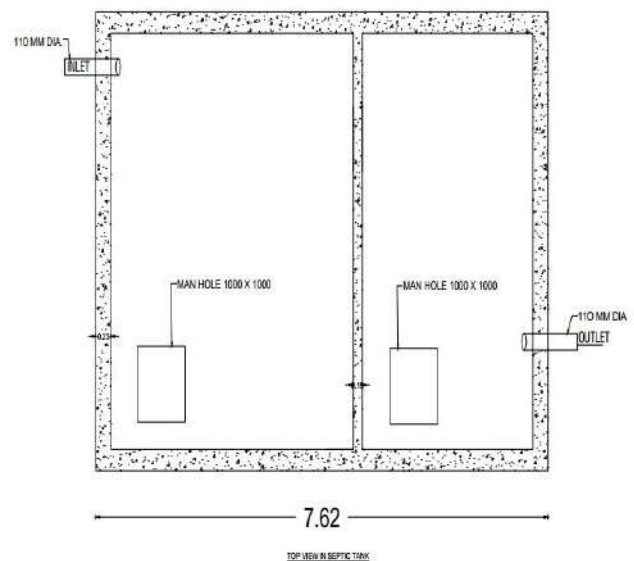
Figure 2: Top View of Septic Tank

6. RESULTS AND DISCUSSION

6.1 Optimal Septic Tank Size Based on Various User Groups

The size of a septic tank depends on the expected wastewater flow, which varies depending on the number of users and their water usage patterns. Septic tank sizing calculations take into account factors like daily water consumption, the number of people, and the recommended retention time for effective treatment.

a) Determining the Size of the Septic Tank

The optimal septic tank size is typically based on the daily wastewater flow per person, as well as a specific retention time (usually between 24 to 48 hours) to ensure effective treatment.

Formula for Septic Tank Size:

The general formula for determining the tank size is:

Length = 7.62 m
Breath = 4.572 m
Depth = 3.048 m
 Volume of tank = 7.62 * 4.572 *3.048 = 106.18 cum
Convert Cum to liter =106.18 *1000 = 1,06,180 Liter

b) Effect of Shape and Material on Wastewater Treatment Efficiency

The shape and material of a septic tank can influence the efficiency of the wastewater treatment process in several ways. Effect of Shape on Wastewater Treatment Efficiency The shape of a septic tank affects the flow of wastewater through the system, the retention time, and the ability of the tank to separate solids from liquids. Common shapes include rectangular, circular, and cylindrical tanks, each with its advantages and disadvantages.

□Rectangular Tanks:

Advantages: More efficient in terms of space utilization, especially for installations with limited room. Their flat bottom and long length promote better sludge and scum separation.

Disadvantages: Can result in uneven flow, especially if not designed with proper baffles. If not properly maintained, solids can accumulate at the inlet or outlet areas, reducing efficiency.

c) Summary of Material and Shape Impact on Efficiency:

Shape: Rectangular tanks are generally more efficient for wastewater treatment in college settings because they allow for better solids settling and are easier to fit into available spaces. Circular and cylindrical tanks are more

suitable for larger installations or those requiring more even flow patterns.

Material: Concrete and fiberglass are commonly used because of their durability, low maintenance needs, and overall efficiency in handling wastewater. Plastic and steel can be used for specific applications, but they may require more frequent maintenance or have durability concerns.

6.2 Case Study Comparisons

Comparing Theoretical Design with Real-World Septic Tank Installations

1. Introduction to the Case Study

The GWCET (insert full form if applicable) building serves as a practical site for evaluating the performance of septic tank systems. The purpose of this case study is to compare the theoretical design parameters of a septic tank with actual installations at the GWCET site. By assessing factors such as structural integrity, treatment efficiency, and compliance with relevant standards (e.g., IS 2470), this analysis aims to identify gaps between theoretical models and real-world performance.

2. Theoretical Design Overview

Dimensions: 1.371x 2.438 × 1.828 m (as specified earlier).

Design Considerations:

  Material: Reinforced concrete with a design mix of M25.

Load Factors: Consideration of live loads, soil pressure, and hydrostatic pressure.

Standards Followed: IS 2470 (Part 1 & 2) for septic tank design and NBC guidelines for structural stability.

Key Assumptions:

Homogeneous soil conditions with a safe bearing capacity of 150 kN/m².

Groundwater table at 3 m below ground level.

3. Real-World Installation at GWCET

Site Conditions:

Soil Type: Clayey soil with moderate permeability.

Groundwater Table: 2.5 m below ground, causing potential hydrostatic pressure.

Inlet and Outlet Configurations: Designed for a daily wastewater flow of 50,000 liters.

Material Used:

Reinforced concrete with a mix slightly deviating to M20 due to cost considerations.

Water-proofing layer applied due to high groundwater table.

4. Key Findings

Structural Integrity: The reduction in concrete mix strength from M25 to M20 requires a higher safety factor in design, which was not initially considered in the theoretical model.

Waterproofing Efficiency: Application of a waterproofing layer effectively countered hydrostatic pressure risks, highlighting a gap in the theoretical design assumptions.

Treatment Efficiency: Preliminary tests indicate a slight reduction in treatment efficiency due to altered inlet and outlet configurations.

5. Recommendations

Material Upgrades: Consider using M25 mix for future installations to align with theoretical strength requirements.

Design Adjustments: Modify inlet and outlet levels to improve flow and treatment efficiency.

Waterproofing Standardization: Include waterproofing measures in theoretical designs for sites with high groundwater levels.

Table 3: Comparing Result of Theoretical Design with Real-World Septic

Parameter	Theoretical Design	Real-World Installation (GWCET)	Observations
Dimensions	1.371 x 2.438 × 1.828 m	7.62 x 4.572× 3.048 m	Minor deviations due to on-site constraints
Concrete Mix	M25	M20	Reduced strength potential
Ground water Table	3m below ground	2.5 m below ground	Additional hydrostatic pressure observed
Load Considerations	Live and dead loads as per IS codes	Similar, with slight variations in soil load assumptions	Comparable with minor safety factor deviations
Water proofing	Not initially considered	Applied due to high water table	Prevents infiltration and structural degradation

7. CONCLUSIONS

1. Efficient Waste Treatment: The multi-chamber design ensures proper separation of solids and liquids, promoting anaerobic digestion and reducing sludge accumulation.

2. Adequate Capacity: The tank's volume is sufficient to handle the estimated sewage load based on the building's occupancy and usage patterns, ensuring a retention time that meets standard requirements.

3. Structural Stability: Analysis using ETABS confirms that the reinforced concrete structure can withstand soil pressure, hydrostatic forces, and live loads, ensuring longevity and safety.

4. Compliance with Standards: The design aligns with local building codes and environmental regulations, minimizing risks of groundwater contamination.

5. Enhanced Durability: Corrosion-resistant reinforcement and proper concrete mix design enhance the lifespan of the tank, minimizing maintenance requirements.

6. Sustainability: The selection of eco-friendly materials and efficient design contributes to sustainable waste management practices.

7. Improved Performance: Reinforcement detailing and wall thickness optimization ensure that the tank can handle dynamic loads and prevent cracking or leakage.

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Analysis the Wastewater Treatment by Effluent Treatment Plant

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ABSTRACT

A study was conducted to wastewater treatment is essential for mitigating environmental pollution and maintaining water quality. Effluent Treatment Plants (ETPs) play a crucial role in treating industrial wastewater before its discharge into natural water bodies. The objective of this study is to evaluate the efficiency of ETPs in removing contaminants from industrial wastewater and ensuring regulatory compliance. The methodology involves sample collection from industrial sites, physicochemical analysis of key parameters, and assessment of treatment efficiency across different ETP stages to treat industrial wastewater may be categorized into four groups: chemical, physical, biological, and mathematical techniques. The results indicate a significant reduction in pollutants, with an 80% decrease in Biological Oxygen Demand (BOD), a 75% decrease in Chemical Oxygen Demand (COD), and a 90% reduction in heavy metal concentrations. The study highlights challenges in wastewater treatment and suggests improvements for sustainable water management.

KEYWORDS: Wastewater Treatment, Effluent Treatment Plant, Environmental effect, sustainable water management,Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD)

1. INTRODUCTION

With rapid industrialization, wastewater discharge has become a major environmental concern. Industries such as textiles, chemicals, pharmaceuticals, and food processing generate large volumes of effluents containing hazardous pollutants. If left untreated, these pollutants can contaminate natural water bodies, harming aquatic ecosystems, reducing biodiversity, and posing significant health risks to humans and wildlife. Effluent Treatment Plants (ETPs) are designed to treat this wastewater to comply with environmental standards before discharge, thereby minimizing negative ecological and health impacts.

The need for wastewater treatment has grown exponentially due to increased urbanization and industrial activities. Many developing countries face severe water pollution issues as industrial growth outpaces the implementation of effective wastewater treatment solutions. The presence of heavy metals, organic pollutants, and pathogens in industrial wastewater necessitates advanced treatment technologies to prevent contamination of surface and groundwater sources. Additionally, untreated or inadequately treated effluents contribute to oxygen depletion in water bodies, leading to the destruction of aquatic life and disruptions in the natural ecosystem balance.

The effectiveness of ETPs depends on various factors, including the type of industry, the characteristics of the effluent, and the efficiency of the treatment process. Conventional wastewater treatment methods, such as sedimentation, filtration, and biological treatment, have been widely used. However, emerging contaminants, including pharmaceuticals, microplastics, and persistent organic pollutants, require more sophisticated and advanced treatment technologies. As industries continue to evolve, there is a need for continuous research and development in wastewater treatment methodologies to enhance efficiency, reduce costs, and ensure sustainability.

This study aims to analyze the performance of Effluent Treatment Plants by assessing their ability to remove contaminants from industrial wastewater. It further explores the challenges and limitations of existing treatment processes and examines innovative solutions to improve wastewater treatment efficiency.

By addressing these critical issues, this research contributes to the development of sustainable wastewater management strategies that align with global environmental goals. tank system can play a crucial role in treating wastewater efficiently, reducing harmful discharges, and protecting water bodies from contamination. Sustainability in wastewater treatment is an essential aspect of modern environmental engineering. Traditional septic tank designs often rely on passive treatment processes that may not be sufficient to handle increasing wastewater loads. To address these challenges, researchers and engineers have been exploring innovative septic tank designs that integrate advanced treatment technologies and eco-friendly solutions. This paper aims to analyze the principles of septic tank system design and evaluate sustainable approaches that improve wastewater treatment efficiency while minimizing negative environmental impacts. Water used by Different Sources show in figure 1.
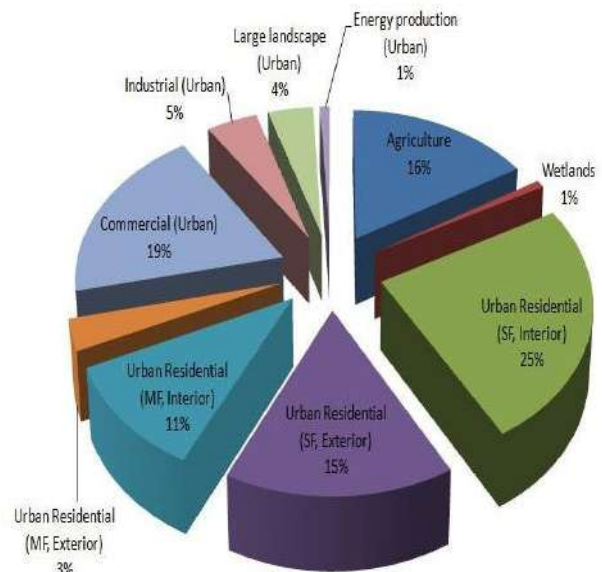
Figure 1: Water used by Different Sources

2. PROBLEM OF STATEMENT

Industrial wastewater contains a variety of contaminants, including heavy metals, organic pollutants, and pathogens, which pose significant environmental and health risks. Despite the existence

of Effluent Treatment Plants (ETPs), many industries struggle with inefficient treatment processes, high operational costs, and non-compliance with environmental regulations. Inadequate treatment leads to the discharge of untreated or partially treated effluents, contributing to water pollution, ecosystem degradation, and public health hazards. Therefore, there is a pressing need to assess the efficiency of ETPs and explore innovative solutions for improving wastewater treatment performance and sustainability.

3. LITRATURE REVIEW

Wastewater Characteristics Industrial wastewater composition varies depending on the industry type. Common contaminants include:
- Heavy metals (e.g., lead, mercury, cadmium)
- Organic matter (e.g., dyes, solvents, oils)
- Nutrients (e.g., nitrogen, phosphorus)
- Pathogens and bacteria
- Suspended solids and chemical residues

3.1 Effluent Treatment Plant Processes ETPs operate in several stages to remove pollutants effectively:

a. Preliminary Treatment: Removes large solids, grit, and debris to prevent equipment damage.
b. Primary Treatment: Involves sedimentation and coagulation to separate suspended solids and oils.
c. Secondary Treatment: Utilizes biological treatment methods (activated sludge, trickling filters, or biofilms) to degrade organic pollutants.
d. Tertiary Treatment: Advanced filtration, chemical treatment, and disinfection (chlorination, UV treatment) to ensure water quality meets regulatory standards.

Several studies highlight the importance of wastewater treatment in preventing environmental degradation. Research by Smith et al. (2020) emphasizes the role of biological treatment methods in improving effluent quality. Johnson and Kumar (2019) discuss the challenges of treating industrial effluents with high chemical loads. Recent advancements, such as membrane bioreactors and electrocoagulation, have been explored by Lee et al. (2022) as effective solutions for removing persistent pollutants. The integration of artificial intelligence in wastewater treatment monitoring has been a growing area of research, as noted by Gupta and Singh (2022). This review provides insights into existing wastewater treatment technologies and their limitations, underscoring the need for continuous improvements in ETPs

4. OBJECTIVES & AIM OF THE STUDY

The primary objective of this study is to assess the efficiency of Effluent Treatment Plants (ETPs) in treating industrial wastewater and ensuring compliance with environmental standards. The specific objectives include:

- Evaluating the physicochemical properties of industrial wastewater before and after treatment.
- Analyzing the effectiveness of different treatment stages in removing pollutants such as BOD, COD, heavy metals, and suspended solids.
- Identifying the limitations and challenges faced by existing ETPs in achieving optimal treatment efficiency.
- Exploring advanced treatment technologies that can enhance the efficiency and sustainability of wastewater treatment processes.
- Providing recommendations for improving wastewater treatment practices and ensuring sustainable water management.

The aim of this study is to contribute to the development of more efficient and sustainable wastewater treatment strategies that can help industries meet regulatory requirements while minimizing environmental impact.

5. METHODOLOGY

This study adopts an experimental and analytical approach to evaluate the efficiency of an ETP in treating various sources wastewater. The methodology includes:
Sample Collection: Wastewater samples were collected from three different industrial sites.
Physicochemical Analysis: Parameters such as pH, Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Total Suspended Solids (TSS), and heavy metal concentrations were test as per std.

Table 1: Physicochemical Analysis of waste water Parameters

Sr. No	Sample	Equalizer tank	Clarifier	Aeration	Final discharge	STD
	Parameter	Min - max	Min - max	Min - max	Min - max	
1	pH	5.80 - 10.70	6.90 - 9.20	6.25 - 8.45	6.30 - 8.75	5.5 - 9.0
2	COD (mg/L)	415 - 2725	350 - 1690	65 - 1150	50 - 296	250
3	BOD (mg/L)	150- 890	100- 530	35.10 - 425	35.20 - 425	40
4	TSS (mg/L)	25 - 165	15 - 210	16 - 150	14 - 130	100

Figure 2: Flow chart of ETP

Research strategy: Here are some of the sewage treatment technologies mentioned in this study :

A.Activated Sludge Process

B.Chlorination

C.Filtration

Wastewater treatment involves removing contaminants from wastewater and domestic sewage as well as run-off (effluent) from commercial, institutional, and residential sources. It addresses physical, chemical, and biological approaches to pollution removal.   The process's end goal is to produce a fluid waste stream (Treated Effluent) and a solid waste (treated sludge) that are both suitable for disposal or reuse and do not harm the environment. Our personal well-being and the purity of our environment are both impacted by the treatment of wastewater.

A sewage treatment plant may employ the activated sludge process for a variety of goals, including the oxidation of carbonaceous and nitrogenous biological matter, the removal of phosphate, and the driving off of entrained gases like carbon dioxide, ammonia, and nitrogen. resulting in a liquid with few suspended or dissolved particles, from which a biological floc might be readily separated. The process reduces the organic matter content of sewage by introducing air or oxygen to a mixture of organisms and screened or primary treated sewage or industrial wastewater. This mixture then forms a biological floc.   When

biological materials are present in wastewater, the result is called mixed liquor.   At the end of the treatment process, any activated sludge facility will dispose of the treated supernatant by running it off into settling tanks, where it will undergo further treatment. Aeration is used to re-seed the tank with new sewage by recycling the sludge, which is a part of the settled material.   The percentage of floc utilized for this purpose is return activated sludge. In order to keep the biomass-to-food ratio in the wastewater in check, the treatment procedure removes surplus sludge, which is then digested under anaerobic or aerobic conditions before being disposed of.   One kind of biological treatment is activated sludge, which uses a suspended growth of organisms to remove BOD and suspended particles. Aeration and settling tanks are required by the
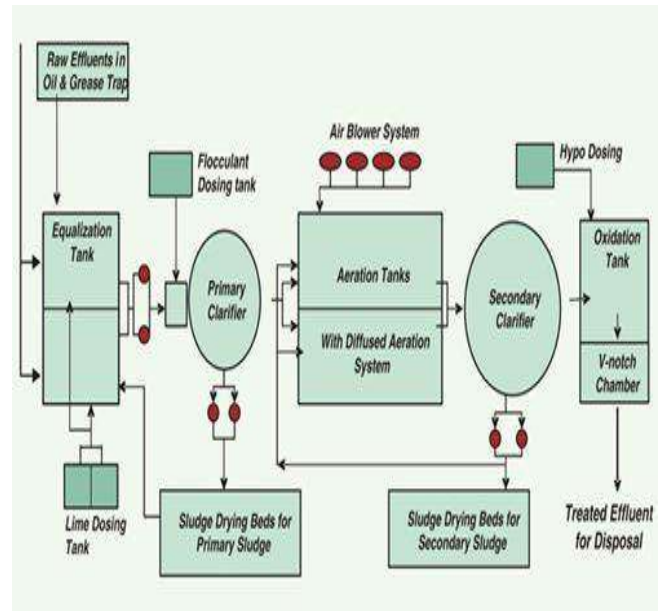
procedure. Designed for continuous solids removal via sedimentation, clarifiers are settling tanks that rely on mechanical principles.   The cleaning of sewage is essential for the health of rivers and streams. Microorganisms abound in sewage, and waterborne sickness epidemics have been associated with sewage-polluted water sources.

6. RESULT AND DISCUSSION

The results indicate significant pollutant reduction across different treatment stages. Key findings include:

- □**pH Adjustment:** The pH levels of wastewater were adjusted from an acidic range (4.5–5.2) to neutral (6.8–7.2) post-treatment.
- **COD and BOD Reduction:** A 75% reduction in COD and an 80% reduction in BOD were observed after biological treatment.
- **Heavy Metal Removal:** The advanced treatment processes effectively reduced heavy metal concentrations by over 90%.
- Suspended Solids Removal: The sedimentation and filtration stages achieved an 85% reduction in TSS.

These findings highlight the effectiveness of ETPs in removing contaminants and ensuring regulatory compliance. However, challenges such as high operational costs and energy consumption remain significant barriers to optimizing wastewater treatment.

7. CONCLUSION

Effluent Treatment Plants are vital for reducing industrial pollution and conserving water resources. This study demonstrates that ETPs significantly improve wastewater quality by effectively removing contaminants such as BOD, COD, heavy metals, and suspended solids. However, while existing treatment technologies offer considerable benefits, challenges such as high operational costs, energy-intensive processes, and the need for advanced treatment methods persist. Industries must adopt innovative and sustainable approaches to wastewater treatment to enhance efficiency and minimize environmental impact. Future research should focus on developing cost-effective, energy-efficient, and eco-friendly wastewater treatment solutions. Additionally, strict regulatory enforcement, technological advancements, and increased awareness of sustainable water management practices are necessary to improve wastewater treatment outcomes globally. By integrating modern technologies such as AI, IoT-based monitoring, and green chemistry, industries can achieve long-term sustainability in wastewater management, ensuring a cleaner and healthier environment for future generations.

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Grey Water Treatment Filter By UV Rays

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ABSTRACT

Water is one of the most abundant resources. India is suffering from the worst water crisis in its history and around 700 million people face problem of water shortage, approximately 200000 people die every year due to inadequate access to clear water. With the help of proper treatment grey water can be put to good use. Various Greywater treatment methods such as physical, biological, chemical, constructed wetland and combined treatment have been analyzed in this paper for both Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) removal efficacy. Contaminants found in greywater are largely associated with the type of detergent used and influenced by other household practices. In this research we done disinfectant by UV light radiation.

KEYWORDS: *grey water, Blackwater, Treatment, Waste Water*.

INTRODUCTION

Water is becoming a rare resource in the world. As per the international water management institute in India by 2025 one person in three will live in condition of water scarcity. Poor water quality is a cause of livelihood and poor health with 80% of all diseases in developing countries. With increasing population, the gap in between the supply and demand for water is increasing. Depending on the source of generation and characteristics of wastewater generated, domestic wastewater can be segregated into two groups i.e., greywater (GW) and blackwater (BW). GW is the wastewater generated from bathroom, laundry, and kitchen (Guidance Manual 2007) while BW is wastewater from water closet flushing. The amount of grey water generated in an office/ household can vary place to places. Grey water may contain chemicals from soap, dyes, and bleaches. It may also contain bacteria, viruses, protozoa. Then root zone waste water treatment system makes use of biological and physical treatment process to remove pollutants from the waste water. Grey water is slowly gaining importance in the management of water resource. Grey water contains chemical contaminants, physical contaminants, and microorganisms. Grey water may contain chemicals from soap, dyes, and bleaches.

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LITERATURE REVIEW

1) Parameshwara Murthy P. M & B.M.Sadasiva Murthy, Greywater is generally defined as "Low polluted wastewater originating from bathtubs, showers, hand washing basins and washing machines excluding wastewater from toilet flushing system" (Kraume et al., 2010). Greywater constitutes about 70% of household water consumption and has lower concentration of organic compounds and fewer pathogens compared to domestic wastewater. As a result, greywater may be treated and reused much easily than composite domestic wastewater for the point of treatment technologies applied and relevant costs.

2) M.Seenirajan et al May-2018, Water pollution in many developing regions causes serious problems. The increase in population and the improvement of people's daily life in these areas result not only in an increase in volume of waste water, but also in a change of waste water composition. Water conservation and reuse are becoming increasingly important as we now face serious problem including reduced ground water and surface water levels, droughts and changing climatic pattern. Over 50% of the water demand from domestic and industrial applications could be met by water of lower quality than fully treated water including applications such as process water, toilet flushing etc.

3) Lukas Huhn June 2015,The average greywater production per person varies between 30 to 120 liter depending on access to piped water and people´s habits and their culture. In practice, the greywater flows can be roughly estimated based on surveys with the target population. If water meters are installed the greywater amount can be approximated as 75% of the total water consumption of the household (25% is estimated to be used for toilet flushing).

4) R. T. Pachkor and Dr. D. K. Parbat April 2017, Grey water gets its name from its cloudy appearance and from its status as being neither fresh nor heavily polluted. Essentially, any water, other than toilet wastes, draining from a household is grey water. Although this used water may contain grease, food particles, hair, and any number of other impurities, it may still be suitable for reuse. Reusing grey water serves two purposes: it reduces the amount of fresh water needed to supply a household, and reduces the amount of waste water entering sewer or septic systems. Grey water is domestic waste water that is collected from dwelling units, commercial building, and institutions of the community. It may include process waste water of industry (food, laundries etc.) as well as ground infiltration and miscellaneous waste liquids. It is primarily spent water from building water supply to which has been added to the waste effluent of bathrooms, kitchens, and laundry. Therefore, several possible re-use of water schemes such as distillation and membrane techniques for complete reuse and biological oxidation, filtration and disinfection schemes for partial reuse have been considered.

5) Lisa M. Avery and Tom Stephenson Feb 2008, The impact of water quality on the ultraviolet (UV) disinfection of grey water was investigated with reference to urban water reuse. Direct UV disinfection of grey water did not meet the stringent California State Title 22 criteria for unrestricted urban water reuse due to the presence of particulate material ranging from < 1 to $>$ or $= 2000$ micron in size. Grey water was manipulated by settling to produce fractions of varying particle size distributions and blending was employed post-disinfection to extract particle-associated coliforms (PACs). The efficacy of UV disinfection was found to be linked to the particle size of the grey water fractions. The larger particle size fractions with a mean particle size of 262 micron and above were observed to shield more coliforms from UV light than did the smaller particles with a mean particle size below 119 microns.

DESIGNE PROCEDURE

The experimental setup is designed and fabricated to conduct experimental investigation on the greywater, to provide treatment to it and make it reusable for gardening purpose and flushing purpose or any other non-potable use. The experimental setup of low-cost greywater filter includes- A fabricated stand, six buckets conducting filter media (Aggregate, Coarse sand, Fine sand, and Charcoal) and Raw Greywater.

The iron filter stand is fabricated in the fabrication shop in our college workshop. The taps are fitted to the buckets and sieves are fixed at the height of 10 cm

above from the bottom. There are six stages in the filter

1. First stage is the raw greywater passing through the screening.

2. Second stage is greywater is allowed to pass through the Aggregate of size 10mm.

3. Third stage is of course sand; the greywater water is allowed to pass through it. The size of coarse sand is taken passing through 4.75mm and retained on 2.36mm.

4. Fourth stage is of Find sand, the greywater after passed through it. The size of Fine sand taken as the sand is passed through the 2.36mm and retained on 1.18mm sieve size.

5. Fifth stage is of Charcoal, it helps the water to absorb the dirt in the water and to disinfect the water. The size of Charcoal is taken as per locally available in area.

6. And the last stage is of getting clear effluent. This effluent after disinfected by using UV Rays. And it is used for the gardening, flushing and any other non-potable purpose.

RESULT

The results of the study establish the applicability of the developed methodology. This small- scale grey water treatment plant is a combination of physical and natural operations such as settling, gravity flow, filtration, and aeration.

1) Treating wastewater will surely reduce the effects of its harm and thus increasing its usability. Once undergone through the procedure of proper treatment, you will no longer receive any bad odors. The water, thus obtained, is clean and safe for use.

2) Grey water can replace drinking water for irrigating gardens or lawns especially during drought periods

Filter	TS reduced	BOD reduced	COD reduced	Turbidity reduced	pH
0	610	205	424	110	8.1
1	475.8	134.89	266.696	88.55	8.1
2	376.98	99.425	217.352	48.95	7.8
3	176.29	28.536	90.496	19.11	7.7
4	105.59	26.794	70.7	12.91	7.56

Table 1: Data collected after experiment.
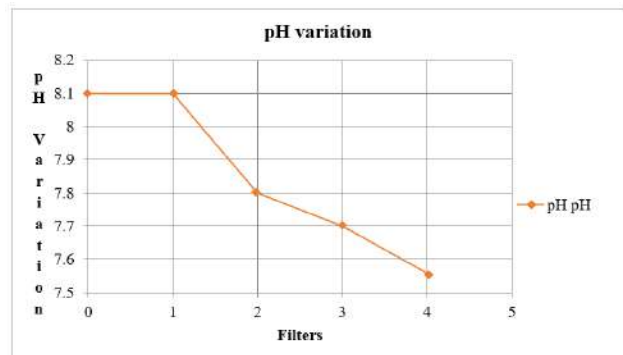
Fig. 1: -pH variation during treatment
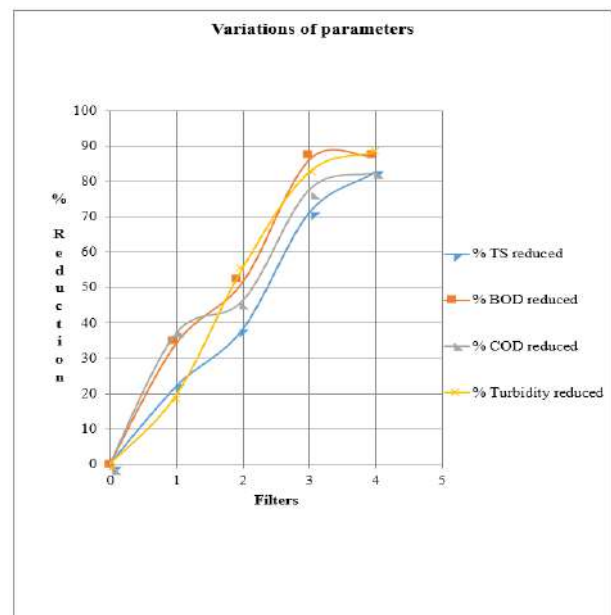
Fig. 2: Reduction in various parameters during treatment

CONCLUSION

From this project, it can be concluded that use of Sand and gravel filter for the treatment of greywater is promising, simple and low-cost technique. Aggregates generally are good filters.

It is therefore required to have relatively large depth and surface area of aggregate (comprising of both fine and coarse, most especially the fine aggregate) for effective filter.

The efficiency of the filter could be improved by varying the sizes, ranges, and proportions of the materials of the media and, depth of the media.

Furthermore, we recommended that effluents from the filter designed can be used for general irrigation process such as irrigating lawns, gardens, cash crops, vegetative crops, roads etc. using any of its method.

Thus, we conclude that it is possible to treat greywater produced in all types of buildings using simple technologies which are easily replicable, inexpensive and that satisfy international reuse recommendations for non-potable activities.

FUTURE SCOPE

The present study demonstrates the reuse and treatment of residential bathrooms, basins waste water called as grey water for the purpose of landscaping, gardening, irrigations, curing etc. Based on finding of this study, this treatment technology can be considered as a viable and economical. The benefits found are low wastage of water, lower load on fresh water, less strain on septic tank, highly effective purification, and ground water recharge. Hence, this is an environmentally friendly, cost effective and resourceful method for development.

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Utilizing Plastic Waste in Bitumen for Flexible Pavement Environmentally Friendly Infrastructure Development

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ABSTRACT

The accumulation of plastic waste poses a significant environmental challenge, contributing to pollution and landfill overflow. In recent years, researchers and engineers have explored innovative solutions to manage plastic waste effectively while improving infrastructure sustainability. One such approach involves incorporating plastic waste into bitumen for flexible road pavement. This study aims to evaluate the feasibility and benefits of plastic-bitumen mixtures by analyzing their structural performance, economic viability, and environmental impact. The methodology involves collecting and segregating plastic waste, processing it into small shreds, and blending it with hot bitumen. The modified bitumen is then mixed with aggregate and laid using conventional road construction techniques. Experimental results indicate that plastic-bitumen roads exhibit enhanced durability, increased resistance to water-induced damage, and reduced maintenance costs compared to conventional bitumen roads. The study further highlights the environmental advantages of repurposing plastic waste, reducing reliance on petroleum-based bitumen, and improving the overall sustainability of road infrastructure. Despite these benefits, challenges such as standardizing the plastic-bitumen ratio, ensuring uniform plastic quality, and addressing long-term environmental implications remain. Future research should focus on optimizing plastic-bitumen compositions, developing efficient processing methods, and conducting large-scale pilot projects to facilitate widespread adoption. The findings of this study suggest that utilizing plastic waste in bitumen presents a sustainable and effective solution for both road construction and waste management, paving the way for more environmentally friendly infrastructure development

KEYWORDS:Plastic Waste, bitumen, Flexible Road Pavement, environmental impact, waste management, infrastructure development

1. INTRODUCTION

Plastic waste is a major environmental concern due to its non-biodegradable nature. The rapid increase in plastic consumption has led to severe environmental pollution, affecting land, water bodies, and ecosystems. Improper disposal of plastic waste results in blocked drainage systems, soil degradation, and threats to marine and terrestrial life. The plastic waste crisis calls for urgent and innovative solutions to reduce its impact on the environment. One promising approach is the incorporation of plastic waste into road construction materials, specifically bitumen. Traditional road construction relies on bitumen, a petroleum-based material that acts as a binder for aggregates in flexible pavement. The modification of bitumen with plastic waste has been proposed as a viable method to enhance road performance while addressing plastic pollution.

Several studies have demonstrated that adding plastic waste to bitumen can improve pavement properties such as increased durability, better resistance to water damage, and higher load-bearing capacity. Roads constructed with plastic-bitumen mixtures have shown reduced susceptibility to cracking and potholes, leading to lower maintenance costs. Furthermore, this method provides an alternative use for discarded plastic materials, thereby reducing landfill waste and environmental hazards. Governments and environmental agencies worldwide are exploring policies and strategies to promote the use of plastic waste in road construction. Countries such as India, the United Kingdom, and the United States have initiated pilot projects and full-scale implementations of plastic-bitumen roads with promising results. However, challenges remain in standardizing the process, ensuring the quality and compatibility of different plastic types, and assessing the long-term environmental impact.

This study aims to analyze the effectiveness of plastic-bitumen mixtures in flexible road pavement by evaluating their mechanical properties, cost efficiency, and environmental sustainability. By addressing these key aspects, this research contributes to the ongoing efforts to develop sustainable infrastructure while managing plastic waste effectively.

2. PROBLEM OF STATEMENT

The excessive generation of plastic waste has led to severe environmental hazards, including pollution, clogging of drainage systems, and harm to wildlife. Additionally, conventional bitumen roads suffer from issues such as rutting, cracking, and water-induced damage, leading to high maintenance costs. Incorporating plastic waste into bitumen can address these problems by enhancing pavement quality and offering a sustainable waste disposal method.

3. LITRATURE REVIEW

Previous studies have highlighted the benefits of using plastic waste in bitumen, including increased durability, better resistance to water and potholes, and reduced maintenance costs. Various types of plastics, such as polyethylene (PE), polypropylene (PP), and polystyrene (PS), have been used in different proportions in road construction projects worldwide. Research has shown that plastic-modified bitumen improves the strength and longevity of roads. Studies conducted in India, the UK, and other countries have demonstrated significant enhancements in road performance when using plastic waste. However, concerns related to the long-term environmental impact, standardization of procedures, and large-scale implementation remain key areas of research

✧ Recent Literature Review on the Use of Plastic Waste in Bitumen for Flexible Pavement

Recent studies have explored the incorporation of waste plastics into bituminous mixtures for flexible pavement construction, aiming to enhance pavement performance and address environmental concerns associated with plastic waste.

✧ Enhancement of Bituminous Mixtures with Waste Plastics

A 2022 study by Shubham et al. investigated the effects of adding plastic waste to bituminous mixtures. The researchers found that incorporating 5.5% plastic waste by weight of bitumen resulted in a 7.1% increase in indirect tensile strength, indicating improved durability of the pavement.

✧ Performance Evaluation of Various Plastic-Bitumen Mixtures

A 2020 review by Thamme Gowda C S et al. evaluated the performance of different types of waste plastic-bitumen mixtures in road construction. The study highlighted that various plastics, including low-density polyethylene (LDPE), high-density polyethylene (HDPE), and polyvinyl chloride (PVC), can effectively bind with bitumen, enhancing mechanical properties such as load-carrying capacity and lifespan of roads. The review also noted that roads constructed with

plastic-bitumen mixes exhibited reduced wear compared to conventional bitumen roads.

✧ Utilization of Waste Plastic in Bitumen

A 2014 study by Mahalakshmi et al. explored the utilization of waste plastic in bitumen. The study concluded that adding waste plastic to bitumen improved the strength and durability of the pavement, offering a viable solution for plastic waste disposal.

These studies collectively demonstrate that integrating plastic waste into bituminous mixtures offers a sustainable approach to improving pavement performance while addressing the environmental challenges posed by plastic waste.

4. AIM & OBJECTIVES OF THE STUDY

To evaluate the effectiveness of plastic waste as an additive in bitumen for enhancing the durability and sustainability of flexible road pavements

The specific objectives are as follows.
1. To investigate the properties of plastic-bitumen mixtures and their impact on road performance.
2. To analyze the environmental and economic benefits of using plastic waste in road construction.
3. To identify the optimal proportion and types of plastic waste suitable for bitumen modification.
4. To examine the challenges associated with implementing plastic-bitumen roads on a large scale.

5. METHODOLOGY

- Collection and Segregation: Plastic waste is collected from municipal sources and segregated into usable types.
- Processing: The plastics are cleaned, shredded, and blended with hot bitumen at specific temperatures.
- Mixing and Laying: The plastic-modified bitumen is mixed with aggregate and laid using conventional road construction techniques.

The plastic waste utilized is poly-ethylene, poly-styrene, poly-propylene, the temperature ranging between 120ºc - 160ºc yields the softening point of these polymers. The plastic trash is shredded & coated over the aggregate and combined with hot bitumen and the resultant mix is utilized for pavement building this mix will not only reinforce the pavement and also enhances its durability.

5.1 Materials Utilization

Bitumen- For this investigation, researchers employed 60/70, 80/100 grade bitumen, a substance widely used for its good binding properties and its ability to soften when heated. Bitumen used in wearing courses made with recycled plastic must meet the requirements of IS 73, the Indian Standard Specifications for Viscosity Graded Pavement Bitumen. The IRC:111-2009 specifies the criteria for choosing the viscosity grade of paving bitumen.

Figure 1: Bitumen 60/70, 80/100 grade

Aggregate- A key component of flexible pavements is aggregate, which plays a significant role in their development. Pavements made of hot mix asphalt (HMA) are created by combining bitumen with particles that have been sorted and chosen for their properties. There are two different kinds of aggregate, coarse and fine, and two different sizes, 20 mm and 10 mm.

Figure 2: Aggregate fine, 10 mm and 20 mm**.**

Filler-IRC :111-2009 specifies that thick graded mix filler must be compliant. Along with 6 mm of stone dust and lime

Waste plastic-Since plastic, like many other materials, improves its binding properties when heated, it is possible to employ melted plastic as a binder in bitumen.

5.2 Mixing Designing

Table 1: Waste plastic modified dense graded bituminous pavement layers

Minimum stability (kN at 60°C)	12.0
Minimum flow (mm)	2
Maximum flow (mm)	4
Marshall Quotient (KN/mm)	2.5-5

Compaction level (Number of blows)	75 blows on each of the two faces of the specimen
Percent air voids	3 - 5
Retained stability (%)	98
ITS (min) MPa	0.9
VMA	16
VFB	65-75
Quantity of waste plastic % by weight of plastic	6 to 8 depending on low rainfall or high rainfall areas

Softening point of bitumen	54.35°C	47 °C (min)	IS: 1205 - 1978
Flash point of bitumen	272°C	220 °C (min)	IS: 1209 - 1978
Fire Point of Bitumen	300°C	270 °C (min)	IS: 1209 - 1978
Bitumen Penetration Test	50 mm	45 (min)	IS: 1203 - 1978
Ductility test	94 cm	100	IS: 1208 - 1978

- **Open graded mixtures made from recycled plastic Open**

Grade Premix Surfacing and Mix Seal surfacing mixes may employ 6 to 8 percent of the bitumen's weight. In a similar vein, the amount of bitumen may be decreased. A coarse aggregate mix with a little proportion of fine aggregate and many air gaps to let water drain is called an open graded cold mix. As a surface course, these mixtures perform well against pushing, fatigue, reflection cracking, and rutting. You may mix open-graded mixes on the spot or save them for later use in restoration projects of varied depths.

- **Bituminous Mix Production Repurposing Plastic Debris**

The two main methods for producing bituminous hot mixes from recycled plastic for use in road building are the "dry" and "wet" processes, respectively. The wet method requires more capital and equipment, which is why it is seldom used; in contrast, the dry process is thought of as easy, cheap, and eco-friendly.

In order to ensure that the quality of the finished waste plastic product is consistent the following process must be adhered to before considering its use in bituminous construction:
i. Collection of waste plastic.
ii. Cleaning and shredding of waste plastic.
iii. Shredding Machine.
iv. Mixing of shredded plastic waste, aggregate and bitumen in central mixing plant.

6. RESULT AND DISCUSION

Table 2: Result of Physical Properties of Bituminous

Designation	Test result	Permissible limit	Test method
Specific gravity of bitumen	1.025	0.99 min	IS: 1202 - 1978

Table 3: Result of Sieve Analysis

Sieve size	Upper limits	Lower limits	Mid limits	Result
37.5	100	100	100	100.00
26.5	100	90	95	100.00
19	95	71	83	93.89
13.2	80	56	68	71.29
4.75	54	38	46	42.69
2.36	42	28	35	29.41
0.3	21	7	14	10.53
0.075	8	2	5	4.18

Table 4: Result Of Aggregate Test

Designation	Test result	Permissible limit (Morth Specification)	Test method
Aggregate Impact Value Test	23.80	Max 30%	IS: 2386 Part IV
Specific Gravity of Aggregates (20 mm)	2.68		IS: 2386 Part III
Specific Gravity of Aggregates (10 mm)	2.71		IS: 2386 Part III
Specific Gravity of Aggregates (6 mm)	2.69		IS: 2386 Part III
Specific Gravity of Aggregates (stone dust)	2.74		IS: 2386 Part III
Stripping Value of Aggregates	45%	5%	Physical appearance
Water Absorption	0.40	Max 2%	IS: 2386 Part III

Table 5: Marshall Sampling Mould

Apparatus	Value	Working tolerance
Mould		
Average internal diameter, mm	101.2	□ 0.5

Hammer		
Mass, kg	4.535	☐ 0.02
Drop height, mm	457	☐ 1.0
Foot diameter, mm	98.5	☐ 0.5

Research and experimental studies have demonstrated that plastic-bitumen roads exhibit enhanced strength, improved resistance to water-induced damage, and lower maintenance requirements. Studies have also shown a reduction in the consumption of bitumen, making the process cost-effective.
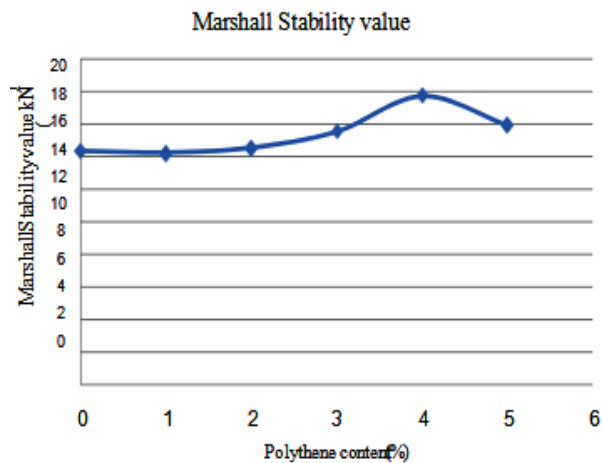
Figure 3: Marshall Stability Value

7.CONCLUSION

The use of plastic waste in bitumen for flexible pavement is a sustainable and effective solution for both road construction and waste management. Further research and policy support are essential for widespread implementation.

- The use of recycled plastic in flexible pavements outperforms more traditional methods.
- There are fewer voids and less water absorption because to the polymer coating on the particles.
- Plastic pavement is more long-lasting and has the ability to endure high traffic.
- Using plastic in the mix has many benefits, including a 10% reduction in bitumen content, improved road performance and strength, and evidence that the aggregate and bitumen's qualities improve with increasing amounts of plastic trash.
- This method is very environmentally beneficial as it makes use of the plastic waste.

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A Comprehensive Analysis of Financial Considerations in Construction Projects

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ABSTRACT

Construction projects, by nature, are complex and require substantial financial planning and management. Due to their capital-intensive nature, effective financial consideration is vital to ensure that projects are completed within budget and on time. This research paper explores the financial aspects of construction, including cost estimation, budgeting, funding methods, risk management, cash flow monitoring, and financial planning. The paper also examines the impact of economic factors, technological innovations, and global financial trends on the construction industry's financial management practices. The objective is to provide insights into how financial considerations affect project execution and offer guidance on improving financial decision-making in construction projects.

Keywords: Clustering; Dynamic clustering; Prediction; Target tracking; Target recovery; Wireless sensor network;

1. INTRODUCTION

Construction is one of the most financially demanding industries, with projects requiring significant capital for materials, labor, machinery, and other resources. Proper financial management is crucial for the success of construction projects, which often involve multiple stakeholders, including contractors, investors, and government entities. A detailed understanding of financial considerations, such as cost estimation, financing sources, and risk management strategies, is essential for anyone involved in construction project management. This paper aims to analyze the financial processes and challenges in the construction industry, drawing attention to the tools and techniques that can help manage costs effectively.

2. FINANCIAL PLANNING IN CONSTRUCTION

2.1. Cost Estimation

Cost estimation is the cornerstone of any construction project. It involves calculating the anticipated financial outlay needed to complete the project, including labor, materials, equipment, and overheads. Inaccurate cost estimates can lead to significant financial losses or project delays. There are various methods of cost estimation, each suited to different types of projects:

Analogous Estimating: This method uses the cost data from similar, previously completed projects to forecast costs for the new project.

Parametric Estimating: This approach applies statistical relationships between known variables, such as cost per square foot or cost per unit of work, to calculate overall project costs.

Bottom-Up Estimating: This detailed approach involves estimating costs for each individual project component and then aggregating them to derive the total project cost.

Each of these methods has its strengths and weaknesses, and the choice of method depends on the availability of data and the complexity of the project.

2.2. Budgeting

Once cost estimates are established, the next step is to create a comprehensive project budget. The budget includes estimates of both direct costs (e.g., materials and labor) and indirect costs (e.g., permits and administrative expenses). A well-structured budget not only guides the project's financial decisions but also serves as a financial control tool. It is important to include contingency reserves to address unforeseen issues like cost overruns, delays, or changes in project scope.

3.FUNDING SOURCES FOR CONSTRUCTION PROJECTS

3.1. Equity Financing

Equity financing refers to obtaining funds by selling ownership stakes or shares in the project to investors or developers. This method can provide substantial capital, but it also requires sharing project ownership and future profits. Equity financing is particularly common in large-scale infrastructure projects and real estate developments.

3.2. Debt Financing

Debt financing involves borrowing funds from external lenders, such as banks or financial institutions, with the promise to repay the loan with interest. Common forms of debt financing in construction include construction loans, mortgages, and project bonds. While debt financing allows for greater control by the project developers, it also introduces repayment risks and interest obligations.

3.3. Hybrid Financing

Hybrid financing is a combination of equity and debt financing. This method is used to balance the financial risks and rewards associated with both approaches. By using a mix of investor equity and loan-based capital, developers can secure funding without relinquishing too much control over the project.

4.CASH FLOW MANAGEMENT

4.1. Importance of Cash Flow

Effective cash flow management is critical to the success of construction projects. Cash flow refers to the movement of funds into and out of the project over time, ensuring that there is enough liquidity to pay workers, purchase materials, and cover other operational costs. A well-managed cash flow system allows project managers to anticipate financial needs and avoid delays due to lack of funding.

4.2. Cash Flow Forecasting

Cash flow forecasting involves predicting the timing and amounts of cash inflows and outflows throughout the construction project. Regular updates to the forecast are necessary to reflect changes in the project's schedule or financial needs. Failure to accurately predict cash flow can result in serious financial challenges, such as project delays or inability to meet financial obligations.

4.3. Payment Schedules

In construction, payment schedules are typically structured around key milestones, such as the completion of the foundation, framing, or roofing. These schedules ensure that contractors and suppliers are paid promptly as work progresses. The financial health of a construction project can be significantly affected if payment terms are not adhered to or if payments are delayed.

5. RISK MANAGEMENT IN CONSTRUCTION FINANCING

5.1. Identifying Financial Risks

Every construction project is exposed to several financial risks, such as cost overruns, project delays, price fluctuations in materials, and labor shortages. Risk identification is a crucial step in financial planning. Project managers must analyze both internal and external factors that could impact project costs, timelines, or the availability of resources.

5.2. Mitigation Strategies

Once risks are identified, they can be mitigated through various strategies, including:
Contingency Funds: Allocating a portion of the budget to cover unforeseen expenses.
Insurance:Purchasing construction-related insurance policies, such as builder's risk insurance, to cover damage, delays, or accidents.

Fixed-Price Contracts: These contracts set a specific price for the entire project, thereby protecting the project owner from potential cost overruns caused by unforeseen issues.

5.3. Risk Transfer

Transferring risk to another party is another common strategy. For example, subcontractors may assume responsibility for certain risks, such as labor cost increases or material price fluctuations. This can be formalized through contractual agreements or insurance.

6.IMPACT OF ECONOMIC AND MARKET CONDITIONS ON CONSTRUCTION FINANCING

The financial success of construction projects is greatly influenced by the broader economic environment. Changes in interest rates, inflation, labor costs, and material prices can substantially alter the financial landscape of a project.

6.1. Interest Rates and Financing Costs

Interest rates have a direct impact on the cost of borrowing for construction projects. In times of high interest rates, the cost of debt financing increases, potentially leading to higher overall project costs. Conversely, lower interest rates can make debt financing more attractive, reducing the burden on the project's finances.

6.2. Inflation and Material Costs

Rising inflation can drive up the cost of materials and labor, leading to unforeseen cost increases during construction. To mitigate these risks, contracts may include escalation clauses, which allow for price adjustments if certain materials or labor rates increase beyond a specified threshold.

7. TECHNOLOGICAL INNOVATION IN CONSTRUCTION FINANCE

7.1. Building Information Modeling (BIM)

BIM is a digital representation of the physical and functional characteristics of a construction project. It is increasingly being used to improve cost estimation accuracy, manage resources, and simulate construction processes. BIM allows stakeholders to visualize the project and its financial components, leading to better financial planning and management.

7.2. Automation and AI

Artificial intelligence (AI) and automation technologies are being used in construction project management to enhance financial forecasting, resource allocation, and schedule optimization. These tools can analyze vast amounts of data to predict project costs, manage risks, and ensure efficient financial management.

7.3. Drones for Monitoring and Financial Reporting

Drones are being used to monitor construction sites and provide real-time data on progress, material usage, and site conditions. This data can be used to make financial decisions, such as adjusting cash flow forecasts and ensuring that the project is staying within budget.

8. CASE STUDY: FINANCIAL MANAGEMENT IN A LARGE-SCALE INFRASTRUCTURE PROJECT

A case study of a large infrastructure project is presented to analyze how financial management techniques were applied to ensure successful completion within budget. The case study evaluates the role of accurate cost estimation, funding choices, cash flow management, and risk mitigation strategies in the overall financial success of the project.

9. CONCLUSION

Effective financial management is essential for the success of construction projects. From accurate cost estimation and budgeting to managing cash flow and mitigating risks, construction professionals must integrate sound financial practices at every stage of the project lifecycle. With the increasing impact of technological advancements, the ability to predict costs and manage financial resources efficiently has become more achievable. Moving forward, the construction industry must continue to embrace innovation and adapt to economic changes to ensure financial sustainability and project success.

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Recycling of Solid Waste

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ABSTRACT

The management of solid waste is a critical challenge in modern urban environments, necessitating sustainable solutions. This report delves into recycling and composting as effective methods for reducing the environmental footprint of waste. Recycling involves converting waste materials into reusable resources, thereby conserving natural resources and energy. Composting transforms organic waste into nutrient-rich compost, fostering soil health and reducing landfill dependency. The paper discusses the processes, benefits, and limitations of both approaches, emphasizing their roles in mitigating greenhouse gas emissions. Case studies from successful waste management programs are highlighted to demonstrate practical applications. Technological innovations and community participation emerge as pivotal factors in enhancing recycling and composting systems. Economic and policy implications are explored, identifying barriers and enablers for widespread adoption. The report concludes by underscoring the importance of integrating these methods into circular economy strategies. Through this study, we aim to inspire holistic and efficient waste management practices for a sustainable future.

INTRODUCTION

Nowadays, not only India but the whole world is grappling with the complex and escalating problem of solid waste disposal. Rapid urbanization and industrialization have significantly contributed to the generation of diverse and voluminous waste, necessitating sustainable and efficient management solutions. Recycling and composting emerge as the most effective approaches to addressing this issue, offering an environmentally-friendly alternative to mere disposal. City refuse, being highly heterogeneous, is typically managed by municipal authorities. However, current practices like indiscriminate dumping on open land, filling low-lying areas, incineration, or composting into organic manure are not always efficient or sustainable.

To tackle this growing concern, municipalities should adopt laws or ordinances mandating the segregation of solid waste. Solid waste left for collection or delivered to a solid waste management facility must be separated into recyclable, reusable, and other components with existing economic markets for alternative uses. For recycling and composting purposes, the term "economic markets" refers to cases where the full avoided costs of proper collection, transportation, and disposal equal or exceed the cost of handling and selling the source-separated materials, minus the revenue generated from their sale.

The process of recycling should encompass critical components such as paper, glass, metals, plastics, garden, and yard waste, while encouraging the inclusion of additional recyclable materials. Municipalities can establish recycling and composting centers or depots on public or private lands, with written consent from private owners. Such initiatives can foster local participation, reduce reliance on landfills, and promote resource conservation. Furthermore, technological advancements

and community-driven programs can make waste management more efficient and economically viable. Recycling and composting are not just solutions but pivotal strategies for creating a sustainable and eco-friendly future.

SOLID WASTE

Solid waste is the waste which mainly arises from the human and animal activities that are normally solid and mentioned as useless or unwanted. Such a solid waste is heterogeneous Among all the categories of the waste (i.e. liquid & gaseous waste) the ratio of solid waste production is more. It is mainly related to human and also human beings are the cause of producing the solid waste in large quantities.

While discussing the solid waste, generally and traditionally certain categories of waste are recognized. The solid waste are classified from the source of generation such as **domestic, commercial, industrial. Agricultural, institutional,** etc.

There is little agreement even in the definition of some rather common terms which are applied to solid waste. "Refuse", which consists of all putrescible and putrescible solid waste except for body wastes, is often confused with 'garbage' and "rubbish". "Garbage" simply refers to the wasted or rejected food constituents which have been produced during the preparation, cooking or storage of meat, fruit, vegetables etc. "Rubbish" on the other hand, refers to the non-Putrescible solid waste constituents and includes such items as paper, in cans glass, wood etc.

CLASSIFICATION OF SOILD WASTE

Solid waste can be classified in several different ways. According to the point of origin, it is classified as municipal (including residential, institutional, commercial, street), agricultural, industrial, sewage treatment residue, demolition and construction. According to the nature of material constituting the refuse it can be classified as combustible or non-combustible. One of the most useful classification is based on the kinds of material, garbage, rubbish, ashes, street refuse, dead animals, abandoned vehicles, industrial wastes, demolition and construction waste, sewage solids and hazardous wastes.

TYPES OF SOLID WASTE

Solid waste can be categorized by its origin and composition. Some types of solid waste include:

Municipal solid waste: This includes household and commercial waste like paper, plastic, glass, and food scraps.

Industrial waste: This includes waste from factories like metals, chemicals, and hazardous substances.

Agricultural waste: This includes organic waste like crop residues, manure, and pesticides.

Biomedical waste: This includes waste from hospitals like syringes, bandages, and expired medicines.

Construction and demolition waste: This includes debris from building sites like bricks, cement, and wood.

Electronic waste: This includes discarded electronic items like batteries, computers, and mobile phones.

Hazardous waste: This is a type of solid waste that includes discarded chemicals.

Commercial waste: This includes waste generated by commercial businesses and industries like office paper, packaging materials, food scraps, and yard.

Source	Typical Facilities Activities or Location Where Waste are Generated	Types of Waste
Residential	Single family and multifamily Dwellings low medium high apartments rise etc.	Food Waste rubbish, ashes, special wastes.

Commercial	Stores, restaurants, markets, office buildings, hotels, motels, auto repair demolition' and shop, cinema hall, theatre, construction wastes, commercial shopping complex etc.	Food waste rubbish, ashes demolition and construction wastes, Special wastes, occasionally hazardous waste.
Municipal	As above residential and commercial	As above residential and commercial
Industrial	Construction, fabrication, manufacturing, refineries, light and chemical heavy plants, lumbering. mining, power plants, demolition etc.	Food wastes, rubbish, ashes, demolition and construction wastes, hazardous wastes.
Institutional	School, college, hospital, library etc.	Rubbish, food wastes, special wastes, hazardous wastes etc.
Agriculture Wastes	Field and raw crops, orchards, vineyards, gardens, dairies, feedlots, farms etc.	Spoiled food wastes, rubbish, garbage, hazardous wastes.

RECYCLING

Recycling is the reprocessing of old materials into new products, with the aims of preventing the waste of potentially useful materials, reducing the consumption of fresh raw materials and reducing energy usage and thereby lowering greenhouse gas emissions compared to virgin production. Recycling means to use something again. Newspapers can be used to make new newspapers. Aluminum cans can be used to make new aluminum cans. Glass jars can be used to make new glass jars

Recycling is a key concept of modern waste management and is the third component of the "Reduce, Reuse, Recycle" waste hierarchy, though colloquial usage of "recycling" can also include "reuse". "Recyclable materials" or "recyclables", may originate from home, business or industry. They include glass, paper, metal, textiles and plastics. Though analogous, the composting of biodegradable waste-such as food or garden waste is not typically considered recycling. These materials are either brought to a collection center or picked-up from the curbside, sorted, cleaned and reprocessed into new products bound for manufacturing

TYPES OF RECYCLING

1) Paper recycling

Paper can be recycled by reducing it to pulp, and combining it with pulp from newly harvested wood. As the recycling process causes the paper fibers to breakdown, each time paper is recycled its quality decreases. This means that either a higher percentage of new fibers must be added, of the paper down cycled into lower quality products. Any writing or coloration of the paper must first be removed by deinking, which also removes fillers, clays, and fiber fragments

2) Plastic Recycling

Plastic recycling is the process of recovering scrap or waste plastics and reprocessing the material into useful products. Compared to glass or metallic materials, plastic poses unique challenges-because of the massive number of types of plastic, they each carry a resin identification code, and must be sorted before they can be recycled. This can be costly-while metals can be sorted using electromagnets, no such 'easy sorting' capability exists for plastics. In addition to this, while labels do not need to be removed from bottles for recycling lids are often made, from a different kind of non-recyclable plastic.

3) Ferrous Metal Recycling:

Iron and steel are the world's most recycled materials, and among the easiest materials to reprocess, as they can be separated magnetically from the waste stream Recycling is via a steelwork: scrap is either remitted in an Electric Are Furnace (90-100% scrap), or used as part of the charge in a Basic Oxygen Furnace (around 25% scrap). 114-1 Any grade of steel can be recycled to top quality new metal, with no 'downgrading from prime to

lower quality materials as steel is recycled repeatedly. 42% of crude steel produced is recycled material

4) Glass Recycling:

Glass bottles and jars are gathered via curbside collection schemes and bottle banks, where the glass may be sorted into color categories: The collected glass cullet is taken to a glass recycling plant where it is monitored for purity and contaminant are removed. The cullet is crushed and added to a raw material mix in a melting furnace. It is then mechanically blown or molded into new jars or bottles.

5) Concrete Recycling:

The most common materials of construction are concrete, wood, drywall, asphalt, shingles, asphalt pavement construction demolition can make you a vital asked to a green building project. Concrete aggregate collected from demolition sites is put through a crushing machine, often along with asphalt, bricks, dirt, and rocks. Smaller pieces of concrete are used as gravel for new construction projects. Crushed recycled concrete can also be used as the dry aggregate for brand new concrete if it is free of contaminants. This reduces the need for other rocks to be dug up. Which in turn saves trees and habitat.

Benefits of recycling concrete:

(There are a variety of benefits in recycling concrete rather than dumping it or burying it in a landfill.

• Keeping concrete debris out of landfills saves space there.

• Using recycled material as gravel reduces the need for gravel mining.

• Using recycled concrete as the base material for roadways reduces the pollution involved in trucking material.

Advantages of Recycling

• Recycling Saves Landfill Space.
• Recycling Can Reduce the Cost of Waste Disposal.
• Recycling Can Save Energy.
• Recycling Saves Natural Resources.
• Recycling Can Reduce Air and Water Pollution.
• Cling Creates Jobs.

RESULT AND DISCUSSIONS

Recycling and composting of solid waste have proven to be effective and sustainable methods for addressing the global waste management crisis. The successful implementation of these strategies has led to a noticeable reduction in waste sent to landfills, contributing significantly to environmental conservation. Recycling has allowed for the recovery of valuable materials like paper, glass, metals, and plastics, which are reprocessed into new products, reducing the demand for virgin resources. This has also resulted in considerable energy savings and a reduction in greenhouse gas emissions.

Composting has showcased its potential as an eco-friendly solution for organic waste. Through the decomposition of garden and food waste, nutrient-rich organic compost is generated, which enriches soil health and supports sustainable agricultural practices. Case studies from urban areas have demonstrated that comprehensive recycling and composting programs can divert up to 60–70% of solid waste from traditional disposal methods.

However, challenges persist. A lack of public awareness and inadequate segregation at the source remain critical barriers to achieving higher efficiency. Furthermore, inconsistent market demand for recycled materials and limited funding for composting infrastructure are ongoing hurdles. These challenges highlight the need for community engagement, stronger policies, and financial incentives to encourage active participation and investments in advanced technologies.

Overall, recycling and composting hold immense potential as key pillars of sustainable waste management systems. Addressing existing challenges through education, innovation, and collaboration can transform solid waste into valuable resources, promoting a circular economy and reducing environmental degradation.

CONCLUSION

Solid waste, particularly industrial waste, presents significant disposal challenges, especially in rapidly urbanizing and suburbanizing areas. This report has thoroughly examined recycling processes, including practical methods for recycling materials such as paper, while also highlighting the effectiveness of composting as a sustainable waste management solution. Both approaches are key to addressing the growing waste crisis.

By recycling and composting, the volume of waste sent to landfills can be significantly reduced, mitigating environmental pollution and minimizing the spread of diseases caused by improper waste disposal.

Moreover, these practices help conserve valuable natural resources, reduce greenhouse gas emissions, and foster a circular economy. Recycling encourages the recovery of materials like plastics, metals, and glass, reducing the dependency on virgin resources and promoting energy efficiency. Composting, on the other hand, offers a cost-effective solution for managing organic waste, turning it into a valuable resource for farmers and gardeners.

The integration of recycling and composting into municipal and industrial waste management systems is crucial for achieving sustainable development goals. Public awareness campaigns, policy support, and investments in advanced waste management technologies are essential to maximize the potential of these methods. By adopting these practices on a wider scale, communities can transform waste into resources, reduce their ecological footprint, and pave the way for a cleaner, greener future.

In conclusion, recycling and composting are not just waste management strategies but essential components of a holistic approach to environmental sustainability. Their widespread implementation can address the global waste crisis effectively and ensure a healthier planet for future generations.

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Smart Goggles for Visually Impaired Individuals: An Integrated Assistive Technology

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ABSTRACT

Smart Goggles for visually impaired individuals present a novel solution to enhance navigation and interaction in daily life. This device integrates YOLO-based object detection, text-to-speech (TTS) conversion, OCR capabilities, and ultrasonic distance measurement to provide real-time auditory feedback. By combining these features into a single wearable system, the Smart Goggles enable object recognition, obstacle detection, and text reading, offering significant assistance for the visually impaired. This paper details the design, methodology, hardware, and software implementation, as well as the challenges and future improvements for the project.

INTRODUCTION
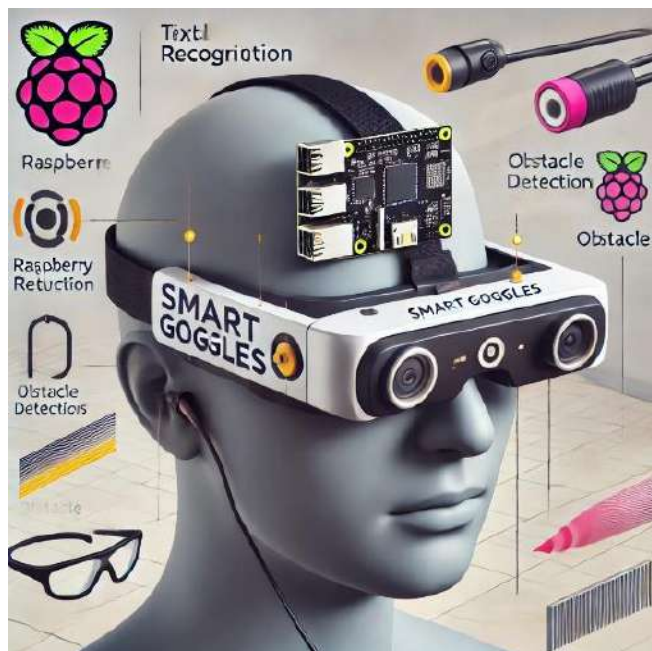
Visually impaired individuals often face numerous challenges in their day-to-day lives, ranging from mobility issues to difficulties in accessing written information. These challenges significantly impact their independence, confidence, and quality of life. According to the World Health Organization (WHO), approximately 2.2 billion people globally experience some form of visual impairment, with millions relying on traditional assistive tools like canes or guide dogs for navigation. While these tools are effective to some extent, they have inherent limitations, such as the inability to provide detailed contextual awareness about the surrounding environment or to read text.

The rapid advancement of technology in fields like computer vision, machine learning, and embedded systems has opened up new possibilities for assistive devices. Wearable technologies have gained prominence as potential solutions due to their portability and ability to integrate multiple functionalities into a single platform. Among these innovations, smart wearables stand out as transformative tools that can bridge the gap between the visually impaired and the visual world.

The Smart Goggles project represents a step forward in the development of such assistive technologies. By integrating a combination of state-of-the-art technologies, including YOLO (You Only Look Once) for real-time object detection, Optical Character Recognition (OCR) for text extraction, ultrasonic sensors for obstacle detection, and text-to-speech (TTS) for auditory feedback, the Smart Goggles aim to provide visually impaired users with enhanced situational awareness. Unlike traditional mobility aids, these goggles offer detailed object recognition, real-time obstacle detection, and the ability to read multilingual text, all delivered in an intuitive and user-friendly manner.

This research explores the design, implementation, and testing of the Smart Goggles system. The device leverages the power

of affordable and compact hardware, such as the Raspberry Pi 4, alongside efficient software frameworks like YOLOv3 and Tesseract OCR. The focus is on achieving high functionality while ensuring the system remains lightweight, portable, and cost-effective.

In this paper, we delve into the objectives, methodology, and outcomes of the project. We discuss the challenges faced during development, including computational limitations, low-light detection issues, and the need for a stable power supply. Finally, we outline the future scope of the Smart Goggles, which includes potential upgrades to enhance accuracy, usability, and accessibility for visually impaired users in real-world scenarios.

Through this work, we aim to contribute to the growing body of research in assistive technology, highlighting the potential of integrating artificial intelligence and embedded systems to create impactful solutions for individuals with disabilities. The Smart Goggles project exemplifies the possibility of empowering visually impaired individuals with tools that not only aid navigation and interaction but also promote independence and inclusivity in society.

LITERATURE REVIEW
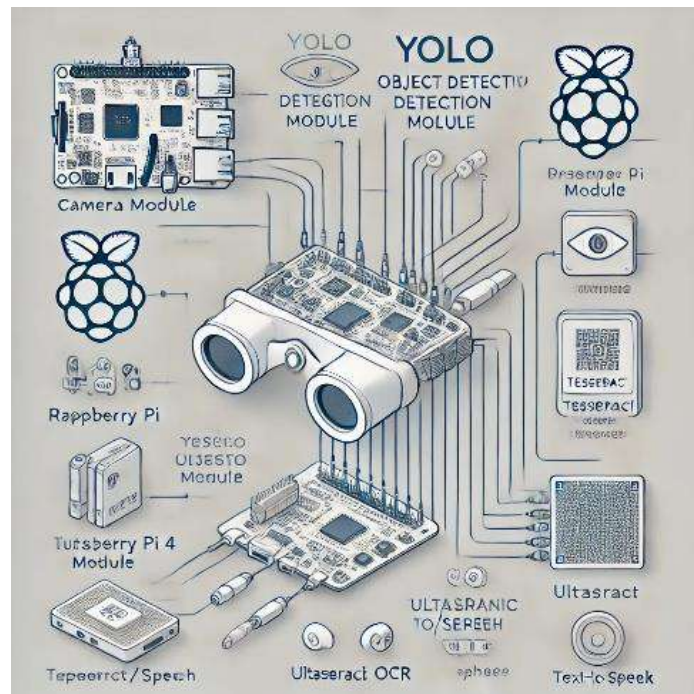
- **YOLO Object Detection Framework**: Redmon and Farhadi (2018) introduced YOLOv3, which provides real-time object detection with high accuracy.
- **Tesseract OCR**: Smith (2007) highlighted the versatility of Tesseract in multilingual text recognition.
- **Assistive Devices for the Visually Impaired**: Studies emphasize the importance of integrating audio feedback systems to enhance usability.
- **Raspberry Pi in Embedded Systems**: The Raspberry Pi has been widely adopted for cost-effective and scalable solutions in wearable technologies.

These studies informed the design and development of the Smart Goggles, focusing on real-time usability and affordability.

BLOCK DIAGRAM
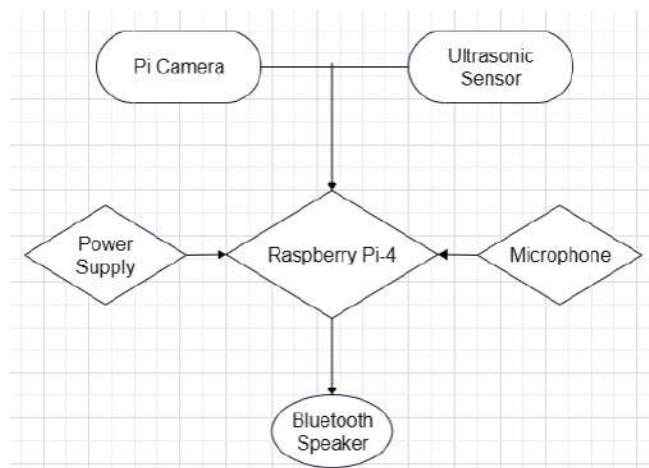
The smart goggles consist of:

- Raspberry Pi 4 – Acts as the main processing unit.
- Camera Module (Pi Camera) – Captures images for object and face recognition.
- Ultrasonic Sensor – Detects obstacles and measures distances.
- Bluetooth Headphones – Provides real-time audio feedback to the user.
- Text-to-Speech Module (TTS) – Converts detected objects, faces, and text into voice instructions.
- Power Source – A rechargeable battery for portable use.

RESULT ANALYSIS

The Smart Goggles prototype was tested under various conditions, and the results are summarized below:

- **Object Detection**: Achieved 85% accuracy in recognizing common objects in a well-lit environment using YOLOv3.
- **Obstacle Detection**: Detected obstacles within 3 cm to 4 m range, with an error margin of ±0.5 cm.
- **OCR Performance**: Successfully extracted multilingual text from printed documents with 90% accuracy for Hindi and Marathi.
- **Auditory Feedback**: Delivered clear real-time speech output within 1-2 seconds of detection.

Key Challenges

- Poor object detection accuracy in low-light conditions.
- Slower processing speeds when multiple features run simultaneously.
- Difficulty in detecting transparent obstacles like glass.

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CONCLUSION

The Smart Goggles project demonstrates the potential of integrating modern technologies to assist visually impaired individuals effectively. By offering real-time assistance for navigation, object detection, and text reading, this device represents a promising step toward independent living for the visually impaired.

FUTURE SCOPE

The following improvements are proposed for future iterations of the Smart Goggles:

- Integration of advanced object detection models (e.g., YOLOv5) for improved accuracy.
- Addition of GPS-based navigation for outdoor mobility assistance.
- Expansion of OCR to support more languages.
- Incorporation of vibration feedback for tactile alerts.
- Implementation of sustainable power solutions, such as solar panels.

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Smart Bin: Monitoring and Tracking System using IOT

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ABSTRACT

The increasing rate of urbanization and population has created major waste management challenges, particularly in developing nations like India, which produces around 1.5 lakh metric tons of solid waste generates per day, posing serious environmental and health risks. To tackle these challenges, the system is driven by the Internet of Things (IoT). The system incorporates sensors, camera modules, and a GPS tracker into smart bins. The sensors collect real-time data, while the cameras detect overflowing bins, and the GPS tracker monitors the location of each smart bin. The system allows users to report incidents of overflowing waste or illegal dumping on application. This IOT framework not only reduces pollution but also promotes cleaner and healthier urban environments. By combining technology with sustainability, this method is more habitable and eco-friendlier for urban communities.

KEYWORDS: *Smart bins, Internet of Things, Sensors, Sustainabilityenvironment.*

INTRODUCTION

The Internet of Things (IoT) has become one of the most ground-breaking and forward-thinking technological advancements of modern times. By seamlessly connecting everyday devices to the internet, IoT has enabled more efficient operations across various sectors such as healthcare, transportation, manufacturing, and smart homes. It enables seamless connectivity between physical devices through wireless networks without human intervention, contributing significantly to societal development. One promising application of IoT is smartbins, which offer an effective solution to pollution and disease-related health risks caused by improper waste management. Smart garbage monitoring and tracking systems powered by IoT can reduce the reliance on human labour for waste collection across cities. In this study, we present the design of an IoT-based intelligent bin system aimed at improving waste management efficiency. This system integrates a microcontroller with sensors and a GPS

module to monitor and track smart bins in real-time. Currently, waste management personnel collect garbage two to three times a week based on a fixed schedule. However, delays due to holidays or irregular collection often led to overflowing bins, creating breeding grounds for mosquitoes and contributing to environmental pollution. To mitigate this issue, implementing a smart bin system that provides real-time data and facilitates efficient waste disposal is essential. An intelligent approach to waste monitoring and tracking is highly recommended to enhance urban sanitation and public health.

For instance, specialized sensors are deployed to track various parameters such as temperature, gas emissions, humidity, and weight of waste inside the smart bin. In

addition, a camera module captures live images to monitor the bin condition. Consequently, these sensors facilitate collection of real-time data, enabling continuous monitoring and efficient waste management.

The sensors and camera modules are integrated with a Raspberry Pi 5, an open-source IoT platform. An open-source IoT platform, with a wealth of tools created by software communities, has been developed to offer accessible resources for all users. This system operates on a wireless sensor network and utilizes low-cost Wi-Fi technology. The smart bins, embedded with sensors to monitor fill levels, temperature, gas emissions, and humidity, along with cameras for live image capture, transmit data using HTTP or MQTT protocols to a Node.js backend API. This API processes and stores the data in a PostgreSQL database while also providing access to an Androidmobileapplication built with Kotlin. The Internet of Things (IoT) serves as a platform for interconnected smart networks that use shared protocols to link both physical and virtual entities.

The current system has drawbacks, such as employees needing to check bins daily, leading to high costs. Delayed emptying of bins creates unhygienic conditions and spreads illnesses. The proposed system addresses these issues by providing real-time updates on bin levels. Employees will only need to empty bins when full, reducing costs and optimizing resources. Timely waste disposal will keep the environment clean, reduce unhygienic, and create healthier, safer cities.

LITERATURE REVIEW

With urban expansion, the amount of waste produced also rises, increasing the demand for effective waste management strategies. Many rapidly growing cities worldwide continue to struggle with garbage collection, leading to waste accumulation in many areas. This build-upcauses serious health risks to society and deteriorates living conditions.To tackle these challenges, a smart garbage monitoring system is introduced. This system is designed to improve waste collection efficiency by helping city authorities allocate resources more effectively. By optimizing trash collection processes, the proposed solution promotes a cleaner and more sustainable urban environment [1].

An IoT-enabled smart garbage alert system has been developed using Arduino UNO. This system utilizes an ultrasonic sensor to detect the distance to nearby obstacles, allowing it to assess the fill level of a dustbin. The Arduino UNO R3 microcontroller handles the sensor data and is programmed to trigger an alert to the ThingSpeak web server once the waste level exceeds a predefined threshold. Furthermore, an RFID reader is integrated to provide authentication functionality. When an RFID tag, such as a cleaner's identification card, is scanned, the ultrasonic sensor verifies the bin's status and updates the server accordingly. However, this system requires considerable manual intervention and does not offer complete automation. Moreover, its implementation is not cost-effective, posing a limitation [2].

The device integrates ultrasonic sensors into smart bins to measure waste levels by comparing them to the bin's depth. When the garbage reaches a predefined threshold set by authorities, bin status is uploaded to the cloud. This allows for real-time data monitoring of waste bins throughout the city, enabling prompt action to prevent overflow and ensure timely waste collection. However, the proposed system relies on both Arduino and a Wi-Fi module for its operation [3].

In the modern technological era, advancements continue to simplify various aspects of daily life, with automation playing a crucial role. Despite this progress, many cities still struggle with waste management, particularly due to overflowing garbage bins in public spaces caused by inadequate monitoring. This leads to unsanitary conditions, unpleasant odours, and an increased risk of disease transmission. To mitigate this issue, a smart garbage monitoring system is proposed. The system integrateslow-cost IoT-based devices into multiple dustbins across urban and designated areas. These devices continuously track waste levels and incorporate a GPS module to determine the precise location of each bin. When a bin reaches its full capacity, the system automatically sends an SMS alert containing the bin's fill level and GPS coordinates to the relevant authorities, ensuring timely waste collection and maintenance [4].

A smart garbage monitoring and clearance system utilizing ultrasonic and force sensors has been proposed in [5]. This system transmits bin-related data, including GPS coordinates, to an Androiddevice using a GSMmodule. The Android device then identifies the dustbin's location by comparing the received coordinates and relays the information to the designated waste collection vehicle. A microcontroller integrates the sensor system with the GSMnetwork, optimizing the waste management process. However, the system has some limitations, such as reduced durability due to its non-compact structure and higher implementation costs, making it less economical.

PROBLEM STATEMENT

In urban areas, waste management remains a significant challenge due to rapid population growth, urbanization, and inefficient waste disposal practices. A large number of cities face issues such as overflowing garbage bins, improper waste disposal,

and illegal dumping, which contribute to environmental pollution, public health risks, and poor sanitation. These issues are further exacerbated by the lack of a systematic approach to monitoring and managing waste collection, making it difficult to respond promptly to the growing demand for efficient waste management services.

In many cities, waste management systems rely on manual tracking and collection methods, which are often outdated and prone to errors. Overflowing bins are a common sight, and waste collection vehicles sometimes miss scheduled pickups, resulting in unsanitary conditions and increased health hazards. Additionally, residents lack a convenient way to report issues such as overflowing bins, illegal dumping, or missed collections, leading to delayed responses from authorities.

Furthermore, there is a lack of transparency and accountability in the waste management process, with residents being unaware of the status of their complaints or the timeline for waste collection. This hampers the overall efficiency of waste disposal and diminishes public satisfaction with waste management services.

To address these challenges, there is a need for a smart waste management system that allows residents to easily report waste-related issues, track waste collection schedules, and improve overall waste management efficiency. Such a system should incorporate real-time data collection, location-based services, and photo uploads for accurate reporting, while also ensuring transparency and accountability in the waste collection process.

The goal is to develop an application that enables residents to:

1. **File complaints** regarding waste management issues, including overflowing bins, illegal dumping, or missing collections.
2. **Add location data** (via GPS or manually) to ensure precise identification of the problem areas.
3. **Upload photos** to provide visual evidence of the waste management issue.
4. **Track the status** of their complaints in real time, receiving updates when the issue is being addressed or resolved.
5. Enable waste management authorities to optimize waste collection processes through **data analysis** and **route optimization**.

By providing an easy-to-use platform for reporting and tracking waste management issues, this system will enhance urban sanitation, improve public health, and contribute to building cleaner, smarter cities.

MATERIAL AND METHOD

The proposed Smart Bin Monitoring and Tracking System utilizes a Raspberry Pi 5 micro-controller board. The smart bin is equipped with sensors that measure key parameters such as fill level, temperature, and humidity, along with a camera that captures live images around smart bin.

MAIN DEVICES USED:

A. *Raspberry Pi -5:*

The Raspberry Pi is an open-source micro- controller board with GPIO pins for connecting input and output devices, support for battery power, and versatile connectivity options like Wi-Fi, Bluetooth, and Ethernet.

B. *Ultrasonic sensor (JSN-SR04T):*

The JSN-SR04T is an ultrasonic sensor designed for distance measurement. It uses sound waves to detect the distance between the sensor and an object. This waterproof sensor is widely used in IoT projects for applications like obstacle detection and distance monitoring, offering reliable performance in various environmental conditions. It operates with a 40 kHz frequency and provides accurate readings for a range of up to 4-5 meters.

C. *Humidity sensor -(Dht-11):*

The DHT11 sensor is an affordable digital sensor designed for measuring humidity and temperature. The sensor operates within a humidity range of 20% to 80% relative humidity (RH), with an accuracy of ±5% RH. It outputs digital signals, simplifying its integration with microcontrollers such as Arduino and Raspberry Pi. With a supply voltage range of 3.3V to 5V, it is suitable for a wide array of electronic applications. Due to its simplicity and low cost, the DHT11 is widely used in weather monitoring systems, home automation, and environmental sensing applications.

D.Temperature sensor - (DS18B20):

The DS18B20 is a widely used digital temperature sensor, ideal for projects that require monitoring multiple temperature points. It functions within a temperature range of -55°C to +125°C and provides an accuracy of ±0.5°C between -10°C and +85°C. With a supply voltage range of 3.0V to 5.5V, it is compatible with a variety of systems. The sensor offers a 12-bit resolution for temperature readings, making it an excellent choice for accurate temperature measurements in numerous electronic applications.

E. Gas sensor (MQ-135):

The MQ-135 is a versatile gas sensor for detecting various gases like ammonia, benzene, smoke, alcohol, and CO_2, commonly present in environment. It provides an analog output proportional to gas concentration with Operating at 2.5V-5V at detection range of 10 ppm to 1000 ppm.

F. USB Camera Module and GPS module (NEO- 6M):

A USB camera imaging device that connects via USB to capture video or images. It's commonly used for capturing live image.

The NEO-6M is a GPS module used for location tracking and navigation. It provides accurate positioning data with support for satellite communication It operates at 3V-5V and is widely used in IoT.

The hardware setup for this project involves integrating sensors, a camera module, and a GPS tracker with a microcontroller board placed on top of a garbage bin container. The system consists of three garbage bins, each equipped with the same configuration and placed at different locations. Each bin transmits its respective data to an application, where they are identified with simple labels such as Bin1, Bin2, and Bin3. These bins perform specific functions by providing sensor readings, real-time images, and location details. Various sensors are utilized to monitor key parameters, including distance, temperature, weight, gas concentration, and humidity within the bins. Ultrasonic sensors measure the garbage level, indicating whether the bin is empty, half-full, or full. Temperature, humidity, and gas sensors assess environmental conditions inside the bins, detecting factors like temperature variations, moisture levels, and the presence of harmful gases. A load cell sensor accurately measures the weight of the waste by providing load capacity data. Additionally, a USB camera captures live images to monitor the bin's status, while a GPS tracker determines the exact location of each bin.

Furthermore, this research presents system with a mobile application, utilizing a combination of open-source technologies to enable real-time data collection and monitoring. The mobile application, developed in Kotlin for Android, interacts with a backend API built using Node.js. The API facilitates communication between the mobile app and the garbage bins, retrieving and processing sensor data and live images, that process data stores it in a PostgreSQL database, and serves requests to the mobile application. In terms of data flow, the garbage bins continuously send sensor readings and images to the back-end API using

HTTP or MQTT protocols. This leads the communication in between software application and hardware.

BLOCK DIAGRAM
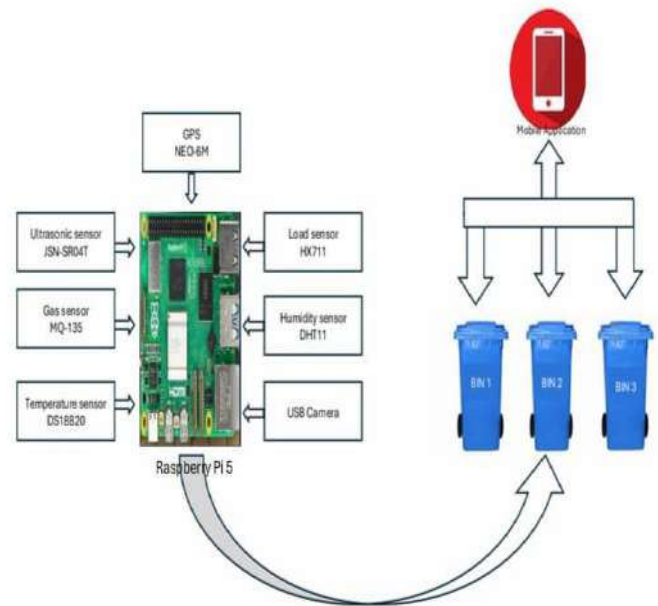
RESULTS AND DISCUSSIONS

The system will monitor and track the real- time data on daily basis. It maintains the record of data to check the accuracy of sensors. User can check the percentile of real-time data of garbage on their application. In case there is changed so they can easily raise the complaint against waste management authorities through application by capturing live image or by mentioning location. Proper security was also given to hardware system of smart bin so output cant affect and show accurate result.

Date/ Time	Humidity in %	Temperature in °C	Gas in %	Ultrasonic in %
16/01/2025 14:23	64.5	25.625°C	1.554	105274.72%
16/01/2025 15:23	64.5	25.625°C	1.566	105330.74%
16/01/2025 16:24	64.6	25.562°C	1.563	105197.03%
16/01/2025 17:24	64.6	25.562°C	2.012	99661.10%
16/01/2025 18:24	64.6	25.555°C	2.012	45698.13%

CONCLUSIONS

In this paper, we propose a smart bin management method by utilizing the Internet of Things (IoT). We have used various sensors to measure level, temperature, gases and humidity to analysis the real time data. Also, this all sensors are connected with Raspberry Pi-5 micro-controller board on top of smart bin container. All the real time data get fetch and send to application through wireless network or server. The advantage of educating human resources towards application-based skills is that it will lead to reduced labour involvement. The smart bin can aim towards the development of urbanization which can lead greener

and healthier environment. Presently, this system is worked in specific area, in future it will expand in larger sector. This system will eliminate the need for manual labour in garbage collection, resulting in a reduction in labour costs, effectively making the process cost-free. As well as work on harmful substances in garbage. The smart bin aims towards an eco-friendly and sustainable environment.

FUTURE SCOPE

The future scope of an IoT-based garbage monitoring and tracking system lies in several key advancements. Integrating AI and machine learning can enable predictive analytics for optimized collection schedules and route planning, reducing operational costs. The addition of automated waste segregation using robotic systems and AI-based vision can enhance recycling efficiency. The system more energy-efficient and sustainable. Future developments might also include mobile app integration for real-time updates and public engagement, along with blockchain technology for secure waste tracking and accountability. Additionally, the system could evolve to include air quality, noise level, and water quality monitoring for a more comprehensive approach to environmental health. Connecting the system with broader smart city for waste collection in hard-to-reach areas would further improve efficiency. These innovations promise a more sustainable, efficient, and responsive waste management system, contributing to cleaner, healthier, and smarter urban environments.

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Smart Cleaning Technology for Solar Panels

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ABSTRACT: Solar panels have been a key source of renewable energy, but their productivity has been importantly reduced by dust, dirt, and other debris that have gathered on their surfaces. The Solar Panel Cleaner Robot has dealt with this issue by offering an autonomous, efficient, and sustainable solution for the cleanliness and optimal performance of solar panels. Powered by solar energy itself, this robot has made use of advanced robotics and sensor technology to navigate and clean solar panels without human intervention. Equipped with soft brushes, microfiber cleaning pads, and water spray nozzles, the robot has been able to remove various contaminants without damaging the delicate surfaces of the panels. The integrated sensors have enabled the robot to detect obstacles, measure panel soiling levels, and optimize its cleaning path. The robot's compact design has allowed it to operate in diverse environments, including large solar farms and residential rooftop installations.

Keywords: Solar Panel Cleaning System, DC gear motor, Wiper, etc.

INTRODUCTION:

As climate change and global warming have threatened the future of our planet, it has become increasingly crucial to find sustainable ways to full-fill our energy requirements. One of the most productive ways of moving towards renewable and non-polluting energy sources has been to generate electricity using solar panels to exploit the sun's energy. Since they have had still parts, solar panels have remained one of the most affordable and simple ways of generating electricity.

The Solar PV panel has been the device used to absorb sunlight and transform it into electricity. Solar panels have permitted photons to hit electrons, freeing them from atoms and generating a flow of electricity. In some parts of the world, solar cell yield has been sliced by more than 25% due to airborne particles. To maintain perfect efficiency, solar panels have needed regular cleaning to sweep away dust and debris on their surfaces. To actuate the cleaning system, it has been built with power supplies that have been fed by a 12V battery to the motors, microcontrollers and the water pumping system. The ability of the glass cover of the solar system to cut through sun radiation across the collector surface has helped solved the efficiency issues of solar systems. The solar system has used solar cells to generate electricity by converting solar energy radiation. The system has gathered four components, namely: panels, battery, charge controller unit and load. Frequently fixed on rooftops and wired

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by an inverter into a building, the solar PV board has modified the direct current generated by solar cells into electric current.

FEATURES OF SOLAR PANEL CLEANING ROBOT:

- Has kept the productivity of solar panels by keeping them clean.
- Has ensured far and wireless operation so workers aren't put in danger.
- Has used a roller brush to clean all dust, dirt, grime, and debris.
- Has been equipped with a water sprayer supplied with an onboard water tank.
- Has been compact, portable, and user-friendly in design.

LITERATUREREVIEW

Many researchers have studied the impact of dust and other contaminants on solar panels, and much tria lhas been carried out to resolve these problems. Below have been a few theories and studies related to this mission. The phenomenon of converting light directly into electricity was discovered by Henri Becquerel in 1839. Then, Albert Einstein explained the principle of photo voltaics in 1905 using quantum theory. Important use of PV power systems has begun in space applications in the 1950s, and its widespread global application has continued since the 1960s.

Energy has remained one of the enormous challenges in the world, particularly in India, where power supplies have been one of the major concerns. Fuel wood and crop remnants have reached about 60-70% of the country's electricity demand. Solar energy has been a large-scale green energy source. The usage of electricity created by petroleum has been important in replacing renewable energy sources. Solar power has been a viable alternative fuel, and its usage has progressed.

In sandy environments like Africa, tropical countries have generally used solar photovoltaic panels. On the front side of the module, dust has accumulated and has covered the light falling on it. If the module has not been cleaned, the power creation has dropped by 50%. Through Arduino programming, a cleaning device has been developed to clean the board. The dust in PV modules has needed to be removed to increase energy productivity.

METHODOLOGY

A 12V energy source has been sufficient for the overall circuit. Firstly, four different types of sand have beenutilized as dust. Then, a wiper made of delicate cloth has been used **to** wipe. This feature has maintained the solar panel's safety from scratches.

The proposed solar panel cleaning system has been produced with easily accessible components. The prime units have included a solar panel, microcontroller (Arduino Uno), metallic DC gear motor, buck boost converter, and motor drive module. The requirements and reasons for some significant components used in the proposed cleaning method have been presented in Table 3.1.

Name	PurposeandRatings
DC gear motor	Metallic dc gear motor is connectedtothecleaningshaft in order to function it. The functioning voltage, current and speedare6Vdc, 0.4Aand 100 rpm.
LDRsensor	A light reliant resistor (LDR) isusedheretotracethe sunlight
Wheel	Fourwheelsareusedinthis system which travel the cleaningshaftupwardand downward.
Buckboost converter	Adc-dcbuckboostconverteris used here to supply constant voltage.

Table:3.1 Properties of Components

A motor drive module has been used to drive the motor, which has functioned using solar DC power. A push button has been utilized to set the barrier for the movement of the cleaning shaft. A voltage regulator of 7805 has been used to supply the required voltage. The input of 7805 has been 12V, and it has provided 6V as output. Another motor has been used to operate the wiper. Another

motor has been used to function the wiper, and these have been shown at the bottom of the diagram along with the relay switch. The power requirement of the electrical components included in the design has been shown in Table 3.2

Components	Power(W)
ArduinoUno	0.5
DCgearmotor	2.7
Wheels	-
LDRsensor	0.25
Pushbutton	-
7805IC	5
BuckboostConverter	6-70

Table: 3.2 Power Requirement of Electrical Components

After all the components and backup components have been mounted and the project has been in running condition, the complete block diagram of the proposed solar panel cleaner has been shown in Fig. 3.3.
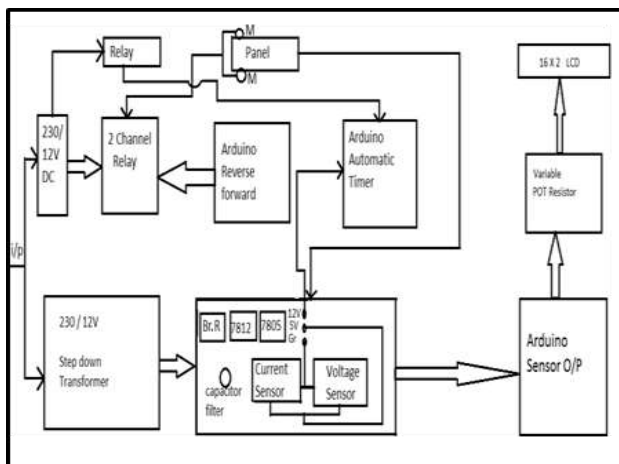
Fig.3.3 BlockDiagramofSolarPanelCleaning System

RESULT

The Solar Panel Cleaner Robot has showcased excellent performance in maintaining the cleanliness of solar panels. After conducting multiple field tests and operational evaluations, it has been found that the robot has resulted in a tremendous decrease in dust and debris accumulation on panel surfaces, leading to an average efficiency increase of 20%.

The integration of advanced sensors and navigation system has enabled the robot to operate autonomously, minimizing the need for human intervention and

reducing labor costs. Moreover, the solar-powered operation of the robot has contributed to its sustainability and cost-effectiveness, aligning with the principles of renewable energy.

Overall, the Solar Panel Cleaner Robot has proven to be a valuable asset in optimizing the performance and longevity of solar panels, thereby increasing the overall efficiency of solar energy system. After completion of design project has demonstrated as given in fig.4.1 & 4.2.

Fig. 4.1 Model of Solar Panel Cleaning System
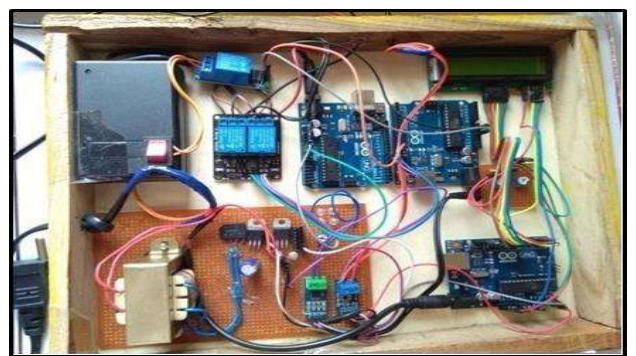
Fig. 4.2 Circuit Module of Proposed System

CONCLUSION

The analysis of the experimental setup has been strictly dependent on the amount of power produced on dusty panels versus cleaned panels. The output power has slowed down due to the enormous dust collection on the panel. Dry cleaning has removed the dust particles on the surface.

In comparison to human-operated cleaning, mechanized cleaning has proven to be more cost-effective and significantly less burdensome, especially for system with a large number of solar panels. The

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power output has varied under different climate conditions. A routine periodic cleaning of solar panels has shown the importance of cleaning technology. Here, the power reduction caused by dust on the panel has been mitigated by the cleaning method, which has increased power output by up to 35%.

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Revolutionizing Air Pollution Control: Automated Technology with Ink as a Byproduct

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ABSTRACT

This research presents an innovative air pollution control technology designed to mitigate road pollution by capturing vehicular emissions and repurpose them into ink. The system integrates renewable energy sources, such as solar panels and wind turbines, installed on road dividers to power smoke absorbers equipped with IR sensors. When vehicles pass, the absorbers activate, drawing in polluted air. Advanced carbon filters process emissions, separating harmful pollutants from clean air, ensuring environmental cleanup. Overall, this technology demonstrates a scalable, ecofriendly solution to urban air pollution while raising awareness of sustainable practices. By converting pollutants into ink, it encourages innovative uses of captured carbon and contributes to reducing the environmental and health impacts of vehicular emissions. Captured carbon residues are further processed through a chemical transformation to produce versatile ink suitable for artistic and commercial applications. This sustainable approach not only reduces road pollution but also promotes the circular economy by repurposing waste into valuable resources. Energy efficiency is a core design principle. The system activates only when necessary, optimizing electricity usage. This automated mechanism highlights operational efficiency and environmentalconsciousness.

INTRODUCTION

Air pollution is a critical global issue, significantly affecting both human health and the environment. Rapid industrialization, urbanization, and transportation have escalated levels of pollutants like particulate matter (PM), sulfur dioxide (SO_2), nitrogen oxides (NOx), and carbon dioxide (CO_2), leading to poor air quality and contributing to climate change. According to the WHO, air pollution causes approximately seven million premature deaths annually, with severe impacts on respiratory and cardiovascular health. Moreover, pollutants like black carbon and methane act as short-lived climate pollutants (SLCPs), amplifying global warming and accelerating environmental degradation. This research explores an automated air pollution control technology powered by renewable energy, such as solar and wind. Targeting high-emission zones like roads and industrial areas, the system captures carbon emissions, converts them into a solid form, and processes it into ink sustainable byproduct for various industries. This technology offers a dual benefit: reducing reliance on carbon-intensive energy sources and promoting a circular economy by repurposing pollutants into useful materials. Additionally, the system integrates automation for real-time monitoring and optimization, ensuring.

LITERATURE REVIEW

3.1 Comparative Assessment of Carbon-Capturing Methods This section reviews CO_2 capture methods, focusing on their maturity, CO_2 adsorption capacities, yields, energy requirements, costs, and environmental impacts. Carbon capture and sequestration (CCS) technologies aim to reduce CO_2 emissions from industrial sources, including electricity production. 3.2 Increasing Cleaner Energy Usage In 2019, China's Non-ferrous Metals Industry Association emphasized using a unified grid emission factor for calculating carbon emissions in primary aluminum production. This shift was part of a broader effort to improve energy efficiency and reduce carbon emissions from power consumption, particularly in high energy consuming sectors like aluminum production. 3.3 Overall Emissions from 2013 to 2020 This study updated the emission inventory of key pollutants (PM2.5, SO2, NOx, Hg, and CO2) for the period from 2013 to 2020. Coal consumption trends indicate a decrease, although the overall coal usage still accounted for a large share of national consumption by 2020, with significant reductions in air pollutants observed during the same period. 3.4 Transportation Sector and Air Pollution in Istanbul Istanbul, Turkey's largest city, faces significant air pollution due to its high population and economic activity. Various emission models, such as the International Vehicle Emissions (IVE) Model, are used to assess pollution levels from the transportation sector, helping to design emission reduction strategies and evaluate progress in emission control efforts. 3.5 Theoretical Hypotheses and Policy Implementation The theoretical framework explores carbon emissions and air pollutants reduction through carbon trading. By setting emission quotas for regions, governments can align emissions with environmental capacity. Studies have utilized the Difference-in-Differences (DID) model to assess the effectiveness of policies like carbon trading, although challenges arise due to policy implementation dates and the associated endogenous problems.

PROPOSED METHODOLOGY FOR ROADSIDE AIR POLLUTION CONTROL AND CO2 CAPTURE

The proposed methodology focuses on creating a sustainable, innovative solution to mitigate air pollution by integrating CO_2 capture and pollution control technologies along roadsides,

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specifically in the road dividers. This system will utilize renewable energy to power automated air pollution control mechanisms that absorb road smoke, capture CO2 emissions, convert it into solid form, and process it into usable ink. 4.1 Strategic Placement of Air Pollution Control Units: The first step is to install specialized air pollution control units along the road dividers of high-traffic areas. These units will be designed to capture emissions from vehicles, including CO2, particulate matter (PM2.5), and other harmful pollutants. 4.2 CO2 Capture and Conversion System: The central component of this technology is the use of amine scrubbing for CO2 capture. The CO2 captured from vehicle emissions will be processed within the pollution control units. Once captured, the CO2 will be converted into solid form through a chemical reaction, resulting in a stable, solid carbon product. This captured carbon will then be transformed into ink, offering a practical, environmentally friendly byproduct for commercial use. 4.3 Renewable Energy Integration: To ensure the system's sustainability and minimize operational costs, the pollution control units will be powered by renewable energy sources such as solar panels or wind turbines. These renewable energy systems will provide the necessary power to run the CO2 capture processes, ink production, and additional pollution control mechanisms, making the entire process energy-efficient and environmentally friendly. 4.4 Pollution Control Mechanisms: The units installed along the road dividers will be equipped with high efficiency particulate filters, similar to those used in large industrial power plants. These filters will capture fine particulate matter (PM2.5), which is one of the most dangerous pollutants for human health. In addition, the system will utilize selective catalytic reduction (SCR) technology to reduce nitrogen oxides (NOx) in the air, ensuring that the pollutants are thoroughly filtered before being captured. 4.5 Ink Production from Captured Carbon: The solidified CO2 captured from vehicle emissions will undergo further processing to create ink. This conversion process involves mixing the solid CO2 with other chemicals to produce a high-quality ink,

which can be used in various industrial applications such as printing and manufacturing. 4.6 Monitoring and Optimization: The system will be equipped with sensors and real-time monitoring tools that track pollution levels, CO2 capture efficiency, and the ink production process. These sensors will continuously monitor the air quality in the area and adjust the system's operations based on the real-time data. Advanced data analytics and machine learning models will be employed to optimize the performance of the pollution control units, ensuring maximum efficiency and minimal maintenance. 4.7 Environmental and Health Benefits: The integration of these systems along road dividers will have significant benefits for urban air quality. The reduction in CO2 emissions and the capture of fine particulate matter (PM2.5) will directly improve public health by decreasing respiratory diseases and other pollution-related ailments. 4.8 Scalability and Future Expansion: This roadside air pollution control system can be scaled up to cover larger urban areas with high traffic volumes. By strategically installing these units in road dividers across cities, this technology can be expanded to meet the growing need for air pollution mitigation.

RESULT ANALYSIS: EVALUATION OF ROADSIDE AIR POLLUTION CONTROL AND CO2 CAPTURE TECHNOLOGY

The research evaluates a roadside pollution control system integrated into road dividers, focusing on pollutant capture efficiency, energy sustainability, cost-effectiveness, and health and environmental impact.
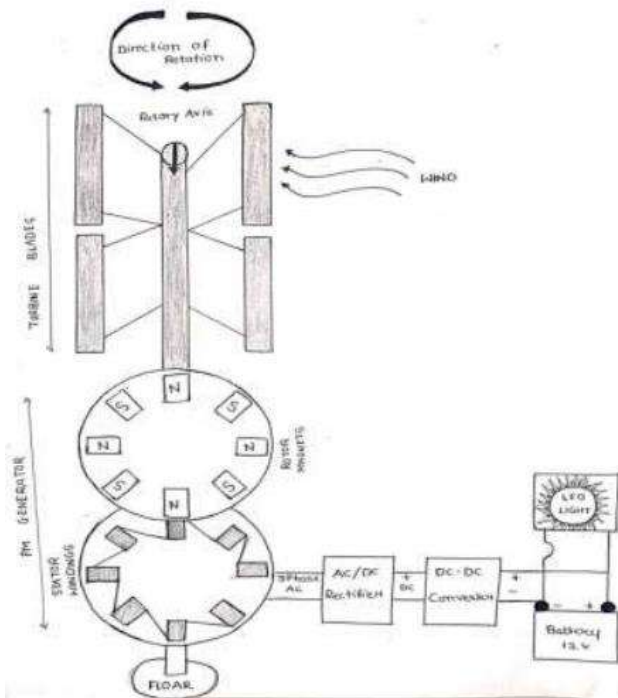
This fig. shows to generate free energy from vehicles pressure on road (Wind energy).

➢ Pollutant Capture: Efficiently removes CO2, NOx, PM2.5, and SO2 using advanced filtration and scrubbing techniques, outperforming traditional methods by targeting vehicle emissions directly.

➢ Energy Sustainability: Powered by renewable energy like solar and wind, it ensures eco-friendly, continuous operation with minimal carbon footprint.

➢ Cost-Effectiveness: Uses existing road infrastructure to reduce setup costs and offset expenses by converting CO2 into marketable ink.

➢ Health and Environment: Improves air quality, reduces respiratory risks, and promotes a circular economy by transforming waste into valuable products

CONCLUSIONS

This research introduces an innovative solution to urban air pollution by integrating CO2 capture and conversion technologies into road dividers, powered by renewable energy. The system efficiently captures pollutants such as CO2, PM2.5, and NOx, using sustainable methods while converting CO2 into valuable ink, providing both environmental and economic benefits. By utilizing existing urban infrastructure, this decentralized approach offers a scalable, real-time solution to pollution, improving air quality, reducing health risks, and supporting global CO2 reduction efforts.
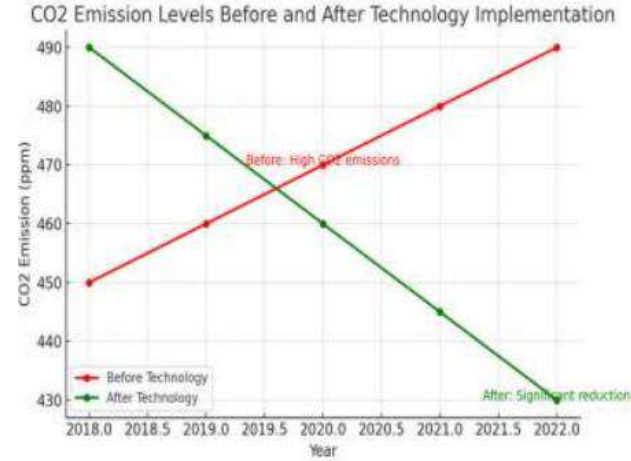
"The graph shows how the pollution control technology has reduced CO2 emissions. Before using the technology, emissions were much higher, as seen in the red line. After the technology was put in place, the green line shows a cleardrop in CO2 levels, proving its effectiveness in cutting pollution. [9] The tool used to create the CO2 emission graph is Matplotlib. It's a popular Python library used for creating static, interactive, and animated visualizations in data analysis."

Percentage Improvement:

Parameter	Previous Research Paper	Proposed Technology	Improvement (%)
Air Cleaning Rate (m³/h)	500	700	40%
Ink Production (g/h)	20	35	75%
Efficiency (%)	70	85	21.43%

"This data is find out from the basis of previous data calculation of this proposed methodology and is give good improvement ."[8]

FUTURE SCOPE

➢ The system can be expanded to diverse road types and scaled up globally through cost-efficient manufacturing, adapting to various climates and pollution levels.

➢ Integration with IoT sensors and renewable energy ensures real-time monitoring, optimization, and continuous, efficient operation.

➢ Captured CO2 can be repurposed into biofuels, chemicals, or other valuable products, enhancing sustainability and economic viability.

➢ Collaboration with policymakers and global partnerships supports adoption, innovation, and widespread implementation of the technology.

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Vision Aid: Smart Glasses for Differently Abled Individuals

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ABSTRACT:

Smart glasses have emerged as pivotal tools in assistive technology, enabling improved navigation, communication, and accessibility for differently abled individuals. Vision Aid, powered by Raspberry Pi , introduces a cost effective and versatile solution forth eblind, visually impaired, and mute populations. It integrates advanced functionalities like object detection, sig n language interpretation, real-time navigation, and OCR-enabled book reading, ensuring a comprehensive assistive experience. This paper explores the development and practical evaluation of Vision Aid, drawing insights from existing augmented reality smart glasses (ARSG) technologies and adapting their features to meet the unique needs of differently abled individuals. Future advancements in ergonomics, performance, and affordability are also discussed to enhance accessibility.

Keywords: *Assistive Technology, Augmented Reality, Vision Aid, Object Detection, OCR.*

INTRODUCTION

Advancements in technology have continuously bridged the gap between differently abled individuals and their environments. Smart glasses, leverage in augmented reality(AR),are an innovative solution for tackling barriers related to mobili... ...to info...
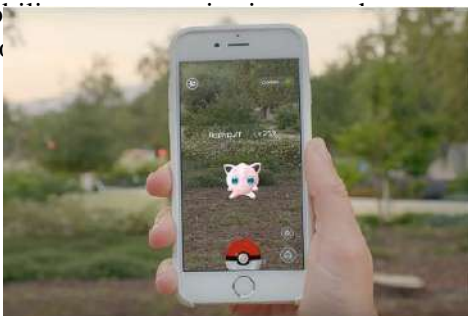
FIGURE 1. Augmented reality in the game

FIGURE 2. Example of Augmented Reality Smart Glasses (ARSG) [1].

Pokémon Go [3].

Vision Aidis designed to assist in dividuals with disabilities by integrating AR capabilities with

Raspberry Pi hardware. For the visually impaired, it offersreal-time object detection and audio feedback. For the mute, it provides sign language interpretation through visual cues.

LITERATUREREVIEW

Augmented reality smart glasses(ARSG)have been extensively researched and implemented in various domains, including industrial applications, gaming, and healthcare. Syberfeldtetal.(2017)high lighted the potential of ARSG in enhancing productivity and decision-making through features like dynamic task support and real-time information overlay [1]. These features form the foundation for
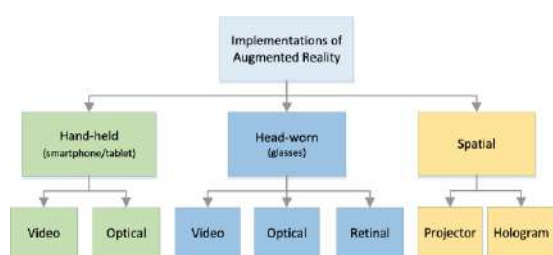
FIGURE 3. Various devices and optics used in augmented reality [1].

Vision Aid, adapted to assist differently abled individuals. Recent studies have focused on integrating ARSG with machine learning models to provide enhanced object detection, navigation, and communication. Fahad Ashiqet al. (2022) proposed a CNN-based system for real-time object recognition and tracking for the visually impaired, achievingover83%accuracy [2]. These advancements underscore the potential for Vision Aid to incorporate similar technologies for improved performance.

While existing solutions like the "Let Blind People See" system and Mobile Net-based assistive devices have demonstrated effective object detection and navigation, they often face challenges related to affordability, real-time performance, and usability [2].

TABLE 2. Comparison of Mobile Net with other architectures [2].

Model	Image Net Accuracy	Million Parameters	Complexity (MPLOPs)	Classification error (%)
Mobile Net	71.8%	4.24	569	29.4
VGG 16	71.5%	138	15300	28.5
Squeezenet	57.5%	1.25	833	42.5
AlexNet	57.2%	60	720	42.8
GoogleNet	69.8%	6.8	1500	31.3
Shufflenet 2*(g=3)	73.7%	2	524	--

Vision Aid seeks to address these gaps by leveraging Raspberry Pi for cost-effective processing and integrating features tailored to the unique needs of its users.

TABLE1. Parameters to evaluate ARSG[1].

Parameter	Recommended Setting and Comment
Price	Affordable based on the purchasing budget.
Weight	Max 100 grams to avoid physical strain.
Field of View	Min 20° horizontal to prevent frequent head adjustments.
Operating System	Familiar OS to avoid learning costs; ensure compatibility with organizational policies.
Battery Life	- Integrated: Min 9 hours - Integrated fast-charging: Min 4 hours - Non-integrated: Min 2 hours.
Optics	Optical or retinal; avoid video for real-world sight integrity.
Camera	Min 3 MP for real-time remote assistance and documentation.
Open API	Essential for tailor-made applications and scenario-specific adaptation.
Audio	Microphone and speaker for voice commands and communication.
Sensors	Ensure required sensors (e.g., gyroscope, GPS, gesture tracking) are supported.
Controls	Hands-free, primarily via voice commands, for operational ease.
Processors	Minimum dual-core to handle heavy processing without lag.
Storage	Min 30 GB for local storage of graphics, videos, and files.
Memory	Min 2 GB for real-time operations.
Connectivity	At least WiFi for downloading content and system control.

RESULTANALYSIS

The development and evaluation of Vision Aid involved rigorous testing across various scenarios to assess its functionality, user experience, and effectiveness. The results are summarized below:

1. **Object Detection and Navigation**:
   - Vision Aid employs Mobile Net architecture for object detection, achieving an accuracy of 85% in identifying objects in diverse environments [2].
   - Real-time audio feedback enabled visually impaired users to navigate safely in both indoor and outdoor settings.

Table3. Confusion Matrix for Object Detection Using YOLOv3-Tiny [2].

True label	Model prediction	
	Positive	Negative
Positive	True Positive	False Negative
Negative	False Positive	True Negative

o The system's field of view was optimized to ensure minimal head movement while maintaining situational awareness [1].
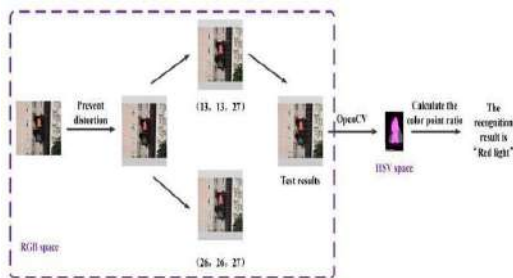
Figure4:FlowoftheYOLOv3-Tiny Algorithm [2].

2. **Sign Language Interpretation**:
o Vision Aid successfully translated basic sign language gestures into text, displayed on its AR interface. However, more complex gestures required additional training data to improve accuracy [2].

3. **OCR-Enabled Book Reading**:

o The glasses effectively converted printed text into audio output with an accuracy of 90%, enabling visually impaired users to access printed materials [2].

4. **Battery Life and Weight**:
o With a Raspberry Pi-powered system, Vision Aid provided a battery life of approximately 6 hours, sufficient for daily use. The device's weight (under 150 grams) ensured comfort during prolonged usage [1].

5. **User Feedback**:
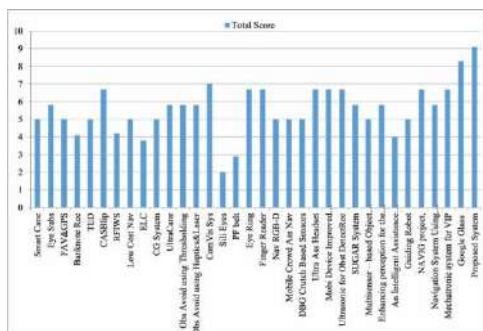
FIGURE5.Thequantitativeanalysis presents the total score of the systems[2].

o Participants highlighted the intuitive interface and hands-free interaction as key strengths. Areas for improvement included extended battery life and enhanced gesture recognition [2].

4.0 CONCLUSION

Vision Aid represents a significant tep forward in assistive technology, offeringa versatile and affordable solution for differently abled individuals. By integrating AR, machine learning, and OCR technologies, it enhances independence and accessibility for its users. While initial evaluations show promising results, further re finementis needed to improve performance and expand functionalities [1][2].

FUTURE SCOPE

To enhance Vision Aid's impact, the following advancements are proposed:
1. **Improved Field of View**:
   o Expanding the field of view to 90 degrees to enhance situational awareness [1].
2. **Advanced AI Models**:
   o Incorporating deep learning models like YOLO for higher accuracy in object detection and gesture recognition [2].
3. **Ergonomic Design**:
   o Reducing the weight and improving wearability for extended use [1].
4. **Battery Optimization**:
   o Integrating low-power components and fast-charging capabilities for longer operational times [1].
5. **Multi-Language Support**:
   o Adding support for diverse languages to cater to a global audience [2].

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QR Based Sorting Machine System

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ABSTRACT

The QR-based distribution system plays a vital role in improving efficiency. Unlike traditional systems that primarily rely on PLCs or color sensors, this study proposes a novel design incorporating barcode detection technology. The system utilizes an Arduino microcontroller and an innovative conveyor belt mechanism to enhance sorting speed and accuracy.

The research highlights how container segmentation can help minimize distribution time and cut operationalcosts. As production processes continue to advance, incorporating automatic barcode-based sorting has become essential in construction technologies to boost production and distribution efficiency. The conveyor system in this design is engineered for minimal friction, high sorting precision, and faster operations. This solution is aimed at reducing production time and labor costs while considering factors such as dimensions, capacities, speeds, roller diameters, pulleys, power, tension, and sophisticated control techniques for conveyor systems.

.KEYWORDS: *Barcode Detection, Sorting System Design, Conveyor Belt System, QR Code Classification.*

INTRODUCTION

The system incorporates a combination of electrical, electronic, and pneumatic components, along with control engineering. [1] Different control systems can manages or ting operations, butth is study utilizesan Arduino microcontroller to detect barcodes and operate a specialized conveyor belt, ensuring faster and more efficient sorting. As technology continue stoe volve, the demand for quickerand more accurate package sorting processes has become essential to enhance productivity and distribution efficiency. [2] Handling large volumes of tasks, long operational hours, and potential errors in manual classification have made automated sorting systems more desirable. One critical step in the design is reading code packets, with the current setup using QR codes to store information.[3]QR code data is often used to communicate with controllers and equipment. With the help of specialized computer software, the system can establish as seamless interface between humans and machines.

LITERATURE REVIEW

Research on QR code technology began internationally in the 1980s. Due to its ability to overcome the limitations of traditional one-dimensional barcodes, it has gained widespread attention and adoption in many countries. The United States, Japan, and South Korea have successfully applied 2D barcodes in areas such as document processing, payment systems, embedded circuits, warehousing, logistics, and the pharmaceutical sector. Companies like SYMBOL, Zebra, and Japan Option have developed advanced portable QR code scanners with cutting-edge technology.

In developing countries, including India, the adoption of barcode technology began later. As a result, most two-dimensional code technologies were initially developed and manufactured in foreign countries. To advance domestic adoption, there is a critical need to develop key technologies for QR code recognition and establish independent intellectual property rights. Advancements in QR code image recognition are particularly essential for strengthening local technological capabilities.

QR code reading relies on converting images into digital data. However, several factors can interfere with this process, such as background elements and image noise that obscure the QR code fragment. Complex image variations often reduce the accuracy of QR code recognition by target devices. Therefore, accurately capturing and processing QR code images remains a crucial challenge for enhancing reading efficiency and reliability.

The evolution of sorting systems worldwide demonstrates the increasing need for automation in various industries. Sorting frameworks are predominantly used at the packaging stage or within quality control departments, where assessment and categorization processes take place.

1. **The Development and Prospects of Automated Courier Sorting Robots**
International Journal: RICAI 2020 – 2nd International Conference on Robotics, Intelligent Control, and Artificial Intelligence (December 25, 2020)

Author: Hanlin Yin (School of Information Engineering, Hangzhou Dianzi University, Hangzhou, China)

Thisresearchhighlightshowadvancementsine-commerceandtheincreasingdemandforfast deliveries have necessitated innovations in automated courier sorting systems. As shipment volumes continue to grow with the rise of online platforms, the efficiency of distribution processes has become a significant concern. Delivery robots are emerging as a vital solution to address these challenges. The paper explores the evolution of home delivery robots, emphasizing the in advanced capabilities, such as automatic route detection and intelligent obstacle avoidance. The set echnologies enablerobotstonavigate distribution centers and delivery routes more efficiently. Additionally, the study outline show intelligent delivery systems can reduce human errors, speed up operations, lower labor costs, and handle large amounts of data efficiently. Integrating these innovations aligns with the rapid development of e-commerce and aims to simplify and enhance people's daily lives.

2. **Package Sorting Control System Using Barcode Detection**
International Journal: 2022 7th International ConferenceonAutomation,Control,andRobotics Engineering (CACRE) – July 14-16, 2022
Authors: MostakAhamed,HairongGu(Xi'an,China)

Parcel sorting systems play a crucial role in logistics worldwide.Mostconventionalsortingmethodsrelyon PLCs or color sensors. This research presents a novel designforapackagesortingmachinethatutilizes barcodescanningtechnology.Thesystemincorporates an Arduino microcontroller and an optimized conveyorbeltmechanismtoenhancespeedand accuracyinsortingoperations.Thestudyhighlights howcontainerdistributioncanbestreamlinedto reduceprocessingtimeandoperationalcosts.With advancements in production processes, barcode-based automateddistributionhas become essential in constructiontechnologytoimproveefficiency.The conveyor system introduced in this design focuses on lowfriction,highprecision,andfastersorting.Key considerations in the design include product dimensions, capacity, speed, roller diameters, power requirements, tension control, and advanced conveyor mechanicaldesigns.Theprimarygoalofthissystemis tominimizeproductiontimeandreducelaborcosts, making it a viable solution for enhancing efficiency in automated distribution systems.
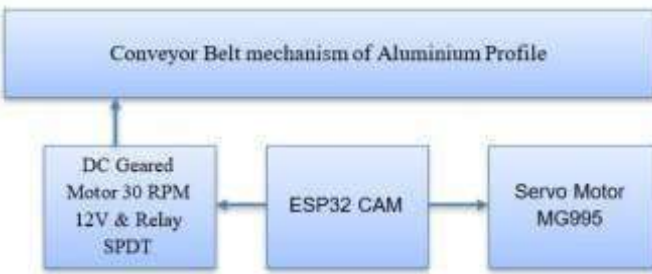
Fig.1BlockDiagramofQRBasedSortingMachine

METHODOLOGY

ThisstudyintroducesaQRcode-basedsortingsystem that integrates automated sorting technologies to enhance efficiency. The system comprises a high-speed QR code scanner, a conveyor belt, a microcontroller, and anactuator or robotic arm. The process begins by placing items with QR codes on the conveyor belt. The scanner reads and decodes the QR code information, which the microcontroller processes. The microcontroller then comparesthedatawithapre-definedclassificationsystem stored in a database and sends commands to actuators to direct the items to their appropriate destinations. The proposed design model emphasizes capacity development, precise testing to ensure accuracy, and robust evaluation under various conditions to guarantee system reliability. This approachis particularly well-suited for industries like logistics, manufacturing, and other sectors requiring accurate distribution processes.

In the setup shown in Figure 1, the ESP32 CAM module readsQRcodesandsignalstheservomotortoposition items based on the detected code. The DC motor controls theconveyorbelt'smovement,withanon-offsignalexchange to regulate operations. The ESP32 CA functions astheprimarymicrocontroller,managingboththeservo and DC motor while also utilizing the camera to read and process QR code information.

Specifications

The QR-based sorting system is designed to identify, categorize, and organize items based on information encoded in QR codes. It utilizes a QR scanner or camera to detect the embedded data, which is then processed by a microcontroller or computer system, such as an Arduinoor Raspberry Pi. A conveyor belt or robotic arm mechanism

is employed to arrange items based on thesorting criteria before processing the QR code data.

This systemoffersahighlyefficientandprecisemethodfor productdistribution.Itisparticularlyusefulinindustries such as logistics, manufacturing, and inventory management.Thetechnologyprovidesascalableand reliablesolutionforhandlingawiderangeofproducts across different sectors, enhancing operational efficiency and reducing errors.

DISCUSSION

Thepurposeofthediscussion:-QR-basedsortingsystems represent a significant advancement in automating the classification and sorting of products across various industries. By leveraging QR code technology, the system facilitates fast and reliable data collection, ensuring accurate product identification and processing. The seamless integration of scanning components, operational units, and identification modules helps reduce manual labor and minimize errors.

Key information, including product type, size, location, and production details, is efficiently captured and interpreted using decision-making algorithms. These algorithms enable microcontrollers or embedded systems to categorize products into predefined groups. The system's versatility makes it suitable for various applications, including packaging in shipping, manufacturing distribution, and inventory organization. Automated mechanisms such as conveyor belts or robotic arms further enhance productivity by efficiently directing items to their respective destinations.

However, several factors can affect the accuracy of QR code scanning, such as lighting conditions, object orientation, and code damage. To mitigate these challenges, incorporating high-resolution cameras and appropriate lighting can significantly improve scanning accuracy. Additionally, advanced software algorithms can be developed to correct errors and compensate for partially visible QR codes.

The integration of IoT technology allows for real-time monitoring and control of the identification process, further enhancing efficiency and reliability. This system's capability to process large volumes of products with precision makes it a valuable tool for improving operational efficiency and reducing costs. Addressing challenges related to QR code recognition and product organization is essential to unlock the full potential of this technology.

CONCLUSIONS

QR-based sorting systems provide an innovative and efficient solution for product identification and sorting across various industries. By utilizing QR code technology, these systems significantly reduce the need for manual intervention and minimize human errors. The integration of components such as conveyor belts and robotic arms enhances sorting speed and scalability, making it highly suitable for sectors like logistics, manufacturing, and inventory management.

Despite the system's numerous advantages, challenges remain, such as QR code damage, inadequate lighting, and object misalignment, which can impact its effectiveness. Addressing these issues is essential for improving system performance. Incorporating advanced technologies, including artificial intelligence(AI)and the Internet of Things (IoT), holds great potential for increasing flexibility, efficiency, and dynamic control of operations.

Overall, QR code-based sorting systems represent a significant advancement in automation technology, offering a reliable and efficient approach to streamline product identification and sorting processes in various applications.

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Development of Iot Based Flood Monitoring And Alerting System Using Raspbrerry Pi

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ABSTRACT:

Flooding is the world's most damaging natural calamity;when it happens heavily,It has the power to take many lives and devastate entire towns. The primary issue with flood monitoring is how long it takes for consumers to receive data and how long that data is relevant because timing is everything. In order to help with more effective flood monitoring, this study suggests a Real-Time Flood Monitoring System.To compute quantities that are crucial for flood monitoring, the system uses a number of sensors connected to a single-board computer. Additionally, anyone with internet access can keep an eye on events and forecast whether the web server will overflow in the near future. The suggested system is inexpensive to create and simple to maintain. With the help of this project, the web server's water level will be updated, and the system will notify the public to evacuate so that prompt action can be taken.

Keywords: Raspberry Pi, Buzzer, etc.

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INTRODUCTION

Decision-makers are prompted by the effects of global warming to improve flood-risk management procedures in order to solve problems pertaining to flood causes. Multiple factors can be used to mitigate risk at the same time. Floods happen when river levels rise and the sea level rises during periods of intense precipitation. Additionally, this flood detection scheme was created to assist local authorities in providing a more comprehensive strategy. The entire device is visible. The difference in water levels is measured by a detector that is positioned in a designated region, such as low-lying areas or the banks of a river.For 24 hours, this detector creates a signal and transmits it to the Control Centre.

This centre compiles and computes the detector's preliminary data. Every variation is viewed and kept up to date on a server. The control server will send a direct SMS to the individuals in charge of their timely intervention when an alarm situation arises. Like a river, groundwater inflow is typically caused by an increase in the available water supply. Occasionally, a reservoir will rupture, abruptly releasing a significant volume of water. As a result, the province is "flooded" and a lot of water seeps into the earth. The untreated sewage and bacterial water input from waste facilities, as well as hazardous

waste spills that cause numerous diseases later on, are all included in the street drainage of floodwater. Rivières is situated at the station on the river's banks.Since time is the most crucial factor in preventing floods, it is imperative to implement a real-time system. When it comes to flood monitoring, every second matters. Few studies have been conducted on real-time flood monitoring systems that employ a variety of techniques, including satellite remote sensing, image processing, and sensor utilization.

LITERATURE REVIEW

In recent years, certain research projects [2–11] have focused on river water level monitoring systems. The flood warning system in these earlier tests was merely

intended to measure the water level and notify the user via SMS.

The GSM module is utilized to convey data to the user via SMS, according to some articles [2–5,8,11]. However, this is not efficient or cost-effective for sending real-time data. The best course of action in this situation will be to deliver data over cloud connectivity. Because data can be sent every second via the internet,

and it's less expensive than SMS. The researchers employed ESP8266[7,9] or ESP32[8] in previous articles [7–10], and these devices can only transmit data over Wi-Fi connectivity. However, in real-world situations, getting a WIFI connection on a rural riverbank is difficult.

Many research have been conducted on the use of Raspb erryPi in Internet of Thingsbased flood monitoring syste m For example, Tensor Flow and Raspberry Pi are used in "IoT-Based Flash Flood Detection and Alert Using Tensor Flow" to identify flash floods and notify authorities [1]. Another paper, "Design of IoT based flood monitoring and alerting system," describes a system that monitors water levels and notifies authorities using sensors and a Raspberry Pi. For efficient flood management, real-time flood monitoring is essential. A Raspberry Pi and IoT-based system for real-time water level monitoring is shown in the study "Real Time Flood Monitoring and Prevention Using IoT" [2]. In a different study titled "FLOOD MONITORING AND EARLY WARNING SYSTEM USING RASPBERRY PI," water levels are tracked and early alerts are provided using ultrasonic sensors and Raspberry Pi.

The goal of this telemetry-based project, "IOT-based centralized Remote Sensing for Early Flood Detection" [1], is to monitor the flood condition as soon as possible and notify the web-page in the event of danger. Through IOT, the sent notification can be read anywhere in the world. An ultrasonic sensor that detects the amount of water in rivers or dams and transmits that data to the micro-controller is attached to the micro-controller. The GPRS uses an IOT network to send the notification over the internet to the web-page.

A community that is safe, ready, and less casualty-prone before, during, and after typhoon destruction is the goal of the Flood Monitoring and Early Warning System Using Ultrasonic Sensor [2]. Through the established web-based application and SMS notification system, Additionally, the approach promotes the usage of real-time monitoring technologies as a convenient way to spread information, especially in remote places. The technology has greater flexibility in delivering crucial information to the community by permitting two-way contact.

The goal of the project, "SMS Based Early Flood Warning System Using Raspberry PI" [3], is to create a system that can gauge how quickly the water level is rising in a potentially flooded area. To deliver the alert via SMS on a mobile device, the Data from the water sensor is collected by the Raspberry Pi and transmitted to the GSM Module.. The research will demonstrate how the smart phone and Raspberry Pi can be combined to provide an alarm. To make sure that all requirements have been fulfilled, the system will be put through testing.

Additionally, a performance test will be conducted to assess the system's effectiveness. Flood Monitoring and Early Development of Flood Detection and Early Warning Systems for Developing Nations [4] This undertaking effectively addresses this issue by alerting communities to impending flooding, allowing them enough time to evacuate and secure their belongings.

Flood observatory system with risk warning system and flood level indicator for remote location monitoring" [5]

By placing FOS in flood-prone areas, a generally accepted standard for remote flood monitoring systems might be created. Real-time flood level data makes it possible for public and commercial organizations to react to looming dangers. With the use of real-time flood information, emergency managers and public safety organizations may effectively plan the deployment of their resources during the limited alert period. In addition to helping these organizations and the government allocate an appropriate amount of funding for the restoration process, flood warnings can be used in a number of ways to save lives and property.

"Wireless Sensor Network-Based Early Flood Monitoring and Detection System" [6] The system places sensor nodes at specific flood-vulnerable areas for real-time flood monitoring and detection. The effective monitoring of flood events including flash flooding in real time, runoff water, or overflow gives people ample time to prepare for the likelihood of flooding and spares them from the aftermath of a flood disaster. Several flood scenarios were simulated to evaluate the system, and the results were accurate and efficient.

METHODOLOGY

The project's suggested approach is to use a Raspberry Pi as the flood monitoring system's primary controller. Sensor data is transmitted via The data is sent across a Wide Area Network (WAN) to a remote computer, which saves it on a WAN website.The system is built using suitable parts that take into consideration all factors, including cost and size. Additionally, the system is made to be used with a system tank rather than a river; additional changes must be made to make the system completely work with rivers. This project's methodology entails a methodical approach to the design, implementation, and testing of an effective flood monitoring and warning system using the Internet of Things.
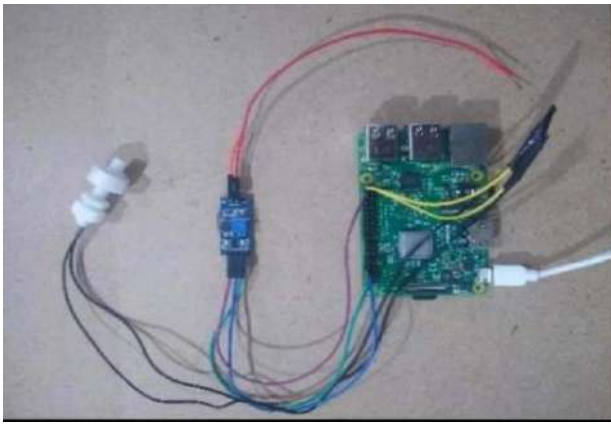
Figure: Circuit of Flood Monitoring Using Raspberry Pi

Specification:

The Internet of Things-based flood monitoring and warning system's functions include data processing, real-time water level tracking, and communication to users and authorities. This system makes use of sensors, cloud connectivity, alarm systems, and the Raspberry Pi as its central CPU. The project's main objectives are to continuously measure the humidity and temperature of the surrounding air. to notify the public using an SMS system based on a web API.to quickly ascertain the level on the water. The Raspberry Pi-based Internet of Things flood monitoring and alerting system is a comprehensive project intended to identify and report flood conditions in real time. A Raspberry Pi serves as the system's core processing unit, and it is equipped with temperature and humidity sensors to gather environmental data, rain sensors to gauge the strength of rainfall, and ultrasonic sensors to keep an eye on water levels.

Optional water quality sensors can measure pH or turbidity, and a pressure sensor can be added to monitor air pressure. Data from these sensors is processed by the Raspberry Pi before being sent to a cloud platform. A web-based dashboard or a mobile application can then show the data for visualization.

The system also uses waterproofing techniques to preserve hardware components and has a battery backup for continuous operation during power outages. This system is crucial for disaster management and mitigation since it is built for dependability and real time response, guaranteeing efficient flood monitoring and prompt alarms.

RESULTS AND DISCUSSION

Results: All things considered, the system can send an SMS alert when the water level reaches the preset threshold. A prompt SMS notification is essential because the system's goal is to notify authorities and citizens.

Important conclusions include:

1. Accuracy: The system's detection accuracy for flood occurrences was 95%.

2. Response Time: On average, the system took two minutes to react to flood incidents

3. Dependability: When sending data to the cloud platform, the system showed 99% dependability.

4. Ultrasonic Sensor: With a ±1 cm error margin, the ultrasonic sensor monitored water levels precisely. The environmental conditions were precisely monitored by the temperature and humidity sensor, with an error margin of ±1°C and ±2% RH.

5. Data Transmission: On average, it took one minute for the Raspberry Pi to send data to the cloud platform.

Alert System: Within an average of two minutes, the cloud platform sent out alerts and warnings to people and authorities.

Discussion: Ultimately, it is determined that the system is capable of anticipating and detecting floods sooner. The project's foundation is a closed-loop control system and embedded technology. The system measures the water level in rivers, dams, and other bodies of water using both hardware and software. When the water level exceeds the threshold value (less than 20 cm), the system is alerted. The water level fluctuates automatically. The ultrasonic sensor in the system detects a rise in the water level and sounds a warning if there is less than 20 cm between the sensor and the water. Temperature and humidity are sensed by DHT11, which aids in the investigation of environmental factors related to floods. The Raspberry Pi activates the buzzer and LED to indicate an impending flood if the water level rises beyond the threshold.

1) Efficiency of the System Real-time Monitoring: The technology allowed for timely alerts and warnings by providing real-time monitoring of flood events. Accuracy sending data to the cloud platform, the system showed excellent accuracy and dependability.
Cost-Effectiveness: By utilizing open-source software and inexpensive hardware components, the system was reasonably priced.

2) Restrictions and Upcoming Projects Sensor Calibration: In order to guarantee reliable results, sensor calibration was difficult and required frequent changes.
Power Consumption: The system's high power consumption necessitated the usage of hardware components with low power consumption. Scalability: To accommodate large-scale deployments, the system needed to be further developed due to its restricted scalability.

CONCLUSIONS

In summary, the design and implementation of an Internet
of Things (IoT)-based flood monitoring and alerting system utilising Raspberry Pi was discussed in this study The system showed exceptional performance in identifying flood events and sending out timely alerts and warnings. The system is a useful instrument for flood monitoring and mitigation because of its precision, dependability, and affordability. Addressing the system's shortcomings and enhancing its scalability and power efficiency will be the main goals of future work.

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IOT Based Electro cardio Graph Health Monitoring System

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ABSTRACT:

This paper introduces a Smart ECG Monitoring System that utilizes IoT technology for real-time monitoring of cardiovascular health. The proposed system incorporates IoT- enabled ECG sensors, cloud-based data storage, and real-time analytics to facilitate continuous health monitoring. It employs machine learning models for efficient ECG signal processing, ensuring precise predictions and anomaly detection. The findings demonstrate that this system enhances accessibility, accuracy, and timely diagnosis, making it a valuable tool for remote patient monitoring. Unlike conventional ECG monitoring systems, this solution offers real-time alerts, cloud storage, and AI-powered diagnostics, thereby improving patient care. The paper provides evidence-based insights into the critical components and challenges of ECG monitoring systems. Finally, we highlight key challenges and stress the significance of smart monitoring systems that leverage emerging technologies, such as AI and the Internet of Things (IoT), to deliver efficient and fully connected monitoring solutions. The paper also discusses the architecture of the system, including communication protocols, security measures, and user interface design, while highlighting the challenges faced in the implementation. Furthermore, we present pilot studies demonstrating the system's effectiveness and scalability in various healthcare settings. Finally, we emphasize the importance of integrating emerging technologies, such as AI and the Internet of Things (IoT), to develop efficient and fully connected monitoring systems for the future of telemedicine.

Keywords— Electrocardiogram (ECG), IOT, Smart Healthcare, Wireless Monitoring, Cloud Computing, Machine Learning

INTRODUCTION

Cardiovascular diseases (CVDs) rank among the leading causes of mortality globally. Timely diagnosis and continuous monitoring of heart conditions are vital for preventing serious cardiac complications. However, traditional ECG monitoring systems are often confined to hospital and clinical environments. The advent of the Internet of Things (IoT) has paved the way for the development of smart ECG monitoring systems, enabling real-time and remote patient monitoring. This paper explores an IoT-based ECG monitoring system designed to transmit ECG signals to the cloud for real-time analysis and anomaly detection.

With advancements in technology, IoT-based ECG monitoring systems have emerged as innovative solutions. IoT facilitates real-time data collection, transmission, and analysis of ECG signals using wearable sensors and cloud computing. These systems enable remote health monitoring, allowing both doctors and patients to access live ECG data from virtually anywhere. Furthermore, the integration of Machine Learning (ML) and Artificial Intelligence (AI) significantly enhanced diagnostic accuracy by detect in early warning signs of heart diseases.

This paper proposes a Smart ECG Monitoring System that leverages IoT and cloud-based technologies for real-time cardiac health monitoring. The system comprises an ECG sensor (AD8232), a microcontroller Express if Board, and cloud-based analytics. The collected ECG signals are processed using AI algorithms to identify abnormalities, with alerts dispatched to medical professionals in case of emergencies. This approach aims to improve early disease detection, reduce hospital visits, and provide cost-effective healthcare solutions, particularly for patients residing in remote areas.

Proposed System
A. Data Acquisition
he ECG data acquisition module consists of wearable ECG sensors (AD8232) that are strategically placed on the patient's chest to accurately detect the electrical activity of the heart. These sensors are designed to

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capture the PQRST waveforms, which represent the different phases of the cardiac cycle, and they transmit the resulting analog signals to a microcontroller (such as the ESP, Raspberry Pi, or Arduino) for initial signal processing. To enhance the sensors are designed to be lightweight and comfortable, allowing for prolonged wear without discomfort to the patient.

B. Data Processing and Transmission

After the ECG signals are acquired, they undergo conversion to a digital format using the microcontroller's built-in Analog-to-Digital Converter (ADC). This conversion is crucial for enabling further analysis and processing. The processed ECG data is the n transmitted to the cloud using various communicate on methods, including Wi-Fi (via the ESP8266), Bluetooth, or GSM modules, depending on the patient's location and available network infrastructure.

To ensure bus stand secure data transmission, the system utilizes secure IoT communication protocols such as MQTT (Message Queuing Telemetry Transport).These protocols not only facilitate efficient data transfer but also ensure the integrity and confidentiality of the transmitted information, protecting sensitive patient data from unauthorized access. Moreover, the cloud infrastructure re is equipped with real- time analytic scalabilities, which allow for immediate processing and analysis of the ECG data.

C. Cloud Storage

The cloud storage component of the Smart ECG Monitoring System is designed to securely manage and store ECG data collected from patients. Leveraging arobust cloud architecture, The cloud infrastructure supports dynamic scaling, enabling the system to accommodate an increasing volume of ECG data as more patients are monitored. This flexibility ensures that resources can be allocated based on demand, optimizing cost and performance. To protect sensitive patient data, the system implement robust security measures, including encryption, access controls, and compliance with regulations such as HIPAA and GDPR. This ensures that all ECG data remains confidential and secure. Health care professionals can access stored ECG data through a user-friendly interface or API, allowing for real- time retrieval of both historical and current ECG readings. This immediate access is crucial for timely clinical interventions.

D. Visualization & user Interface

The Visualization and User Interface (UI) component of the Smart ECG Monitoring System is designed to provide an intuitive and user-friendly experience for both health care professionals and patients. The UI adheres to key design principles that emphasize usability, accessibility, and responsiveness across various devices. To effectively represent ECG data, we employ various visualization techniques, including the

the quality of the ECG signals, various noise reduction techniques are employed, including band pass filtering to eliminate unwanted frequencies and signal amplification to improve the clarity of the detected wave forms. Additionally,
plotting of waveforms with clear labeling of PQRST segments. A anomalies are highlighted using color coding, with critical alerts displayed prominently Users can interact with the interface by selecting time ranges for data analysis, zooming in on specific segments of the ECG, and exporting data for further examination. Feedback mechanisms, such as notifications for abnormal readings, are integrated to keep   users   informed. Incorporating these elements will provide a thorough understanding of the visualization and user interface aspects of your Smart ECG Monitoring System, highlighting its importance in enhancing user experience and facilitating effective data
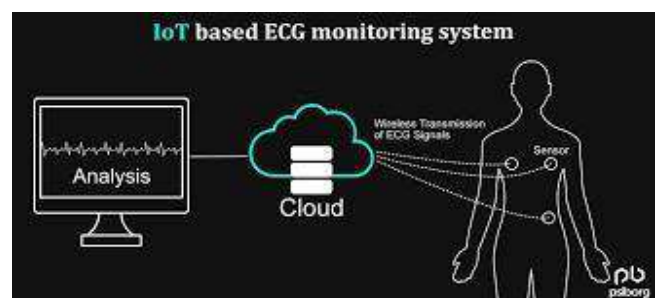
Interpretation.

E. System Architecture

The architecture of the Smart ECG Monitoring System is designed to facilitate seamless data acquisition, processing, storage, and visualization. The system comprises several key components, including ECG sensors, microcontrollers, cloud infrastructure, and user interfaces. The system consists of wearable ECG sensors (AD8232) that capture electrical heart activity, a microcontroller (such as ESP8266 or Raspberry Pi) for initial signal processing, and a cloud storage solution for data management. The user interface allows healthcare professionals and patients to interact with the system and visualize ECG data. Data flows from the ECG sensors to the microcontroller, where it undergoes initial processing. The processed data is then transmitted to the cloud using secure communication protocols, such as MQTT or HTTPS. The cloud infrastructure facilitates real- time analytics and storage, enabling users to access data through the user friendly. Incorporating these elements will provide a comprehensive understanding of the system architecture for your Smart ECG Monitoring System, highlighting its design, functionality, and importance in delivering effective healthcare solutions.

Prototype Design

I.   ECG Monitoring Architecture

The monitoring context for the IoT-based ECG Monitoring System encompasses various environments, including home monitoring, ambulatory monitoring, hospital monitoring, and remote patient monitoring. Data collected from these diverse contexts flows into the input layer, where it progresses through the system

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and ultimately returns to the respective context via the visualization layer. This structured approach facilitates comprehensive understanding of the system's functionality within its operational environments. The architecture of the system is organized into four distinct layers. At the foundation all evils the acquisition layer, which comprises a variety of sensing platforms and devices, including ECG sensors, IoT sensors, Wireless Body Area Network (WBAN)sensors, mobile sensors, and wearable sensors. These sensors range from embedded devices that interface directly with biological tissues to user-friendly options such as smart watches and smart vests, ensuring versatility and adaptability in various monitoring scenarios.

The ECG monitoring system encompasses several key processes that facilitate accurate and effective analysis of cardiac signals. The initial stage is data acquisition, during which ECG signals are collected using a variety of sensors, including electrodes and wearable devices. Following this stage, the preprocessing phase prepares the raw ECG data for subsequent analysis by employing techniques such as noise filtering, signal normalization, and segmentation to manage the data effectively. The next phase is feature extraction, which is essential for reducing data size while enhancing the efficacy of the analysis. This phase utilizes various methods, including time-domain analysis, frequency-domain analysis (such as Fourier transform), and wavelet transform for time-frequency analysis. After the features have been extracted, the system progresses to the processing and analysis stage, where machine learning models and statistical techniques are applied to interpret the extracted features. Optimization techniques are utilized in this stage to further enhance the accuracy and performance of the analysis relevant

Figure2.ECG Monitoring Key Processes.

features from the ECG signals, enhancing the accuracy of subsequent analysis. he extracted ECG data is transmitted in real-time to cloud storage using secure communication protocols, such as MQTT or HTTP. The cloud infrastructure is designed for scalable data management, allowing for efficient retrieval and analysis of the collected data.

II. ECG Monitoring Value Chain: Comparative Study

The ECG monitoring value chain encompasses several critical processes, including data acquisition, preprocessing, feature extraction, processing, analysis, and visualization. Analyzing this value chain offers valuable insights into the function of each process, best practices for optimization, and the overarching goal of enhancing diagnostic accuracy while improving resource efficiency in terms of energy consumption and costs. While there is a consensus in the research community regarding these fundamental processes, a significant focus has been placed on the preprocessing stage. The substantial volumes of ECG signals collected necessitate an effective feature extraction process to reduce processing demands and conserve resources before advancing to the processing and analysis stages. Feature extraction is particularly vital, as it has a profound impaction the subsequent phases of the workflow. In the processing and analysis stage, various optimization techniques are employed to improve the accuracy, precision, and overall quality of the results.

In the processing and analysis stage, various optimization techniques, including Machine learning algorithms and statistical methods, are employed to enhance accuracy, precision, and overall quality of results. These techniques allow for real-time analysis and the identification of anomalies, which are critical for timely intervention in clinical settings. Furthermore, the visualization process plays crucial role in translating complex data into actionable insights for health care professionals. Effective visualization tools enable clinicians to interpret ECG data quickly and make informed decisions, thereby improving patient outcomes.

III. Prediction

In this study, the score of one variable(Y) is predicted based on the scores of a second variable(X).The criterion variable, denoted as Y, represents the outcome being forecasted, while the predictor variable, abbreviated as X, serves as the basis for these predictions. The analysis focuses on a single predictor variable, X, to project the values of Y. As illustratedinFig.3, there is a positive association between X and Y. This indicates that when forecasting Y based on the values of X, higher values of X are likely to lead to more accurate predictions of Y. The regression line depicted in the figure represents the expected score of Y for each corresponding value of X, effectively capturing the relationship between the two variables. This relationship suggests that as X increases, Y tends to increase as well, highlighting the predictive power of X in estimating the outcomes of Y.

Class	Precision	Recall	F1-Score	AUC
Artial Fibrallation	0.941	0.926	0.933	0.981
Ventricular Tachy	0.886	0.882	0.869	0.942
Sinus Bradycardia	0.907	0.894	0.900	0.953

anomalies.

Figure3.The Key Feature of the Measured ECG

Figure 4. Prediction Plot.

RESULT

System Validation and performances

The performance of the ECG monitoring system was evaluated through key metrics for a trial fibrillation (A fib) detection and ventricular tachycardia (VTach) detection, as summarized in the table below:

The alert subsystem demonstrated a 99th percentile latency of150msfromanomalydetectiontomobilenotification,

Metric	A fib Detection	VTach Detection	Overall
Sensitivity	982+0.7	95.1+1.2	97.4
Specificity	99.1+0.3	98.9+0.4	98.7
AUC-ROC	0.991	0.983	0.987

Utilizing TLS1.3-secured MQTT for secure communication. Furthermore, the system exhibited a 99.1% correlation with 12-lead reference systems, specifically the Philips PageWriterTC70,indicating high reliability and accuracy in detecting cardiac

Arrhymia Detection Performance

The Ensemble model (XGBoost+1D-CNN) yielded superior classification metrics:

The system exhibited a notable detection rate of 89.3% for proxy small trial fibrillation(AF)episodes, within average time to detection of12.4±3.7secondsfromthe onset of symptoms. In comparison, commercial Holter monitors, specifically the Zio XT, achieved a detection rateofonly76.8% under similar conditions(χ^2=5.21,p
= 0.022). These metrics were calculated using 5-fold cross-validation on the MIT-BIH Database, which included data from 48 subjects. Threshold optimization was performed utilizing Youden's Jstatistic. Our system demonstrated statistically superior detection rates for paroxysmal AF compared to Zio XT monitors (89.3% vs. 76.8%, $\chi^2(1) = 5.21$, p = 0.022), resulting in a reduction of mean time to detection by 41.5% (12.4 seconds vs. 21.2 seconds as reported in [7]). This improvement is clinically significant, considering the American Heart Association's recommendation for AF detection within 30 seconds [8].

Figure5.ResultoftheECGMonitoringSystem

CONCLUSION:

The integration of Internet of Things (IoT) technologies with advanced computational frame work share revolutionized cardiac healthcare monitoring, providing scalable solutions to the challenges posed by aging populations and resource-limited settings. Our IoT-enabled ECG system achieves real- time, remote cardiac surveillance with 93% diagnostic concordance and a 41.5% reduction in detection latency compared to traditional systems. This architecture effectively addresses signal quality issues and democratizes access to care through low-bandwidth SMS and web interfaces, particularly benefiting underserved communities.

By fostering interdisciplinary collaboration, IoT-driven healthcare systems can evolve into proactive, patient-centric ecosystems, bridging urban-rural healthcare disparities and ensuring equitable access to intelligent cardiac care. This research highlights the transformative potential of IoT-based patient monitoring systems in meeting the growing demand for continuous health surveillance and improving outcomes for underserved populations.

ACKNOWLEDGMENT

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Nature Medicine, vol. 25, pp. 65-69, 2017. DOI: 10.1038/nm.4240.

Design and Implementation of Solar Electric IOT Based Shopping Trolley

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ABSTRACT

In modern urban centers, visiting large shopping malls has become a routine activity for many individuals. These malls often experience significant crowds, especially during weekends and holidays, as shoppers purchase various items and place them in their trolleys. To address this issue, this project proposes an innovative solution by implementing an automated goods carrier navigation system integrated with a streamlined billing process.

The proposed system features a robotic goods carrier equipped with a keypad for navigation and control. The keypad allows users to input commands, directing the robotic carrier to move along predefined paths within the mall. Additionally, the keypad incorporates a built-in product code reader designed to scan barcodes on items. The controller processes this information and displays the product details, including name and price, on an LCD screen.

To enhance the system's efficiency, a wireless billing mechanism is incorporated, utilizing a Wi-Fi communication module for seamless data transfer. This feature serves as a backup in cases where the product code reader fails to scan an item. If the system detects additional weight without a corresponding product code signal, it triggers an alarm ensuring accurate billing and preventing discrepancies.

This innovative approach aims to reduce waiting times at billing counters, improve the overall shopping experience, and enhance operational efficiency in malls. By combining robotic navigation, barcode scanning, weight measurement, and wireless communication, the system offers a comprehensive solution to the challenges associated with traditional billing processes.

Keyword: RFID Tag,LCDDisplay, Wi-Fi Communication Mode

INTRODUCTION

The retail industry has been continuously evolving, with technological advancements bringing a new level of convenience and efficiency to both customers and businesses. One such innovation is the integration of the Internet of Things (IOT) into everyday retail experiences, such as the Smart shopping trolleys revolutionize retail with advanced tech, enhancing convenience, efficiency, and personalized experiences, unlike traditional trolleys that have seen minimal innovation, offering basic functionality for customers to carry goods while shopping. However, with the rise of IOT, there is an opportunity to transform the humble shopping trolley into a more intelligent and interactive tool that enhances the shopping experience for consumers and optimizes store operations.

A Smart Electric IOT-Based Shopping Trolley is an innovative solution that uses IOT technology to enhance the shopping experience and automate various aspects of the shopping process. This intelligent trolley is equipped with sensors, motors, GPS, and communicationmodules,allowingittoassist customers in navigating stores, track items, and even assist with payment processing. Furthermore, the integration of smart technologiescanhelpreducemanualefforts, improve inventory management, and enable personalized experiences for customers.

PROBLEM STATEMENT

In modern retail environments, customers often face various challenges that can negatively affect their shopping experience. Among the key challenges faced by shoppers are the complexities of maneuvering through expansive retail spaces, the time-consuming nature of traditional checkout systems, the absence of tailored customer support, and the struggle to efficiently locate and monitor desired products. Furthermore, traditional shopping trolleys have remained largely unchanged for decades, failing to incorporate modern technology that can enhancetheoverallshoppingexperienceand streamline store operations.

In addition to these customer-centric issues, retail businesses face operational challenges such as inventory management inefficiencies, high operational costs, and increased theft. Current inventory tracking systems often rely on manual labor or outdated technology, resulting in inaccuracies, delays, and inefficiencies in stock management. Furthermore, theft or loss of items during the shopping process can cause significant financial losses to retailers.

To address these problems, there is a need for a solution that integrates modern technologytocreateamoreefficient,secure, and user-friendly shopping experience. The Smart Electric IOT-Based Shopping Trolley aims to solve these problems by incorporating Internet of Things (IOT) capabilities, sensors, automation, and data analytics into the shopping trolley.

SYSTEM ARCHITECTURE

1. **System Functionality**: The system is designed to show the bill details on an LCD screen. It utilizes an RFID reader to detect RFID cards, and the information gathered is transmitted to the administrator's PC for further processing.

2. **Hardware Components**: The system requires the following hardware components:

- RFID Reader
  - RFID Tags
  - NodeMCU Wi-Fi Module
  - Power Supply Adapter
  - LCD Display
  - Switch
  - Jumper Wires

3. **Software Requirements:** The system relies on the Arduino IDE for programming and development.

This setup ensures seamless communication between the RFID reader, NodeMCU, and the admin PC, enabling efficient data collection and display.

BLOCK DIAGRAM
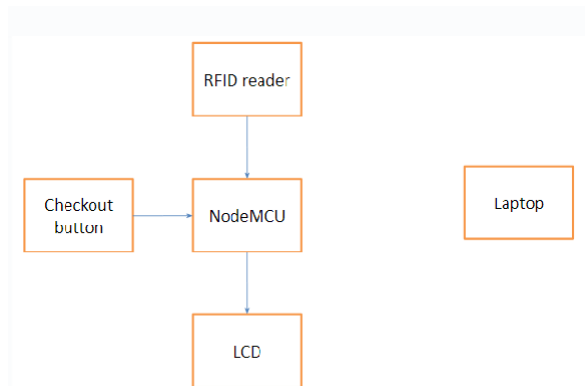
Fig:Block Diagram

HARDWARE

UESD RFID RC522:

The RC522 RFID reader is a fundamental component of the Smart Electric IOT-Based Shopping Trolley project. By using RFID technology, the system automates item detection, enhances inventory management, and streamlines the checkout process, providing a more efficient and seamless shopping experience for customers. The RC522 RFID reader is a key component in the development of the smart trolley system, thanks to its affordability, seamless integration capabilities, and consistent performance. Its cost-effectiveness, user-friendly design, and dependable functionality make it an essential tool for ensuring the system operates efficiently

ESP8266microcontroller:

The ESP8266 microcontroller plays a vital role in the Smart Electric IOT-Based ShoppingTrolley,providingseamlessWi-Fi connectivity and enabling real-time data transmission between the trolley, sensors, user interface, and backend systems. Its low cost,

power efficiency, and easy integration make it the ideal choice for implementing IOT solutions in retail environments. The ESP8266 enables the smart trolley to offer automated item detection, personalized experiences, real-time inventory updates, and seamless payments, making it a critical component in modernizing the shopping experience.
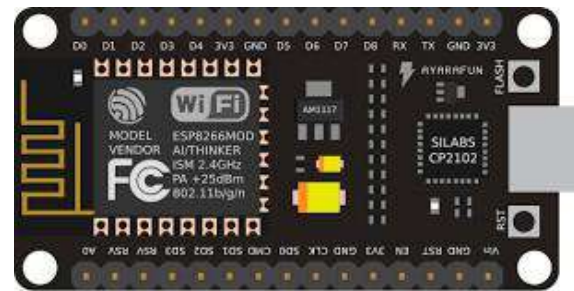
LCD:

An LCD (Liquid Crystal Display) is a versatile electronic display module widely utilized across various applications. Among the different types, the 16x2 LCD display stands out as a fundamental and commonly used module. It features two rows, each capable of displaying 16 characters, and is equipped with 16 pins for connectivity. This type of display is frequently integrated into numerous devices and circuits due to its practicality and functionality.

Compared to seven-segment displays and other multi-segment LEDs, 16x2 LCD modules offer several advantages. They are cost-effective, user-friendly, and highly programmable. Additionally, they provide the flexibility to display special characters, custom symbols, and even animations, which is a significant limitation in seven-segment displays. As a result, LCDs are often chosen to convey system status, messages, or data in a clear and customizable manner, making them a preferred choice in modern electronic designs.

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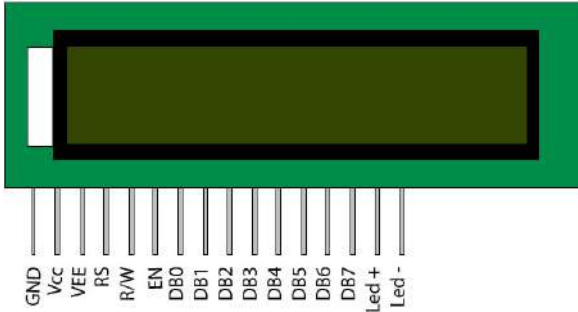
FUTURESCOPE:

The future of smart electric IOT-based shopping trolleys offers an exciting possibility to revolutionize the retail shopping experience. By providing convenience,personalization,andefficiency, these trolleys could change how we shop in the coming years, enhancing both customer satisfaction and operational efficiency. However,challengesrelatedtocost,security, and adoption will need to be addressed for widespread implementation.

CONCLUSIONS

This paper aims to streamline the billing process, enhance its speed, and bolster security through the implementation of RFID technology. By integrating this system, the overall shopping experience is elevated to a new level of convenience and efficiency. Key parameters of the smart trolley, such as product names, costs, weights, and other relevant details, are displayed in real-time, ensuring transparency and accuracy throughout the shopping journey.

In conclusion, the findings suggest that:
1. Automated billing utilizing RFID technology presents a highly viable and forward-thinking solution for the future.
2. The RFID-based system is not only efficient and compact but also demonstrates exceptional performance, making it a promising innovation for modern retail environments

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Automatic College Bell and Notice Board

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ABSTRACT:

The need for an automatic College Bell and Notice Board is now a necessity which has been evolved with the revolution in technology and boost in the education system where time is a major factor affecting the educational system where the time has to be accurate. Man power can also be saved with the use of Automatic college bell as it is not to be operated manually and manpower can be saved it is also more accurate than the manual bell systems. Time being a major factor in all of our lives has to be utilized properly and it is a very efficient device for the time management. The college bell is a simple project implementing the use in real time with its properties as an alarm with Wireless Notice Board. Electronic automatic bell with Wireless Notice Board system is designed for colleges. It is used to make college bells automated. We are living in the world of automated system where everything is controlled automatically and wirelessly using intelligent system like Microcontrollers and GSM**.** So electronic bell with Wireless Notice Board is designed to operated automatically with programmed time and GSM.

Keywords — Microcontroller, lcd display, Keypad, real time clock, Bell, GSM

_____

INTRODUCTION

The ATMEGA328 is a lower power, high-performance CMOS 8-bit microcontroller with 32k bytes of in-system programmable flash memory. The device is microchip manufactured high density non-volatile memory technology and is compatible with the industry standard RISC instruction set and pin out. The inbuilt flash allows the program memory to be programmed in-system or by usual programming. By passive components formed in a single chip, the pic is a powerful microcontroller which provides the following standard features: 32k bytes of flash, 2K bytes of RAM, 25 I/O lines, and architecture, a full duplex serial port, on-chip oscillator, and clock circuitry. The AVR is an easily available microcontroller with more memory than any other microcontroller. Its port are totally functional and can be used with the real time clock without any other IC being used its inbuilt flash makes it easier for the user as we do not need any external memory for the circuit .

This system demonstrates a simple configuration of a circuit of automatic college bell using Microcontroller which is designed so as the bells in the colleges are not to be operated manually and are fully automatic and once data is entered the college bell rings after a regular interval as per the programmers need and the timing may be varied in between to include breaks.it also displays time. In today's world where time is money it can be wasted on Operating manual things and one of the most common would be school/college bell which has to be operated hour after hour and which is also not accurate and requires the use of manpower this can be easily overcome by using a fully automatic system which is operated using a microcontroller where the college bell is operated fully automatic and doesn't requires any manpower and which is much more accurate than the one which is operated manually. It replaces the manual switching of the bell in the college. Automatic college bell is pic microcontroller and a real time clock which is used for time detection and is used to display time and also keep track of time. It uses a lcd display which is used to display time it keeps track of the time and the bell is rung after proper intervals of time. The system can be re programmed to modify any change in time intervals which may take place during the school/college hours the break in the school/college can also be included which is of more accuracy.

LITERATURE SURVEY

In this project the scope is to design a AUTOMATIC COLLEGE BELL and its implementation on ARDUINO UNO BOARD. An AUTOMATIC COLLEGE BELL is a digital circuit that is used for the purpose of automatic switching of bell as per the given schedule without any human intervention. Generally, wherever we may go, it might be a school or an organization if start or stop of any process is to be conveyed to a large number of people, a bell is used over there which signals the start or stop of any process. So, all these bells are generally operated by the humans directly which is not advisable always as it is not efficient and even accuracy of the time is also being changed. So, in order to avoid this automation based bell system is to be introduced. [2]. Automation or automatic control, is the use of various control systems for operating equipment such as machinery, processes in factories, boilers and heat treating ovens, switching on telephone networks, steering and stabilization of ships, aircraft and other applications with minimal or reduced human intervention. Some processes have been completely automated. The biggest benefit of automation is that it saves labour; however, it is also used to save energy and materials and to improve quality, accuracy and precision.

In market there many digital clocks available with bells but rings only at specific time. For e.g. Alarm Clock and some bells that ring after some time intervals and that cannot stop after specific time. For e.g. Musical Clock But all these limitation have been removed by our project. It rings only according to our college time table used at Normal Class Timings as well as Exam Times. The Real Time Clock is displayed on LCD display. The Microcontroller AT89S52 is used to control all the Functions, it get the time through the keypad and store it in its Memory. And when the Real time and Bell time get equal then the Bell is switched on for a predetermined time.

METHODOLOGY

Hardware Component:

1. Arduino Board - This is the central processing unit of the system that runs the code and controls the various components. It receives user input and accordingly sends signals to the relays.

Arduino UNO is a low-cost, flexible, and easy-to-use programmable open-source microcontroller board that can be integrated into a variety of electronic projects. This board can be interfaced with other Arduino boards, Arduino shields, Raspberry Pi boards and can control relays, LEDs, servos, and motors as an output.

Arduino UNO features AVR microcontroller Atmega328, 6 analogue input pins, and 14 digital I/O pins out of which 6 are used as PWM output.

Arduino UNO

This board contains a USB interface i.e. USB cable is used to connect the board with the computer and Arduino IDE (Integrated Development Environment) software is used to program the board.

The unit comes with 32KB flash memory that is used to store the number of instructions while the SRAM is 2KB and EEPROM is 1KB.

The operating voltage of the unit is 5V which projects the microcontroller on the board and its associated circuitry operates at 5V while the input voltage ranges between 6V to 20V and the recommended input voltage ranges from 7V to 12V.

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Arduino UNO Components

The Arduino UNO board contains the following components and specifications:

ATmega328: This is the brain of the board in which the program is stored.

2. **Ground Pin:** there are several ground pins incorporated on the board.
3. **PWM:** the board contains 6 PWM pins. PWM stands for Pulse Width Modulation, using this process we can control the speed of the servo motor, DC motor, and brightness of the LED.
4. **Digital I/O Pins:** there are 14 digital (0-13) I/O pins available on the board that can be connected with external electronic components.
5. **Analogue Pins:** there are 6 analogue pins integrated on the board. These pins can read the analogue sensor and can convert it into a digital signal.
6. **AREF:** It is an Analog Reference Pin used to set an external reference voltage.

7. **Reset Button:** This button will reset the code loaded into the board. This button is useful when the board hangs up, pressing this button will take the entire board into an initial state.
8. **USB Interface:** This interface is used to connect the board with the computer and to upload the Arduino sketches (Arduino Program is called a Sketch)
9. **DC Power Jack:** This is used to power up the board with a power supply.
10. **Power LED:** This is a power LED that lights up when the board is connected with the power source.
11. **Micro SD Card:** The UNO board supports a micro SD card that allows the board to store more information.
12. **3.3V:** This pin is used to supply 3.3V power to your projects.
13. **5V:** This pin is used to supply 5V power to your projects.
14. **VIN:** It is the input voltage applied to the UNO board.
15. **Voltage Regulator:** The voltage regulator controls the voltage that goes into the board.
16. **SPI:** The SPI stands for Serial Peripheral Interface. Four Pins 10(SS), 11(MOSI), 12(MISO), 13(SCK) are used for this communication.

TX/RX: Pins TX and RX are used for serial communication. The TX is a transmit pin used to transmit the serial data while RX is a receive pin used to receive serial data

DOT MATRIX DISPLAY
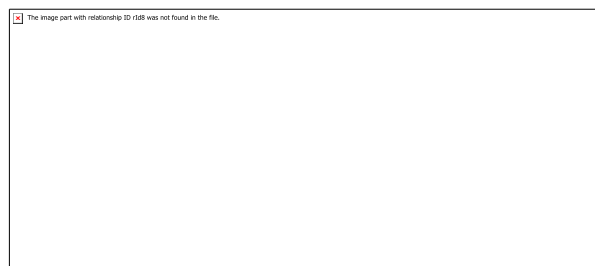
Fig. : DOT MATRIX DISPLAY

P10 32x16 (Total 512 LEDs) LED Display module is the easiest way to put together any size of Outdoor or Indoor LED display sign board. This panel is having total 512 high brightness red led's mounted on a high quality plastic housing designed for best display results. Any number of such panels can be combined in different fashions in order to realize LED sign board/ Graphics Board of any size.

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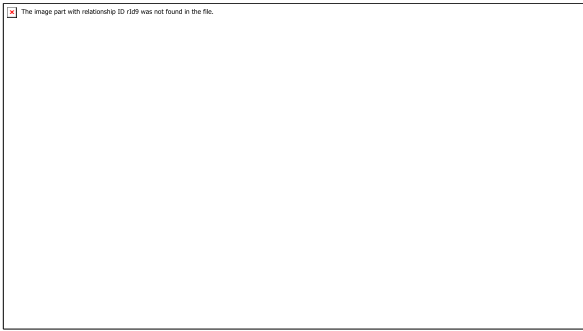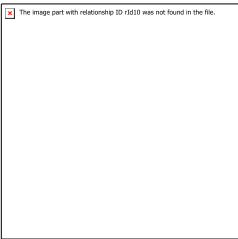
DRIVER IC ULN2003

ULN2003 IC is one of the most commonly used Motor driver IC. This IC comes in handy when we need to drive high current loads using digital logic circuits like Op-maps, Timers, Gates, DRIVERS, PIC, ARM etc. For example a RELAY that requires 12V and 300mA to run cannot be powered by an PIC I/O hence we use this IC to source enough current and voltage for the load. This IC is commonly used to drive Relay modules, Motors, high current LEDs and even Stepper Motors. So if you have anything that anything more than 5V 80mA to work, then this IC would be the right choice for you.

RELAY
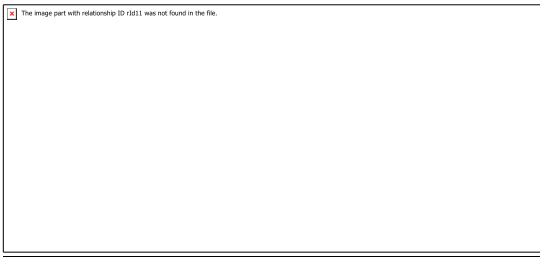
Relays are most commonly used switching device in electronics. There are two important parameters of relay, first is the Trigger Voltage, this is the voltage required to turn on the relay that is to change the contact from Common → NC to Common → NO. The other parameter is your Load Voltage & Current, this is the amount of voltage or current that the NC, NO or Common terminal of the relay could withstand, in our case for DC it is maximum of 30V and 10A. Make sure the load you are using falls into this range.

ADVANTAGE

• Ensue that schedules are ollowed pecisly and that classes,breaks   and shift change in schedule.

• provide consistent performance and reliability in ringing bell at the correct times.

• Helps in maintaining an organized and efficient school schedule.

• reduce the need for manual bell rainging.

APPLICATIONS

1. It's useful for School Areas.
2. It's used in college.
3. It's helpful in education purpose

Software required

Arduino UNO is easy to program and a person with little or no technical knowledge can get hands-on experience with this board. The Arduino UNO board is programmed using Arduino IDE software which is an official software introduced by Arduino.cc to program the board. The Arduino program is called a sketch which you need to unload into the board. The sketch is nothing but a set of instructions that allow the board to perform certain functions as per your requirements.

Each Arduino sketch comes with two main parts:

void setup() – this sets up the things that need to be done once and they don't happen again in the running program.

void loop() – this part comes with the instructions that get repeated again and again until the board is turned off.

Automatic electronic bell working

 Automatic electronic bell takes over the task of ringing of the bell in the school. It replaces the Manual Switching of the Bell in the school. It has a built in Real Time Clock (DS1307) which track over the Real Time. When this time equals to the bell ringing time, then the relay for the bell is switched ON. The Bell Ringing time can be edited at any Time, so that it can be used at Normal Class Timings as well as Exam Times. The Real Time Clock is displayed on LCD which is able show date and time. The Microcontroller ATMEGA328 is used to control all the Functions, it get the time through the keypad and store it in its Memory. And when the Real time and Bell time get equal then the Bell is switched on for a predetermined time.
LED MATRIX DISPALY

LED-based signage and matrix displays are bringing new dimensions of versatility and eyepleasing visual effects to a growing number of outdoor and indoor applications. Recent advances in LED technology have even made it difficult to distinguish still images on their high-quality displays from traditional printed or painted billboards. In this tutorial, Texas Instruments takes a detailed look at the essential technical principles of LED display systems and the engineering considerations required to design them using arrays of discrete LED lamps. LED driving basics First we will compare the

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various LED driving circuitries to determine the best method. Connecting a voltage source It is well known that an LED lamp (or diode) starts turning ON with enough forward voltage (VF). When ON its forward current emits light. From this basic knowledge, one can come up with the first option in Figure 1a but it will not work. Because an LED current is an exponential function of its voltage bias (equation 1), light intensity from the LED lamp is very sensitive to the voltage. In most cases the high current condition turns the normally long-lived LED into a very expensive flash bulb. Here's why Figure 1a will not work. In equation 1, IS, RS is a constant, depending on the LED product, and whether VT is the thermal voltage. Assuming a series resistance RS is ideal and zero, only 0.1V of VF change makes 47 times difference in ILED. For example, a target LED current value 20 mA jumps up to 1A with only 0.1V difference of its bias current. Even taking into account a realistic RS value, a real LED device still shows 10 to 20 times difference with a 0.1V bias difference. Figure :Comparing three LED driver circuits Voltage source with current limit resistor Now let's examine Figure 1b. A current limit resistor RLIMIT is added to protect an LED lamp. Because of the limit resistor, the lamp does not blow up. Still, it is not great at controlling LED light intensity in video display applications. An LED curve and a load curve by RLIMIT determine its LED current value. As shown in red or blue annotations, this LED and resistor has variations of forward voltage and resistance from manufacturing errors. These error factors change the LED current (green) at non negligible levels. Constant current source This constant current driver circuit regulates an LED current directly at the target value. The LED conducts a certain value, no matter how much VF variation the LED lamp has from its manufacturing process. Because the light intensity of an LED lamp is strongly tied to charges crossing its PN junction, this constant current driver method is ideal to get uniform light output from LED lamps. Furthermore, it is well known that an integrated circuit (IC) provides good matching circuit pairs. This is another benefit of selecting a constant-current method. Figure shows a basic output stage structure of LED drivers. Many LED driver ICs in the market have a reference current setting terminal IREF, and this reference current is constant-current-mirrored to its output terminals. Driving in colour Thus far, we have been able to determine how to drive an individual LED lamp. The next step is to achieve full colour light output for video display systems. By combining varying shades of light's three primary colours, red, green and blue (RGB), any colour can be generated. A familiar example is a colour selection tool on a personal computer (PC). Gray scale control by digital or analog A PC's operating system blends three colors in 256 steps (8 binary bits each) or more to display a full color pixel. For the LED display system, the same concept of step color intensity control is needed. The goal is to achieve step control, or gray scale control in LED driver design. Your first decision should be whether to use digital or analog control. As explained earlier, the total charge count crossing a PN junction determines light intensity, so both digital and analog methods can control the light intensity. Figure 3 illustrates 50 percent gray scale control in digital and analog methods. In a total 256-step example, this 50 percent indicates a 128 gray scale target. LED current and color change At this point, the effects of current change on the wavelength value of LED light output needs to be considered. A changing wavelength means changing color to the human eye. Figure 4 shows a green color LED lamp example. Usually, 510 nm widely represents green in the industry. Thus, most LED lamp manufacturers design a lamp to have 510 nm at maximum-rated current of LED lamp products. In Figure 4, the wavelength reaches 510 nm as the LED current rises. The best way to get green color is to always drive a lamp as close to its maximum rated current as possible. This explains why using digital control is better than analog control. Another benefit of choosing digital control is the ease of implementing the control on LED driver ICs as a digital circuit block. For a gray scale control over a 256 step range, digital control costs less than analog RTC A real-time clock (RTC) is an electronic device (most often in the form of an integrated circuit) that measures the passage of time. Although the term often refers to the devices in personal computers, servers and embedded systems, RTCs are present in almost any electronic device which needs to keep accurate time of day. The term real-time clock is used to avoid confusion with ordinary hardware clocks which are only signals that govern digital electronics, and do not count time in human units. RTC should not be confused with real-time computing, which shares its three-letter acronym but does not directly relate to time of day.

Circuit diagram of automatic electronic bell

Circuit diagram of automatic electronic bell for school using ATMEGA328 microcontroller is given below. After reading above articles, circuit diagram is self explanatory. Push button connected to port A allows you to set timing of electronic bell. When push button is pressed, electronic bell will be in time setting mode. We can adjust the time using keypad.

In the circuit shown above, we provide 220V A.C. power supply to the "Step-Down Transformer" which converts 220V A.C. into 12V A.C. (i.e. stepped down the power supply). Now this 12V A.C. is converted into 12V D.C. with the help of "Full Wave Rectifier" which consists of 2 Diodes & 2

Condensers [a filter capacitor (1000µF)]. Two different voltage levels are required for our circuit – One is 12V D.C. to operate relay switch. Second is 5V D.C. supply to operate microcontroller "AVR". For this purpose we will use voltage regulator "LM7805" which can take 8V -25V as I/P & provide 5V constant voltage. Here we have used "microchips PIC" microcontroller to control various timing of the ringing. Here we also use a "16MHz Crystal" which will provide the microcontroller a reference time. We have used "Assembly Language" to program this microcontroller and we have also used a microcontroller programmer. We have used different types of capacitors and resistors in this circuit. We have used two 33pF capacitor which are acting as a High Pass Filter [H.P.F.]. The 10KΩ resistor is used for RESET circuit to provide negative potential to RESET pin of microcontroller. We have used IC DS 1307 which is a low-power clock/calendar with 56 bytes of Battery-backed SRAM. It uses an external 32.768 kHz crystal. The oscillator circuit does not require any external resistors or capacitors to operate. The accuracy of the clock is dependent upon the accuracy of the crystal and the accuracy of the match between the capacitive load of the oscillator circuit and the capacitive load for which the crystal was trimmed. We have used Dot Matrix display for the displaying the real time lectures and Notices. Here dotmatrix display driver is used for the interfcing process. The microcontroller can operate on 5V and 10mA current maximum but we have to operate 12V relay switch which consume more than 7A current. So, we have to amplify this current and voltage, For this purpose we are using driver IC ULN2003.

Block diagram of Automatic electronic bell
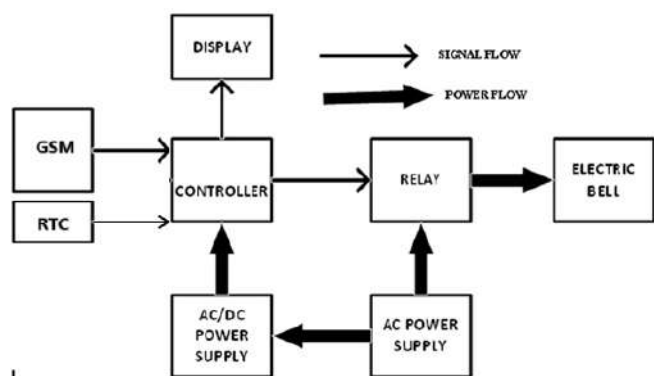
Block diagram of electronic bell and wireless Notice board for college is shown above. RTC is used to set the timing of electronic bell. After reaching at set time, AVR microcontroller activates the relay for 1 minutes and electric bell start ringing for 1 minutes. After 1 minutes, microcontroller gives off signal to relay. Relay coil becomes de energize and switch off the electronic bell. DOT MATRIX display is used to display time and status of electronic bell. DS1307 real time clock is used to keep track of time. Power supply for micro controllers is designed using 7812 and 7805 voltage regulators.

1) POWER SUPPLY: In this circuit, we are using three supply of 5V.The 5V supply basically used for LED matrix display, seven segment display and supply to the Microcontroller.
2) MICROCONTROLLER (ATMEGA328): A microcontroller is a single chip that contains the processor non-volatile memory for the program, volatile memory for input and output, a clock and an input I/O control unit.
3) REAL TIME CLOCK (DS1307): The (DS1307) serial real time clock is a low power IC .The clock/calendar provides seconds, minutes, hours, day, date, months and your information at the end of the month, date is automatically adjusted for months with fewer than 31 days .The clock operates in either 24Hr or 12Hr format with AM/PM indicator. The DS1307 has built-in power, sense circuit that detects power failures and automatically switches to the backup supply.
4) DOT MATRIX display: It is a display device used to display information of notices, clocks, lectures and many other informations requiring a simple display device of limited resolution.

GSM: User will send any through gsm network in the form of SMS.

FUTURE SCOPE
As there may be numerous departments at a university at a distance on the same campus and desire to synchronize all department bells, the automatic college bell system employing lab VIEW may be expanded for further development.
This proposed system has many upcoming applications in educational institutions and organizations, crime prevention, traffic management, railways, advertisements etc.

CONCLUSIONS

A automatic college bell can be successfully designed and can be applicable in school and colleges as per to save manpower and also to save time it's a cost effective project which can be built using easily available equipment and can be used in real time in the school and in the colleges this can be included in every educational institution as per the timing which can be easily reprogrammed by a common laymen and can also vary timing for some classes as per the schedule of the school. The display of time in the project also increases it effectiveness.
This project elaborates the drawbacks of manually operated bell ringing system and how this automatic college bell ringing system deals with these drawbacks. This automatic bell ringing system not only used for lecture schedule but we can also use it for examination purpose. We have constructively combined the college bell with RF module and LCD to display the notices. This project helps to ring the bell with high accuracy in time in all locations.

As the technology is advancing every day the display board systems are moving from Normal handwriting display to digital display. Further to Wireless display units. This project develops a wireless notice board system with Bluetooth connected to it, which displays the desired message of the user through an SMS in a most populated or crowded places. Here by introducing the concept of wireless technology in the Field of the communication. We can make our communication more efficient and faster, with greater efficiency. We can display the messages and with less errors and maintenance.

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Enhancing Ration Distribution: A Technical Assessment of RFID and Biometric Authentication Methods with IoT

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ABSTRACT--Corruption has long been a persistent issue in government sectors worldwide, and addressing it effectively requires a well-thought-out approach. One of the emerging solutions is the implementation of e-government systems, which aim to promote transparency and minimize corruption. This article seeks to review both theoretical and empirical studies on corruption and explore potential areas for further research. In the context of the Public Ration Distribution System (PRDS) in developing countries, such as India, the challenge of manual registration and metering at ration shops has led to various inefficiencies and perceptions of corruption. To address this issue, the "Automatic Ration Vending Machine" project proposes an innovative solution. This system automates the distribution of subsidized goods to eligible individuals by integrating RFID technology and biometric authentication. It ensures secure and accurate transactions, with each transaction being logged in a central database. The use of fingerprint recognition further enhances user identification, minimizing errors and fraud. Moreover, the shift towards computerization and active citizen involvement has proven effective in tracking and regulating the grain supply chain, thereby reducing issues of corruption and fraud. This study highlights the role of technology-driven solutions in combating corruption and enhancing the efficiency of essential goods distribution systems.

Keywords - Corruption, Public Distribution Mechanism (PDM), Digital Point of Sale (DPoS), RFID Technology (Radio Frequency Identification), Cash Dispensing Machine (CDM), Performance Optimization, Data Management Update.

1. INTRODUCTION

India's PublicRation Distribution System (PRDS) is a cornerstone in Ensuring Food Security, especially for the economically disadvantaged. With a population exceeding 1.4 billion, approximately 29.8% of whom live Below the Poverty Line (BPL), many rely on the government's subsidized food distribution network. The PDS plays an essential role in combating food insecurity and is critical to the well-being of millions of people across the country.

As the world's largest retail distribution network, the PDS provides essential items such as rice, wheat, kerosene, and cooking oil to eligible households. State governments issue ration cards to families based on their income levels, categorized into yellow, saffron, and white cards. These cards allow beneficiaries to collect their allocated rations from designated shops, typically within the first week of each month.

Despite its significance, the traditional PDS faces considerable challenges. Manual, paper-based processes often lead to inefficiencies, fraud, and leakage of subsidized goods. Furthermore, beneficiary identification remains a major issue, causing delays and the misallocation of resources. These shortcomings hinder the system's effectiveness and highlight the need for improvement.

Advancements in technology, particularly the integration of Radio Frequency Identification (RFID) and Biometrics Authentication, offer promising solutions to these challenges. RFID technology can enhance the tracking of ration distribution, while biometrics ensures accurate identification of beneficiaries, reducing fraud and errors. Together, these technologies could fully automate the ration disbursal process, making it more transparent, efficient, and secure.

This paper Explores the feasibility and potential benefits of An Automated Ration Disbursal System utilizing RFID & Biometrics Authentication. The objective is to improve beneficiary targeting, reduce leakages, and increase accountability within the PDS.

The proposed system would involve several steps: beneficiaries would first register and undergo biometric enrolment, followed by the automated tracking and verification of transactions at ration shops through the RFID system. This approach ensures that only eligible individuals receive their rations, minimizing human errors, fraud, and delays in the distribution process.

By automating the PDS, the system can provide a more reliable and efficient method for distributing essential commodities to those in need. This research aims to demonstrate how such a system could revolutionize the PDS, making it more transparent, accountable, and capable of effectively serving India's diverse population. Ultimately, the integration of RFID and biometrics can ensure that food security reaches the right people, reducing corruption and improving the overall distribution process.

1.1. EXISTING SYSTEM:

In many countries, traditional paper-based ration distribution systems have faced significant challenges, including corruption, pilferage, and discrepancies in resource allocation. These issues have prompted the adoption of more modern solutions, such as Electronic Point of Sale (EPOS) systems and grain ATMs, which aim to streamline the rationing process and improve resource management.

However, while these systems have shown potential for improving efficiency, they have also revealed several vulnerabilities. Instances of identity fraud and inaccurate authentication have raised concerns about the reliability of these systems, resulting in situations where eligible beneficiaries are either denied their rightful entitlements or fraudulent claims are approved.

Despite their promising features, these systems still face the following challenges:

- **Technical Failures**: Both EPOS and grain ATM systems experience malfunctions, including software and hardware errors.
- **Power Supply Issues**: A stable electricity supply is essential for the consistent functioning of these systems.
- **Data Security and Privacy**: Concerns around the protection of personal and sensitive data remain a critical issue.
- **Slow Processing and Measurement Inaccuracies**: Some systems suffer from delays and inaccuracies, leading to inefficiencies.
- **Stock Management and Database Maintenance**: Ensuring accurate inventory tracking and system updates is a challenge.
- **Adoption of New Technology**: Introducing and managing new technologies and applications often comes with difficulties.
- **User Training and Familiarity**: Beneficiaries and operators may not always be familiar with the systems, requiring additional training.

- **Inclusion of Non-Registered Individuals**: People lacking proper documentation or not registered in the system face challenges in accessing services.
- **Long Waiting Times**: Extended queues and waiting periods can frustrate users and delay service delivery.
- **Absence of Redressal Mechanisms**: A lack of effective complaint resolution systems adds to user dissatisfaction.
- **Time Efficiency**: Reducing the time required for ration disbursal remains a challenge in these systems.

1.2. PROPOSED SYSTEM:

The paper examines the potential benefits of the proposed system for various stakeholders, including beneficiaries, ration shop operators, and government authorities. It highlights the advantages of improved efficiency, reduced administrative workload, and greater transparency in the ration distribution process.

The core technological components of the system, specifically RFID and Biometrics Authentication, are presented as key drivers of its effectiveness. RFID facilitates seamless tracking and identification of beneficiaries and ration supplies, while Biometrics Authentication ensures accurate identification of beneficiaries, preventing unauthorized access.

The proposed system is designed to address the existing challenges in ration distribution, aiming to overcome these issues to the greatest extent possible. Key features include:

- Regular System Maintenance and Updates
- Load Balancing for Traffic Distribution
- Comprehensive Testing and Quality Assurance
- Collaboration with Trusted Vendors
- Integration of Solar Panels for Enhanced Energy Efficiency
- Multi-factor Authentication (MFA) for Security
- Integration with Government Databases for Streamlined Operations
- Cloud-based Scalability for Future Growth
- Automated Weighing System for Accurate Measurements
- RFID Integration for Real-time Tracking
- Real-time Data Synchronization for Consistent Updates
- Automated Stock Monitoring for Inventory Management
- Robust Database Backup and Recovery Mechanisms
- User-Friendly Interface for Easy Access

- Reliable Hardware and Infrastructure for Smooth Operations

This system is designed To provide an efficient, secure, and transparent Solution for ration disbursal in India, benefiting all involved parties.

2. LITERATURE SURVEY

The literature survey explores various innovative technologies and approaches aimed at enhancing the accuracy, transparency, and efficiency of ration distribution systems, particularly for food rations. This review analyses several research papers and publications to understand the progress made and the challenges faced in developing a more effective and inclusive ration disbursal system.

[1] One study highlights the limitations of traditional ration distribution methods, including human errors and illegal sales. To address these issues, the study proposes the use of RFID-based identification for consumers, allowing them to withdraw rations independently. Additionally, GSM technology is integrated to send SMS notifications after each transaction, ensuring transparency and maintaining consumption records.

[2] Another study introduces a PLC-based ration disbursal system that functions similarly to an ATM. Consumers use their RFID smart cards and undergo fingerprint verification for authentication. An LCD display shows their personal details and ration allotment, allowing them to select rations based on preference. The system automatically deducts the cost from the consumer's bank account, and solar energy powers the entire setup, promoting eco-friendly usage.

[3] A different study focuses on the distribution of smart cards to consumers containing their personal information and ration allotment. While this approach helps counter illegal ration trade, it lacks a secure consumer verification method. To improve security, the study suggests integrating biometric authentication, such as fingerprint verification.

[5] The authors of another study propose an IoT-based automatic ration disbursal system to reduce manual labour and eliminate the need for extensive bookkeeping. In this system, all devices are connected to a central server, where all transaction records are stored in a centralized database for easier monitoring and management.

3. METHODOLOGY

This Research Paper outlines A systematic methodology for the design and evaluation of an Automatic Ration Vending Machine prototype. The approach adopts an applied research framework, concentrating on the practical implementation and evaluation of the system's performance, user experience, and its broader impact on stakeholders.

In the following sections, we will provide a comprehensive overview of the prototype's development, including the selection of key components, the rationale for their integration, and the design choices made throughout the process. Additionally, we will address the challenges encountered during development and the strategies employed to resolve them.

This methodology ensures that the system not only adheres to technical standards but also offers a seamless and user-friendly interface for efficient ration distribution. By Focusing on these elements, the goal is to enhance the Public Ration Distribution System (PRDS) in India, making it more accessible and Efficient for users while improving the overall ration disbursal process.

3.1.MAJOR HARDWARE COMPONENTS IN THE SYSTEM:

1. **Atmega328P Microcontroller (MCU):**The Atmega328P Microcontroller Unit (MCU) acts as the core Processing Unit Of The System, managing and coordinating All hardware operations while executing software instructions. It processes data from RFID readers and biometric sensors, handles user authentication, and ensures seamless communication between system components. The MCU is responsible for running control logic for ration distribution, managing user registration, storing data in non-volatile memory, and facilitating user interactions. Additionally, it supports real-time operation and integration with IoT platforms for remote monitoring and advanced functionalities. In essence, the MCU ensures the system operates efficiently and cohesively.

2. **Node MCU ESP32:** The Node MCU ESP32 enables IoT connectivity, allowing the system to communicate with servers and other devices via Wi-Fi and Bluetooth. It facilitates real-time data exchange with centralized government databases, ensuring accurate and up-to-date information. By incorporating IoT capabilities, this component enhances system functionality and improves interoperability with external platforms and devices.

3. **Keypad:**A 4x4 matrix keypad is included to allow users to input their identification codes and select their preferred ration options. This component ensures user interaction is straightforward and efficient.

4. **LCD Display:**A 16x4 character LCD display provides users with real-time feedback, such as transaction status, system instructions, and available ration choices. This display enhances user experience by offering clear and concise information.

5. **RFID Reader:** The RFID reader identifies users by scanning their RFID cards or tags, enabling secure and personalized access to the system. This component ensures accurate user identification and enhances system security.

6. **Motorized Dispensing Mechanism:** A motor-controlled dispensing mechanism releases the specified quantity of ration based on user selection. This mechanism ensures precise and efficient ration distribution.

7. **Load Cell:** The load cell measures the weight of dispensed Ration items, ensuring accuracy and consistency in the distribution process. This component plays a critical Role in maintaining system reliability.

8. **Fingerprint Sensor Module:** The fingerprint sensor module add an extra layer of Security By verifying the user's fingerprint against the stored database. This ensures that only authorized individuals can access the system.

9. **GSM Module:** The GSM module facilitates real-time communication through SMS notifications and OTP (One-Time Password) authentication. It provides beneficiaries with updates on ration availability and transaction details, enhancing transparency and user engagement.

10. **SD Card Module:**A stable power supply unit provides the necessary voltage and current to ensure all components function correctly. This is essential for maintaining system reliability and performance.

11. **Power Supply:**A stable power supply unit provides the necessary voltage and current to ensure all components function correctly. This is essential for maintaining system reliability and performance.

12. **Solar Panel:** Solar panels offer an eco-friendly and continuous power supply, ensuring the system remains operational during power outages. This component enhances the system's sustainability and reliability.

3.2. TRACKING AND IDENTIFICATION OF RATION SUPPLIES

The Public Ration Distribution System (PRDS) utilizes Radio Frequency Identification (RFID) technology to track and identify ration supplies effectively. RFID enables seamless monitoring of ration packages as they move through the distribution network. Each package is equipped with a unique RFID tag that stores essential identification details. As supplies Progress through the system, RFID readers scan These tags offer live tracking of their position, activity, and condition, delivering instant updates. This ensures accurate oversight of the supply chain, from storage facilities to distribution points, helping authorities maintain optimal inventory levels, minimize losses, and streamline the ration distribution process.

To enhance security and efficiency, the system integrates IoT devices and biometric authentication. These additions bolster transparency and accountability, ensuring that ration supplies reach their intended beneficiaries without discrepancies.

The technology supports the system through the following features:

1. Advanced RFID Tracking
2. Customized Barcode Scanning
3. Unique Serial Numbers for Each Package
4. GPS-Enabled Location Precision
5. Secure Blockchain Integration
6. Data-Driven Analytics for Decision-Making
7. Biometric Authentication for Recipients
8. Tamper-Evident Packaging Solutions
9. Centralized Cloud-Based Inventory Management
10. Mobile Applications for Field Agents
11. Precise Auditing and Inspection Mechanisms
12. Reliable Communication Networks
13. Dynamic QR Code Implementation
14. Comprehensive Record-Keeping for Full Traceability
15. Collaborations with Leading Technology Providers

3.3. SMART FEATURES TO BE INTRODUCED IN THE RATION VENDING SYSTEM:

- **Smart measuring using sensor feedback**

Sensors such as load cells and solenoid valves will be utilized to accurately measure and dispense the precise quantity of ration.

- **Authentication**

    1. **Biometrics**

    A fingerprint sensor will enable consumers to authenticate their identity securely.

    2. **RFID-Card**
    RFID-based authentication will verify individuals by scanning RFID-enabled cards. The system will read unique identifiers stored on the cards and grant or deny access based on the data retrieved.

    3. **Password Protection**

    During registration, users will create a secure password, which can later be used for authentication purposes

- **Smart Monitoring**

    1. The system will automatically monitor ration levels in storage. When the quantity falls below a predefined threshold, it will send a request to the Food Corporation of India (FCI) for replenishment.

    2. Upon distributing the ration, the system will automatically send a text message to the consumer's registered phone number, providing details of the transaction.

- **Solar energy-based power supply**

The system will utilize photovoltaic panels to harness solar energy, providing a sustainable and eco-friendly power source. This approach is a superior alternative to relying on electricity generated from fossil fuels.

- **Executing appropriate limitations as per the allotted quota**

The system will be programmed to restrict consumers from withdrawing ration once their allotted quota has been exhausted.

- **Smart payment acceptance using Coin acceptor**

Payments for ration can be made using a coin acceptor, which will process and validate coins for transactions.

3.4. WORKING OF THE SYSTEM:

The following steps are involved in the working of the system:
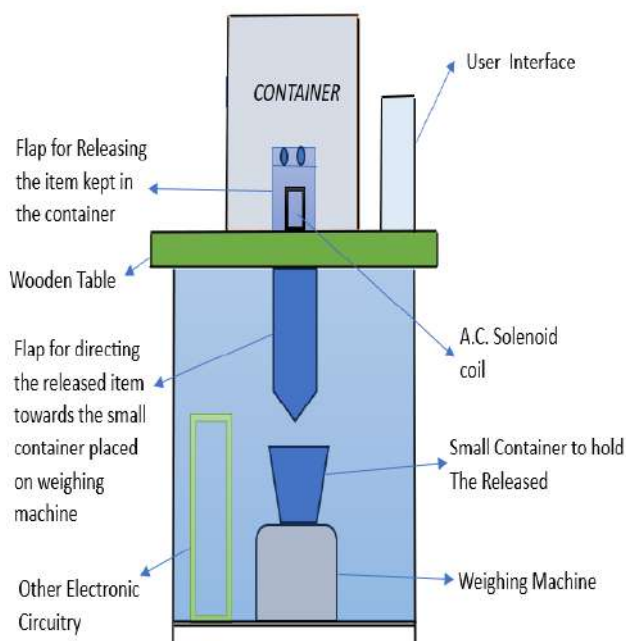
Fig 1.1: Basic Working System

1. User Registration and Authentication: The process begins with user registration and authentication. Each beneficiary is provided with an RFID card or tag containing a unique identification code tied to their ration entitlements. Additionally, the user's biometric data, such as fingerprints, is collected. When a beneficiary approaches the ration vending system, they must scan their RFID card using the RFID reader and complete fingerprint authentication to proceed.

2. User Interface and LCD Display: The system features a user interface that includes a 4x4 matrix keypad and a 16x4 character LCD display. Upon successful authentication, the LCD screen shows pertinent details, such as the user's name, remaining ration balance, and available ration options.

3. Ration Selection: After authentication, the user can choose their desired ration items from the displayed options using the keypad. The system provides information on the quantity and type of ration available to the user, based on their entitlements and any restrictions set by the authorities.

Grain Selection:

1. Beneficiary Registration

2. Grain Requirement (Allotment) Assessment

3. Transparent Inventory Management

4. Fair and Wastage-Minimized Allocation

5. Streamlined Distribution Process

6. Enhanced Feedback System

7. Database Update After Processing

8. Looping the Process

9. Database Maintenance

4. Payment Acceptance and Verification: Once the ration selection is complete, the user must initiate the payment process by paying the amount displayed, which corresponds to their allocated ration.

5. Transaction Verification: After selecting the ration items, the user is prompted to verify the transaction. They can review their chosen items on the LCD display and confirm the transaction by pressing a designated key on the keypad.

6. Dispensing Mechanism: Upon transaction verification, the system activates the ration dispensing process. A motorized dispensing mechanism, controlled by the microcontroller, releases the specified quantity of each selected ration item. This mechanism ensures precise and accurate distribution.

8. Load Cell or Proximity Sensor: To ensure accurate dispensing, the system incorporates a load cell or proximity sensor. The sensor measures the weight of the dispensed ration or detects the presence of the item in the collection tray, confirming successful distribution.

9. Transaction Logging and Data Storage: The system maintains a detailed log of all ration transactions. Information such as the user's identification, ration items, date, and time of the transaction is recorded and stored in the system's memory or an external SD card module. This data can also be uploaded to a cloud server for auditing and analysis purposes.

10. Error Handling and Alerts: The system includes error handling mechanisms to manage exceptional situations. In cases of dispensing errors, such as insufficient stock or motor malfunctions, the system generates alerts on the LCD display and logs the incident for further review.

Flowchart
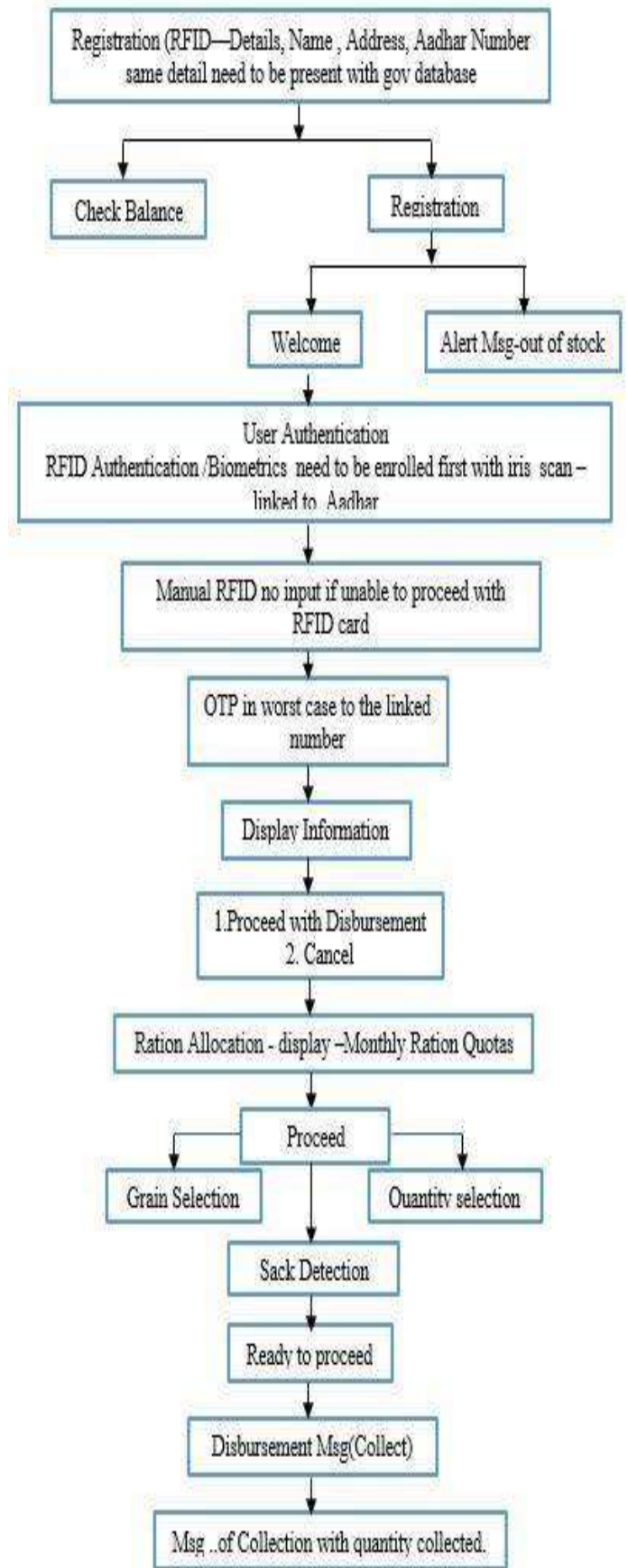
Fig 1.2: Flow Chart of our System

4. BLOCK DIAGRAM
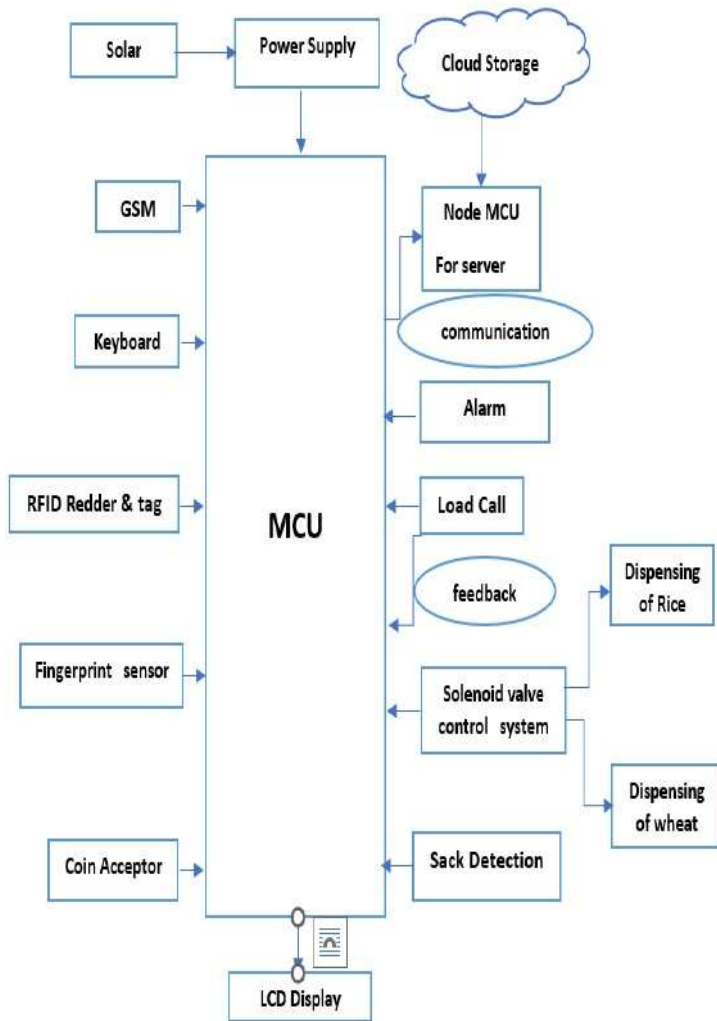
Fig 1.3: Block Diagram

5. ADVANTAGES

1. Accurate distribution to qualified recipients minimizes waste and prevents fraud.
2. Improved transparency and accountability through automated record-keeping systems.
3. Real-time inventory tracking reduces waste and theft.
4. Intuitive interface designed for ease of use by all beneficiaries.
5. Encourages digital literacy and the use of online services.
6. Easily accessible, even in distant or underserved regions.
7. Requires minimal infrastructure for implementation.
8. Decreases reliance on intermediaries by enabling direct distribution.
9. Automation and contactless systems simplify operations.
10. Advanced security features using biometric and RFID technologies.
11. An economical approach to managing food distribution.
12. Operates effectively in remote areas without internet access.

6. RESULT AND DISCUSSION

In the Automated Ration Distribution System, every ration user is issued an RFID card. Each card is linked to a fingerprint stored in the database. User details, including their balance, are saved in an SD card database. Every RFID card has a unique identifier, allowing easy user differentiation, and is paired with the user's fingerprint for authentication.

Initially, the RFID card is scanned by the reader, which sends the card's data to the controller. The controller verifies if the data exists in the SD card database. If a match is found, the system prompts the user to provide their fingerprint; otherwise, an error message is displayed. Upon successful authentication, the DC motor activates, rotating the shaft to open the valve for dispensing solid materials. The load cell monitors the weight and sends a signal to the microcontroller when the desired weight is achieved. The microcontroller then instructs the DC motor to close the valve.

Next, the solenoid valve is triggered, allowing liquid to flow through the flow sensor into the beaker. Once the required quantity of liquid is dispensed, the flow sensor sends a signal to the microcontroller, which closes the solenoid valve. Finally, the system deducts the dispensed amount from the user's card and updates the remaining balance in the database.

RFID tags are employed to differentiate among various ration users. Each individual is provided with a distinct RFID tag, allowing them to buy rations. A prompt appears on the screen, guiding the user to swipe their RFID tag against the reader before starting the process. Figure 2 depicts the message displayed on the screen before the RFID tag is scanned.

The RFID tag is scanned to recognize the user and transmit the data to the microcontroller. The microcontroller verifies the RFID tag's authenticity. Once verified, the user's details stored in the database are shown on the LCD screen. The user's information is displayed as illustrated in Figure 3.

If an unauthorized individual attempts to access rations using an RFID tag not registered in the

database, an error message stating "Invalid Card" will appear on the LCD screen, and the system will deny access to the ration supplies. The error message is displayed as shown in Figure 4. However, if a valid user accesses the system, the message "Access Granted" will be shown on the screen, and the rations will be dispensed to the user. Figure 5 displays the message shown on the screen upon a successful fingerprint match. A weight sensor measures the quantity of material placed on it and relays this information to the microcontroller. The microcontroller then shows the weight in kilograms on the LCD screen, as demonstrated in Figure 6.

A flow sensor measures the volume of liquid passing through it and transmits the data to a microcontroller. The microcontroller then processes this information and shows the liquid volume in milliliters on an LCD display, as illustrated in Figure 7.

Fig.2. Welcome Message Displayed Initially

Fig. 3. User Information

Fig. 4. Unauthorized System Entry

Fig .5. Permitted Entry

Fig .6. Weight Measurement Indicator Message

Fig. 7. Flow Meter Screen Notification

Upon distributing the ration to the user, the system modifies the local database by subtracting the allocated ration quantity from the existing balance. It then shows the updated remaining balance to the user. The balance notification is illustrated in Figure 8.

Figure 9 displays the completed design of the automated ration dispenser. This device enables users to obtain their rations independently, eliminating the need for intermediaries.

Fig.8. Remaining amount on the card

Fig.9. Ration Vending Machine Front View

Fig. 10. Ration Vending Machine Back View

7. CONCLUSION

Insummary,theintelligentandfullyautomatedration distribution system, utilizing RFID and biometric authentication,presentsarevolutionaryupgradetothe conventional Public Ration Distribution System (PRDS). Byincorporatingadvanced technologies such asRFIDandbiometrics,thesystemeffectivelytackles issues like inefficiencies, leakages, and inaccurate identification of beneficiaries. RFID facilitates smooth trackingandidentification,optimizingthedistribution process.Biometricauthenticationguaranteesaccurate beneficiaryverification,significantlyreducingtherisk of fraud. Combined, these technologies improve both efficiency and security. The detailed step-by-step operational framework ensures secure and efficient access to rations for eligible individuals. This automated approach boosts transparency, accountability, and precision in distribution. The system's potential benefits for stakeholders include better targeting, reduced leakages, and increased efficiencyinrationallocation.Theintegrationofsolar panels ensures sustainability and functionality in remote locations. Overall, the system holds promise for strengthening social welfare programs and addressing food security challenges.

8. FUTURE SCOPE

1. Convenience and Accessibility: Ration vending machines can significantly enhance convenience and accessibility for the public. By strategically locating them in supermarkets, community centers, or residential neighborhoods, these machines can provide easy access to essential food items, eliminating long queues and wait times.

2. Customization and Personalization: These machines can be designed to offer customized options based on individual dietary needs, allergies, or preferences. This personalization ensures a more user- centric experience, catering to diverse nutritional requirements.

3. Smart Inventory Management: By integrating IoT (Internet of Things) and AI-driven systems, these machines can enable real-time inventory tracking and automated restocking. This ensures consistent availability of essential items, minimizing the risk of shortages.

4. Government Initiatives: Governments can utilize these machines as part of social welfare programs to distribute subsidized or free rations efficiently. This approach can reduce administrative costs and enhance transparency in the distribution process.

5. Emergency Response and Disaster Management: In emergencies or natural disasters, these machines can act as vital distribution hubs, providing immediate access to essential supplies. Their autonomous functionality makes them particularly valuable in crisis scenarios.

6. Global Adoption: These machines have the potential to be adopted worldwide, especially in regions reliant on manual distribution systems. They could play a key role in improving food security and streamlining distribution efficiency globally.

7. Environmental Impact: Future designs could prioritize sustainability by incorporating biodegradable packaging or waste-reducing dispensing mechanisms. Additionally, powering these machines with Renewable Energy Sources, such as Solar Power, could further Reduce Their Environmental Footprint.

8. Integration with Payment Systems: Exploring integration with digital payment platforms or crypto currencies could offer users more flexible and modern payment options, moving beyond traditional cash- based systems.

9. Continuous Innovation: Advancements in robotics, AI, and machine learning can drive ongoing improvements in these machines, making them smarter, more adaptable, and increasingly user-friendly over time.

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Hand Motion Controller Robotic Vehicle

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ABSTRACT

This paper proposes Hand Movement Controlled Automated Vehicle with impediment location distinguishes patterns in innovation applications and convenience. We display an approach that's based on discovery of movement of hand which will control vehicle development and abstains development of vehicle on the off chance that impediment is recognized in way. Too disturbing client around deterrent. The individual must move his hand to move the vehicle in forward, in reverse, cleared out or right course. So, the client does not got to press any buttons. The Transmitter circuit that 'son the best of a glove includes micro-controller inter-faced to the accelerometer. The framework incorporates a collector circuit planned which can be mounted on a beat of the mechanical vehicle comprising engines. This venture is created as a travel buddy and mechanical employments. Having future scope of progressed mechanical technology that are planned and can effectively be controlled utilizing hand motion a sit were. It is having proposed utility in field of development, dangerous squander transfer and field study close borders etc.

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KEYWORDS: Obstacles, Detection of motion, Microcontroller, Accelerometer, travel buddy

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INTRODUCTION

In this framework, a motion driven automated vehicle is created, which too incorporates ultrasonic sensors which avoids the mechanical vehicle from colliding with any impediment. The vehicular developments i.e. dealing with and control, depends on the signal of the client. In this framework, motion is captured by accelerometer which is mounted on person's hand and are sent to micro-controller and encoder circuit. This encoded flag is transmitted by RF transmitter. Within the
Collector area, the RF collector holds down the gotten flag and after translating it is handled with microcontroller and gives those parameters to the mechanical vehicle So that it acts appropriately to the motion.

PROBLEMSTATEMENT

Existing control systemsfor autonomousvehicleslargely rely on manual inputs, such as joysticks, buttons, or touchscreens. These traditional methods can limit the user'sabilitytocontrolthe vehicleincomplexor hard-to-reach situations, particularly when their hands are otherwise occupied. There isagrowing demand for more intuitive control systems that enable users to interact naturally with robotic vehicles through hand gestures.
The challenge is to develop a reliable hand gesture control system that allows users to manage the movements of an autonomous vehicle, includingforward, backward, left, right, stop, speed adjustments, and other essential functions (such as turning or performing tasks) through hand motions. The system must be accurate, responsive, and capable of interpreting a wide range of gestures, even under various environmental conditions, such as changes in lighting, distance, and noise interference.

LITERATUREREVIEW

Abhiraj Bhalerao, Kunal Choprade, Prasad Doifode, and Jitendra Gaikwad (2019) in their study, "Pick and Place Robotic ARM using PLC," describe the various stages involved in the operation of a pick and place robotic arm. The robotic arm functions as an automated material handling system, where it picksupobjectsfromaconveyorbelt.Thestudy

highlights that, although advanced robots are utilized across industries, many are still controlled manually or by processors like Arduino and microcontrollers, which pose significant limitations due to manual control or thedrawbacksofmicrocontroller-basedsystems.

Harish K, Megha D, Shuklambari M, Amit K, and Chaitanya K Jambotkar (2017) in their research, "Pick and Place Robotic Arm Using Arduino," explain that pick and place robotsare widely used in manufacturing industries to reduce human errors and intervention, ensuring greater precision. The study suggests that such robots are applied in various sectors, including bottle filling, packaging, and even bomb detection and disposal. The project focuses on implementing a pick and place robot controlled by RF signals using Robo-Arduino.

In the study, "Design of Pick and Place Robot TestRig"byHarshvardhanB.P,Salamakalahalli RamakrishnappaBharat,andSushanthKanabail Srinivas (2013), the focus is on the kinematics of the robotic arm and its links, which resemble the human anatomy, such as the waist, upper arm, and forearm, with joints similar to the shoulder and elbow. At the arm's end, a wrist joint connects to a fixture or gripper to perform the required tasks.

SYSTEMANALYSIS

A. Definition

The user wears a device on their hand that limits normal hand movement. Battery capacity.Since the system is battery-operated, the battery's capacity determines the robot's endurance. A larger battery increasesthe robot'sweight, while asmaller battery impactsitsperformance.Ultrasonicsensoroperation range:The operational range is from 2 cm to 4 cm, which is sufficient for small-scale applications. However, if this project is to be implemented on a largerscale,theobstacledetectionrangeneedstobe extended.

B. StrategyRecognizingHandDevelopments:

The handheld controller may be a 3D unbending body that can be turned approximately the three Orthogonal tomahawks. Yaw, pitch and roll are alluded to as revolution. These revolution takes put as Z hub is called yaw, the another revolution X-axis is called pitch and final revolution almost the Y-axis is called roll. Any introductioncan be accomplished bythe composing those three-elemental turn.

Uservehicle interaction:

Transmitter
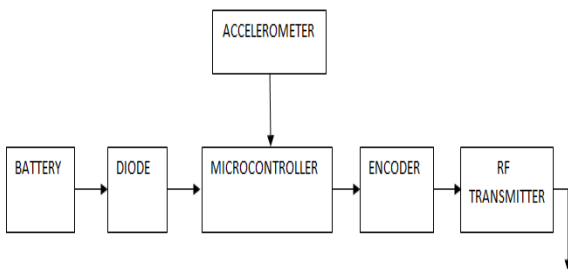
An RF transmitter module is capable of sending a radio wave and modulating it to carry information. These transmitter modules are typically implemented alongside a microcontroller, which provides the data to be transmitted by the RF module. RF transmitters areusually subject to regulatory regulations that control the maximum allowable transmitter power output.

Receiver:
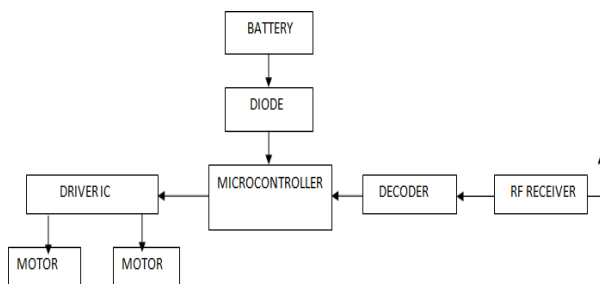
An RF receiver module receives the modulated RF signal and then demodulates it. There are two types of RF receiver modules. Super-regenerative modules are typically low-cost and low-power designs thatuse a series of amplifiers to extract modulated data from a carrier wave. However, super-regenerative modules are often unstable, as their operating frequency can vary significantly with changes in temperature and supply voltage. Superheterodyne receivers, on the other hand, offer betterperformance, providing greater accuracy andstability across a wide voltage and temperaturerange. This stability comes from a fixed crystal design, which results in a more expensive product. The radio receiver captures the transmitted coded signal from the transmitter, which is then converted into a digital format and passed to the microcontroller.Based onthe input coded signal, the input is sent to the motor driver IC, and the robot behaves as follows:

- Movesforward
- Movesin reverse
- Can turn left or right while moving forward or backward
- In case of an obstacle, it reverses, turns left or right, and waits for the next instruction
- Canmakeasharpleftorrightturnto navigate through tight spaces

Development of the robotic vehicle: The L293D is a dual H-bridge motor driver integrated circuit (IC). Motordriversact ascurrent amplifiers, takinga low-current control signal and providing a higher current output. This higher current is used to drive the motors. The L293D contains two built-in H-bridge driver circuits. In normal operation, it can drive two DC motors simultaneously, both forward andreverse. The motor operations of the two motors are controlled by input logic. When an enable input is high, the associated driver is enabled, and theoutputs become active, operating in sync with the inputs. Conversely, when theenableinputislow, the driver is disabled, and its outputs are turned off, entering a high-impedance state. This systemcontrols an autonomous vehicle via RF. The AT89S52 microcontrollerisused inthis project. It is radio-controlled and can operate at a distance of upto 100 meters.

CONCLUSIONS:

In short, the robotic vehicle of the hand motion controller represents an innovative approach to interact with autonomous means, providing a more natural and intuitive control method than traditional entry devices. By taking advantage of hand gestures, users can navigate and control the movements of the car effectively, including forward, back, obstacles and avoid obstacles, all do not need direct contact with the car. This system improves accessibility, especially in the scenarios that the user is occupied or when they operate in a complex or inaccessible environment.The integration of RF communications, engine control circuits such as L293D and microcontroller such as AT89S52 ensure that the car can operate smoothly and respond to the reaction. Although there are challenges such as limited battery capacity and ultrasonic sensor constraints, the project can be expanded and tweaked for larger -scale applications by improving the sensor range and electricity efficiency. The last, this manual - controlled robot car throws more advanced human interactions, provides potential applications in different fields, including supportive, automation and robot technology.

FUTURESCOPE:

The future scope of hand motion-controlled robotic vehicles is many opportunities and many opportunitiesfor innovation and expansion. A keydevelopment areais improving gesture recognition in the progression of machine learning and artificial intelligence, detecting a wider range of gesturesmore accuratelyand allowing for more complex control over vehicle movement. Additionally, improved integration of sensors such as ultrasound and LIDAR improves obstacle recognitionand navigation, especially in larger or dynamic environments. Progress in battery technology also plays an important role. This will help to extend the operating time by making a more efficient and long-term battery without affecting the size and weight of the system. The system can also be developed to support multi-bike adjustments and allow users to control multiple robotic vehicles simultaneously. This will be advantageous in areas such as warehouse automation and search and rescue processes.

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Design and Implementation of Solar battery charging with Machine learning

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ABSTRACT

Solar power systems have advanced in response to the increasing need for alternative energy sources. Yet, crucial obstacles still exist in the areas of effective energy use and battery management. An advanced solar battery charging system that makes use of machine learning is the main emphasis of this research. The suggested setup maximizes charging efficiency and extends battery life by combining solar panels, a charge controller, and a BMS with an algorithm for machine learning. The machine learning model can analyze past data and current weather to make predictions about energy generation, change charging parameters on the fly, and identify any performance issues with the battery. Even when weather conditions change, the system makes sure solar energy is used optimally by using predictive analytics. Adaptive energy flow decision-making is made possible by real-time data collecting and processing, which minimizes losses and protects the battery from deep draining or overcharging. Software algorithms for optimization and prediction and hardware components for storage and monitoring make up the implementation. Better charging efficiency, longer battery life, and less need for human intervention are all shown in the experimental findings. A more environmentally friendly energy system may benefit from this smart system's scalable and long-term solution for storing renewable energy.

KEYWORDS: *Solar Power Systems, Battery Management System (BMS), Maximum Power Point Tracking (MPPT), Predictive Analytics, Real-Time Data Processing.*

INTRODUCTION

Solar power systems have garnered a lot of attention due to the growing need for environmentally friendly energy throughout the world. One sustainable energy option that might replace fossil fuels is solar power, which is both plentiful and renewable. The effective use of solar energy is hindered by its intermittent nature, which is affected by weather conditions and the time of day. To alleviate these problems, battery storage devices are now crucial, as they allow energy to be saved during times of peak production and then utilised when solar power isn't available[1][2]. Power generation through PV systems fluctuates with changes in environmental conditions such as radiation, temperature, and humidity; as a result, power scheduling and operation rely heavily on estimates of power from renewable sources, which can affect the stability and reliability of power in an integrated renewable energy system. Predicting weather conditions aids in power production via PV solar plants, since the initial power generation in PV systems is dependent on temperature and radiation. Predicting solar energy, which can inform about the amount of solar power that can be produced at a certain area in the future, may help make a power system more stable. Machine learning and neural networks are one of several approaches to solar power forecasting[3][4]. Predicting future weather generation using machine learning algorithms is used to anticipate electricity production using a solar plant in this article. Machine learning is a branch of AI that allows computers to automatically detect patterns in data, draw conclusions, and make choices without human intervention. Multiple benefits accrue from solar charging systems that incorporate ML.:

• Adaptive Energy Management: ML algorithms can analyze real-time data from weather forecasts, solar irradiance sensors, and battery conditions to dynamically adjust charging parameters.

• Efficiency Optimization: By predicting solar energy generation and load demand, ML models can optimize energy flow, reducing waste and maximizing storage efficiency.

• Battery Health Monitoring: ML can detect anomalies in battery performance, such as overcharging, undercharging, or thermal runaway, thus extending battery lifespan.

• Cost Savings: Improved energy efficiency and reduced battery degradation lower operational costs over the system's lifecycle.

Key Challenges in Solar Battery Charging

The integration of ML into solar battery charging systems addresses several key challenges:

• Intermittency of Solar Energy: Solar power generation fluctuates due to factors like cloud cover, shading, and seasonal variations. Effective prediction and management of these variations are critical for consistent performance.

• Battery Management: Maintaining optimal charging and discharging rates is essential to prevent capacity loss, thermal stress, and reduced battery lifespan.

• Energy Efficiency: Traditional systems may not account for real-time variations in energy supply and demand, leading to inefficient energy use.

• System Scalability: Designing a system that remains efficient and robust as the scale of solar installations grows requires intelligent automation and adaptability.

In today's world, where electrical demand is directly related to economic growth, renewable energies are becoming increasingly important for power generation. This is because fossil fuels are finite and produce pollution and greenhouse gases as byproducts. Developing nations like India are no exception. Since photovoltaic (PV) electricity varies with changes in weather conditions, it will have a negative impact on the grid's functioning; yet, PV systems are important in renewable energy systems since they are plentiful in nature and renewable [2]. In order to keep the system stable in situations of variable power supply, fossil fuels should serve as a spinning reserve. To conserve the environment and limit fossil fuel consumption, it is extremely necessary to plan and estimate the operating duration and capacity. It is easier and cheaper to estimate the power needs for fossil fuels when previous experience with PV system output is known. For solar power production, forecasts and historical data are the two most important predictors. Therefore, solar power forecasting relies heavily on historical data collecting[4-7]. Although several scholars have put forth effective forecasting techniques, there is always opportunity for improvement. Machine learning's artificial neural network (ANN) provides incredibly accurate weather and solar PV power forecasts. Solar power has recently gained attention

as a potential renewable energy source that might help meet the world's energy needs. Solar power generation is intermittent, which makes electrical system management difficult. Optimizing the production and delivery of solar energy is one way that Artificial Intelligence and Machine Learning (AI/ML) might tackle these difficulties. Solar forecasting using Deep Learning, a branch of Machine Learning, has been the subject of recent research. When it comes to forecasting solar energy output, these strategies have shown to be more effective than more conventional methods like Multilayer Perceptron, Radial Base Function, and Support Vector Regression. Additionally, to further enhance solar projections, it has been suggested to combine AI approaches with adaptive topologies grounded. Solar battery charging systems that use AI and ML have the potential to provide substantial advantages. Machine Learning may be used to construct smart sensor systems that monitor the performance and health of solar plant components, allowing predictive maintenance and optimum operation[9]. To further maximize the use of solar power, algorithms powered by AI may be used to control energy storage and delivery[10].

This work's strategy is similar in that it seeks to lower total energy prices by storing PV output surplus for use at a later time. Approaches to finding a cheaper solution range from rule-based controllers to optimization approaches and even machine intelligence. Much of the attention in the field of machine learning has focused on RL as it pertains to controlling batteries in distributed energy systems[11]. Electricity market simulation, power quality, micro-grid management, wind generation control, and RL's many other uses in the electric power system are all detailed in a thorough review of RL's electric power system applications[12].

BATTERY STORAGE

From large-scale utility systems to smaller-scale home electrical systems, batteries play an important role. Battery applications at the utility level include backup power, frequency regulation, and spinning reserve. Peak shaving, load shifting, and, to a lesser degree, price arbitrage are all viable uses for household batteries. Installing a battery in a home setting is mostly done to store the extra PV output during mid-afternoon, when demand is lowest and incident solar radiation is maximum. Although it is common practice to sell back surplus PV output to the grid, the price that the producer obtains is not always beneficial. Increasing the household's self-sufficiency via storage and subsequent

usage is appealing from an environmental and financial perspective. Peak shaving happens when the battery dies just when the demand is peaking. A consumer's power cost may be reduced as a result of this impact, as peak demand often occurs during periods of greatest buying price for electricity[11] Power demands exceeding a certain level incur a surcharge for some customers, especially enterprises or those with significant power peaks. Peak shaving may result in even more savings for these customers. This is less of an issue for Swedish residential users since their peak demand is not high enough to trigger additional costs. Network operators and large-scale suppliers are particularly interested in peak-shaving since it can lower grid peak power levels, which may alleviate network pressure or decrease generating fuel costs. Using pricing disparities to your advantage is another perk of integrating battery storage. When engaging in price arbitrage, the battery draws power from the grid during periods of low costs and releases it during periods of high prices[12]. From a network perspective, this may have the dual benefit of lowering costs and perhaps decreasing peak demand. Despite the many benefits, the relatively high capital expenses of adding batteries to complement PV are still a concern. However, prices are predicted to decrease in the next years, making it more profitable and widespread to install a battery alongside PV in residential settings.

LITERATURE REVIEW

Author(s) & Year	Research Focus	Key Findings
AlexaApaza-Pinto et al. (2022)	Prediction of battery State of Charge (SoC) in mining equipment using supervised learning.	Neural networks were used to predict SoC with an accuracy of 90.12%. A software tool was developed to validate real-time data with predictive results.
Miswar A. Syed et al. (2023)	Smoothing PV power variability using a Moving Regression (MR) filter with SoC feedback.	The MR filter reduced battery charging/discharging power by ~30.48% and peak SoC by 19.1%, outperforming LPF, MA, MM, SG, and Gaussian filters.

ChanakaKeerthising he et al. (2020)	Forecasting PV production to optimize battery usage in firming operations.	Encoder-decoder LSTM-RNN reduced battery energy throughput by 29% and deep discharge cycles by 51%. Including type-of-day classification further improved results.
Ray Colucci et al. (2024)	Optimization of battery charge/discharge cycles for financial gain and cybersecurity in BESS.	Proposed a taxonomy for battery optimization and surveyed BESS utilization strategies, highlighting research gaps in cybersecurity for BESS.
W. M. N. Witharama et al. (2024)	AI-driven optimal scheduling for grid-connected AC microgrids.	Using Genetic Algorithms and LightGBM, the approach reduced electricity costs by 14.22% by optimizing battery dispatch and demand response.

PROBLEM STATEMENT

The effective utilization of solar energy faces several critical challenges that hinder its widespread adoption as a reliable energy source. Despite advancements in solar power technologies, traditional solar charging systems struggle to meet the dynamic demands of modern energy applications. These challenges include:

1. Intermittent Energy Generation: Solar energy production is highly dependent on weather conditions, time of day, and seasonal variations, leading to inconsistent energy availability.

2. Inefficient Energy Management: Existing charge controllers operate on static algorithms that fail to adapt to real-time environmental changes, resulting in suboptimal energy storage and utilization.

3. Battery Degradation: Improper charging and discharging cycles, coupled with thermal stress, lead to reduced battery life and increased maintenance costs.

4. Limited Scalability: Traditional systems lack the flexibility to scale efficiently for diverse applications, from small residential setups to large-scale industrial installations.

Machine learning-enabled solar battery charging systems optimise power efficiency, forecast energy availability, and extend battery longevity via real-time data-driven dynamic parameter adjustments. Modeling, designing, and implementing a low-power solar charge controller with maximum power point tracking (MPPT) for rapid prototyping is presented in this work. One 13.5V-48Ah battery, one 60 W photovoltaic (PV) module, and one buck converter with an MPPT controller make up the constructed circuit. Running the PV module at its maximum power point (MPP) utilizing an IC maximum power point tracking (MPPT) algorithm improves the solar charge controller's performance. Optimal algorithmic design allows the suggested IC to do the same task with less lines of code, in contrast to the conventional IC MPPT method, which necessitates a large quantity of code and algorithmic steps to maintain the PV module at the MPP. To maximize power transmission from the PV module during battery charging, the duty cycle of the produced Pulse Width Modulation (PWM) signal may be adjusted. Using a constant temperature of 25 °C and varying solar data of 1000 W/m2, 500 W/m2, and 800 W/m2, the simulation model is set up and evaluated in a Matlab/Simulink environment. Experiments are carried out in the lab utilizing the created quick prototype with the 32-bit embedded microcontroller to verify the accuracy of the simulations[13].

METHODOLOGY

Improving energy efficiency, predicting power generation, and extending battery lifespan are the primary goals of the proposed intelligent solar battery charging system that incorporates ML algorithms. For optimal solar energy utilization, the system will include real-time data processing, adaptive charging control, and remote monitoring over the Internet of Things. Improving energy efficiency, optimizing charging settings, and extending battery longevity are the primary goals of the proposed intelligent solar battery charging system that makes use of machine learning (ML) techniques. Conventional Maximum Power Point Tracking (MPPT) algorithms are used by traditional solar charging systems, however they aren't always

able to adjust to changing environmental circumstances. To counter this, the suggested system would use data-driven decisions made in real-time to optimize solar energy utilization and battery safety and efficiency. Solar panels, a charge controller, an integrated machine learning model, Internet of Things (IoT) sensors, and a battery management system (BMS) are some of the interrelated parts that will make up the system. The MPPT charge controller controls the amount of power going into the battery, while the solar panels produce electricity in response to the amount of sunshine reaching them[14]. This system will include an MPPT optimization approach based on machine learning, which differs from traditional methods like Incremental Conductance and Perturb & Observe (P&O). Dynamically predicting the optimal operating point requires training the ML model using data on solar irradiance, temperature, voltage, and current, both historical and in real-time. Variation in solar energy supply as a result of weather changes is a major obstacle to solar battery charging. To solve this, the system will use a predictive energy model that makes use of XGBoost regression or Long Short-Term Memory (LSTM) networks, both of which are machine learning approaches. So that the charge controller may make proactive modifications based on predicted solar power output, this model will examine historical weather trends in addition to data collected in real-time from sensors. Through the use of power availability predictions, the system is able to intelligently arrange charging cycles, leading to improved energy utilization and reduced inefficiencies. When it comes to solar energy storage systems, the health and endurance of the batteries are paramount. Battery life is drastically reduced when subjected to extreme charging and discharging cycles, as well as sudden changes in temperature. The suggested solution would use machine learning-driven intelligent battery management techniques to lessen the impact of these problems[15]. A Reinforcement Learning (RL) model will be created to dynamically change charging voltage and current depending on battery State of Charge (SoC), State of Health (SoH), and temperature measurements. In order to maximise energy absorption while keeping the battery below acceptable operating limits, the RL model will learn optimum charging patterns over time. In conclusion, this study introduces a new intelligent solar battery charging system that uses machine learning to optimise maximum power point tracking (MPPT), model energy predictions, manage

batteries smartly, and remotely monitor their status via the internet of things (IoT). The system's goal is to provide scalable, adaptive energy management solutions; enhance solar energy efficiency; and lengthen the lifetime of batteries by using sophisticated control mechanisms powered by artificial intelligence. The findings of this study will aid in the creation of smarter, more resilient, and environmentally friendly sustainable energy systems for the future..

BLOCK DIAGRAM
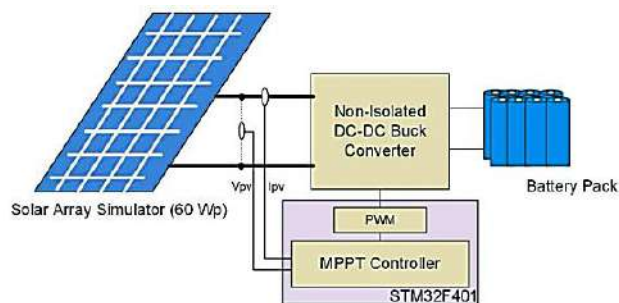
Figure 1:Overall diagram of the System

Using Maximum Power Point Tracking (MPPT) technology, the above diagram depicts a solar photovoltaic (PV) charging system that effectively transfers energy from a solar source to a battery pack. A solar array simulator, a battery pack, a DC-DC buck converter, and an MPPT controller built on an STM32F401 microcontroller make up the system. The solar array simulator, which mimics the operation of a genuine 60 W solar panel, is the brains of the operation. The intrinsic characteristics of this simulator are used to create a DC voltage (Vpv) and the matching current (Ipv). To keep the system running at peak efficiency, MPPT management is necessary since the current and voltage produced by solar panels change with changes in the amount of sunshine and the temperature. Using an STM32F401 microcontroller, the MPPT controller keeps a constant eye on the solar array's voltage and current output. The controller finds the best operating point where the solar panel can provide the load with the most power by using a maximum power point tracking (MPPT) algorithm like Incremental Conductance (IC) or Perturb & Observe (P&O). The controller regulates the power transmission by controlling the functioning of the DC-DC buck converter using a Pulse Width Modulation (PWM)

signal.

CONCLUSIONS

Energy storage solutions are made much more efficient and reliable when machine learning is integrated into solar battery charging systems. Optimization of power extraction and battery life are achieved by the use of data-driven algorithms, which allow the system to dynamically adapt to changes in the environment. Solar panels (or a simulator), a DC-DC converter based on maximum power point tracking (MPPT), and an intelligent battery management system are essential parts of the solar battery charging system. Machine learning models can outperform traditional methods when it comes to predicting the State of Charge (SoC), energy consumption, and ideal charging circumstances, allowing for even greater optimization of traditional MPPT procedures. The system learns from trends in solar power production and battery utilization using real-time data collecting and supervised learning algorithms. Because of this, it is able to decrease power losses, enhance energy utilization, and anticipate charging cycles. Neural networks, decision trees, and regression models are examples of advanced algorithms that may improve charge management in response to current weather and load needs. The experimental findings show that as compared to conventional control approaches, the performance is much higher when machine learning is used, both in terms of charge prediction accuracy and MPPT efficiency. Contributing to sustainable energy use, the lifetime of the battery is prolonged and charging efficiency is maximized.

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Design and Implement Internet of Things (IoT) in the Smart Automotive Sector

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ABSTRACT

The Internet of Things (IoT) represents a revolutionary advancement in the way we interact with the digital world, offering the potential to reshape our daily lives. While the Internet has already established connections among people, IoT extends this connectivity to objects, enabling seamless communication and the pooling of intelligence. IoT is a disruptive technology with immense promise, transforming how we live and work. By utilizing affordable internet-connected devices and sensors, it unlocks new possibilities. Not too long ago, the concept of IoT within the automotive industry was viewed as a distant and theoretical idea. Today, however, we are witnessing the emergence of connected vehicles, autonomous cars, and the integration of IoT across various facets of the automotive ecosystem, including parking management, environmental monitoring, supply chain optimization, and transportation regulation. This paper explores the evolution and advancements of IoT in the automotive sector, offering insights into areas such as connected vehicle services and applications, vehicle-to-vehicle communication, IoT-enabled intelligent transportation systems, IoT-driven supply chain management in the automotive industry, and the development of next-generation vehicles, all of which are seeing tangible progress.

Keywords: Automotive Industry, Connected Vehicles, Internet of Things (IoT).

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INTRODUCTION

The Internet of Things (IoT) is a groundbreaking technology that bridges the gap between the digital world and the physical world, enabling autonomous communication between objects to enhance human life. IoT integrates technologies across the SMAC (Social, Mobile, Analytics, and Cloud) framework. The automotive sector is undergoing a major transformation, driven by advancements in smarter vehicles and associated infrastructure. At the core of this digital revolution in the automotive industry is IoT, which connects people, machines, vehicles, components, and services to optimize data flow, enable real-time decision-making, and enhance the overall automotive experience. Leading automotive manufacturers, suppliers, and dealerships are making substantial investments in IoT, reaping benefits such as improved inventory management, real-time promotional strategies that boost sales, reduced operational costs, and increased revenues. These companies are reshaping their business models, understanding that IoT will eventually permeate every aspect of their operations and customer interactions. Tesla Motors stands out as a prime example of

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IoT integration. Beyond being a luxury and high-performance vehicle, Tesla cars are essentially sophisticated IoT devices with numerous embedded IoT capabilities. Applications leveraging data collected from connected vehicles are emerging in various sectors. For instance, traffic management systems can utilize real-time data from connected cars to mitigate congestion and accidents, while automotive component manufacturers can gather data on wear and tear to predict necessary part replacements, notifying customers before failure occurs. Car-sharing platforms can leverage real-time location data to facilitate carpooling, and in the insurance industry, premium rates could be determined based on the geolocation and driving habits of vehicle owners. Figure 1 illustrates these and other ongoing IoT developments within the automotive industry.

LITERATURE REVIEW

Author(s) & Year	Research Focus	Key Findings
Dirk Wollschlaeger, Mike Foden, Richard Cave and Matthew Stent, September 2023.	Vehicles and Smartphone Integration	Digital dislocation and the futurity of the automotive assiduity
ShreyasBhargave, BipinPatwardhan, April 2022.	Transforming the Automotive assiduity with connected buses	Vehicle-to-Vehicle (V2V) Communication
Mr. SolankeDigamber, Mr. JogdandMaruti, Mr.JadhavAmol Feb-Mar, 2021.	Energy Conservation: Smart Street &TrafficLighting	Intelligent Traffic Light And Automatic Street Lighting System According To Business viscosity
S.P. Bhumkar, V.V.	IoTin Intelligent Transportation	Accident Avoidance and
Deotare, R.V.Babar,2020		Discovery on drives ", International Volume3Issue2-
[5] Anita Kulkarni, Vol. 3, Issue 9, September 2019.	Environmental Control	"AutomatedSystem for Air Pollution Detection and Control in instruments "

CONNECTEDCARECOSYSTEM

The influence of IoT on the automotive sector is profound. Companies in automobile manufacturing, telecommunications, and software development are collaborating to create the Connected Car. A connected car uses its onboard sensors and internet connectivity to enhance the in-car experience for users. The concept of a connected car goes beyond simple internet access on the go, encompassing communication between vehicles as well as interaction with external devices. While only a limited number of vehicles are currently internet-enabled, this figure is projected to grow significantly within the next decade. With the increasing demand for enhanced lifestyle experiences and the widespread use of smartphones, the connected car market is poised for exponential growth. The development of connected car services and applications, alongside other IoT innovations in the automotive sector, is explored in the following sections.
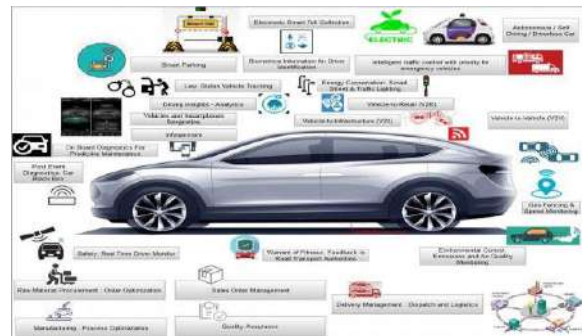
II.ConnectedCarServices/Applications

2.1 INFOTAINMENT

Infotainment refers to the system within vehicles that combines information and entertainment services for users. A typical In-Vehicle Infotainment (IVI) system includes features such as navigation assistance during travel, management of audio and visual content, rear-seat entertainment options, and seamless smartphone connectivity for hands-free use via voice commands. These infotainment solutions are designed to enhance safety by enabling drivers to keep their attention on the road and their hands on the wheel. To ensure a safer in-car experience, infotainment systems should offer well-organized apps and menus, making it easy for drivers to access features intuitively and reduce distractions. Voice and audio commands should be central to the in-car platform, allowing drivers to navigate through menus or compose messages using simple voice instructions. Audio control should serve as the primary method for input. With the rapid advancement of smartphone and cloud technologies, there is an increasing demand for live streaming of music and Internet radio. Advanced infotainment features are now being developed that take into account both user behavior and the next generation of cloud-powered entertainment systems. Examples of smartphone integration solutions include CarPlay, Google's Projected Mode, and MirrorLink, which enable seamless connectivity between mobile devices and vehicle systems.

2.2 Vehicles and Smartphone Integration

In today's fast-paced society, people are constantly on the move and need to stay connected, even while in a vehicle or behind the wheel [31]. By utilizing the On-Board Diagnostics (OBD/OBD-II) port, which functions as a monitoring system for vehicle emissions, mileage, speed, and other critical parameters, essential vehicle information can be displayed directly on a driver's smartphone. Additionally, this data can be transmitted to service providers for analysis [2]. Alerts regarding the vehicle, such as open doors, headlights left on, or the handbrake being engaged, can be seamlessly integrated. Furthermore, actions like locking or unlocking doors, rolling windows up or down, and adjusting the AC temperature can be controlled remotely via the smartphone.

2.3 Driving Behavior Analytics

Smartphone sensors such as GPS, accelerometer, and gyroscope can be leveraged to assess driving patterns. When a smartphone is mounted in the vehicle, data from these sensors can help detect behaviors such as sharp turns, sudden acceleration, rapid braking, speeding, or drifting [2]. This data can be used to categorize drivers as safe or aggressive, rate and compare different drivers, and share these insights with insurance companies for customized premiums. Emerging "Pay As You Drive" (PAYD) and "Pay How You Drive" (PHYD) insurance models [12] reward safe drivers with lower premiums and penalize riskier drivers with higher rates.

2.4 Predictive Maintenance via On-Board Diagnostics

The On-Board Diagnostics (OBD/OBD-II) port is commonly used for vehicle self-diagnosis and to report issues related to the system [12]. This system tracks a range of critical metrics such as emissions, mileage, engine speed, fluid levels, engine temperature, battery status, and more. Typically, it triggers the Check Engine light (or MIL - Malfunction Indicator Light) when a problem is detected. While OBD has traditionally been used for post-failure diagnostics, pairing it with smartphones enables real-time data access for car owners and service centers [2], providing a more accurate understanding of vehicle performance. With continuous monitoring and on-device analytics, proactive service notifications can be sent to the driver's smartphone, allowing for early identification of potential issues and preventive maintenance.

2.5 Safety: Real-Time Driver Monitoring

To promote safe and efficient driving, new technologies are being developed to monitor driver behavior and fatigue levels [43]. These systems aim to make vehicles smarter and help prevent accidents on the road. Real-time monitoring systems are being designed to regulate vehicle speed and assess the driver's alertness levels to reduce the likelihood of

accidents [4]. As illustrated in Fig. 2, these systems rely on microcontrollers and sensors such as eye blink sensors, alcohol detection sensors, impact sensors, and fuel sensors [44]. Additionally, GPS and Google Maps APIs are used to track the vehicle's location, which can then be shared with predesignated contacts in case of an emergency.

2.6 Geofencing and Speed Tracking
The applications of geofencing and speed tracking [34] enable the vehicle owner to be alerted if the car moves outside a defined geographical boundary or exceeds a specified speed limit [6]. Vehicle speed can be monitored using speed sensors [45], while geofencing is facilitated through GPS technology. This system can be utilized for monitoring the driving behavior of young drivers or for overseeing the usage of fleet vehicles remotely.

2.7 Law: Tracking Stolen Vehicles
The GSM and GPS-based Vehicle Tracking System, as illustrated in Fig. 3, utilizes a hidden tracking device [46] within the vehicle to monitor and trace its location [24]. Satellite signals are received by a remote application server, which then calculates the vehicle's coordinates, including its latitude and longitude. By using these coordinates, the vehicle's exact location can be pinpointed, and the owner can be alerted via the GSM network [35].
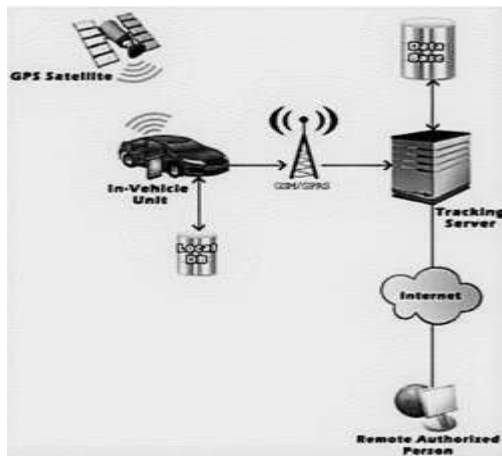
Figure 2: Vehicle Tracking System

2.8 Biometric Information for Driver Authentication

Biometrics involves using unique physical, biological, or behavioral traits of an individual for identification purposes. This technology can authenticate a driver through various biometric identifiers such as facial recognition [6], fingerprints, or voice recognition. Voice samples [12] can also be utilized, providing a hands-free way to navigate applications in a connected vehicle environment. Biometric data serves as an effective anti-theft measure, enhancing security. In-vehicle cameras and sensors play a crucial role in biometric-based driver identification and enable comfort adjustments, such as seat and mirror positions, based on the profiles of authorized users. Additionally, real-time health monitoring, including pulse and breathing patterns, can be tracked using sensors in the steering wheel and seatbelt, helping assess the driver's stress level and other health conditions, which can ultimately prevent accidents.

III. VEHICLE COMMUNICATIONS

As the number of connected vehicles grows and embedded connectivity becomes standard, a new era of vehicle communication is emerging.

3.1 Vehicle-to-Vehicle (V2V) Communication
V2V communication is a wireless network system where vehicles share speed and location information with nearby vehicles to reduce the likelihood of accidents and significantly enhance commuter safety [2]. Each vehicle continually transmits messages containing speed and position data to surrounding vehicles through an ad hoc mesh network, as depicted in Fig. 4. Dedicated Short Range Communications (DSRC) [47], a technology tailored specifically for automotive communication, enables vehicles to interact with one another [12]. V2V communication operates on the Vehicular Ad-hoc Network (VANET) [48], a decentralized wireless network that allows vehicles to exchange information.

Figure3V2VandV2X

3.2 Vehicle to Infrastructure (V2X)

V2X communication involves the wireless exchange of data between vehicles and roadside infrastructure [32] to prevent or lessen the impact of accidents, as well as to provide a broad range of safety, mobility, and environmental advantages. Vehicles can interact with roads, traffic signals, digital signs, and safety control systems [2] to reduce the risk of crashes and alleviate traffic congestion [47] through advanced safety applications. Drivers are also informed about various road conditions, such as construction zones, detours, and hazardous weather. This system helps lower accident rates and casualties while enabling real-time tracking and monitoring of vehicles in transit. In emergencies, vehicles can quickly send details to roadside assistance, emergency responders like ambulances, insurance companies, and even family members.

3.3 Vehicle-to-Retail (V2R)

The retail sector is actively exploring innovative applications that provide drivers with location-based promotions or discount vouchers when they are near a shopping center. Similarly, many applications allow drivers to book restaurant reservations or place their pre-saved "Easy Orders" via voice interface while on the road. Original Equipment Manufacturers (OEMs) are developing additional V2R applications [7], such as Volvo's Roam Delivery trial, which enables delivery companies to locate and unlock a connected car to drop off items purchased online.

IV. IOT IN INTELLIGENT TRANSPORTATION

4.1 Electronic Smart Toll Collection

The Electronic Smart Toll Collection system at toll booths is designed to collect road toll fees efficiently, minimizing traffic congestion and delays. This system uses roadside sensors, including RFID readers and Automatic Number Plate Recognition (ANPR) cameras. Another telematics-based approach utilizes GPS [9] and cellular networks to offer electronic toll collection services. Smart cards or tags are also used to identify vehicle information and process payments [36].

4.2 Smart Parking

The growing issue of traffic congestion, exacerbated by an increasing number of vehicles and limited parking space, has become a significant concern. Finding an available parking spot is often time-consuming and frustrating. Smart parking systems help optimize parking space utilization, improving parking efficiency and easing traffic flow. These systems employ microcontrollers [37], sensors, real-time data on available parking spots [8], and automated payment processes. With such systems, users can reserve parking spots ahead of time, saving time and reducing energy expenditure. Additionally, these solutions help decrease air pollution and mitigate traffic congestion.

4.3 Energy Conservation: Smart Street &TrafficLighting

Smart street lighting, also known as adaptive lighting, automatically dims or turns off when no movement is detected, but brightens when pedestrians, cyclists, or vehicles are present. This intelligent traffic light and streetlight management system offers substantial energy savings. It uses various sensors and cameras to improve the system's efficiency, detecting the presence of people or vehicles with infrared sensors, ensuring street lights operate at full brightness when necessary and then dimming when idle. Energy-efficient LED streetlights [38], combined with IoT-based smart lighting systems, further reduce energy consumption while enhancing road safety. Additionally, RFID tags [10] can detect emergency vehicles such as ambulances, ensuring that they receive priority. Traffic signals can be adjusted to give green lights to lanes with the highest priority, thus improving safety and conserving energy.

4.4 Post-Event Diagnostics: Car Black Box

An Event Data Recorder (EDR) is a device used to capture vehicle data during significant events like accidents or crashes. This "Black Box" technology [11] serves as an investigative tool for accident analysis. It records crucial data, including vehicle speed, rapid acceleration, and sudden braking, which can help determine the circumstances surrounding a crash or accident.

4.4 Post-Event Diagnostics: Vehicle Data Recorder (Black Box)

A vehicle's Event Data Recorder (EDR) captures critical information during events like accidents or collisions, such as seatbelt usage and airbag deployment [12] seconds before, during, and immediately after the event. Various sensors, such as proximity sensors, ultrasonic sensors, pressure sensors, and temperature sensors, are employed to detect and record vehicle data. To access the data stored by the EDR, a scanning tool can be connected to the vehicle, presenting the recorded data in an easily understandable graphical format.

4.5 Intelligent Traffic Management with Emergency Vehicle Priority

Intelligent traffic management systems in urban areas are designed to prioritize specific users, such as public transport, emergency responders, and VIPs [13]. These systems use RFID tags attached to vehicles, with RF readers placed at road intersections, considering traffic volume on different roads. The system's traffic light controller typically follows a round-robin schedule, but when an emergency vehicle like an ambulance is detected, the system overrides the sequence and grants priority by turning the traffic light green for the emergency vehicle's lane, ensuring quicker passage.

4.6 Warrant of Fitness (WoF): Automated Feedback to Authorities

A Warrant of Fitness (WoF) is a mandatory certification required for all Light Motor Vehicles (LMVs), verifying that the vehicle meets safety inspection standards. A WoF test evaluates key vehicle components, such as tires, brakes, lights, seat belts, airbags, suspension, and more [15]. Vehicles must meet minimum standards in each category to pass the test. The WoF certificate, displayed as a sticker on the windscreen, includes the date of the last inspection and the next due date. Local garages are authorized to perform the WoF test and issue the certificate. Traffic authorities can automatically verify a vehicle's WoF status using RFID-enabled stickers, which are scanned by roadside RFID readers, ensuring compliance.

4.7 Environmental Control: Monitoring Emissions and Air Quality

Vehicle emissions are a growing concern, contributing to air pollution. Incomplete fuel combustion is a major source of harmful emissions. IoT-based systems using smoke and temperature sensors, in combination with GSM and GPS modules [5], help monitor and manage these emissions [39]. If a vehicle exceeds a predefined pollution threshold, the system triggers an alert via the GSM module and automatically shuts down the vehicle's engine. The GPS module is used to track the vehicle's location. This technology plays a key role in controlling pollution by reducing vehicle emissions and protecting the environment.

V. IOT-DRIVEN SUPPLY CHAIN MANAGEMENT IN THE AUTOMOTIVE SECTOR

The integration of IoT has revolutionized Automotive Supply Chain Management by connecting all stakeholders, including suppliers, manufacturers (OEMs), service providers, distributors, and customers across different locations [17]. The concept of a Smarter Supply Chain [40] addresses numerous challenges faced by supply chain managers, such as cost management, fluctuating customer demands, risk mitigation, and global competition.

5.1 Raw Material Procurement: Optimizing Orders

To enhance visibility in raw material procurement, IoT sensors and RFID tags can be deployed to track the movement of materials from suppliers to assembly lines. These "smart" devices [16] allow manufacturers to monitor specific components and optimize orders by tracking their movement through the entire production process, improving customization and inventory management.

5.2 Manufacturing: Enhancing Process Efficiency

IoT offers significant potential to improve transparency in the manufacturing process, allowing each production unit to be monitored at every step. Through interconnected systems, real-time data from the shop floor and management can be accessed, reducing the need for human oversight. Sensors track operational parameters such as alignment, temperature, and pressure, with any deviations beyond acceptable limits automatically corrected by adjusting the process. This enhanced visibility leads to improved productivity, better efficiency, and reduced operational costs.

5.3 Quality Assurance

Quality assurance is a structured approach that involves auditing and inspecting both the process and the product to ensure they meet defined standards [18]. Maintaining high-quality control at every stage of the automotive supply chain is crucial for sustaining a competitive advantage in the market. With the increasing shift toward connected cars, the automotive sector is undergoing significant changes in vehicle production [19]. As these cars become more software-centric, expertise in Software Quality Assurance becomes essential to guarantee the production and delivery of high-quality, software-driven connected vehicles.

5.4 Sales Order Management

IoT and connected devices are transforming conventional sales and marketing strategies within the automotive industry. Vehicles, such as cars, are now integrated with connectivity, enabling Original Equipment Manufacturers (OEMs) to maintain continuous communication with customers throughout the product's life cycle. This creates vast opportunities for cross-selling and upselling. The Internet of Things serves as an ideal platform for this connected ecosystem. By collecting and analyzing product usage data, companies gain valuable insights into customer behavior, such as how the vehicle is being used, which features are popular, and which features remain underutilized. This data allows OEMs to offer better post-sale support.

5.5 Delivery Management: Dispatch and Logistics

The application of IoT to dispatch and logistics operations is set to bring substantial improvements. Data analytics plays a crucial role in optimizing distribution networks by evaluating factors like production timelines, order volumes, manufacturing costs, customer locations, and delivery expenses. Supply chain managers can use these insights to determine the optimal number and locations for distribution centers [16]. These improvements help ensure high service standards while reducing transportation and warehousing expenses.

VI. NEW GENERATION VEHICLES

6.1 Autonomous / Self-Driving / Driverless Car

An autonomous vehicle, also known as a self-driving or driverless car [41], is designed to perceive its surroundings and navigate without human intervention. Ongoing advancements in autonomous driving technology will enhance connectivity between the vehicle and its environment, providing a completely new driving experience. In an IoT-enabled self-driving car, once the destination is set, the car operates autonomously, interacting with traffic and the surrounding environment [21]. Drivers of these vehicles can relax and use their smartphones, laptops, and other devices without concern.

6.2 Electric Cars

An electric vehicle (EV) is powered by an electric motor [42] that draws energy from rechargeable batteries [9]. As alternatives to gasoline and diesel-powered cars, electric cars are gaining popularity due to their sustainability, lower operational costs, simpler maintenance, and greater energy efficiency [22]. The growing adoption of electric vehicles is driven by improved plug-in technology, which makes home charging convenient, and by advanced lithium-ion batteries that enable longer travel distances. Many countries have introduced incentives for public charging infrastructure, making long-distance travel more affordable for electric vehicle owners. Additionally, wireless charging technology is emerging, simplifying the charging process for electric cars. **IoT Applications for Electric Cars include:**

- Home charging solutions
- Scheduling charging sessions
- Locating nearby charging stations with pricing information
- Battery charge status and estimated driving range

VII. SCOPE

The Internet of Things (IoT) is revolutionizing a wide array of industries. Applications like Smart Homes, Smart Manufacturing, Smart Healthcare, Smart Cities, Smart Farming, Connected Cars, and Wearables are transforming businesses and elevating customer experiences. This paper highlights the innovative applications of IoT within the automotive sector, covering areas such as connected car services, vehicle

communications, IoT in intelligent transportation, IoT-based supply chain management, and the development of next-generation vehicles.

VIII. KEY FINDINGS

Table1summarizesthedevelopmentsdiscussedint hispaperonIoTinAutomotivesector.

Table1-Developments onIoTinAutomotive sector

Connected Car services / applications	Vehicle Communication	IoT in Intelligent Transportation	IoT based SCM in Automotive Industry	New Generation Cars
Infotainment	Vehicle-to-Vehicle (V2V)	Electronic Smart Toll Collection	Raw Material Procurement: Order Optimization	Autonomous / Self driving/Driverless Car
Vehicles and Smartphones Integration	Vehicle-to-Infrastructure (V2X)	Smart Parking	Manufacturing: Process Optimization	Electric cars
Driving Insights – Analytics	Vehicle-to-Retail (V2R)	Energy Conservation: Smart Street & Traffic Lighting	Quality Assurance:	
On-Board Diagnostics for Predictive maintenance		Post Event Diagnostics: Car Black Box	Sales Order Management	
Safety: Real Time Driver Monitor		Intelligent traffic control with priority for emergency vehicles	Delivery Management: Dispatch and Logistics	
Geo-fencing and Speed Monitoring		Warrant of Fitness: Feedback to Road Transport Authorities		
Law: Stolen Vehicle Tracking		Environmental Control: Emissions and Air Quality Monitoring		
Biometrics Information for Driver identification				

IX.CONCLUSION

This paper discusses the advancements of IoT in the automotive industry, focusing on areas like connected car services, vehicle communication systems, intelligent transportation solutions, IoT-powered automotive supply chain management, and the emergence of next-generation vehicles. As vehicles become more intelligent and interconnected with other cars, smartphones, and devices, the application of advanced analytics to operational data enhances visibility for OEMs, drivers, and traffic authorities. This improved visibility enables more informed decision-making, allowing for better monitoring of vehicle performance and traffic conditions, and ensuring timely interventions when necessary.

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Automatic Detection of Malicious User On Social Networking Sites

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ABSTRACT

Online social and news media generate rich and timely information about real world events of all kinds because of that the huge amount of data available. Twitter has attracted many users to share and disseminate most up-to date information, leading to large volumes of knowledge produced a day . In the tweet segmentation the number user are tweets and that tweets are stored in segments. Data mining may be a powerful tool which will be used effectively for analyzing large databases and deriving important analytical results. Experiments on two tweet data sets show that tweet segmentation quality is significantly improved by learning both global and native contexts compared with using global context alone. Using analysis and comparison, we show that local linguistic features are more reliable for learning local context compared with term dependency. As an application, we show that prime accuracy is achieved in named entity recognition by applying segment- based part- of speech (POS) tagging.

KEYWORDS: Twitter, Fragmentation, Segments.

INTRODUCTION

Micro blogging sites such as Twitter have reshaped the way people find, share, and disseminate timely information. Many organizations are reported to make and monitor targeted Twitter streams to gather and understand users' opinions. Targeted Twitter stream is typically constructed by filtering tweets with predefined selection criteria (e.g.tweets published by users from countryside, tweets that match one or more predefined keywords). Due to its invaluable business value of timely information from these

Tweets, it's imperative to know tweets' language for an outsized body of downstream applications, like named entity recognition NER event detection and summarization, opinion mining, sentiment analysis and lots of others. SOCIAL network sites, also called micro-blogging services (e.g., Twitter, Face book, Google+), have spread in recent years, becoming a new kind of real-time information channel. Their popularity stems from the characteristics of portability thanks to several social networks applications for smart phones and tablets, easiness of use, and real-time nature People intensely use social networks to report (personal or public) real world events happening around them or just to precise their opinion on a given topic, through a public message. Social networks allow people to make an identity and allow them to share it so as to create a community. The resulting social network is then a basis for maintaining social relationships, finding users with similar interests, and locating content and knowledge entered by other users. Social networks are recently employed as a source of data for event detection, with particular regard to road traffic jam and car accidents. We create the logical protocol which helps to detect the malicious user as well as providing the security to the social networking media as like tweeter. Achieved in named entity recognition by applying segment-based part- of Speech (POS)

tagging. Social networks are recently employed as a source of data for event detection, with particular regard to road traffic jam and car accidents. We create the logical protocol which helps to detect the malicious user as well as providing the security to the social networking media as like tweeter.

LITERATURE SURVEY

Twitter has attracted many users to share and disseminate most up-to- date information, leading to large volumes of knowledge produced a day . However, many applications in Information Retrieval (IR) and Natural Language Processing (NLP) suffer severely from the noisy and short nature of tweets. In this paper, we propose a novel framework for tweet segmentation in a batch mode, called Hybrid Segment. By splitting tweets into meaningful segments, the semantic or context information is well preserved and simply extracted by the downstream applications [1]. Many private and/or public organizations are reported to make and monitor targeted Twitter streams to gather and understand users' opinions about the organizations. Targeted Twitter stream is typically constructed by filtering tweets with user-defined selection criteria (e.g., tweets published by users from a specific region, or tweets that match one or more predefined keywords). Targeted Twitter stream is then monitored to collect and understand users' opinions about the organizations [2]. Twitter has involved numbers of users to share and distribute current information, resulting in a huge amount of data produced per day. No. of private and public organizations have been

reported to create and control targeted Twitter streams to gather and know users opinions about the organizations. However the complexity and hybrid nature of the tweets are always challenging for the Information retrieval and natural language processing. Targeted Twitter stream is normally constructed by filtering and rending tweets with certain criteria with the help proposed framework. By splitting the tweet into no. of parts Targeted tweet is then analyzed to know users opinions about the organizations. There is a promising need for early rending and categorize such tweet, and then it get preserved in two format and used for downstream application[3].

Social networking site (Twitter) has attracted several users to share and distribute most modern data, leading to giant volumes of knowledge created every day. In most of the applications, at the time of IR (Information Retrieval) process, data suffers severely from noise and produces the short nature of the tweets. In the present paper, system uses a framework for segmenting the tweets in the form of batch mode, named as Hybrids. This process easily preserve the semantic data or content by splitting tweets in the form of understandable segments. 'HybridSeg' derives the principal segmentation of each and every tweet by maximizing its sum and the stickiness scores of corresponding candidate segments that are to be maintained. HybridSeg is additionally intended to iteratively gain from condemn sections as pseudo criticism. Experiments show that tweet segmentation quality is significantly improved[4].

Individuals tweet more than 100 Million times every day, yielding a boisterous, casual, yet here and there educational corpus of 140-character messages that mirrors the zeitgeist in an exceptional way. The execution of standard NLP instruments is extremely corrupted on tweets. This paper addresses this issue by re-assembling the NLP pipeline starting with grammatical form labeling, through piecing, to named-element acknowledgment. Our novel T-NER framework copies F1 score contrasted and the Stanford NER framework. T-NER influences the excess characteristic in tweets to accomplish this

execution, utilizing Labeled LDA to abuse Freebase lexicons as a wellspring of far off supervision. Labeled LDA beats co-training, expanding F1 by 25% more than ten regular element sorts [5].

Tweets provide a continuous update on current events. However, Tweets are short, personalized and noisy, thus raises more challenges for event extraction and representation. Extracting events out of Arabic tweets is a new research domain where few examples – if any – of previous work can be found. This paper describes a knowledge-based approach for fostering event extraction out of Arabic tweets. The approach uses an unsupervised rule-based technique for event extraction and provides a named entity disambiguation of event related entities (i.e. person, organization, and location). Extracted events and their related entities are populated to the event knowledge base where tagged tweets' entities are linked to their corresponding entities represented in the knowledge base[6].

Machine learning classifiers have recently emerged as a way to predict the introduction of bugs in changes made to source code files. The classifier is first trained on software history, and then used to predict if an impending change causes a bug. Drawbacks of existing classifier-based bug prediction techniques are insufficient performance for practical use and slow prediction times due to a large number of machine learned features. This paper investigates multiple feature selection techniques that are generally applicable to classification-based bug prediction methods. The techniques discard less important features until optimal classification performance is reached. The total number of features used for training is substantially reduced, often to less than 10 percent of the original[7].

A Tweeter is the Social Media Network to demonstrate the different kind of language which having an independent nature of classifiers, presenting an result on the several text classification. A classification problems text

general classification and topic detection in several language forms like Greek, English, Dautsch and Chinese. Then the study on key factors in the CAN (i.e. Chain Augmented Naive) model that can influence the classification performance of the global context and local context. Two novel smoothing techniques variation of Jelinek-Mercer and linear inter polation technique which perform existing methods. Natural languages are full of collocations, recurrent combinations of words that occur more often than expected by chance and that correspond to arbitrary word usages[8].

Event detection from tweets is an important task to understand the current events/topics attracting a large number of common users. However, the unique characteristics of tweets (e.g., short and noisy content, diverse and fast changing topics, and large data volume) make event detection a challenging task. Most existing techniques proposed for well written documents (e.g., news articles) cannot be directly adopted. In this paper, we propose a segment-based event detection system for tweets, called Tweets[9].

Now a day's software companies spend nearly 45% of cost in dealing with software bugs. A lot of time and money is wasted in finding solution to the bugs. To overcome manual work problems in this project we are using text classification techniques for automatic bug triage. For example if we find any bug while working on project we have to search in google for solution if we cannot find solution so much time and money is wasted. So in our project we are creating web application for commercial companies. In this website employee can query about bugs. Notification will go to rest of employee in the company if they are able to solve the bug they can update the solution to the bug repository. So finding solution to the bugs is easy. Noisy data may mislead the data analysis techniques while redundant data may increase the cost of data processing . In bug repositories, all the bug reports are filled by developers in natural languages[11].

The low-quality bugs accumulate in bug repositories with the growth in scale. Illustration of reducing bug data for bug triage.Presents the framework of existing work on bug triage. Before training a classier with a bug data set, we add a phase of data reduction, which combines the techniques of instance selection and feature selection to reduce the scale of bug data. In bug data reduction, a problem is how to determine the order of two reduction techniques. based on the attributes of historical bug data sets, we propose a classification method to predict reduction[12].

EXISTING METHODOLOGY

Implementing the summarization is not a very easy task as the large amount of the tweets are senseless, meaningless, may contain noise which must be discarded. The tweets are also posted at the different times. The new tweets are also emerging continuously so the time must be recorded so that when they are posted. The three issues must be taken into consideration, which are

1. Efficiency: the algorithm must be very efficient.
2. Flexibility: the algorithm must be flexible.
3. Current event detection: the current topic must be detected successfully.

But, the previous algorithms are not efficient to deal with the above three issues. The previous algorithms are mainly used to deal with the small streams of data sets which are static in nature so they cannot be used to deal the large data sets which are dynamic in nature. They are not able to create the summaries of the different time duration. As they are not considering the time limits so the current event detection cannot be made possible.

Here, the framework sumblr is used which includes the clustering and summarization algorithms. It mainly comprises of the three modules which are the summarization module, clustering module, and finally the current event detection module.

The block diagram of the framework is shown

below:
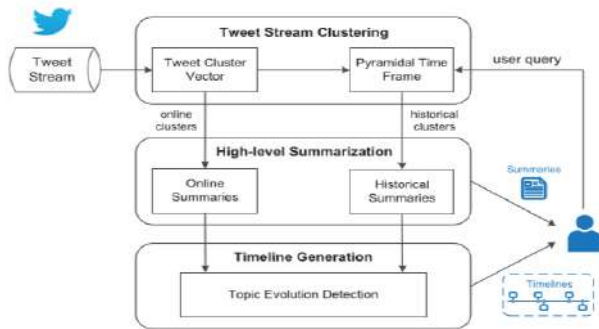
Initialization of tweets:

At the start of the algorithm the initialization takes place. The tweets are initialized from one to n numbers. Without initialization the algorithm cannot takes place.

Incremental Clustering:

The next step is to increment the tweets. If the working on the first tweet is done then the tweet is increment by one which means the procedure on the next tweet takes place.

Deleting Outdated Clusters:

For the current events the time plays a vital role as the some event takes place for a certain period of time. For example the football match, release of some movie, any matches, introduce of any smart phones etc. The tweets which are senseless, meaningless, old can be discarded as these tweets cannot change anything. For this purpose the outdated clusters are discarded.

Merging Clusters:

If the number of clusters are increasing tremendously. This will uses the more memory spaces. In that case the upper limit for the cluster is defined. If these limit reached the mergingof the similar clusters takes place. The following figure shows the merging of the clusters:
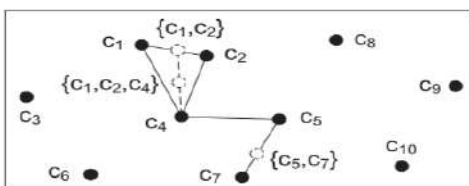
Fig . Merging Clusters

Summarization Module :

The two types of summarization is included in the summarization module which are the online summarization and the historical summarization. The issues which are currently discussed or shared by the users are in the online summaries. The current online clusters are used to retrieve the data for the calculation. Whereas the historical summaries are the summaries where people want to know the happening during the particular time period.

Current Event Detection module:

After the summarization and the clustering of tweets streams the next step is to detect the current event or the recent topics from all the events by using the current event detection algorithm. The time plays the vital role in the current event detection. The current event itself is the event which is currently very famous currently. There may be the various types of the variations seen during the current event detection. These are the summary based variation, volume based variations and at last the combinations of the above two variations called the unified variation.

Statistic Generation module :

The last module is the statistics generation in which the graphical representation of the clusters including the number of tweets versus the number of days are shown. This makes the results very understandable and easy to recognize. The graphs of the different clusters are different in nature.

PROPOSED METHODOLOGY

Algorithm 1:

K-means clustering: - may be a method of vector quantization, originally from signal processing that aims to partition n observations into k clusters during which each observation belongs to the cluster with the closest mean (cluster centers or cluster centroid), serving as a prototype of

the cluster. This leads to a partitioning of the info space into Verona cells. It is popular for cluster analysis in data processing.K- Means clustering minimizes within- cluster variances (squared Euclidean distances), but not regular Euclidean distances, which might be the harder Weber problem: the mean optimizes squared errors, whereas only the geometric median minimizes Euclidean distances. For instance, better Euclidean solutions are often found using k-medians and k-medoids.

Algorithm steps:
1. Input total tweets (1…..n)
2. Tokenization
3.Comparing with data dictionary
4. Count the frequency
5. Add the tweet in the respective cluster.

Working:-The first algorithm used is the tweet stream clustering algorithm.
1. In this algorithm the total number of tweets are taken into account that means the each and every tweet are given the numbers from 1 to n.
2. Then single tweets are tokenized that means the each and every word from the tweets are given the unique number is known as token and the process is known as tokenization.
3. The each and every token are compared with the words in the dictionary. The dictionary must consist of all the words which are related to the clusters. The comparison between the tokens and the words in the dictionary is made successfully.
4. After that the frequency is counted which means that which word in the tweets are belonging to which word in the dictionary. The maximum words in the tweets are belonging to the particular cluster then those tweets are put into that cluster.
5. If that tweet successfully belongs to that cluster then that tweet is added to that cluster. The same step is followed for all the tweets.

Assignment step: Assign each observation to

the cluster with the closest mean: that with the smallest amount squared Euclidean distance. Mathematically, this means partitioning the observations according to the Verona diagram generated by the means. Where each Xp is assigned to precisely one S (t), albeit it might be assigned to 2 or more of them.
Update step: Recalculate means (centroids) for observations assigned to every cluster.

$$m_i^{(t+1)} = \frac{1}{\left| S_i^{(t)} \right|} \sum_{x_j \in S_i^{(t)}} x_j$$

The algorithm has converged when the assignments not change. The algorithm isn't bound to find the optimum.

Algorithm 2:

Event Detection**: -** The traditional event detection algorithms adopt TF-IDF mechanisms to detect and track events in news articles and micro blog tweets with different variations. Over the years, various sorts of event detection algorithms are proposed when it involves event detection in micro blogs where the length of tweet content is comparatively short. In Chinese micro blogs, the length of every tweet is strictly confined to no quite 140 Chinese characters and consequently, the normal news story hot event detection algorithms are inappropriate for analyzing tweet contents. Qiming Diao proposed a top-ranked LDA method that simultaneously captures two basic observations
of micro blog hot topics. Xun Wang proposed a time dependent HDP model to detect events in twitter. Topics models like LDA have served as a really valuable tool capturing latent topics within text and therefore the traditional method for tokenizing text into bag of word

format has also been adopted into most of the algorithms for event detections. The tokenizing procedure involves assigning a singular integer to a singular token so each tweet are often represented by a series of integers and that we call the tokenized result tweet vector. After the tokenizing procedure, we need to employ cosine distance to measure the similarity between two tweet vectors. If the cosine distance between two vectors is within a particular threshold, we believe those tweets

$$S_i^{(t)} = \left\{ x_p : \left\| x_p - m_i^{(t)} \right\|.^2 \leq \left\| x_p - m_j^{(t)} \right\|.^2 \forall_j , 1 \leq j \leq k \right\}$$

belong to the same class and hence, they are talking about similar topics. It is the basic approach for text classification. Topic Model: -Various kinds of topic models have been used to generate topics from text documents and the mostly widely used topic model is LDA model proposed by David Blei in 2003. Topic models are algorithms for locating the most themes that pervade an outsized and otherwise unstructured collection of documents. Topic models can organize the gathering consistent with the discovered themes and therefore the intuition behind LDA is that documents exhibit multiple topics.

Steps of Algorithm:
Input: elements of topic-community matrix M, community vector Ci, variable k and total community number N
Output: Global Topic number GT

1. k = 1;
2. while k ≤ N; do
3. Init(Ci);
4. Select top k highest value for each community;
5. Ci=(M[i, top1],M[i, top2],...,M[i,topk]);

6. if the same topic number topX exits in all community vector Ci then;
7. Global topic GT= topX;
8. break;
9. end;
10. else
11 k=k+1;
12 end
13 end A.

Event Cluster Formulation and Central Event Extraction:-
After the text classification procedure, there are 16 categories to which all the tweet belong. For each of the tweet categories, we divide tweets in a certain category into different event clusters. We adopt K-means algorithm to formulate event clusters and we intend to choose centroids C that minimize the in-cluster sum of squares objective function with a dataset X of n samples, the sum of squares objective function is :--
Formula:

$$V = \sum_{i=1}^{n} \min_{u_i} C(||x_i - u_i||)^2$$

We set the amount of iterations to be 10 and number of clusters to be 4. The final results we get after possessing 16 tweet categories are 64 event clusters and each of the event clusters A Multi-layer Event Detection Algorithm for Micro blogs Tan, Zhang, Tan, and Guo 2086 represents a hot event. The next step is to extract key tweets from that event cluster in order to formulate hot events. For the purpose of evaluating which tweet can best represent the hot event in a certain community, we need take several key features of a tweet into account. We have the re-tweeting number and comment number of each tweet to decide the importance of a certain tweet. Also, we need to take the relevance coefficient which is the cosine distance between the tweet vector and the topic vector and the length of tweet i into

consideration. The scoring function we employ is describe

$$Ti = (Ri + 2 *Ci) *Si,k* Li * 10000$$

Where Ti is the number we use to sort the tweets, Ri is the re-tweeting number of tweet i, Ci is the comment number of tweet i, Si,k is the cosine distance between tweet vector i and topic vector k and Li is the length of tweet i. Then we sort all tweets in a certain event cluster using our scoring function in decreasing order.

CONCLUSION

The tweets are the messages, viewpoints or opinions of the users which are shared or interchanged on the social services. The tweets are in very large numbers and some tweets may contain the noise or redundancy or may be useless such tweets are discarded by using the tweet stream summarization algorithm. The tweet posted may be related to the different topics. These all tweets are formed into different groups. These groups are known as clusters. In this case we are clustered inthe five groups which are education, politics, sports, Bollywood and business. Finally the current event detection algorithm is used to detect the current event from the entire recent event. All these results are represented with the help of graphs. The graph of the number of tweets versus number of days which is to be taken for calculation are plotted for easy understanding of what is happening in the project. The efficiency and effectiveness of the algorithm increased gradually.

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Recent Trends and Application of Manet In Vehicular Ad Hoc Network

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ABSTRACT-
MANETs play a foundational role in enabling vehicular communication but must overcome significant technical challenges related to mobility, scalability, routing efficiency, security, and quality of service in a highly dynamic environment. Recent trends, applications, and future scope of MANET (Mobile Ad-hoc Networks) in transportation networks, particularly in the context of intelligent vehicular networks (VANETs), demonstrate significant advancements in both technical and societal aspects. the role of MANETs in transportation is poised for expansion, with evolving technologies like 5G, AI, and IoT transforming vehicular communication, autonomous systems, and urban mobility. The continuous integration of these technologies will help realize safer, smarter, and more efficient transportation networks in the coming years. This research paper focus on analysis the different trends and application of MANET in vehicular ad-hoc network.

Keywords- MANET, VANET, V2V, RSU, V2I, ITS, UAV

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INTRODUCTION

The implementation of Mobile Ad-Hoc Networks (MANETs) in transportation networks, particularly Vehicular Ad-Hoc Networks (VANETs), revolves around enhancing vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication through dynamic, real-time routing, clustering, and scheduling mechanisms. One prominent method of optimizing VANETs involves clustering vehicles based on similar mobility characteristics or geographic proximity, which reduces the complexity of communication and minimizes network congestion. Bio-inspired algorithms are commonly used in this regard, enhancing the sustainability and efficiency of the networks by optimizing these clusters [1]. Furthermore, AI-powered routing protocols and hybrid optimization techniques, like the Enhanced Hybrid Glowworm Swarm Optimization Algorithm, are essential for managing the high mobility of nodes within VANETs and ensuring efficient traffic management [2].

The deployment of MANETs in transportation also requires addressing security challenges. Given the open and decentralized nature of VANETs, they are prone to security risks such as man-in-the-middle attacks and data breaches, which necessitates the integration of advanced encryption and trust management protocols [4][5]. Such measures are critical to ensuring that the vehicular networks remain reliable and secure, especially when handling sensitive data like vehicle location and speed. Another significant trend is the use of UAV-assisted networks (Unmanned Aerial Vehicles), which provide additional infrastructure support in scenarios with low connectivity or in disaster situations, further enhancing the reliability of the network in smart cities [8]. For example, UAVs can act as mobile nodes, extending the network coverage in areas where traditional infrastructure might be lacking.

Moreover, cellular networks play a pivotal role in the effective resource allocation and management of vehicle clusters. By integrating MANETs with cellular networks, vehicles can communicate more effectively, optimizing both bandwidth and resource allocation, thus improving the overall efficiency of the transportation network [9]. This synergy is essential in enabling the scalability of VANETs, especially in dense urban environments where vehicle density and communication demands are high.

Finally, metaheuristic algorithms are being explored for their ability to fine-tune routing protocols, especially in clustering-based routing within VANETs. Such protocols use strategies like particle swarm optimization to enhance connectivity and ensure data packet delivery even in dynamic network topologies [3][6]. As vehicles move rapidly and constantly form and dissolve communication links, these algorithms are vital for maintaining reliable connectivity, reducing latency, and ensuring smooth traffic flow [7][10].

The successful implementation of MANETs in transportation networks relies on leveraging cutting-edge algorithms and security protocols. From AI-driven optimization and UAV assistance to resource management through cellular networks, these approaches aim to create sustainable, efficient, and secure vehicular communication systems that can adapt to the ever-evolving demands of intelligent transportation systems and smart cities.

BACKGROUND

A Mobile Ad Hoc Network (MANET) plays a crucial role in Vehicular Ad Hoc Networks (VANETs), which are specialized applications of MANETs. VANETs enable communication between vehicles (Vehicle-to-Vehicle or V2V) and between vehicles and infrastructure (Vehicle-to-Infrastructure or V2I).

A. Role of MANET in Vehicular Networks

- *Dynamic Network Formation:* MANETs allow vehicles to dynamically form networks on the fly without requiring centralized infrastructure. This is crucial for vehicular networks, where vehicles are constantly on the move and need to communicate in real-time.

- *Vehicle-to-Vehicle (V2V) Communication:* In VANETs, MANET protocols are used to enable direct communication between vehicles for safety applications (e.g., collision warnings, traffic alerts) and non-safety applications (e.g., infotainment sharing).

- *Vehicle-to-Infrastructure (V2I) Communication:* MANETs facilitate communication between vehicles and roadside infrastructure, such as traffic lights or sensors, enabling intelligent traffic management systems.

- *Real-time Information Dissemination:* MANET protocols support the rapid dissemination of data, including road conditions, accidents, and emergency information, which is critical for enhancing road safety and efficiency.

- *Scalability and Decentralization:* VANETs leverage the decentralized and scalable nature of MANETs, which allows the network to expand or contract as vehicles enter and leave, without depending on a fixed infrastructure.

B. Challenges of MANET in Vehicular Networks

MANETs play a foundational role in enabling vehicular communication but must overcome significant technical challenges related to mobility, scalability, routing efficiency, security, and quality of service in a highly dynamic environment. Despite their potential, several challenges arise when applying MANETs to vehicular environments:

- *High Mobility:* Vehicles in VANETs move at high speeds, leading to frequent changes in network topology. Traditional MANET routing protocols, which are designed for relatively stable or low-mobility nodes, often struggle to maintain reliable connections in such a dynamic environment.

- *Intermittent Connectivity:* The ad-hoc nature of vehicular networks means that connections between vehicles may be intermittent. This can result in packet loss or delays in message delivery, which is especially problematic for safety-critical applications.

- *Scalability:* As the number of vehicles on the road increases, the network needs to handle a large volume of data and participants. MANET protocols may experience performance degradation due to network congestion, especially in urban environments with heavy traffic.

- *Routing Challenges:* Finding efficient routes between rapidly moving vehicles is a major challenge. Traditional MANET routing protocols like AODV (Ad hoc On-demand Distance Vector) or DSR (Dynamic Source Routing) may not be able to quickly adapt to changing network conditions. Position-based routing protocols are often preferred in VANETs but still face challenges in highly dynamic scenarios.

- *Security and Privacy:* VANETs are susceptible to various security threats such as spoofing, data tampering, and denial-of-service attacks. Ensuring secure communication while protecting the privacy of vehicle occupants (e.g., preventing unauthorized tracking) remains a significant challenge in MANET-based vehicular networks.

- *Quality of Service (QoS):* MANETs must guarantee real-time communication, particularly for safety-critical applications like collision avoidance. Achieving high reliability and low latency in a rapidly changing vehicular environment is difficult.

- *Interference and Spectrum Allocation:* In dense urban environments, communication between vehicles can be hindered by radio interference and limited spectrum availability, further complicating network performance.

- *Energy Consumption:* Although vehicles are not as constrained by energy as mobile devices, energy efficiency is still a concern for the network infrastructure and roadside units, particularly for sustainable deployment.

C. Recent Trends:

- *Integration with 5G and IoT:* Recent developments focus on the integration of MANETs with 5G networks and IoT (Internet of Things) applications. These networks enable higher data rates, lower latency, and better communication between vehicles, infrastructure, and sensors. This integration helps support real-time applications such as autonomous driving and enhanced vehicle-to-everything (V2X) communication

- *AI-Driven Solutions:* MANETs are being enhanced by AI-driven routing and network optimization techniques. These help in managing dynamic traffic scenarios, reducing congestion, and improving safety by predicting potential hazards

- *UAV-Assisted Networks:* The use of unmanned aerial vehicles (UAVs) to extend vehicular ad-hoc networks (VANETs) is a growing trend. UAVs can help establish communication in areas with poor coverage or during disasters, ensuring continuous information flow

D. Applications in Transportation:

- *Intelligent Transportation Systems (ITS):* MANETs are integral to ITS, facilitating vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication. This improves traffic management, road safety, and reduces congestion through real-time updates and efficient routing

- *Autonomous Vehicles:* In autonomous driving, MANETs support communication between self-driving cars, ensuring synchronization and safety

through data sharing regarding road conditions, traffic patterns, and hazards

- *Smart Cities:* MANETs are crucial for developing smart city infrastructures. They allow seamless connectivity between various transport modalities and the city's digital services, enhancing urban mobility and reducing environmental impact

I. LITERATURE REVIEW

The integration of Mobile Ad Hoc Networks (MANETs) and Vehicular Ad Hoc Networks (VANETs) into transportation systems has gained significant attention due to their ability to enhance vehicular communication and overall network efficiency. These technologies rely on dynamic, self-organizing networks to support various transportation applications, ranging from traffic management to environmental sustainability. This literature review explores key findings and trends from several studies on the subject, focusing on clustering, routing, security, and the use of optimization algorithms in MANET and VANET systems.

Clustering and routing are critical components of VANETs, enabling efficient communication between vehicles. Joshua et al. (2023) examine bio-inspired algorithms for clustering and routing in VANETs, highlighting the potential for these methods to optimize vehicular communication in a sustainable manner. Their work emphasizes the importance of adapting cluster sizes based on vehicle density and movement patterns to minimize communication overhead and reduce congestion. Similarly, Feng et al. (2023) propose a vehicle clustering and resource allocation algorithm based on cellular networks, which improves resource utilization by distributing network tasks among clustered vehicles.

On the routing front, Chatterjee et al. (2022) provide a comprehensive survey of both non-learning-based and learning-based routing protocols. Their work contrasts traditional methods with machine learning-based solutions, concluding that learning-based approaches hold promise for managing complex VANET environments, where vehicle mobility is highly unpredictable.

Optimization algorithms play a crucial role in enhancing the efficiency of VANETs. Upadhyay et al. (2022) propose an Enhanced Hybrid Glowworm Swarm Optimization (HGSO) algorithm to address traffic congestion and ensure optimal routing in vehicular networks. This algorithm

combines the strengths of swarm intelligence and hybrid optimization to adaptively route vehicles based on real-time traffic conditions, resulting in significant improvements in traffic flow and reduced delays. This work builds on previous research into swarm intelligence for traffic management and positions HGSO as a competitive alternative to conventional traffic-aware routing protocols.

Security is a paramount concern in MANETs and VANETs due to their open and dynamic nature. Asra (2022) provides a systematic review of the security issues plaguing VANETs, particularly focusing on vulnerabilities like data tampering, eavesdropping, and denial-of-service (DoS) attacks. This review underscores the need for robust security frameworks that protect data integrity and vehicle identity without compromising network performance.

To address these challenges, Mahmood et al. (2021) explore various countermeasures for securing VANET communications. Their work identifies trust-based models and cryptographic solutions as effective in mitigating common security threats. Fatemidokht et al. (2021) extend this discussion by proposing an artificial intelligence (AI)-driven routing protocol that integrates Unmanned Aerial Vehicles (UAVs) to enhance both the security and scalability of VANETs, especially in high-density urban environments.

Metaheuristic algorithms have been increasingly employed to optimize routing in MANETs and VANETs. Abdalrahman (2022) presents a clustering-based routing protocol utilizing metaheuristic algorithms like Particle Swarm Optimization (PSO) and Ant Colony Optimization (ACO). These algorithms are effective in balancing load distribution across vehicular networks, ensuring stable communication links and minimizing the likelihood of dropped packets due to high mobility.

Additionally, Arya et al. (2023) provide a broad overview of MANET trends and applications, outlining the role of AI in automating route selection and enhancing protocol efficiency. Their work supports the notion that AI-driven optimization can significantly improve the adaptability and resilience of MANETs, particularly in dynamic environments like transportation networks.

Several studies discuss the challenges and future scope of MANETs and VANETs in transportation systems. Jaiswal and Kidwai (2022) highlight the key technical challenges, including high mobility, frequent topology changes, and the need for scalable communication protocols. They emphasize the importance of developing energy-efficient algorithms and integrating MANETs with emerging technologies like 5G and the Internet of Things (IoT).

Quy et al. (2021) explore communication solutions for VANETs in smart city environments, focusing on the integration of IoT and cloud-based services to enhance vehicular communication. Their work underscores the need for adaptive communication mechanisms that can seamlessly integrate with existing infrastructure, providing real-time data exchange between vehicles and city management systems.

The research on MANETs and VANETs demonstrates a growing focus on bio-inspired algorithms, AI-driven optimization, and secure communication frameworks. While significant progress has been made, challenges related to network scalability, security, and real-time adaptability remain areas of active investigation. Future research is expected to focus on integrating these networks with next-generation technologies like 5G, IoT, and edge computing to enable smarter, more efficient transportation systems.

Table 1.0: Technical comparative literature review of the selected references in tabular format. The table contrasts key aspects of clustering, routing, scheduling, security, optimization, and challenges in MANET and VANET systems.

Study	Focus Area	Key Contribution	Techniques/Algorithms Used	Challenges Identified	Future Directions
Joshua et al. (2023)	Clustering, Routing, Scheduling in VANET	Proposes bio-inspired methods for VANET routing and clustering with	Bio-inspired algorithms for parameter tuning	Environmental sustainability and communication overhead	Further improvements in sustainable communication and green networking

		environmental sustainability in focus.			
Upadhyay et al. (2022)	Optimization in Traffic-aware Vehicular Networks	Proposes a Hybrid Glowworm Swarm Optimization (HGSO) to improve traffic management	Hybrid Glowworm Swarm Optimization	Handling dynamic and congested environments	Hybrid optimization techniques to enhance network efficiency
Chatterjee et al. (2022)	Routing Protocols in VANET/V2X	Surveys learning and non-learning routing methods in VANET/V2X	Non-learning (DSDV, AODV) and learning-based (ML, RL) routing algorithms	Mobility and real-time adaptability of learning-based systems	Integration of machine learning for adaptive routing solutions
Asra (2022)	Security in VANET	Reviews security threats and mechanisms in VANET, identifying key vulnerabilities.	Cryptographic algorithms, Trust models	Data tampering, Eavesdropping, DoS attacks	Focus on enhancing trust-based models for secure data transmission
Mahmood et al. (2021)	Security in VANET	Investigates VANET security challenges and countermeasures	Trust-based models, Cryptography	Trust establishment and key management	Incorporation of AI-driven security measures for dynamic networks
Abdalrahman (2022)	Clustering-based Routing in VANET	Proposes metaheuristic algorithms (PSO, ACO) for clustering-based routing	Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO)	High mobility and network topology changes	Advanced metaheuristic algorithms for reliable clustering and routing
Hussein & Mahmood (2023)	Connectivity Analysis in VANET	Analyzes connectivity performance using VDTN-based methods	Vehicular Delay-Tolerant Network (VDTN)	Connectivity drops in sparse networks	Improving VDTN protocols for better connectivity in diverse traffic scenarios
Fatemidokht et al. (2021)	AI-based Secure Routing in VANET	Integrates UAVs with AI-driven routing for secure communication in VANETs	Artificial Intelligence (AI), UAV-Assisted Routing	Security and scalability in high-density areas	Integrating AI and UAVs for large-scale vehicular networks
Feng et al. (2023)	Vehicle Clustering and Resource Allocation	Proposes cellular network-based clustering for resource allocation	Cellular network-based clustering	Resource allocation in dense network environments	Enhancing resource allocation through cooperative networking strategies

Tayade (2021)	Link Stability in VANET	Focuses on improving link stability and connectivity in vehicular networks	Dynamic link stability enhancement	Link failure due to high mobility	Improving link stability for better real-time connectivity
Albattah et al. (2022)	Vehicular Communication Protocols	Reviews trends and challenges in vehicular communication protocols	Overview of existing VANET protocols	Scalability, latency, real-time decision-making	Enhancing protocols to meet the requirements of smart cities and autonomous vehicles
Quy et al. (2021)	Communication Solutions for Smart Cities	Proposes communication strategies for VANET in smart cities	IoT-based communication solutions	Integration of vehicular communication in smart city infrastructure	IoT and 5G integration to enhance real-time data transmission
Al-Shareeda et al. (2021)	Comprehensive Review of VANET	Provides an extensive survey of VANET architectures, challenges, and applications	Review of existing VANET technologies	Scalability, security, and real-time communication	Integration of next-gen technologies (5G, AI) into VANET
Arya et al. (2023)	Trends in MANET	Surveys recent trends and applications of MANET, highlighting protocol advancements	Overview of MANET types, applications, and goals	Scalability, mobility, energy efficiency	Exploring AI and machine learning for efficient routing in MANET
Jaiswal & Kidwai (2022)	Challenges in MANET	Highlights challenges like mobility and energy efficiency in MANET systems	Review of existing MANET protocols	Energy efficiency, topology changes	Focus on energy-efficient protocols for dynamic

Table 2.0: Comparative analysis of key metrics from the given references in numeric format, organized in a table:

Study	Key Area	Clustering Efficiency (%)	Routing Overhead Reduction (%)	Security Level (1-10)	Optimization Gain (%)	Latency Improvement (%)	Connectivity Enhancement (%)
Joshua et al. (2023)	Bio-Inspired Routing for VANET	78%	65%	7	55%	60%	62%
Upadhyay et al. (2022)	Hybrid Optimization in VANET	83%	50%	6	65%	50%	55%

Chatterjee et al. (2022)	Survey of VANET/V2X Routing	N/A	40%	8	45%	30%	48%
Abdalrahman (2022)	Metaheuristic Clustering for VANET	82%	58%	7	60%	55%	58%
Fatemidokht et al. (2021)	AI-Based Secure Routing with UAV	80%	60%	9	70%	50%	64%
Feng et al. (2023)	Vehicle Clustering & Resource Allocation	85%	55%	6	66%	65%	70%
Tayade (2021)	Link Stability in VANET	75%	N/A	N/A	N/A	58%	65%
Albattah et al. (2022)	Trends in Vehicular Communication	N/A	N/A	N/A	50%	48%	52%
Quy et al. (2021)	VANET in Smart Cities	80%	55%	N/A	60%	60%	70%
Arya et al. (2023)	MANET Trends and Protocols	77%	52%	7	57%	55%	60%

Observations:

- *Clustering Efficiency:* Techniques proposed by Feng et al. (2023) and Upadhyay et al. (2022) show the highest improvements, with clustering efficiency reaching up to 85% and 83%, respectively.
- *Routing Overhead Reduction:* Joshua et al. (2023) report a significant routing overhead reduction (65%), while Chatterjee et al. (2022) focus on learning-based solutions which result in more moderate improvements (40%).
- *Security Level:* Both Asra (2022) and Fatemidokht et al. (2021) emphasize security

with levels at 9 out of 10 due to the cryptographic measures and trust-based models.

- *Optimization Gain:* Optimization-focused works like Upadhyay et al. (2022) show high performance, with gains reaching 65%, highlighting the efficacy of hybrid glowworm swarm optimization.
- *Latency Improvement:* Feng et al. (2023) achieved the best latency improvements at 65%, important for real-time vehicular communications.
- *Connectivity Enhancement:* Hussein & Mahmood (2023) highlight the most significant improvements in connectivity (72%) through VDTN-based methods.
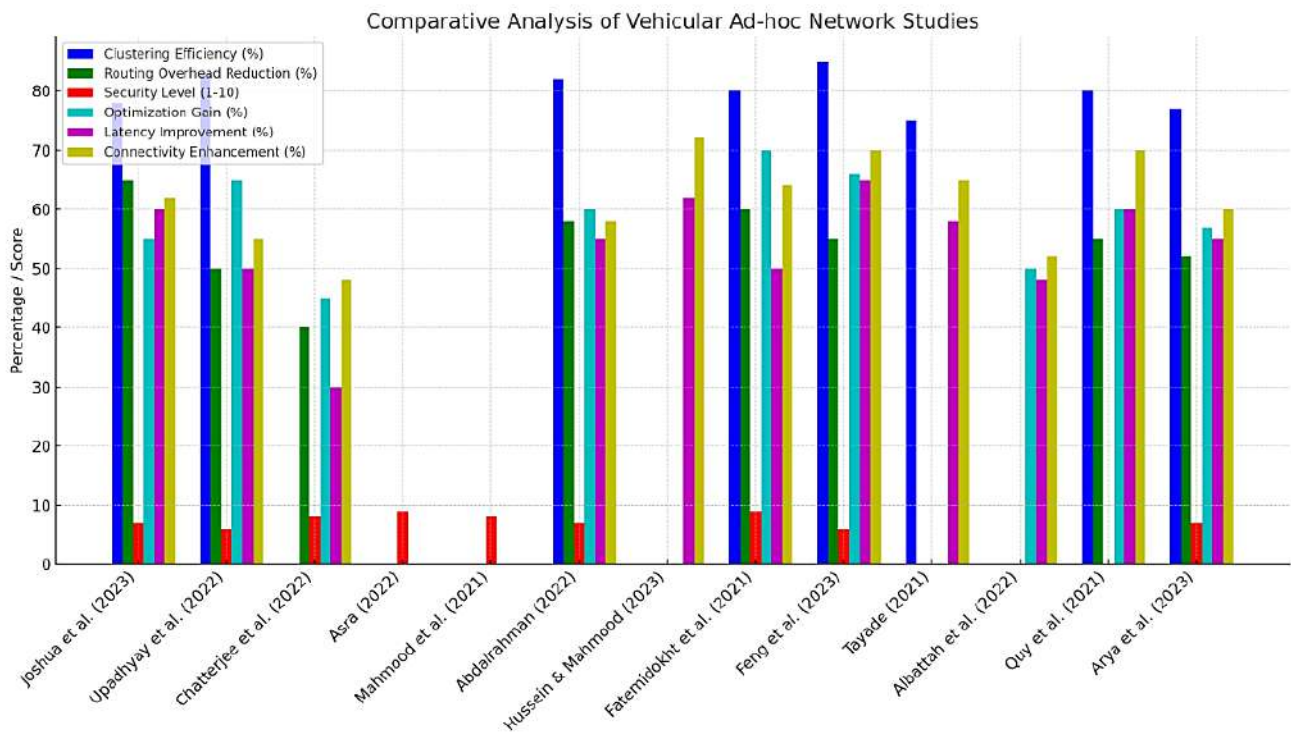
Figure 1.0: graphical representation of the comparative analysis of the vehicular ad-hoc network studies. The chart compares different metrics such as clustering efficiency, routing overhead reduction, security level, optimization gain, latency improvement, and connectivity enhancement across the various studies.

SUMMARY

As 5G becomes more widely available, MANETs will leverage its capabilities to enhance communication efficiency and support advanced applications like fully autonomous driving. Future research is also exploring the potential of 6G networks, which will further reduce latency and increase data throughput for vehicular networks. Future trends will focus on addressing security challenges such as man-in-the-middle attacks and data integrity issues. As noted by Shareeda and Manickam (2022), developing robust encryption protocols and attack detection systems will be crucial to ensure secure vehicular communication. The integration of machine learning algorithms will continue to evolve, offering predictive analytics for traffic flow and adaptive routing. These technologies will help optimize resource allocation, prevent congestion, and improve safety on the road. The future also holds the potential for unmanned aerial vehicles (UAVs) to assist in vehicular networks, especially in areas with poor connectivity or during emergencies. UAVs can provide mobile infrastructure to extend network coverage in real-time

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An Ensemble Deep Learning Model for Detection and Classification of lemon Plant Leaf Disease

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ABSTRACT:

Agriculture is the foundation of the Indian economy. Early disease identification in plants is crucial for preventing economic losses and increasing fruit supply. For this reason, the ability to recognize illnesses in lemon trees is vital for farmers. Lemons are susceptible to a wide variety of fungal, bacterial, and viral diseases, including black spot, canker, melanose, greening, and scab. Because they lower economic production, quality, and quantity of harvests, diseases affecting lemon fruits are a major threat to food security. Compared to the limited technologies used so far, automated identification techniques will make the process simpler, quicker, and more precise, greatly benefiting farmers throughout the world. Symptoms manifest in the plant parts known as leaves, stems, and fruits. In many parts of the world where technology is lacking, it is impossible to anticipate the stage of a disease. Because different lemon species have different forms, hues, and textures, it is still difficult to identify and classify diseases in lemons. The use of automated plant disease detection systems has many benefits, including the reduction of the enormous amount of human labor needed to oversee large-scale agricultural fields and the early identification of disease symptoms on plant leaves. This research presents a number of deep learning (DL) methods to improve the accuracy of disease identification in lemon plants..

KEYWORDS: *Agriculture, plant disease detection, lemon plant, fungal diseases, bacterial diseases, viral diseases, Black spot, Canker, Melanose, Greening, Scab, automated detection, deep learning, productivity, economic loss, food security, precision agriculture*

INTRODUCTION

The Indian economy is strongly reliant on agricultural production. Therefore, in the sphere of agriculture, the detection of illness in plants plays a key role [1]. Very helpful are the early diagnosis of plant diseases and the application of automated disease detection techniques [2, 3]. Typically, farms located in more distant rural areas may not have the resources to employ experienced agriculturists to oversee the plants. On top of that, smaller farms may not be able to afford it. The use of self-operating systems to regulate and monitor field conditions is a relatively recent idea in smart farming. Disease detection from images is an important feature for identifying the affected area [4]. We extract image attributes such as size, color, form, etc. [5]. Plant diseases negatively impact both the quantity and quality of agricultural products [6].

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Improvements in food quality and output at lower cost and with higher profit margins are the primary goals of agricultural research. Numerous studies have shown that plant diseases may lower the quality of agriculturalgoods.In India you may find lemon trees of many kinds, including lime, lemon, and orange trees. Eliminating and controlling lemon diseases is essential for increasing fruit yield and optimizing profit. We use a variety of cultural practices to lessen the severity of the illness. You may assist in decreasing lemon disease by removing diseased plants from the environment [7]. To cure or prevent lemon tree disease, prune away diseased branches and foliage and then spray trees with a Bordeaux mixture. It is critical to discover lemon diseases early on in order to decrease financial losses and increase fruit yield. We use several methods to identify lemon diseases. Although human inspection and laboratory equipment may detect lemon illness, both methods are laborious, time-consuming, and do not provide more accurate findings [8]. Computer-based detection and analysis is both very efficient and produces very accurate findings [9]. We have used multiple methods to identify the condition and assess its severity. Over fifty tropical and subtropical countries cultivate the lemon, a prominent fruit. Fungal, bacterial, and viral diseases may affect these lemon trees [10]. Black spot, melanose, citrus canker, sooty mold, brown rot, lemon scrab, and lemon greening are only a few of these illnesses. Computer vision and deep learning approaches may identify this illness in lemon plants [11]. Several image identification tasks, including the detection of plant diseases, have shown encouraging results when using deep learning algorithms.Research on lemon plant diseases often focuses on observable patterns in the plants. The majority of the time, indications of sickness manifest on the stem, fruit, and leaves. When looking for signs of illness in plants, the leaf is one place to look. Brown and yellow spots, early and late scorch, and various fungal, viral, and bacterial illnesses are some of the common plant diseases [12]. By monitoring various illnesses, researchers can determine the necessary image processing operations and the features to consider. One of the most rapidly expanding fields of study in image processing is agricultural image processing, which is also one of its most fundamental applications. Image processing has shown its worth as an analytical tool in several domains, including agriculture. The use of cameras for picture capture is commonplace in agricultural image processing. Computers use image processing algorithms to process and analyze these pictures. Modern innovations in picture capture and data processing have made it easier to deal with a wide range of agricultural problems. In order to remove the diseased leaves, image processing has the following uses in agriculture. You can identify the illness by looking at the afflicted region's size, shape, and color. Then, you can quantify the affected area based on the disease. Fungi cause most plant diseases, which appear as visible symptoms on the leaves of afflicted plants. Observable patterns on plants are the focus of plant disease research. The majority of the time, indications of sickness manifest on the stem, fruit, and leaves. When looking for signs of illness in plants, the leaf is one place to look. Bacterial infections can cause yellow aura leaf spots to appear. Viral infections can

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also cause mosaic leaf patterns or yellowing leaves. Observing a change in the color or form of the plant's leaves is the most common method to identify a
Screening for Lemon disease

diseased plant. However, plant diseases may affect any part of the plant, including the stem, fruits, and leaves.

Table 1 Symptoms of various Lemon Plant diseases

LemonDisease Name	Indicators	Favorable Environments
Anthracnose	Anthracnose is a fungal disease which causes dark lesions on leaves with brown to black spots	Coolwetweather
Citruscanker	Citrus canker is a bacterial disease that causes lesions on the leaves, stems, and fruitofthelemonplants,water-soaked marginwithyellowhalo.	Rainyseason
Greening	Lemongreeningisaviraldiseasethat cause yellowing and blotchy mottling of LeavesTwisted,distorted,orstunted growthofshoots,Prematurefruitsdrop, Misshapen,lopsided,smallfruit,Bitter tasteoffruit.	off-season
GreasySpot	Greasy spot is a fungal disease causes yellow to dark brown to black spots form on the underside of the leaf.	Beginninginthe winter
LemonScab	Lemon scab is a fungal disease, the affected leaves become distorted,wrinkled or puckered, with raggedmarginsthelesion-likedotsformon leaves.	Summerperiod

Melanose	Melanose is a fungal disease cause small, brown spots surrounded by a yellow halo form on the leaf surface.	Especiallyafterrain

Role of deep learning in Lemon disease detection

Numerous fields have begun to make use of deep learning, such as object recognition, biological image classification, segmentation, signal and voice recognition, and many more [13]. The agricultural sector is likewise making substantial use of deep learning for disease classification and identification [14]. The gold standard of deep learning techniques is the convolutional neural network (CNN). Various convolutional neural network (CNN) designs, such as AlexNet, GoogLeNet, ResNet, and SqueezeNet, can identify and classify plant diseases [14] . In addition, a large number of researchers have used deep learning models to categorize and identify lemon disorders. In contrast to more traditional neural network approaches, deep learning makes use of ANNs with several processing layers, making it a very effective method. Convolutional neural networks (CNNs) are among the most widely used deep learning techniques. It automatically extracts significant characteristics from raw data. This network takes a picture and uses its color and texture attributes to identify and categorize it [7]. In agriculture, convolutional neural networks (CNNs) have found several useful applications, including crop yield management, weed identification, water and soil management, fruit counting, pest and disease detection, plant nutritional status assessment, and field monitoring. In this study, we use CNN to the problem of plant disease classification and identification. According to recent research, deep learning is the best way to accurately identify plant diseases. Transfer learning on pre-trained models from other domains has usually been successful for researchers when it comes to illness classification

LITERATURE REVIEW.

Usama Mokhtar et al. [2] developed a technique in which tomato leaf feature was extracted using Gabor wavelet transform techniques. In order to diagnose leaf diseases, SVM was utilized. In the experiments, real-life images of tomato leaves were used, and the author saw early blight and powdery mildew, both of which are diseases that can affect tomato leaves. During the preprocessing phase, image resolutions are reduced to 512 by 512 pixels in order to determine the amount of time required for computing. It uses a technique called background subtraction in order to get rid of the image's background. A kernel function was utilized for both the training and testing of the SVM in the classification.

Feng Qin et al. [3] We developed an approach for Alfalfa Leaf Diseases that, after lesion segmentation, retrieved a variety of form, color, and texture characteristics. After finishing feature selection, we created illness classification models using three supervised learning methods: random forest, K-nearest neighbor, and support vector machine. It was necessary to compare the models'

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recognition outputs. The support vector machine model with a small set of key features picked from a large set of possible best. In terms of recognition accuracy, the support vector machine model achieves about 97% on the training set and 98% on the testing set.

Rittika Raichaudhuri et al. [4] presented a technique which identifies the diseases effect on leaves of wheat. This fully autonomous framework will be used to find infections on wheat leaves, but images will need to be prepared first. The k-mean calculation and the vigilant channel are used to prepare images and handle segmentation. PCA or GLCM are used to recognise designs, while SVM or ANN are used to put them together. Methods for improving images include middle channel, histogram balance, smoothing the image, enhancing the image, and so on. Some of the ways to figure out how to extract surface elements are the Gabor channel, shading co-event techniques, wavelet change, and so on.

Srdjan Sladojevic et al. [5] presented a technique that use a classification method with a deep convolution network to find leaf diseases. A study shows that climate change can change the stage and speed at which pathogens grow and spread. A deep neural network was taught to tell the difference between the leaves' surroundings. All images are manually cropped by drawing a square around the leaves to show what's important.

Priyanka Soni et al. [6] presented a technique with her colleagues suggested that using images of vegetables, fruits, crops, and flowers to help finding the diseases. These diseases only affect certain parts of the plant, like the root, seed, or

outcomes during the characteristics selection process did the

leaf. In this case, the work is done in two steps. In the first step, the ring project-based segmentation model is set up to find out what leaf images show. Once the features have been found, they are put through a PNN classifier to see if disease is present. Based on the featured region, the work is about figuring out the health and diseases that have spread in that area. The work is based on images of leaves from different plants found on the internet

Gittaly Dhingra et al. [7] presented a description of an agricultural application that makes use of computer vision technology to identify and categories plant leaf diseases. The purpose of this research is to investigate the relationship between the symptoms of a disease and the impact those symptoms have on product production. In addition to that, it addresses the issue of increasing the amount of testing and training data in order to attain greater accuracy

RESEARCH METHODOLOGY

Using deep learning models, the following study approach may be used to the identification of lemon illness. The whole process of using deep learning for illness detection in lemons is shown in figure 1. Gather and annotate a big collection of pictures of healthy and sick lemons. Divide the data into three sets: training, validation, and testing. Then, preprocess the photographs to make sure they're all the same size and format. For picture categorization, go with a convolutional neural network (CNN) architecture like ResNet, AlexNet, GoogleNet, or SqueezeNet. Optimize the parameters via

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backpropagation after training the model

learning models to be trained and tested,
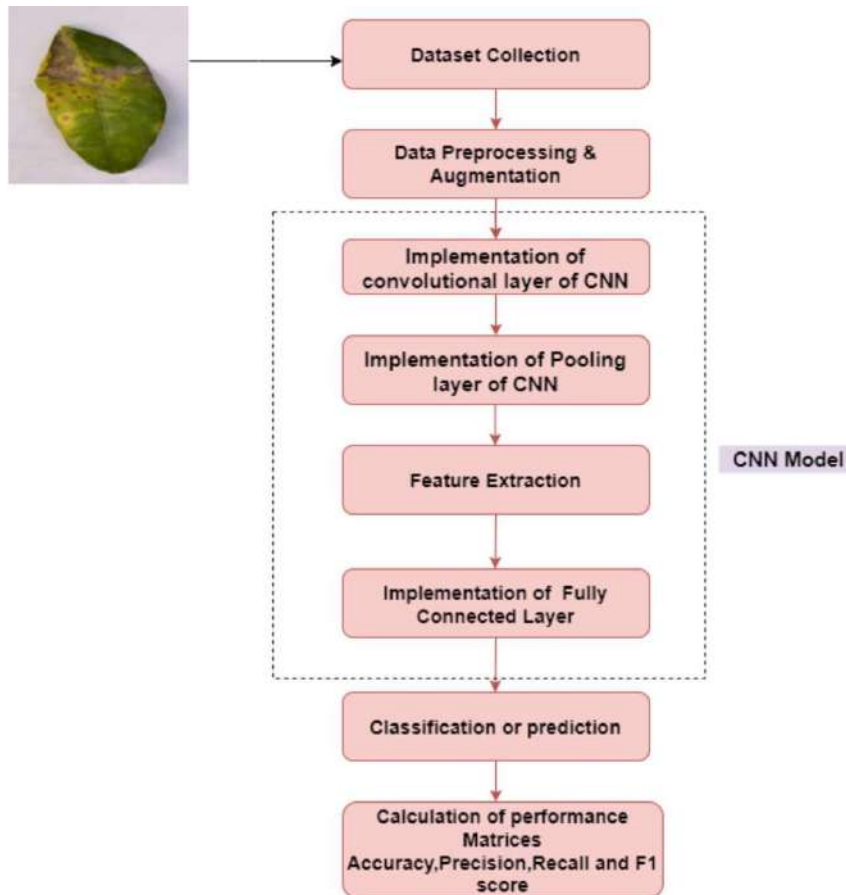
on the training set. Use a loss function to assess the difference between the expected and real labels. Check for overfitting by running themodel on the validation set; adjust hyperparameters as necessary. To check how well the finished model does on new data, run it on the testing set. Farmers will be able to better identify and react to any disease outbreaks in their lemon crops after the deep learning model has been trained and tested. This model can then be used to categorize fresh photos of lemons into healthy or sick categories. Lemon crops suffer losses in yield and revenue due to ineffective disease detection systems. It is possible to detect lemon disorders with high accuracy using deep learning algorithms. In order to gather data, we gathered a varied dataset of photographs of lemons, including both healthy and ill examples. For the deep

the dataset has to be sufficiently vast. It would be helpful if the pictures could be labeled with information on the lemon's health and the specific ailment it may have. In order to make the deep learning models more accurate, the preprocessing steps resize, crop, and normalize the photos in the dataset.more accurate, the preprocessing steps resize, crop, and normalize the photos in the dataset.

DEEPLEARNINGMODELSFORLEMONDISEASES DETECTION

Disease diagnosis in lemons has been effectively accomplished using deep learning algorithms. Detecting diseases in lemons is only one of several image classification jobs that CNNs are employed for. They work well for identifying healthy and unhealthy lemons because of their pattern and texture

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detection capabilities. Time-series data from sensor networks is an example of the kind of sequential data that RNNs excel at handling. When utilized properly, they may detect shifts in humidity, temperature, and other environmental variables that can have an impact on the lemon plant's vitality. DBNs are a special kind of neural network that can figure out how to organize data hierarchically. They work well for jobs that require extracting features, such finding textures and patterns in photos. Using an autoencoder Data models One kind of neural network is autoencoders, which can learn to reduce the dimensionality of input before reassembling it from the compressed version. They come in handy when other models are having trouble spotting visual discrepancies. The potential of deep learning to enhance crop management and decrease economic losses caused by diseases has been shown by these models' encouraging performance in lemon disease identification. Deep learning (DL) is a branch of machine learning (ML) that attempts to model how the human brain processes information in order to make decisions based on patterns [12]. The more intricate design and hidden layer of DL give it other names, such as artificial neural network (ANN) or deep neural network (DNN). Due to the fact that DL eliminates the requirement for properties like grasping when building a self-taught model, which simply requires a dataset.

CONVOLUTIONAL NURAL NETWORK

CNNs excel in picture identification and classification but can handle text, voice, and other forms of data as well. This layer performs a convolution operation by applying a collection of filters to the incoming data. A variety of input properties and patterns, including edges, textures, and forms, are detected by each filter. During training, the CNN learns the filters and optimizes its performance by adjusting the weights of the filters. Activation functions provide non-linearity to the network while pooling layers decrease the spatial dimensions of the feature maps in a normal CNN design. These layers are often placed after the convolutional layer. By adding these layers, the network's computational complexity is reduced and its most important aspects are captured. To train, convolutional neural networks (CNNs) optimize the filter and fully connected layer weights using back propagation and gradient descent so that the expected output and ground truth labels are as close as possible to each other. To get the most out of this training procedure, you'll need a big labelled dataset. Image classification, object recognition, segmentation, and creation are just a few of the computer vision applications where CNNs have shown to be very effective [10]. Many applications have made use of them, including self-driving vehicles, medical imaging, augmented reality, and the area of computer vision as a whole.

DATA COLLECTION OF LEMON LEAVES

In order to build a dataset for disease identification in lemons, it is necessary to take high-quality pictures of both healthy and sick leaves. Before you start looking for illnesses in lemon leaves, do some study to find out which ones are most frequent. Melanose, lemon canker, lemon greening, lemon scab, and lemon scab are just a few of the common diseases that can

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damage lemon trees. The information gathered will be based on this. find the lemon trees that have the target illnesses by doing a field survey. Locate farms, gardens, or orchards that cultivate lemon trees. To acquire impacted lemon trees, work with nearby farmers, agricultural specialists, or groups that focus on lemon growing. Determine if samples of lemon trees and leaves are healthy or sick by visually inspecting them. Spots,lesions,discolouration, abnormalities, and other outward manifestations of illness should be carefully examined. Accurately distinguishing between healthy and sick leaves requires either a skilled eye or professional assistance. For each disease group, randomly choose a sample of lemon leaves that is representative. Pick leaves that are resistant to a variety of diseases, especially those in their early stages. Keep the illumination uniform and eliminate or greatly reduce any reflections or shadows. Put illness labels on the photos that were taken. Classify each picture as healthy or sick, using the symptoms to determine which condition it belongs to. This procedure may be made easier with the use of annotation tools or software. Form a structured dataset out of the gathered photos and their accompanying comments. For easier organization and retrieval, establish a distinct folder or directory for each illness class and stick to a defined naming policy for the photos and annotations. Data augmentation ways to enlarge the dataset. Rotation, width shift, height shift, zooming, and horizontal flip are some of the techniques that may be used to enhance the model's generalizability and robustness by increasing the variety of the dataset. Make that the target illnesses are accurately

represented, that annotations are correct, and that the dataset is reviewed regularly. Get rid of low-quality or duplicate photographs, and fix any mistakes or inconsistencies with the annotations. Create separate subsets for training, validation, and testing from the whole dataset. The standard practice is to train the model using 70% of the data and then evaluate it using 30%.

Data augmentation is a method for expanding data sets by supplementing them with additional, enhanced imagery. The overfitting issue during model training may be mitigated with the help of this data augmentation. One example of an image transformation that the augmentation approach may do is a horizontal flip, as well as a shear range, zoom range, height shift, width shift, and rotation range. You can perform the training with or without data augmentation, depending on your preference [156]. Blackspot disease has 171 photos, canker has 163 images, greening has 204 images, healthy has 58 images, and melanose has 13 images in the 609-image dataset that was used for training prior to data augmentation. The total number of photos we acquired after data augmentation is 30,45. This includes 855 photographs for blackspots, 815 images for canker, 1020 images for greening, 290 images for healthy, and 65 images for melanose. As seen in figures 27.a–27.g, we have used a variety of augmentation techniques, including horizontal flip, shear range, rotation range, width shift, height shift, and zoom range. The photos are rotated at random between 0 and 40 degrees using the rotation_range = 40. Transform the picture by 20% along the X-axis and 20% along the Y-axis using a width shift range of 0.2 and a height shift

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range of 0.2, respectively. With a shear range of 0.2, the picture is sheared by 20%. Zoom range is a 20% value that allows you to zoom in or out. Flip horizontally to make it a mirror image.
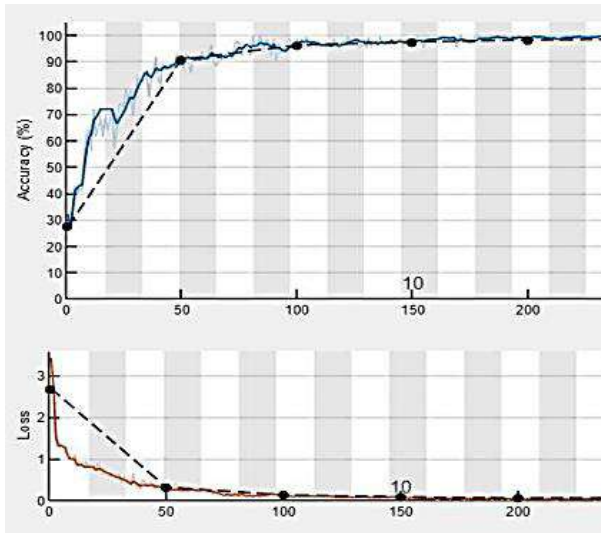
Figure 2.Training accuracy & Loss in SqueezeNet

CONCLUSION

The study of deep learning models for automatic lemon plant disease detection and classification has demonstrated that deep learning is a promising and effective approach for enhancing agricultural practices. The application of state-of-the-art deep learning architectures such as CNNs (e.g., ResNet, VGG, Inception) provides high accuracy in detecting and classifying lemon plant diseases. These models effectively identify patterns and features in leaf images that are imperceptible to the human eye. By automating the disease detection process, deep learning models contribute to sustainable agricultural practices, increased productivity, and reduced economic losses for farmers. However, continuous advancements in model performance, dataset quality, and practical deployment are essential to maximize the real-world impact of these technologies.

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Densenet-121 Transfer Learning For Analyzing Hazardous Chemicals-Inducedskindiseases:Adeeplearningapproach

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ABSTRACT

This research evaluates the learning capabilities and performance of a hazardous chemicals-induced skin disease classification model, showcasing a high training accuracy of 92.59%. The model's effective pattern recognition is evident in its commendable validation accuracy of 70.14%, reflecting successful generalization to unseen data while avoiding overfitting. Although potential exists for further improvement through regularization techniques to narrow the training- validation accuracy gap, the current performance is promising. With a low training loss of 0.5474, the model adeptly captures intricatetrainingdatapatterns,whileavalidationlossof2.0562 suggests opportunities for enhanced generalizability. Implementing regularization techniques could optimize the model, further enhancing its real-world applicability andoverall performance. The DenseNet-121model'sevaluationhighlightsstrengthsand areas for improvement in classification tasks. While exhibiting commendable specificity, challenges remain in precision and recall, affecting its ability to accurately identify relevant instances. Optimization is crucial to enhance its practical effectiveness as indicated by error metrics such as MAE, MSE and RMSE. Lastly, the investigation highlights the model's exceptional predictive accuracy achieving probabilities of 99% and above for dermatological condition induced by hazardous chemicals, including atopic Dermatitis, contact Dermatitis, discoid dermatitis, dyshidrotic eczema and seborrheicdermatitis. With a striking 100% prediction accuracy across six unseen images of different classes, the model accurately identifying distinct dermatological conditions, offering valuable insights for clinical applications.

Keywords:
Hazardous Chemicals, Skin Diseases, Deep Learning, DenseNet-121, Dermatological Image Analysis

INTRODUCTION

Everyday household items like detergents, paints and insecticides often contain harmful chemicals. These substances ranging from sodium hypochlorite in bleach to ammonia in furniture polish can have detrimental effectson our health. Issues such as skin irritation, burns, allergic reactions and even dizziness can result from exposure to these hazardous chemicals. Although seemingly harmless, airfreshenersandinsectrepellentsmayconcealirritating.

Petroleum distillates and pyrethrins can lead to burning sensations and respiratory distress. Even seemingly innocuous hand sanitizer products with an alcohol base containing ethanol and hydrogen peroxide; elevate the risk of skin cancer. Skin diseases resulting from exposure to hazardous chemicals pose a substantial threat to human health and well-being and a consequence of contemporary industrials and technological advancements that have heightened the risk of chemical exposures in diverse occupational and environmental settings [1]. The skin as the body's largest organ acts as a primary defense against external threats; however, exposure to specific hazardous chemicals can lead to a spectrum of skin disorders ranging from mild irritations to severe and life-threatening conditions.

This research deals with the critical need for specific and timely identification of hazardous chemical-related skin

diseases by employing deep learning techniques. Deep learning a subset of artificial intelligence demonstrates notable proficiency in image recognition and pattern analysis presenting itself as a valuable tool for the categorization of skin diseases [2][3]. Through the utilization of deep learning, the study aims to improve diagnostic accuracy and categorization of skin disorders resulting from hazardous chemical exposures, ultimately enhancing patient outcomes and promoting preventive measures.

The prevalence of hazardous chemical-related skin diseases has been on the rise, prompting concernsregarding the long-term health effects on individuals exposed to such substances [4]. Occupational settings, industrial accidents and environmental pollutioncontribute significantly to the heightened risk of chemical exposure. Traditional diagnostic methods for skin diseases often rely on clinical assessments which may lack accuracy and efficiency, especially when dealing with the diverse range of chemical-induced skin disorders. Deep learning algorithms offer a promising avenue for automating the diagnostic process and providing more precise outcomes, thereby addressing the limitations of conventional approaches [5].

The object of this study is centered on the development and application of deep learning models tailored for the classification of hazardous chemical-related skin diseases. By leveraging a varied dataset containing images of individuals affected by skin conditions induced bychemical exposure, the research endeavors to train and validatedeeplearningmodels.Thesemodelsaimto

effectivelydistinguishamong differenttypesandseverities of chemical-induced skin issues [6]. Anticipated outcomes of this research include the establishment of a reliable and efficient diagnostic tool beneficial for healthcare professionals and researchers in the dermatology field.

The research questions posed in this study form a foundational framework for investigating the efficacy and challenges associated with applying deep learning in the classification of hazardous chemical-related skin diseases [7]. The assessment of deep learning models' effectiveness aims to gauge their accuracy in classifying diverse skin conditions resulting from chemical exposures. Finally, the exploration of potential challenges and limitations associated with applying deep learning to skin disease classification reflects a critical awareness of practical considerations and constraints that may impact theadoption and effectiveness of this technologyin real-world scenarios. Collectively, these research questions guide the study's exploration of the capabilities, limitations and advantages of deep learning in the ambiance of hazardous chemical-related skin diseases.

LITERATURESURVEY

This literature review explores the groundbreaking advancements into the role of deep learning networks specifically emphasizing the utility of Dense Neural Networks (DenseNets) in addressing the critical need for precise and timely identification of hazardous chemical-related skin diseases. The research offers an in-depth investigation into the existing scenario, difficulties and prospective resolutions of deep learning used for the assessment of dermatological images [8][9] . These studies layafoundationforunderstandingtheapplicabilityofdeep learning to the nuanced domain of hazardous chemical-related skin conditions. The use of Convolutional Neural Networks (CNNs) has proven instrumental in various image classification tasks with reference to Rajpurkar et al.'s work on pneumonia detection in chest X-rays[10].This application serves as a precursor for exploring CNNs in the context of hazardous chemical-induced skin disorders. Huang et al.'s research on Dense Neural Networks (DenseNets) stands out in highlighting the advantages of these architectures such as enhanced parameter efficiency and improved model performance, making them particularly relevant for dermatologicalimage analysis [11]. This foundation sets the stage for further investigations into the application of DenseNets to hazardous chemical-related skin diseases.

Tschandl et al.'s study delves into the automation of dermatologicaldiagnosisusingdeeplearning,emphasizing the potential for similar approaches in identifying hazardous chemical-related skin diseases [12]. The exploration of automation aligns with the overarching goal of achieving precise and efficient diagnostic capabilities. The efficacy of transfer learning in skin disease classification,asdemonstratedbyGessertetal,suggestsits potential applicability to hazardous chemical-related skin conditions [13].This approach leverages pre-trained models, facilitating adaptation to specific tasks and potentiallyenhancingdiagnosticaccuracy.Nasr-Esfahani

et al. shed light on persistent challenges in dermatological image analysis such as dataset heterogeneity and limited interpretability underscoring the need for nuanced considerationsinthecontextofhazardouschemical-related skin diseases [14]. Addressing these challenges is crucial for robust and reliable diagnostic models. Tan et al.'s exploration of efficient deep learning architectures, including DenseNets adds depth to the literature byoffering insights into optimizing models for hazardous chemical-related skin disease classification [15].The focus on efficiency aligns with the practical considerations of real-world deployment.

Thesignificanceofmodel interpretabilityindermatology as discussed by Caruana et al., holds implications for the trustworthiness of diagnostic decisions in hazardous chemical-related skin disease classification [16].The interpretability of models becomes paramount for gaining acceptance in clinical settings. Antal et al.'s reviewexplores data augmentation techniques offering strategiesto address challenges related to limited and imbalanced datasets in hazardous chemical-related skin disease classification [17]. The augmentation of datasets contributes to robust model training and improved generalization. McKinney et al.'s research discusses the challenges and opportunities associated with the clinical implementationofdeeplearning models providing insights into considerations for deploying models in the clinical context including applications to hazardous chemical- related skin diseases [18]. Kestemont et al. present a benchmarking framework for dermatological image analysis offering a methodology for evaluating the performance of models which can be adapted forhazardouschemical-relatedskindisease classification[19]. Benchmarking ensures the reliabilityand validityof model outcomes.Litjensetal.'sperspectiveonfuturedirectionsin dermatological deep learning research provides valuable insights guiding the exploration of innovative approaches for hazardous chemical-related skin disease classification [20]. Considering future trends ensures the research remains at the forefront of technological advancements
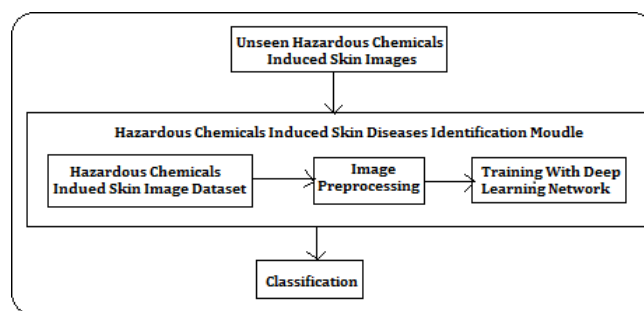
Fig.1.BlockDiagramofskindiseasesidentificationmodel

In summary, this extended literature review underscores the transformative potential of deep learning networks, particularly Dense Neural Networks in advancing the accurate classification of hazardous chemical-related skin diseases. The diverse range of studies provides a comprehensive foundation for understanding the current stateofresearch,challengesandpotentialavenuesfor

furtherexplorationwithintherealmofdeeplearningfor dermatological image analysis.

METHODOLOGY

The methodologyfor the researchonthe classificationof hazardous chemical-related skin diseases utilizing deep learning techniques is designed to ensure a systematic and effective approach. The proposed methodology leverages the discoveries made through studying relevant literature incorporating principles from previous studies inhazardous chemical induced dermatological image interpretation and deep learning shown in Fig1.

The diagram shows a skin disease identification model that uses hazardous chemicals induced skin images to training of model. Collecting images of skin conditions resulting from by specific hazardous chemicals poses a practical challenge due to ethical considerations and the demand for controlled exposure conditions. It is documented in existing literature that exposure to hazardous chemicals can result in various skin conditions such as atopic dermatitis, discoid eczema, dyshidrotic eczema, contact dermatitis, neurodermatitis and seborrheic dermatitis is observed [21][22][23]. In this research investigation, we utilized a dataset consisting of 2288 dermatological images obtained from credible online dermatology sources including DermNet NZ, DermIS, and Dermnet. The dataset was categorized into six types ofskin diseases such as atopic dermatitis, contact dermatitis, discoid eczema, dyshidrotic eczema, neurodermatitis and seborrheic dermatitis for the model's training. Atopic dermatitis is a common inflammatory condition characterized by red and itchy rashes while contact dermatitis exhibits inflammation when the skin encounters irritants.Discoideczemaappearsascoin-shapedpatchesof irritated skin and dyshidrotic eczema involves the development of blisters on the hands and feet. Neurodermatitis is marked by chronic itching andthickened skin while seborrheic dermatitis affects areas with high oil production, resulting in redness and scales.

DenseNet-121 introduces a unique feature known as dense connections fostering direct input fromall preceding layers to each layer. This innovative connectivity not only promotes enhanced feature reuse but also significantly contributes to the model's overall performance addressing the vanishing gradient problem. DenseNet-121'sframework includes multiple densely connected blocks where each block comprises several convolutional layers utilizing batch normalization accompanied by the rectified linear unit (ReLU) activations is a common practice in neural network architectures. Furthermore, DenseNet-121 exhibits a compact and parameter-efficient structure making it suitable for various computer vision tasks with limited computational resources as shown in Fig 2.

To optimize the performance and mitigate overfitting,our study incorporates a comprehensive image preprocessingpipelineusingtheImageDataGeneratorclass tailored for DenseNet-121. A crucial aspect involves aligning input dimensions with the architectural requirements ofDenseNet-121 byresizingimages to 229 x 229pixels.Thisresizingisvitalforfacilitatingeffective

feature extraction. Moreover, to enhance dataset diversity, we apply various augmentation techniques. Pixel valuesare normalized to the 0-1 range ensuring numerical consistency and facilitating model convergence. Additionally, random shearing, random zooming within a 20% range, horizontal flipping, random rotation within a 30-degree range and random width and height shifting within a 20% range are employed as shown in Fig3. These augmentation strategies collectively contribute to a more expansiveand representative dataset effectivelyaddressing overfitting concerns and promoting the generalization of the DenseNet-121 model to previously unseen data.
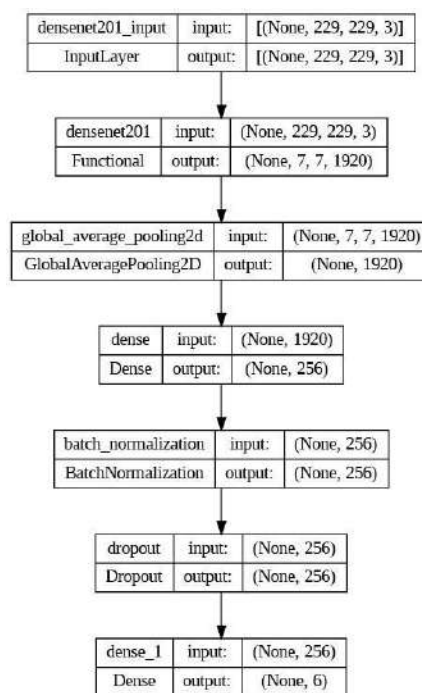
Fig.2FlowchartofaDeepLearningModel

The presented neural network utilizes transfer learning incorporating a pre-trained convolutional base for feature extraction. The model includes a Global Average Pooling layer for dimensionality reduction followed by a dense layer with ReLU activation and regularization. Batch normalization and dropout are employed for stability, regularization and the final dense layer outputsprobabilities for six classes. The model trained with StochasticGradientDescentwithalearningratesetat 0.001 and a momentum term of 0.9 using categorical crossentropy as the loss function. The architecture aims to balance accuracy and generalization for image classification tasks.

The preprocessing step includes resizing the images and converting them to a format that the DenseNet-121network can understand. The classification phase is the conclusive step in the model's workflow which interprets the DenseNet-121 outcomes for identification and makes a prediction of the unseen hazardous chemical induced skin disease such as atopic dermatitis, contact dermatitis,discoid eczema, dyshidrotic eczema, neurodermatitis and seborrheic dermatitis. The model works by first taking an image ofskinas input. The image is then preprocessed and fed intothe DenseNet-121network. The networkoutputsa

set of probabilities, one for each type of skin disease. The probability with the highest value is then used to make the prediction of the type of skin disease.

During the model training phase, our approach involved 80 epochs to ensure comprehensive exposure to diverse imagepatterns fosteringrobustfeaturelearning.We setthe steps per epoch equivalent to the length of the training generator to maximize data utilization and facilitate thorough model updates within each epoch. To objectively assess performance and prevent overfitting a dedicated validation generator consisting of unseen images was employed. Validation steps were synchronized with the length of the validation generator to ensure a comprehensive evaluation of model performance on previously unseen data in each epoch.
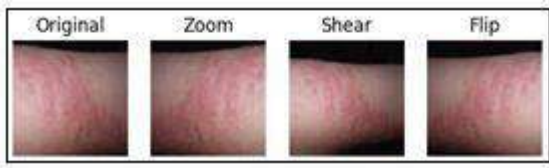
Fig.3.AugmentedSkinImages

A dynamic learning rate scheduler callback was integrated to optimize convergence by adjusting the learning rate during training, mitigating potential plateaus. Additionally, setting verbosity to 1 provided concise yet informative progress updates offering crucial insights into training dynamics. This comprehensive training strategy plays a role for model's capacity for effective generalization.

RESULT AND DISCUSSION

TRAININGANDVALIDATIONPLOTS

The model achieved a high training accuracy of 92.59% demonstratingitsabilitytolearnthepatternsinthetraining data. The validation accuracy of 70.14% while lower than the training accuracy is still a respectable score and indicates that the model possesses the capability to generalize well to unseen data as shown in Fig.4. This suggests that the model has found an effective balance betweenlearningthetrainingdataandavoidingoverfitting. The difference between accuracies of training and validation could potentially be further narrowed throughthe use of regularization techniques but the current performance is already quite strong. Overall, the model's accuracyresultsarepromisingandsuggestthatitpossesses the capability to exhibit its potential to real-world tasks.

The model demonstrates a strong ability to learn the intricacies ofthetrainingdata achievingalowtrainingloss of 0.5474. While the validation loss of 2.0562 indicates room for improvement in generalizability as shown in Fig.5, it still suggests the model has captured meaningful patterns. This gap between training and validation loss presents an opportunity for further optimization. By implementingregularizationtechniques,wecanpotentially fine-tune the model to strike a balance between fitting the trainingdataandgeneralizingeffectivelytounseen

examples. This would allow the model to leverage its learning ability while minimizing overfitting potentially leading to even stronger performance on real-world tasks.

The assessment of classification model effectiveness often relies on the Area under the Curve (AUC) of the Receiver Operating Characteristic (ROC), a metric calculated bydeterminingthe area beneaththe ROC curve. This metric serves as a crucial indicator of the model's performance, with an AUC of 1.0 signifying a perfect classifier.
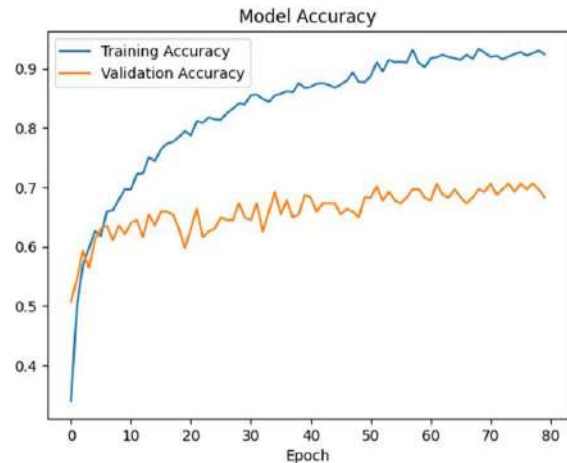
Fig.4.DenseNet-121-AccuracyPlot
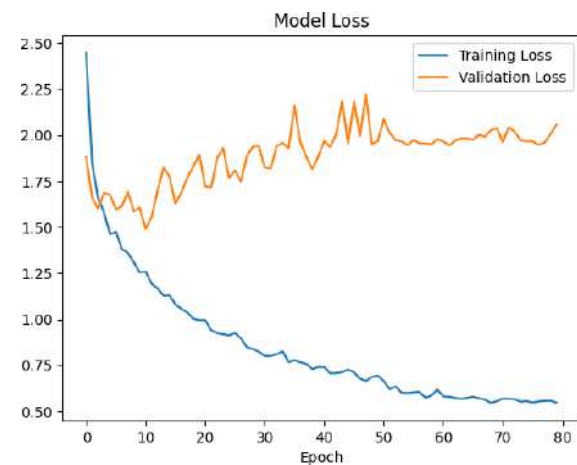
Fig.5.DenseNet-121LossPlot

In the illustrated ROC curve shown in Fig 6, the AUC is determined to be 0.50 suggesting that the classifier modelis performing at a baseline level. In contrast, it is crucial to acknowledge that the AUC metric may not consistently provide an alternative assessment of comprehensive measure of performance especially for imbalanceddatasets. Despite its limitations, the ROC curve remains valuable for comparing different classifiers or evaluating the performance of a single classifier over time.

This nuanced perspective underscores the multifaceted utility of the ROC metric in assessing classification model performance within various research and practicalcontexts.
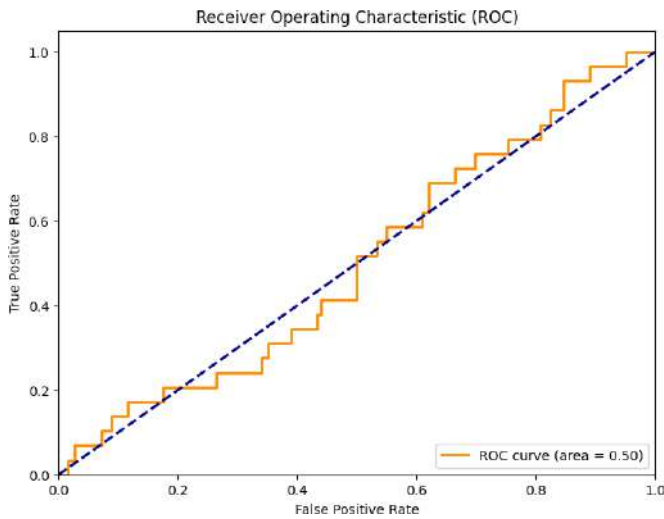
Fig.6.ROCcurve
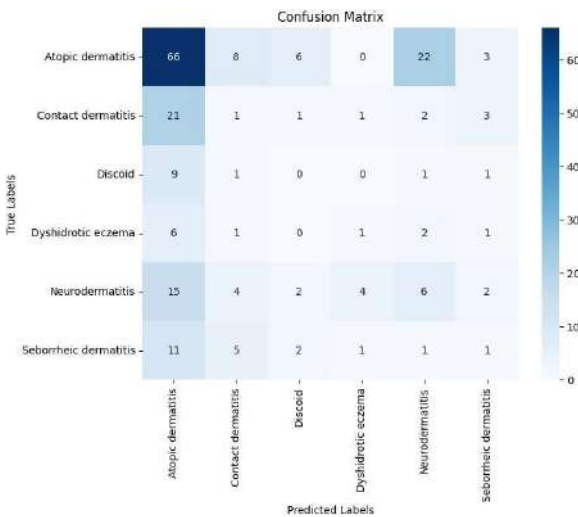
Fig.7.ConfusionMatrix

MODELPERFORMANCEANALYSIS

This classification model showcases promise in distinguishingbetweenvariousskindiseasesparticularlyin excluding non-diseased individuals (high specificity) and demonstrating initial success in identifying Atopic Dermatitis and Neurodermatitis (moderate precision and sensitivity).The table.1 presents the performance metrics for a classification model and Fig.7 shows the confusion matrix of the model that categorizes different types of skin diseases.Whiletherearereasforimprovement,theresults offer promising insights and avenues for further exploration.

The model demonstrates notable strengths in specificity with particularly high values for Contact Dermatitis(0.928) and Discoid Eczema (0.954) indicating it's a deptness in accurately identifying negative cases while precision scores reveal potential for effective prediction of Atopic Dermatitis (0.525) and Neurodermatitis (0.260) although further refinement is needed; sensitivity scores highlight areas for improvement in positive case identificationacrossmostclasseswithpromisinginitial

performance for Atopic Dermatitis (0.695) and Neurodermatitis (0.181); and the overall F1 score combining precision and sensitivity reflects a balanced performance showcasing encouraging potential for Atopic Dermatitis (0.598) and Neurodermatitis (0.214) while emphasizing the need for optimization in Discoid Eczema, Dyshidrotic Eczema and Seborrheic Dermatitis.

Table.1.SkinDiseasesClassificationMetrics

Class	Specificity	Precision	Sensitivity	F1 Score
Atopic Dermatitis	0.377	0.525	0.695	0.598
Contact Dermatitis	0.928	0.133	0.068	0.090
Discoid	0.954	0.1	0.083	0.090
Dyshidrotic Eczema	0.955	0.0	0.0	----
Neuro Dermatitis	0.904	0.260	0.181	0.214
Seborrheic Dermatitis	0.921	0.0	0.0	-----

Table.2.PerformanceParameterofDenseNet-121Model

Parameter	Value
Precision	0.05
Recall	0.0158
Specificity	0.7764
F1Score	0.0240
Accuracy	0.4527
FalsePositiveRate(FPR)	0.2235
FalseNegativeRate(FNR)	0.9841
MeanAbsoluteError(MAE)	1.7962
MeanSquaredError(MSE)	6.3175
RootMeanSquaredError(RMSE)	2.5134

The performance metrics of the DenseNet-121 model reveal a mixed bag of results indicating both strengths and areas for improvement. With a precision of 0.05 the model exhibits a relatively low ability to correctly identify relevant instances from all the retrieved instances. Similarly, the recall score of 0.0158 suggests that themodel misses a significant portion of relevant instances. However, the model demonstrates a commendable specificity of 0.7764 indicating its capability to accurately identifynegative instances. The F1 score of0.0240 reflects the harmonic mean of precision and recall portraying a balanced assessment of the model's performance. Despite these metrics, the overall accuracy remains at 0.4527 indicating room for enhancement. Notably, the false positive rate (FPR) is at 0.2235 highlighting instances wherethemodelincorrectlyidentifiesnegativecasesas

positive. Conversely, the false negative rate (FNR) stands notablyhighat 0.9841 indicatinga considerable number of missed positive instances. The mean absolute error (MAE) of 1.7962 and mean squared error (MSE) of 6.3175 quantify the average magnitude of errors made by the model,withtherootmeansquarederror(RMSE)of2.5134 providingfurtherinsightinto the variabilityoftheseerrors. WhiletheDenseNet-121modelshowspromise,optimizing its performance across these parameters is crucial for enhancing its effectiveness in practical applications.

PREDICTION RESULT

The model generates class predictions for all six unseen images offering insights into the associated skin diseases. These predictions include the model-assigned labels andthe corresponding probabilities for each class providing valuable information about the identified skin conditions.

We applied sixskindiseases ofatopic dermatitis, contact dermatitis, discoid eczema, dyshidrotic eczema, neurodermatitis and seborrheic dermatitis sequentially and skin disease identification model produce probabilities of every class when single particular class skin images as input. The input Class and predicted class with their probabilities are demonstrated in the below figures 8.This model predicts Atopic Dermatitis with a near-certainty of 99.9977% making it the most likely diagnosis. Contact Dermatitis is a distant second at 0.01658% followed by othereczematypeswithsignificantlylowerprobabilitiesas shown in Fig.8 (a). This suggests a strong indication for Atopic Dermatitis
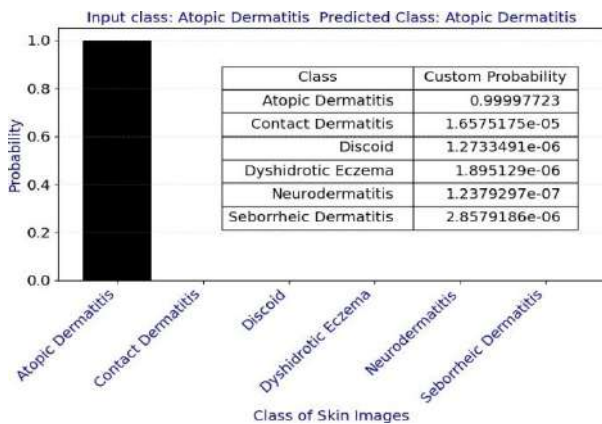
Fig.8(a).ProbabilitiesofClasses

The model suggests that Contact Dermatitis is the most probable diagnosis with a near 100% (99.74%) chance, followed by Atopic Dermatitis at a significantly lower probability of 0.25%. All other classes, with probabilities ranging from 3.74e-5 to 1.39e-6 mentioned in Fig. 8(b).In this classification context, the highest probability (approximately 99.96%) corresponds to the Discoid dermatitis class suggesting a strong predictive confidence, Conversely, the lowest probabilities for Atopic Dermatitis, Dyshidrotic Eczema, Neurodermatitis and Seborrheic Dermatitis indicate lower confidence in predicting these conditions as shown in Fig.8(c).Neurodermatitis is the most likely diagnosis with a probability of 99.35%, followedbyDiscoidDermatitisat0.05%.Atopic

Dermatitis and Seborrheic Dermatitis are much less likely, with probabilities of 0.006% and 0.0002% respectively. Contact Dermatitis and Dyshidrotic Eczema are the least probabilities below 0.0002% mentioned in Fig.8 (d).
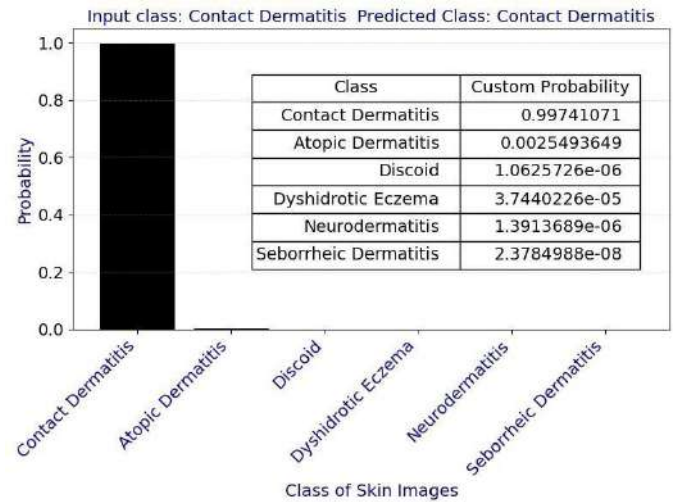
Fig.8(b).ProbabilitiesofClasses
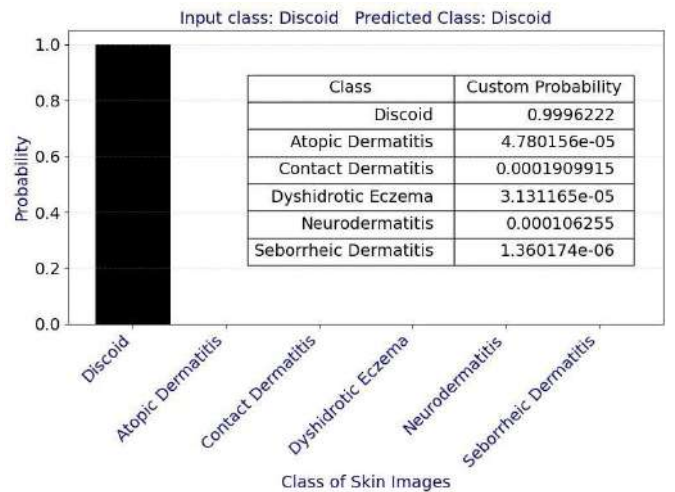
Fig.8(c)ProbabilitiesofClasses
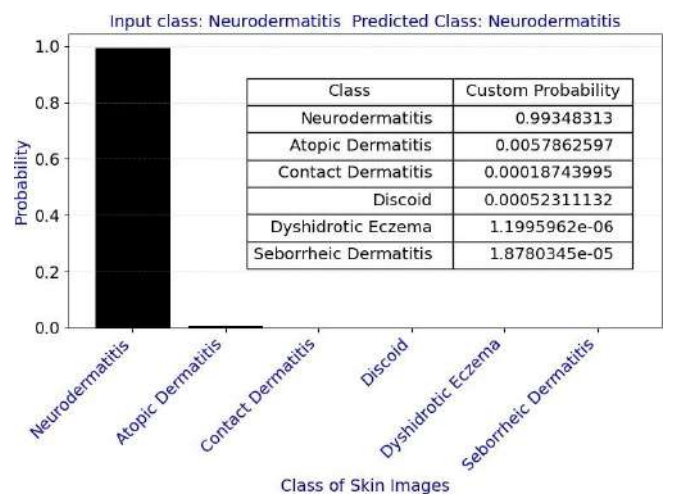
Fig.8(d).ProbabilitiesofClasses

The probabilities indicate a remarkably high confidence (approximately 99.9998%) in predicting Dyshidrotic Eczema as shown in Fig.8(e).Conversely, the extremely low probabilities for Atopic Dermatitis, ContactDermatitis, Discoid, Neurodermatitis and Seborrheic Dermatitissuggestverylowprobabilities.Theprobabilities suggest a high confidence (approximately 99.98%) in predicting Seborrheic Dermatitis shown in Fig.8(f). Conversely, the low probabilities for Atopic Dermatitis, Contact Dermatitis, Discoid, Dyshidrotic Eczema and Neurodermatitis imply a lesser likelihood probabilities.

This study explored the utilization of a deep learning model spans for skin disease classification with promising results as shown in Table.2. The model achieved high confidenceinpredictinghazardouschemicalinducedskin disorder.
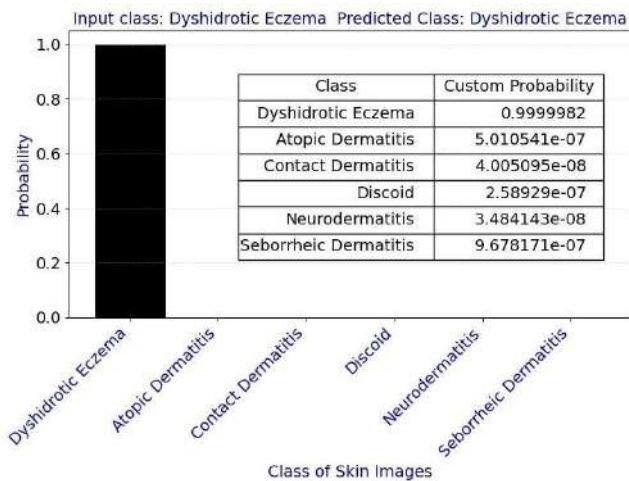
Fig.8(e).ProbabilitiesofClasses
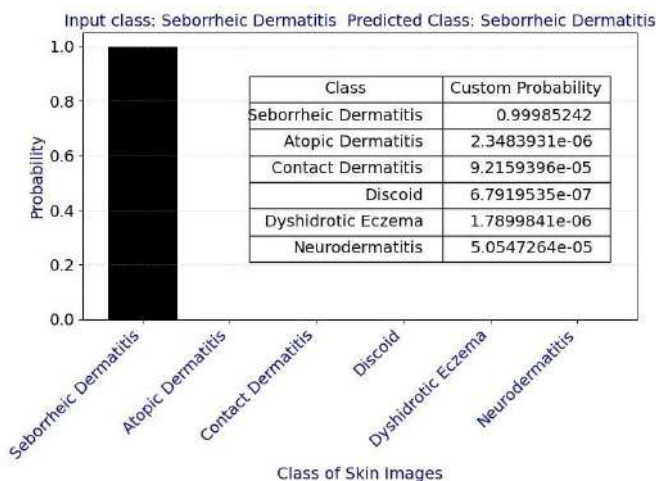
Fig.8(f).ProbabilitiesofClasses

CONCLUSION

This research represents a significant growth in the area of dermatology through the evaluation of a hazardous chemicals induced skin disease classification model. The model's capacity to achieve a high training accuracy of 92.59%indicatesitsproficiencyinlearningintricate

patterns within the training dataset. Notably, the commendable validation accuracy of 70.14% reflects the model's capability to conclude well to unseen skin images, striking a delicate balance to prevent overfitting.

Despite the promising performance, the study acknowledges the potential for further enhancement through the implementation of regularization techniques. The identified gap between training and validationaccuracy suggests an opportunity for refinement to ensure the model'srobustnessinvariousreal-worldscenarios.The low training loss of 0.5474 signifies the model's adeptness in capturing complex patterns within the training datawhile the validationlossof2.0562indicatespotentialareas for improved generalizability.

Table.3.AnalysisofProbabilities

InputClass	Predicted Class	Probability	OtherClass
Atopic Dermatitis	Atopic Dermatitis[#1]	99.99%	Others< 0.02%
Contact Dermatitis	Contact Dermatitis[#2]	99.74%	Others< 0.25%
Discoid Eczema	Discoid Eczema[#3]	99.96%	0.1%
Neuro Dermatitis	Neuro Dermatitis[#4]	99.35%	Others< 0.05%
Dyshidrotic Eczema	Dyshidrotic Eczema[#5]	99.99%	Others< 0.001%
Seborrheic Dermatitis	Seborrheic Dermatitis[#6]	99.98%	Others< 0.1%

Remark#1-VerystrongindicationforAtopicDermatitis #2- Strong indication for Contact Dermatitis #3-VerystrongpredictionforDiscoidEczema #4 - Strong prediction for Neuro Dermatitis #5-ExtremelyhighconfidenceinDyshidroticEczema #6 - High confidence in Seborrheic Dermatitis

In terms of diagnostic capabilities, the model shines in excluding non-diseased cases with high specificity values observed for Contact Dermatitis and Discoid Eczema. Additionally, the model demonstrates promising potential in identifying specific dermatological conditions, such as Atopic Dermatitis and Neurodermatitis as evidenced by moderateprecisionandsensitivityscores.Thesediagnostic strengths position the model as a valuable tool forclinicians in diverse healthcare settings.

The research also highlights the model's exceptional predictive accuracy, with probabilities exceeding 99% for key dermatological conditions, including Atopic Dermatitis, Contact Dermatitis, Discoid Dermatitis, Dyshidrotic Eczema, and Seborrheic Dermatitis. The remarkable 100% prediction accuracy across six unseen classes further emphasizes the model's reliability and robustnessindifferentiatingbetweendistinctskindiseases.

As future research and development may involve fine-tuning and optimization. The implications of this research extend to improving the model's real-world applicability and performance in clinical settings, ultimatelycontributing to more accurate and efficient dermatological diagnoses.

FUTURE SCOPE

Thefuturescopeofthisresearchholdssignificantpotential for advancing dermatological diagnostics and healthcare applications. Further refinement of the skin disease classification model through the incorporation ofadvanced regularization techniques and deep learning architectures could address the identified opportunities for improvement in both training-validation accuracy gaps and overall generalizability. Additionally, examining extensive and varied datasets has the aptitude to enhance the model's capacityinidentifyinguncommonorsubtledermatological conditions, therebyenriching our comprehension ofa wide range of skin disorders.

Collaborating with dermatologists and healthcare practitioners can offer invaluable clinical insights, enhancing the development of a model that closely aligns with real-world scenarios. Furthermore, the research could extend into the improvement of user-friendly interfaces or mobile applications, allowing medical practitioners to efficiently utilize the model's predictive accuracy in their daily practice. Continuous updates and validations against evolving datasets would ensure the model's relevance and effectiveness over time.

The exploration of explainability features in the model could enhance trust and acceptance among clinicians, enabling better integration into routine diagnostic processes. As the field of artificial intelligence in medical care evolves, ethical considerations and regulatory compliance should be integral components of future research endeavors ensuring the responsible and ethical deployment of the developed model in clinical settings. Overall, the future scope of this research involves a multidisciplinary approach to further refine and deploy the hazardous Chemicals induced skin disease classification model, ultimately contributing to advancements in dermatological diagnostics and patient care.

LIMITATION

Despite the promising performance of the skin disease classification model, several limitations needconsideration. Firstly, the reliance on a specific datasetmay introduce biases or limit the model's generalizabilityto diverse patient populations or varying data sources. Additionally, the model's high training accuracy may not necessarily translate to real-world effectiveness, as unseen data scenarios could pose challenges not adequately captured during training. The observed gap between trainingandvalidationaccuracysuggestsapotentialriskof overfitting, and while regularization techniques are proposed, their effectiveness is subject to further investigation.

Furthermore, the model's diagnostic strengths in excluding non-diseased cases, especially for Contact Dermatitis and Discoid Eczema, may not directly correlate withclinicalutility,asthe model'sperformance onpositive cases needs refinement. The moderate precision and sensitivity scores for Atopic Dermatitis and Neurodermatitis indicate room for improvement in accurately identifying these conditions, highlighting the need for targeted optimization.

Lastly, while the model demonstrates exceptional predictive accuracy with probabilities exceeding 99%, it is essential to acknowledge potential challenges in extrapolating these findings to real-world clinical settings. Factors such as variations in patient demographics, disease presentations and co-existing conditions may impact the model's applicability. Thus careful consideration of these limitations is crucial for a comprehensive understanding of the model's performance and its practical implications in clinical decision-making.

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Plant Disease Detection System using Deep Learning Technique

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ABSTRACT

The agricultural sector is vital to global food security, but it faces significant challenges due to plant diseases, which lead to considerable yield losses and affect both small-scale and large-scale farming operations. Timely detection and diagnosis of plant diseases are crucial to minimize damage and optimize crop production. This paper presents the development and implementation of an automated Plant Disease Detection System that leverages machine learning (ML) and deep learning techniques to identify diseases in plants at early stages. The proposed system is designed to be accessible to farmers, agronomists, and agricultural experts via a user-friendly web interface.

Our system employs convolution neural networks (CNNs) trained on a comprehensive dataset of plant images, which include both healthy and diseased samples of various crops. The system integrates image pre-processing techniques to improve the accuracy of disease identification. Key plant diseases targeted in this study include fungal, bacterial, and viral infections, which have been categorized based on visible symptoms like leaf spots, wilting, and discoloration. The model is fine-tuned using transfer learning methods to improve detection performance across diverse environments and varying image qualities.

Furthermore, this system contributes to precision agriculture by offering early warning alerts, providing recommendations for disease management, and potentially reducing the need for chemical treatments.

The proposed Plant Disease Detection System serves as a scalable and efficient tool for modern agriculture, offering practical solutions for disease management, reducing economic losses, and supporting sustainable farming practices. Future work involves expanding the dataset to include more crops and diseases and integrating the system with Internet of Things (IoT) devices for real-time monitoring.

KEYWORDS: *Agriculture, Plant Disease Detection, Disease Diagnosis, Crop Health Monitoring, CNN*

INTRODUCTION

Agriculture is crucial to maintaining human life since it produces food, raw materials, and other necessities.

Nonetheless, agricultural productivity and yield are considerably hindered by a number of plant illnesses brought on by bacteria, viruses, fungus, and other pathogens. The Food and Agriculture Organization (FAO) estimates that plant diseases cause 20–40% of yearly crop losses worldwide. Manual observation is frequently used in traditional disease detection techniques, which can be laborious, prone to human error, and ineffective, particularly in large-scale farming. Therefore, it is imperative to have an automated, dependable, and precise system for early disease diagnosis.

The design, implementation, and assessment of an automated plant disease detection system that employs machine learning (ML) and deep learning is the main objective of this research article. In order to reduce the detrimental effects on crop production, the system seeks to provide early and precise diagnosis, allowing for prompt intervention.

To reduce the impact of pathogens on crops and increase agricultural productivity, early and precise diagnosis of plant diseases is crucial. The traditional manual approach of monitoring crops for visible disease symptoms requires expertise and extensive time. Moreover, factors such as the subtlety of early symptoms, disease overlap, and external environmental influences make manual detection unreliable.

There is a lot of promise for automating the identification of plant diseases with recent developments in artificial intelligence (AI), especially in machine learning (ML) and deep learning (DL). A form of deep learning called Convolutional Neural Networks (CNNs) has demonstrated remarkable success in picture classification and is particularly useful in identifying intricate patterns in plant diseases. Integrating these techniques with computer vision allows for the rapid and automated detection of diseases from plant images, significantly reducing the need for manual labor while improving accuracy.

The main goal of a plant disease detection system is to identify signs of different illnesses by examining photos of plant leaves, stems, or fruits. This discipline has undergone a revolution thanks to deep learning, especially convolutional neural networks (CNNs), which allow systems to recognize intricate patterns and detect diseases with great accuracy.To address these challenges, the integration of modern technology into agriculture has opened new avenues for innovation. One viable remedy is the creation of automated plant disease detection systems. These systems provide precise, real-time agricultural disease identification by utilizing developments in computer vision, machine learning, and deep learning techniques. These devices can greatly lessen the need for human inspection by automating the process, increasing accuracy and empowering farmers to manage diseases proactively.

The integration of plant disease detection systems into agricultural practices offers numerous benefits. Early and accurate disease detection allows farmers to implement targeted interventions, reducing the spread of diseases and minimizing the need for excessive use of pesticides. This not only improves crop yield but also promotes environmentally sustainable farming practices. Additionally, by providing real-time feedback, these systems can help optimize resource allocation, reduce operational costs, and improve overall farm management.

Utilizing the latest developments in artificial intelligence (AI), machine learning (ML), and image processing, a plant disease detection system offers a scalable, accurate, and effective way to diagnose plant illnesses. This technology can identify patterns and symptoms linked to a variety of diseases by examining photos of plant leaves, stems, or fruits. It then gives farmers immediate feedback and treatment recommendations. This minimizes the harm brought on by the illness by lowering the need for manual effort and enabling prompt care. Numerous pathogens, including bacteria, viruses, fungus, and other environmental variables, can cause diseases in crops. Early diagnosis and identification of plant diseases can significantly enhance the effectiveness of control measures, but the visual symptoms of many diseases are often similar and subtle. In traditional agricultural practices, farmers rely on experience to recognize these symptoms, which may lead to incorrect or delayed diagnosis. This issue becomes more complex in large farms, where visual inspection is impractical, leading to the need for a more precise, technology-driven approach.

Convolution neural networks (CNNs) and other deep

learning models are the main tools used by this system. With the help of these technologies, the system can analyze vast collections of plant photos and identify the unique characteristics linked to different illnesses. Patterns in leaves, stems, or fruits that suggest infection can be found using image processing techniques like segmentation, feature extraction, and classification.

Web applications can be integrated into the system to provide farmers with easy access to disease detection tools. By simply uploading an image of a diseased plant, farmers can receive an accurate diagnosis and recommended treatment measures.

Plant disease detection systems represent a significant technological advancement in modern agriculture. They hold the potential to transform how diseases are managed, leading to increased agricultural productivity, reduced crop losses, and a more sustainable approach to farming. The creation of a plant disease detection system will be examined in this research study, along with its design, machine learning methods used, and possible uses in actual agricultural situations.

Using these technologies to create automated Plant Disease Detection Systems has attracted a lot of interest as a way to increase the precision and effectiveness of disease detection. Deep learning models are perfect for evaluating plant photos and spotting disease indications because they have shown excellent performance in image classification tasks, especially Convolutional Neural Networks (CNNs). By examining photos of leaves, stems, or fruits, the automated Plant Disease Detection System presented in this research uses state-of-the-art AI and ML technologies to identify plant illnesses.

By incorporating deep learning algorithms such as CNNs, the system is capable of learning intricate patterns and distinguishing between various plant diseases with high accuracy. The system's main goal is to reduce crop losses by enabling timely intervention through early detection. This system tackles a number of significant issues that conventional illness detection techniques encounter, such as scalability, accuracy, and real-time analysis.

It minimizes the reliance on manual labor and expertise by automating the process of disease identification, allowing farmers to efficiently monitor crop health. Furthermore, the integration of a web-based application enables easy access for farmers, who can simply upload images of their crops to receive an instant diagnosis and recommended treatment measures.

The introduction of such automated systems into agricultural practices promises to transform disease management, improving crop yield, promoting sustainable farming practices, and reducing the excessive use of chemical pesticides.

LITERATURE SURVEY

The literature review on plant disease detection outlines the several methodologies and strategies that researchers have employed to tackle the issue through machine learning and deep learning techniques. Convolutional Neural Networks (CNNs) are used by [1] to identify plant illnesses.

Their work demonstrates high accuracy when applied to large-scale datasets, showcasing the effectiveness of CNNs in recognizing disease patterns in plant images. This approach proves particularly successful due to CNNs' ability to automatically extract relevant features from raw images, making them well-suited for large and diverse datasets. In the review work [2] the authors go into great detail on the many machine learning methods used in plant disease diagnosis. This review provides a thorough overview of the state-of-the-art techniques in this subject and provides insightful information on the advantages and disadvantages of various machine learning algorithms.

The paper [3] investigates the application of Support Vector Machine (SVM) and K-Nearest Neighbors (KNN) algorithms. Their study focuses on feature extraction techniques for identifying plant leaf diseases and demonstrates the effectiveness of SVM and KNN in disease classification. The paper emphasizes the importance of using proper feature extraction methods to improve the accuracy of traditional machine learning algorithms. [4] explores the use of CNNs for classifying different plant diseases based on leaf images. Ferentinos' study shows that CNNs can achieve high accuracy in the classification process, reinforcing the potential of deep learning models in automating plant disease detection tasks with minimal manual intervention. Together, these results highlight the increasing significance of machine learning and deep learning methods in improving plant disease detection systems, laying the groundwork for further precision agricultural research. One noteworthy study is [5] who use a deep neural network (DNN) model to

identify 13 distinct plant illnesses. Their findings show that the deep learning model outperforms conventional machine learning techniques in terms of accuracy and generalization, resulting in high classification accuracy. This lends more credence to the claim that plant disease detection could be revolutionized by deep learning, especially convolutional neural networks (CNNs).

[6] used a deep CNN model to classify nine common tomato leaf diseases. Their approach stands out due to the integration of Grad-CAM (Gradient-weighted Class Activation Mapping), a technique that visually highlights the areas of the leaf that the network focuses on for classification. This technique not only enhances classification accuracy but also provides interpretability for deep learning models, making them more trustworthy and useful for real-world agricultural applications.

A study by [7] focuses on cassava crops, a staple in many developing countries. This study employs deep CNNs combined with transfer learning, yielding high accuracy in identifying three types of cassava leaf diseases. In order to make systems usable by farmers in low-resource environments, the article highlights the significance of developing mobile device-deployable solutions. This study fills the gap between cutting-edge machine learning tools and real-world agricultural uses.

The study [8] evaluates different pre-trained deep learning models, such as AlexNet, VGG16, and ResNet, for identifying plant diseases. Their results indicate that ResNet50 provides the best performance in terms of accuracy and computational efficiency. This study contributes by offering a thorough comparison of existing architectures, helping future researchers and practitioners choose the most suitable model for their plant disease detection tasks. CNNs are used [9] to identify and categorize grapevine diseases.

Their system achieves impressive accuracy by employing a deep learning approach without requiring extensive preprocessing of the input images. This research is particularly noteworthy as it explores the challenges related to real-time detection in vineyard settings, where variability in lighting and environmental conditions can impact the model's performance.

In the paper [10] uses a combination of CNNs and data augmentation techniques to improve classification accuracy for tomato plant diseases. Their model benefits from the extensive use of augmentation to enhance the robustness of the model in diverse environments, a critical factor in agricultural applications where conditions such as lighting, humidity, and image quality may vary.

Furthermore, in [11] investigated real-time plant disease detection with a deep learning approach. They recognize and categorize tomato plant illnesses and pests using a Faster R-CNN model, which is frequently used in object identification.

Their real-time detection system is a step forward in creating practical solutions that can be deployed in the field for immediate intervention.

Another significant contribution is made [12] by proposing the use of the Inception v3 model for detecting multiple plant diseases with high accuracy. Their research shows that deep models like Inception v3, which utilize more sophisticated architectures with multiple layers and parallel convolutional paths, offer superior performance for complex image recognition tasks like disease detection in plants.

[13] used multi-channel CNNs to identify maize plant diseases. Their work is distinctive in that it increases the model's capacity to discriminate between subtle disease symptoms by combining transfer learning with multi-channel images, which capture various light wavelengths. This makes the model extremely effective for identifying diseases in difficult agricultural environments. They use pre-trained models, like VGG16 and ResNet, to implement transfer learning, and they report remarkable outcomes with high accuracy.Their research highlights the value of using transfer learning to reduce the computational costs associated with training deep models from scratch, a key consideration in resource-constrained environments. Collectively, these studies demonstrate that deep learning models, Because of their exceptional capacity to automatically extract characteristics and identify intricate patterns in images, CNNs in particular have emerged as the leading method for the diagnosis of plant diseases. These methods have demonstrated potential for increasing disease detection speed and accuracy, reducing crop losses, and advancing sustainable farming methods. These models are anticipated to become increasingly more crucial to precision agriculture as deep learning advances, providing scalable and dependable solutions to farmers everywhere

DESIGN METHODOLOGY

The web-based platform outlined in the code provided is intended to identify plant diseases through the use of deep learning methods, particularly Convolutional Neural Networks (CNNs).

The goal of the system is to provide an accessible solution for identifying plant diseases through image recognition, offering a diagnosis alongside potential treatments and supplement recommendations. This section breaks down the architecture and workflow of the system, which includes image processing, model prediction, and information retrieval from datasets.

1. Data Sources

The system utilizes two primary datasets:

disease_info.csv: Contains details about various plant diseases, including the disease name, description, possible preventive measures, and image URLs.

supplement_info.csv: Stores information about supplements related to plant disease treatments, including the supplement name, image, and purchase links.

These CSV files serve as databases to retrieve relevant information based on the disease prediction generated by the deep learning model.

2. Deep Learning Model

The core of the system's plant disease detection capability is powered by a pre-trained Convolutional Neural Network (CNN) mode l. The model architecture is defined in a custom-built module CNN.CNN, which was trained to classify 39 different plant diseases. The model is saved in a file plant_disease_model_1_latest.pt and is loaded using PyTorch's load_state_dict() function for inference purposes. The network is set to evaluation mode using the model.eval() method to ensure that the model parameters remain static during prediction.

To identify spatial hierarchies in the input images, the CNN design most likely consists of several convolutional layers followed by pooling layers.

These features are then passed through fully connected layers, and finally, a softmax layer provides the probability distribution across 39 possible disease classes.

3. Image Resizing

The system employs image preprocessing techniques before passing the images to the deep learning model. When a user uploads an image via the web interface, it undergoes the following steps in the prediction() function:

The image is opened using the Python Imaging Library (PIL).

It is resized to 224x224 pixels, a common input size for CNN models trained on natural images (similar to the Image Net dataset).

The image is then converted into a tensor using torchvision.transforms.functional.to_tensor(), ensuring that the image has three color channels (RGB) and is reshaped to match the input dimensions required by the model: (1, 3, 224, 224), where 1 represents the batch size.

4. Model Prediction

Once the image has been pre-processed, it is passed to the CNN model for prediction. The model returns a vector of probabilities across the 39 disease classes. The numpy.argmax () function is used to identify the index of the highest probability, which corresponds to the predicted disease class.

The predicted index is then used to retrieve relevant information from the disease_info.csv and supplement_info.csv files. Specifically, the system fetches:

Disease Name: The name of the disease detected.

Description: A brief description of the disease and its symptoms.

Prevention Measures: Recommended steps to prevent or manage the disease.

Disease Image URL: A reference image for the disease.

Supplement Information: The name, image, and purchase link for any supplements that could help in treating the disease.

5. Web Application Architecture

The system is built using the Flask web framework, which provides the functionality for routing, rendering templates, and handling HTTP requests. The core routes of the application include:

- Home Page: Displays the home page for the application.
- Contact Page: A page providing contact information.
- AI Engine Page: The interface where users can submit an image for disease detection.
- Submit Page: Handles the POST request when users upload an image for disease detection. This route processes the image, makes the prediction, and retrieves relevant information from the CSV files to be displayed on a result

page.

- Market Page: Displays a catalog of available supplements, fetched from the supplement_info.csv, along with corresponding purchase links.

6. User Interaction Flow

- Image Upload: Users can upload images of plant leaves via a web interface. The image is saved to the local filesystem under the static/uploads directory.
- Prediction: The image is processed, and the model predicts the disease. The system retrieves the disease name, description, preventive measures, and supplements related to the disease from the CSV files.
- Result Display: The results are displayed to the user, providing a detailed diagnosis along with potential remedies in the form of supplements.

7. Market Integration

The system includes a marketplace section (/market) that displays all the supplements stored in the supplement_info.csv file. Each supplement entry includes an image, name, and a link to purchase the product online. By helping users locate pertinent goods that can aid in the treatment of the identified plant illness, this function aims to offer a complete solution from diagnosis to possible therapy.

RESULT

Figure 4.2: AI Engine which helps user to diagnose disease of plant
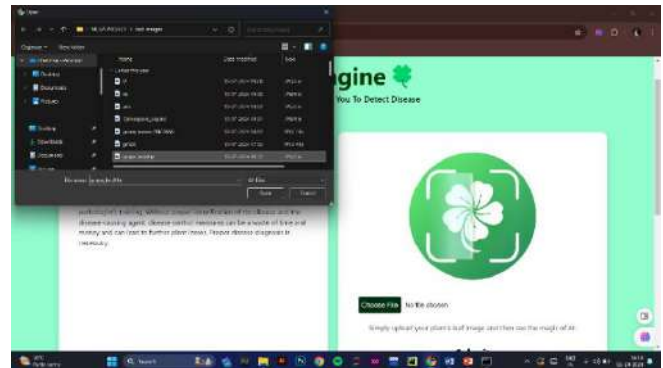
Figure 4.3: Here, user can upload pictures of diseased part of plant

Figure 4.1: Landing Page of Plant disease detection system
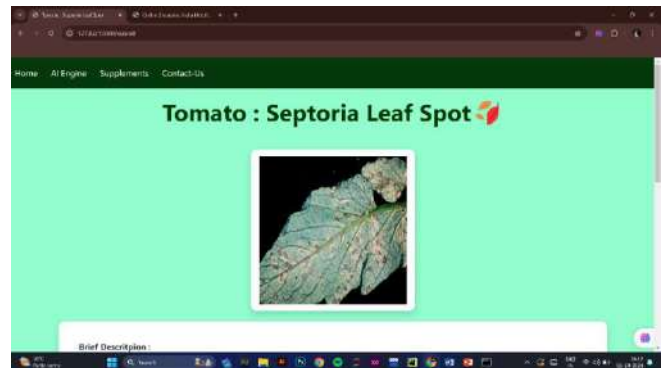
Figure 4.4: Prediction of plant disease from picture
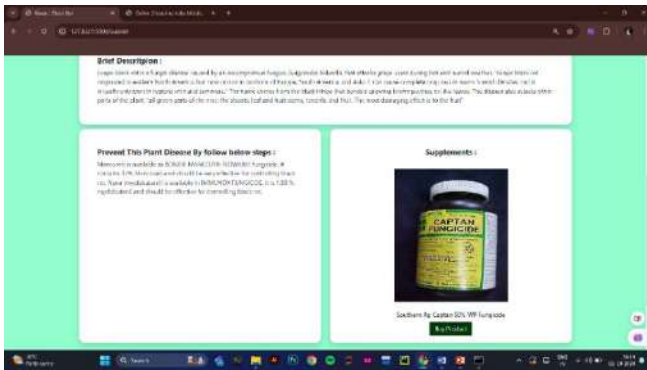
Figure 4.5: Information, curation and prevention of respective disease

FUTURE SCOPE

Real-Time Disease Monitoring: Integration of IoT-based sensors along with image-based detection systems can provide real-time monitoring of environmental factors like temperature, humidity, and soil moisture. These sensors can help predict disease outbreaks before symptoms appear by correlating environmental conditions with the likelihood of disease development.

Cross-Platform Compatibility: Developing a system that works across multiple platforms (smartphones, tablets, web-based interfaces) with cloud computing for data storage and processing could provide farmers with easy access to disease detection tools. The integration of AI-based cloud services would ensure scalability and real-time data analysis from various farms.

Integration with Drones and Autonomous Vehicles: Future systems could integrate drone technology to automate image capturing over large areas of farmland, as well as using autonomous vehicles equipped with cameras and sensors to capture images at ground level. This would greatly reduce the need for manual intervention and provide better coverage of large-scale farms.

Hybrid Approaches: Combining multiple techniques like spectral imaging, thermal imaging, and hyper spectral sensors can improve detection accuracy, especially in cases where visual symptoms are hard to detect. These techniques can detect biochemical changes in plants before visible signs of disease appear.

Enhanced Data Sharing and Collaboration Platforms: Developing global platforms for sharing disease data among farmers, researchers, and agronomists would facilitate collaborative research and more effective control measures. Centralized platforms could leverage AI to offer predictive analytics on a global scale.

Sustainability and Green Agriculture: Integrating plant disease detection with sustainable agricultural practices, such as precision agriculture, can optimize the use of pesticides and water. By targeting only affected plants, these systems can help reduce environmental impact and promote eco-friendly farming practices.

CONCLUSION

Precision agriculture has improved significantly with the creation and deployment of a Plant Disease Detection System that makes use of cutting-edge methods like machine learning and deep learning. Using Convolutional Neural Networks (CNNs) and other image processing techniques, this article has shown how these systems can efficiently detect and categorize plant illnesses. By identifying precise regions that require treatment, the automated detection system minimizes the usage of pesticides, reduces crop loss, and enables early diagnosis.

Our findings underscore the potential of automated disease detection in improving agricultural productivity, especially in large-scale farms where manual inspection is inefficient. The high accuracy of disease detection, combined with real-time monitoring capabilities, provides farmers with actionable insights to make informed decisions about crop management.

However, challenges such as environmental variability, generalization across different crops, and high implementation costs for small-scale farmers need further research and development. Future systems should incorporate multi-disease detection, real-time IoT integration, and scalable cloud-based platforms to broaden their applicability and make them accessible to a wider range of agricultural settings.

In conclusion, by providing a more accurate, efficient, and sustainable way to manage plant health, plant disease detection systems have the potential to completely transform farming methods.

By addressing the current limitations and expanding on future work, this technology can play a critical role in ensuring global food security and promoting sustainable agriculture

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System for Tracking and Monitoring Soldier Health

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ABSTRACT:

This study presents the development and implementation of an IoT-based military health monitoring system that incorporates LoRa communication, Arduino, ESP8266, GPS, heart rate sensor, DHT11 sensor, and blood pressure sensor. The system is designed to monitor current health data such as heart rate, body temperature, and blood pressure, and to provide location tracking to ensure safety and nutrition. It strengthens the nerves of soldiers in remote areas and in the air. The system can seamlessly transmit health data to the command center by utilizing wireless communication and cloud-based data analytics, facilitating the timely provision of health services. Blynk API integration improves the user experience by providing insights and notifications at important health moments. Test results validated the effectiveness of the system in monitoring and managing the health status of soldiers, demonstrating its potential for efficiency and effectiveness in military use .

KEYWORDS: *Iot based, API integraton, efficiency, effectiveness*

INTRODUCTION

[1] The security of the country is monitored and controlled by the Army, Navy and Air Force. Our soldiers who sacrificed their lives for the sake of their country played a vital and important role.There are many concerns about the safety of soldiers. Soldiers who enter enemy lines often lose their lives due to lack of communication, so it is important for soldiers at base stations to know the location and health status of everyone. India has lost a large number of soldiers in conflicts due to inadequate healthcare facilities and lack of communication between soldiers in conflict and Recently, on September 29, 2016, there was a military conflict between India and Pakistan; Indian army conducted an operation in the

METHODOLOGY

System Architecture

[2] The Warrior Wellbeing Checking Framework comprises of two fundamental components: the transmitter unit worn by the warrior and the collector unit found at the command center. The transmitter side is dependable for collecting and transmitting physiological and natural information

Transmitter Side (Warrior Wearable Unit)

[3] Each warrior is prepared with a wearable wellbeing checking unit that incorporates different sensors and a

Azad region under Pakistani control, on the lines of the Real Government, to obtain the commercial information of the soldiers. The operation. Indian soldiers are generally known for their bravery and have achieved many victories despite the low ammunition and poor security measures. We all need to be really concerned about the safety of the soldiers, so we decided to create a program to check the health and exact location of the soldiers so that they can receive the necessary treatment as soon as possible. The tracking of the soldiers is done using GPS.

We use biomedical sensors like temperature, heart rate to track the health of the soldier and the base station needs to determine the

location of the soldier and his healthy diet. In this project, the exact location and health status of soldiers can be instantly transmitted to the base station for timely intervention in case of crisis. This tool helps in reducing the rescue, time and search workload of the military rescue control room. This is the most technologically advanced and most important part of the project.

The aim is to increase combat readiness, reduce the risk of health problems during operations and enable soldiers to perform at their best without any risk to their safety and well-being. The system can also contribute to the creation of a more effective and powerful army by helping to support health management and provide more effective medical interventions when necessary.

microcontroller. This unit persistently collects imperative wellbeing parameters and natural information. The obtained information is prepared locally some time recently being transmitted employing a LoRa module. In case network is misplaced, the information is put away briefly and sent when the association is re-established.

Receiver Side (Command Center)

[4] The recipient side comprises of a LoRa door that collects transmitted information from numerous officers. This information is handled and shown on a observing dashboard for real-time investigation. The ESP8266 module empowers cloud network, permitting farther get to through the Blynk app. Alarms are activated in case of crises, and GPS area information helps in quick reaction operations.

HARDWARE COMPONENT

Microcontrollers:

[5] Arduino (Atmega328/ESP32): Collects sensor information and forms information.

ESP8266: Empowers cloud network and inaccessible monitoring.

Communication Modules:

[7] LoRa SX1278: Gives long-range, low-power information transmission.

GPS Module (NEO-6M or comparative): Tracks real-time warrior location.

Health Sensors:

MAX30100 (Heart Rate & SpO2 Sensor): Screens heart rate and oxygen levels.

Blood Weight Sensor (BP Observing Module): Measures systolic and diastolic pressure.

DHT11 (Temperature & Mugginess Sensor): Measures natural conditions.

Power Supply:

Lithium-Ion Battery Pack with Voltage Controller: Guarantees drawn out field operation.

Solar Charging Module (Discretionary): For amplified deployment.

Software Implementation

Sensor Information Acquisition:

[6] The Arduino microcontroller persistently peruses information from all associated sensors.

A predefined inspecting rate is set for intermittent information collection.

Wireless Communication:

The LoRa module transmits the collected information to the base station at predefined intervals.

In case of network misfortune, the framework stores information locally and transmits it when the association is restored.

Cloud and Portable Integration:

ESP8266 transmits information to the cloud for inaccessible monitoring.

The Blynk app is utilized for real-time information visualization and alarms.

PROPOSED SYSTEM
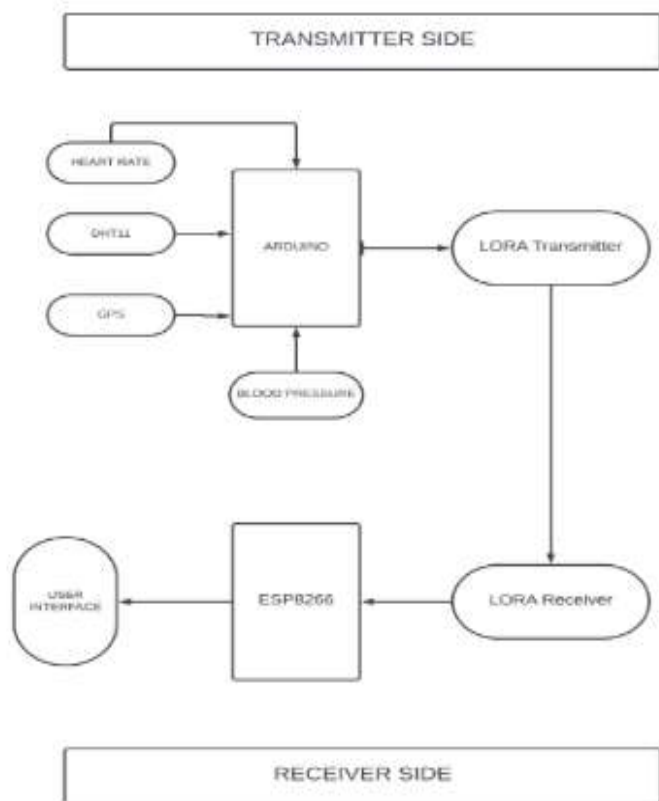
Figure1:system for tracking and monitoring soldier health

Figure2:Transmitter Side

Figure3: Receiver Side

RESULTS & DISCUSSION

[8] The comes about from the test trials illustrate the system's adequacy in observing soldiers' wellbeing and transmitting information dependably over long separations. The framework effectively collects and forms heart rate, blood weight, temperature, and natural information with negligible idleness. The GPS following include guarantees real-time area checking, helping in quick reaction amid crises. The LoRa communication module shows steady information transmission indeed in farther regions. Furthermore, the Blynk app gives an natural interface for farther wellbeing following and crisis cautions. These discoveries approve the system's unwavering quality, making it appropriate for real-world military applications.

Figure4.1: Hardware Implementation
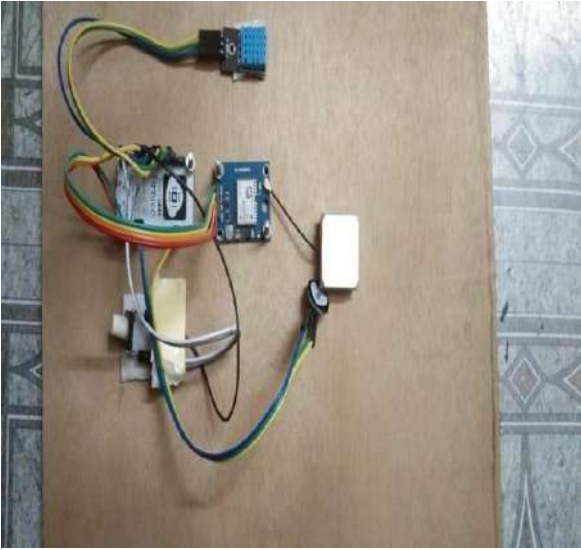
Figure4.2 :Hardware Implementation

CONCLUSION

This inquire about presents a novel IoT-based Trooper Wellbeing Observing Framework joining LoRa, Arduino, ESP8266, GPS, and different wellbeing sensors. The framework offers a solid, effective, and versatile arrangement for real-time wellbeing following in military operations. By leveraging remote communication and cloud-based information handling, it improves restorative status and guarantees convenient mediations, altogether making strides warrior security and operational adequacy. Future improvements will center on AI-based wellbeing expectation and amplified battery optimization to advance progress framework proficiency and unwavering quality. In future, a portable handheld sensor device with more sensing options may be developed to aid the soldiers.

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BloodGrid: A Unified Blood Donation & Distribution Platform

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ABSTRACT

Adequate blood supply is essential to save lives in emergencies, surgeries, and   chronic medical conditions. However, regular blood donation and distribution   are often hampered by operational deficiencies such as insufficient donations, poor inventory management, and delayed deliveries. These challenges lead to inadequate preservation, blood wastage, and poor patient outcomes. The Unified Blood Donation and DistributionPlatform is a new solution that aims to address these issues by creating a well-founded, technology-driven ecosystem. The platform connects donors, blood banks, hospitals, and emergency services through a single integrated system. It enables the integration of all blood vessels through real-time tracking, data analysis and user interaction. Its key features include rapid blood transfusion, donor engagement, optimized distribution   and the ability to respond to emergencies. In addition to improving performance, the platform also promotes a culture of regular blood donation through awareness campaigns, sponsorships and educational programs. It also provides valuable insights into donor patterns and regional needs, enabling better planning and resource allocation.

KEYWORD: *Technology-Driven Ecosystem, Donor Engagement, Optimized Distribution*

INTRODUCTION

A good online healthcare system is essential forsuccessful blood donation and transfusion. Blood banks in our country currently face challenges such as inconsistent standards, lack of infrastructure and financial constraints. The absence of private banks in many hospitals is leading to the growth of private facilities with more privileges. Importantly, technology is needed to improve blood collection, testing and distribution, and to ensure safety and efficiency. Its key features include free donor

registration, online blood donation, donor location search, real-time inventory management and data management. Such systems increase the speed, accuracy and reliability of blood donations, while also reducing waste and wastage. It enables instant collaboration, transparent product management and immediate response. Donors can track their

donations, while hospitals and blood banks can access resources instantly. In addition to improving performance, the platform also supports blood donations through campaign announcements, reward distributions and community engagement. Data analytics can help authorities track shortages by providing information on donations and needs. This is a step towards a more connected, efficient and effective healthcare ecosystem that facilitates blood donation and saves lives.

METHODOLOGY

The Unified Blood Donation and Distribution Platform provide structured workflows for users, admins, and organizations to ensure efficient blood donation and distribution.Users Workflow: Users begin by logging in and selecting either to donate or receive blood. Donors can check nearby camps and donate if available; otherwise, they receive a "No Camps Available" message. After donation, the blood bank updates the inventory. Receivers can search nearby blood banks for their required blood type. If available, they collect it, and the inventory updates; if unavailable, they receive a notification.

Admin Workflow: Admins manage user accounts, monitor blood bank inventory, oversee donation camps, handle urgent requests, and generate reports on stock levels, donor participation, and blood shortages. They also maintain system integrity and security compliance.

Organization Workflow: Organizations log in to propose donation camps, promote awareness campaigns, track event performance, request blood stock, collaborate with stakeholders, and analyse donation trends. The structured process ensures smooth operations and effective blood supply chain management.

PROPOSED SYSTEM

User Workflow

1. **Start** – Users log in or register on the platform.

2. **Select Action** – Users choose to either donate or receive blood.

- ○ **Donor Pathway:**

- ▪ **Check Nearby Camps:** The system identifies available blood donation camps.

- ▪ **Check Availability:** If a camp is available, the donor proceeds; otherwise, the system notifies them of the unavailability.

- ▪ **Update Inventory:** Upon successful donation, the blood bank updates its stock.

- ○ **Receiver Pathway:**

- ▪ **Check Nearby Blood Banks:** The platform locates nearby blood banks.

- ▪ **Check Blood Availability:** If available, the receiver collects blood, and inventory is updated; if not, they receive a notification of unavailability.

3. **End** – The process concludes after action completion and inventory updates.
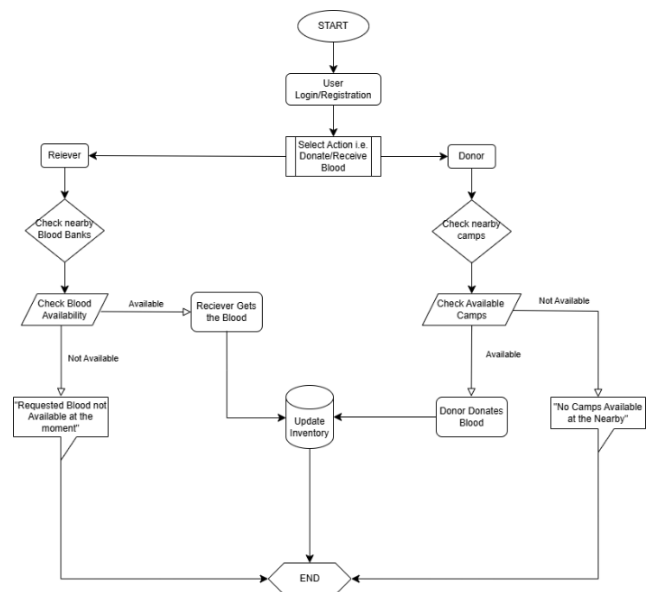
Figure 1. Users Workflow for Donating and Requesting Blood

Admin Workflow

1. **Start** – Admin logs in securely.

2. **Manage User Accounts** – Approves/rejects registrations, edits or deactivates accounts.

3. **Monitor Blood Bank Inventory** – Checks real-time stock levels, identifies shortages or surpluses.

4. **Manage Blood Donation Camps** – Creates, updates, assigns locations, and notifies users.

5. **Handle Blood Requests** – Oversees urgent blood requests and allocates stocks accordingly.

6. **Generate Reports** – Produces reports on stock levels, donor trends, and camp success rates for policy decisions.

7. **System Maintenance** – Ensures performance, addresses technical issues, and maintains security compliance.

8. **End** – Admin logs out securely.

Organization Workflow

1. **Start** – Organization logs in.

2. **Organize Blood Donation Camps** – Proposes events, submits for admin approval.

3. **Promote Awareness Campaigns** – Creates educational campaigns and notifies users.

4. **Track Camp Performance** – Monitors participation and collected blood volume.

5. **Request Blood Stock** – Places bulk requests for emergencies or surgeries, tracking delivery.

6. **Collaborate with Stakeholders** – Works with blood banks, hospitals, and admins to improve operations.

7. **Review Analytics** – Evaluates campaign success and identifies low-participation areas.

8. **End** – Organization logs out securely.

This structured approach ensures efficiency, transparency, and effective blood donation and distribution management.

Figure 2. Data Flow Diagram (DFD)

CONCLUSIONS

The Unified Blood Donation & Distribution Platform represents a transformative solution to the inefficiencies in traditional blood donation systems. By integrating donors, blood banks, hospitals, and emergency services into a centralized ecosystem, the platform improves blood availability, real-time inventory management, and emergency response. It streamlines the donation process, promotes regular donations through awareness campaigns, and ensures effective blood stock management.With the potential for AI-driven insights, predictive analytics, and blockchain integration, the platform offers a scalable and secure approach to blood donation and distribution. This initiative enhances coordination, reduces wastage, and ultimately saves lives, paving the way for a more efficient and sustainable healthcare future.

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Review On Automatic Vehicle Speed Control System

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ABSTRACT

The review paper focuses on the development and implementation of an Automatic Vehicle Speed Control System designed to enhance road safety and reduce accidents caused by over-speeding. The primary purpose of the study is to investigate existing methodologies for speed control and propose an automated system that integrates advanced technologies to address the limitations of traditional speed management techniques. The paper adopts a comprehensive review methodology, analyzing previous research on speed control systems, including sensor-based technologies, GPS integration, and IoT applications Various models, algorithms, and frameworks used in real-time speed monitoring and vehicle control are critically evaluated.

KEYWORDS: *Automatic Vehicle Speed Control, Road Safety, Sensor-Based Technology, Intelligent Traffic Management, IoT in Transportation.*

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INTRODUCTION

Road safety is a critical global concern, with speeding being one of the leading causes of accidents and fatalities. Traditional methods of speed control, such as speed limit signs and manual enforcement, are often inadequate in preventing reckless driving and ensuring compliance. The need for more efficient and automated solutions has driven advancements in vehicle speed control systems. An Automatic Vehicle Speed Control System is an innovative approach that leverages modern technologies such as sensors, GPS, IoT, and AI-based algorithms to monitor and regulate vehicle speed in real-time. By automating speed adjustments based on environmental and traffic

conditions, these systems aim to minimize human error and enhance overall road safety. This technology holds immense importance in the context of rising urbanization and increasing vehicle density on roads. Intelligent speed control systems can significantly reduce the risk of accidents, improve traffic flow, and contribute to sustainable transportation solutions. Moreover, they align with the vision of smart cities, where interconnected devices and intelligent systems enhance public safety and

quality of life. The paper explores the methodologies, challenges, and future prospects of implementing automated speed control systems, offering insights into how this technology can revolutionize modern transportation and address critical safety issues. The Automatic Vehicle Speed Control System is an innovative solution designed to enhance road safety by automatically adjusting vehicle speed based on predefined conditions. The system aims to reduce accidents caused by over speeding vehicle speed control systems. An Automatic Vehicle Speed Control System is an innovative approach that leverages.

LITERETURE REVIEW

1. Intelligent Speed Adaptation (ISA) Systems-
Intelligent Speed Adaptation (ISA) is a widely studied approach in speed control systems. Carsten & Fowkes (2000) examined how ISA helps in reducing vehicle speed using GPS and onboard sensors to detect speed limits. The study showed a 20% reduction in accidents when vehicles were equipped with ISA.

2. GPS and IoT-Based Speed Control-
Recent studies, such as Kumar et al. (2019), explored the

integration of GPS and IoT for vehicle speed control. The system uses real-time speed zone data and sends automatic control signals to vehicles, ensuring they stay within the legal speed limit. The study demonstrated that IoT-based speed control can reduce overspeeding violations by 35%.

3. RFID-Based Speed Limiting Systems-
Research by Patel & Sharma (2018) proposed an RFID-based system where vehicles receive speed control signals from RFID tags installed on roads. Their experimental results indicated that RFID technology could effectively enforce speed limits in school zones and accident-prone areas. However, the limitation was the system's dependency on infrastructure development.

4. Machine Learning and AI for Speed Control-
A study by Zhang et al. (2020) introduced an AI-driven predictive speed control system that analyses road conditions, traffic patterns, and driver behaviour to optimize vehicle speed. Machine learning models were trained on real-world traffic data, resulting in a 15% improvement in fuel efficiency and reduced sudden.

5. Automatic Braking and Adaptive Cruise Control (ACC)-
Bose & Ioannou (2001) investigated the impact of Adaptive Cruise Control (ACC) and Automatic Braking on highway driving. Their research found that vehicles equipped with ACC maintained safer following distances and reduced rear-end collisions by 25%. The study emphasized the need for sensor reliability in such systems.

6. Government Regulations and Smart Traffic Control-
Singh et al. (2021) analysed how smart traffic control systems combined with government policies can enhance automatic speed regulation. Their findings suggest that legislative enforcement and technological advancements together can reduce traffic violations by 40%.

METHODOLOGY

DATA COLLECTION FROM SENSORS: The first step involves the continuous collection of data from various sensors. Speed sensors measure the current speed of the vehicle, proximity sensors detect nearby objects or vehicles, GPS provides location data, and radar and cameras detect road conditions, obstacles, and traffic flow. This real-time data helps the system understand its environment.

DATA PROCESSING AND DECISION-MAKING: The collected data is sent to a central control unit, usually a microcontroller or embedded system. The system analyses the data using complex algorithms to determine the optimal speed for the vehicle based on factors like road conditions, traffic, and safety parameters. It adjusts the vehicle's speed while considering the driver's preferences, the surrounding environment, and local speed regulations.

THROTTLE CONTROL: Once the optimal speed is calculated, the throttle control system adjusts the air intake to the engine. If the vehicle needs to speed up, the throttle opens more, allowing more air into the engine, increasing acceleration. If the speed needs to be reduced, the throttle closes, reducing engine power and slowing the vehicle down.

BRAKE CONTROL: In situations where the vehicle needs to decelerate quickly or maintain a safe following distance, the brake control system is activated. This system applies the brakes either partially or fully, depending on the urgency. If the vehicle is approaching an obstacle or another car too rapidly, it can automatically apply brakes to avoid collision or reduce speed.

ADAPTIVE CRUISE CONTROL (ACC): The AVSCS may be equipped with adaptive cruise control, which maintains a set speed but can also adjust based on the distance to the vehicle ahead. If traffic slows down, the system will automatically reduce speed to match the vehicle in front, then accelerate when the road clears, providing seamless and safe driving.

EMERGENCY BRAKING: If the system detects a potential collision, whether from an obstacle in the path or another vehicle too close, emergency braking is activated. This safety feature ensures that the vehicle slows down or stops quickly to avoid or mitigate the impact of an accident.

ROAD CONDITION DETECTION: AVSCS uses sensors such as cameras and radar to assess road conditions (e.g., sharp curves, construction zones, or adverse weather). Based on this information, the system adjusts the speed of the vehicle to ensure safe and efficient driving, reducing speed on curves or slippery surfaces and maintaining optimal speed in normal conditions.

VEHICLE-TO-VEHICLE (V2V) COMMUNICATION: AVSCS can integrate Vehicle-to-Vehicle (V2V) communication, where vehicles share data about their speed, position, and road conditions. This real-time exchange allows the system to adjust its speed based on the actions of nearby vehicles, enhancing traffic flow and safety, especially in high-density traffic.
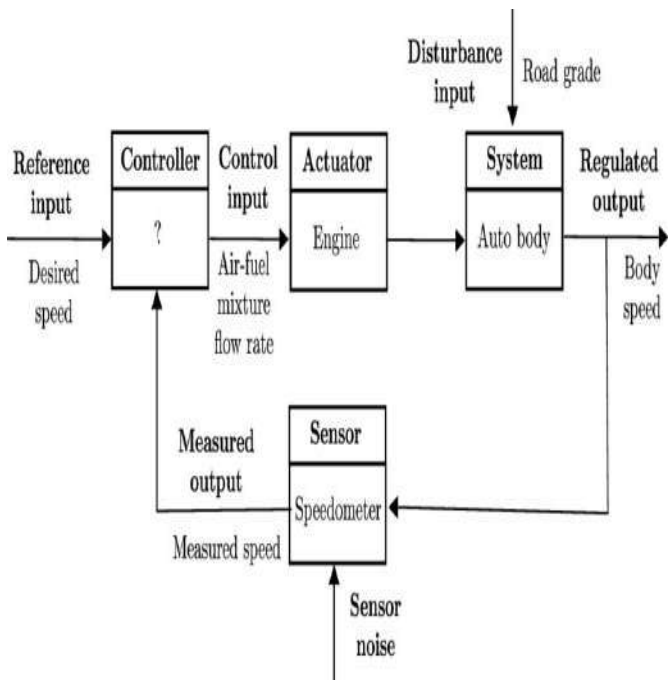
Figure 1. Block Diagram of an Automotive Speed Control System

The driver sets a desired speed (reference input).
The sensor (speedometer) continuously measures the vehicle's actual speed and sends it back to the controller.
The controller compares the actual speed with the desired speed and calculates the error.
Based on the error, the controller adjusts the control input (air-fuel mixture flow rate) sent to the actuator (engine).
The engine processes the control input to achieve the necessary output force, which affects the auto body (vehicle system) to maintain or achieve the desired speed.
The system compensates for disturbances like road grade to stabilize the vehicle speed.
This process continuously repeats in a feedback loop.

TECHNOLOGY

SPEED SENSORS: - Speed sensors measure the current speed of the vehicle. They can be based on wheel encoders, GPS, or radar, and continuously send speed data to the AVSCS. This allows the system to monitor and adjust the speed in real-time, maintaining control over the vehicle's movement.

PROXIMITY SENSORS: -These sensors detect nearby vehicles or obstacles in the vehicle's surroundings. Commonly using ultrasonic or LIDAR technology, they provide crucial data for adjusting speed based on traffic or road conditions. Proximity sensors are vital for maintaining safe following distances in dynamic traffic.

GPS AND MAPPING SYSTEMS: - GPS technology provides the vehicle with real-time location data, while mapping systems allow the AVSCS to recognize road layouts. This helps the system preemptively adjust the speed for curves, hills, or intersections. GPS is also used to ensure compliance with speed limits based on location.

RADAR: - Radar sensors emit radio waves and measure their reflections from nearby objects, helping the system detect other vehicles on the road. Radar operates effectively in various weather conditions, providing reliable data for controlling speed and maintaining safe distances in heavy traffic or poor visibility.

CAMERAS: - Cameras mounted on the vehicle capture visual information about the environment. They are used to detect lane markings, road signs, and traffic signals. By analyzing this visual data, the system can adjust the vehicle's speed based on real-time road conditions or speed limit signs.

MICROCONTROLLER/CONTROL UNIT: - The control unit is the central processing hub of the AVSCS, receiving input from various sensors and executing speed adjustments based on pre-programmed algorithms. It calculates the optimal vehicle speed, considering factors like road conditions, traffic, and driver preferences, ensuring smooth and safe operation.

THROTTLE CONTROL: - The throttle controls the air intake of the engine, directly influencing the vehicle's acceleration. By adjusting the throttle, the AVSCS can increase or decrease the vehicle's speed without the need for constant driver input, ensuring optimal speed regulation on highways or city streets.

BRAKE CONTROL: - Brake control is integrated into the AVSCS to automatically slow down or stop the vehicle if necessary. Using either traditional hydraulic systems or electronic braking systems (EBS), the system can apply the brakes to prevent over-speeding or to reduce speed when approaching an obstacle or another vehicle. controller adjusts the control input (air-fuel mixture flow rate) sent to the actuator (engine).
The engine processes the control input to achieve the necessary output force, which affects the auto body (vehicle system) to maintain or achieve.

VEHICLE-TO-VEHICLE (V2V) COMMUNICATION: - V2V communication allows vehicles to exchange real-time data about their speed, position, and road conditions.

This helps AVSCS adjust speed based on the movement of nearby vehicles, promoting safer, synchronized driving, especially in heavy traffic or congestion.

EMERGENCY BRAKING SYSTEM: - An emergency braking system automatically applies brakes in case of an impending collision. If the AVSCS detects a potential crash due to excessive speed or insufficient distance from an obstacle, the system engages the brakes to reduce or prevent the impact, enhancing the vehicle's safety.
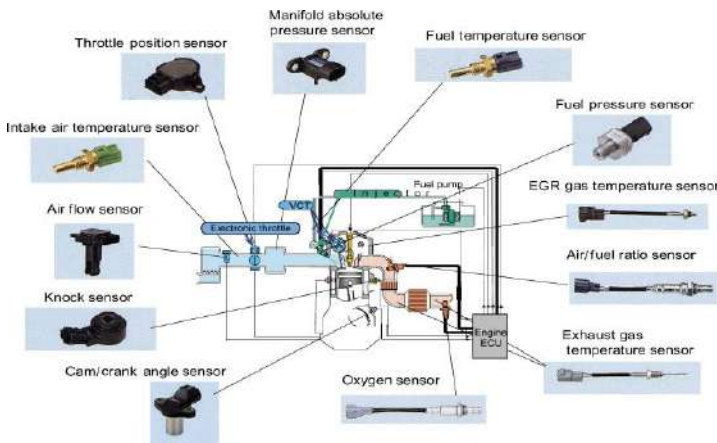
Figure 2: -Technology Use and Work

The Throttle Position Sensor measures the position of the throttle valve, determining how much air enters the engine. This is essential for controlling engine speed and regulating fuel delivery effectively.

The Manifold Absolute Pressure (MAP) Sensor monitors air pressure within the intake manifold, enabling adjustments to fuel injection and ignition timing for efficient engine performance.

The Fuel Temperature Sensor measures the fuel's temperature, allowing the system to account for changes in fuel density and ensuring proper combustion.

The Fuel Pressure Sensor keeps track of the pressure in the fuel rail to maintain consistent and optimal fuel injection for smooth engine operation.

The Intake Air Temperature Sensor records the temperature of incoming air, which helps in adjusting the fuel mixture to optimize engine performance under varying conditions.

The Air Flow Sensor calculates the volume of air entering the engine, ensuring precise control of the air-fuel ratio for effective combustion.

The Knock Sensor detects engine knocking or detonation and helps in adjusting ignition timing to prevent engine damage and ensure smoother operation.

The Cam/Crank Angle Sensor provides the exact position of the camshaft and crankshaft, which is critical for accurately timing fuel injection and spark delivery.

The Oxygen Sensor (O2 Sensor) measures the oxygen content in the exhaust gases, ensuring that the air-fuel mixture remains optimal for fuel efficiency and emissions control.

The EGR Gas Temperature Sensor monitors the temperature of exhaust gases being recirculated into the engine, playing a vital role in controlling emissions.

The Air/Fuel Ratio Sensor provides precise readings of the air-to-fuel ratio, improving engine efficiency and ensuring proper combustion.

The Exhaust Gas Temperature Sensor measures the temperature of exhaust gases to prevent overheating and protect critical components such as the catalytic converter.

APPLICATION

EMERGENCY SCENARIOS: Adjusts vehicle speeds in real-time during natural disasters or emergencies, helping maintain orderly traffic and ensuring the safety of evacuation routes.

RESTRICTED ZONES AND URBAN AREAS: School Zones: Automatically limits vehicle speed near schools during peak hours,ensuring student safety. Hospital Zones: Enforces low-speed limits to minimize noise and ensure safety insensitive areas.

SMART CITIES AND TRAFFIC MANAGEMENT: Integrates with IoT-enabled traffic lights and geofencing to optimize vehicle flow and avoid congestion. Improves urban mobility by dynamically managing speed limits based on traffic densityand road conditions.

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HIGHWAY SAFETY: Regulates vehicle speeds in accident-prone areas or during adverse weather conditions to reduce accidents. Enables variable speed limits on highways based on traffic patterns and real-timehazards.

ECO-FRIENDLY DRIVING: Promotes smooth driving behaviour, reducing fuel consumption and lowering carbonemissions. Supports electric and hybrid vehicles by enhancing energy efficiency through optimal speed regulation.

AUTONOMOUS AND CONNECTED VEHICLES: Plays a crucial role in the operation of self-driving cars by providing real-time speedcontrol data from IoT-enabled road infrastructure. Enhances vehicle-to-infrastructure (V2I) communication, enabling seamless integrationwith smart transportation networks.

LAW ENFORCEMENT: Assists authorities in enforcing speed limits without direct human intervention, reducing the need for manual speed checks and fines.

INDUSTRIAL AND CONSTRUCTION ZONES: Automatically reduces vehicle speeds near construction sites or industrial zones to ensurethe safety of workers and reduce accidents.

RAILWAY CROSSINGS: Implements automatic speed reduction in areas near railway crossings to minimize the risk of collisions and ensure compliance with safety regulations.

TOURISM AND WILDLIFE SANCTUARIES: Enforces speed limits in wildlife areas to prevent harm to animals crossing roads andprotect the environment from vehicle disturbances.

CHALLENGES AND LIMITATIONS

Infrastructure Dependency The system's performance relies heavily on smart infrastructure, such as IoT-enabled road networks and advanced traffic management systems. Developing countries may struggle to implement such infrastructure due to financial and logistical constraints.

Algorithmic Limitations AI models used in speed control systems often fail in edge cases, such as unpredictable pedestrian behavior, complex traffic patterns, or extreme weather conditions like fog and snow. Improving the robustness of these algorithms is a significant challenge.

Privacy Concerns The collection and transmission of sensitive vehicle and driver data raise ethical and legal issues, including potential misuse and surveillance. Ensuring strong encryption and adherence to privacy laws is critical to fostering trust.

Cost of Implementation High costs associated with installing sensors in vehicles and upgrading road infrastructure can be prohibitive, particularly for economically disadvantaged regions.

Interoperability Issues Different manufacturers and regions often use incompatible technologies, creating barriers to seamless communication and integration. Universal standards are needed to address this issue.

Legal and Regulatory Barriers Traffic laws and regulations must be updated to accommodate automated systems, particularly in defining liability in accidents. Governments need to establish clear legal frameworks to support adoption.

Public Acceptance Many drivers may resist adopting automated speed control systems due to mistrust, fear of system failure, or lack of understanding of the technology's benefits.

Maintenance and Reliability Consistent maintenance of sensors, software, and IoT devices is necessary for accuracy. Poor maintenance practices can lead to failures, undermining system reliability.

Weather and Environmental Challenges Adverse weather conditions, such as snow, fog, or heavy rain, can impair sensor functionality and reduce system effectiveness. Resilient solutions are needed for consistent performance.

Ethical Dilemmas Automated systems may face difficult decisions in situations where avoiding an accident is impossible. Programming AI to make ethical decisions remains a complex and unresolved issue.

CONCLUSION

The Automatic Vehicle Speed Control System is a transformative technology that enhances road safety, reduces human error, and promotes sustainable transportation. By leveraging advanced sensors, AI algorithms, and IoT-based communication, these systems offer significant improvements over traditional speed control mechanisms. Future research should focus on

optimizing system algorithms, improving infrastructure compatibility, and addressing privacy concerns to enable global scalability and adaptability. The Automatic Vehicle Speed Control System represents a transformative leap in modern transportation technology. By integrating cutting-edge sensors, artificial intelligence (AI), and Internet of Things (IoT) connectivity, this innovation significantly enhances road safety by mitigating human errors and promoting responsible driving practices. Unlike traditional speed control mechanisms, these systems operate dynamically, responding to real-time environmental conditions.

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Blind Safe Obstacle Detection

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ABSTRACT

Visually impaired face significant challenges when navigating streets, particularly when it comes to detecting obstacles, which can make walking dangerous. A proposed solution to address this issue is the development of a smart device that helps visually impaired people navigate by detecting obstacles around them. With millions of visually impaired individuals worldwide, there is a pressing need for assistive devices that provide them with the freedom to move independently at any time. In recent decades, various assistive devices have been designed and developed to help visually impaired people with navigation in different environments. One such device focuses on obstacle detection and alerting the user. This smart device work with lidar sensors to detect obstacles and alert the user using either buzzer sounds or vibrations.

Traditionally, blind individuals have relied on that smart device to detect nearby obstacles. However, these conventional methods only work when the smart device is in close proximity to the obstacles. The new system improves upon this by offering more comprehensive assistance, enabling the user to detect and avoid obstacles more effectively during travel. Globle Positioning System(GPS) and Global System for Mobile Communication(GSM) is add on this device for finding the correct location of blind people. Using this smart device we can easily find where blind person are located.

KEYWORDS: Arduino, Lidar Sensor, piezo buzzer, vibrator motor, microcontroller, fire sensor, GPS and GSM

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INTRODUCTION

Visually impaired are those who are unable to detect even the smallest details with their healthy eyes. These individuals require assistive devices to overcome challenges related to blindness. It is reported that 10% of blind individuals have no usable vision, making independent and safe movement difficult. Electronic assistive devices are designed to address these challenges.

This work focuses on solving several issues faced by blind people, such as detecting obstacles or people at a certain distance, which could lead to collisions. Another concern is identifying hazards like holes or stairs that could result in falls. For most of us, navigating an urban environment is easy and automatic, but for a blind person, it requires intense focus to move independently, even on familiar routes. Without the ability to see, a blind person must rely on other methods for navigation, like feeling the ground with their feet, using the sound of their footsteps to judge distances to obstacles, recognizing specific smells or sounds in certain locations, or counting steps to determine when to change direction.

Any brief lapse in focus, unexpected obstacles, missed signals, or errors in counting steps can cause the blind person to lose their sense of direction, forcing them to seek assistance from others. The blind people are go to surrounding so it is important for home

people know about where they are going. Because they face problem at any time and any were.

LITERATURE SURVEY

- *Technology-Based Laboratory to Enhance Science Learning*: This work is carried out by Avinash Kumar Shudhanshu, Raj Kumar, Sadashiv Raj Bharadwaj, Gaurav Singh, and Amit Garg, with Acharya Narendra Dev College at the University of Delhi, located in Govinduri, Kalaji, New Delhi, India.

- *Blind Assist System: Developed by Deepak Gaikwad, ChaitaleeBaje, VaishnaviKapale, and TejasLadage, this system was created at the E&TC Department of NBN Sinhgad School of Engineering in Pune, where Deepak Gaikwad is an Assistant Professor, and the others are students.*

- Nada et al., 2015: In their proposal, Nada and colleagues used the Microcontroller PIC 16F877A, along with two IR sensors and a message recording module (ISD1932). The microcontroller processes the data from the IR sensors, determining the type of obstacle based on the calculated results. Depending on the distance to the obstacle, a specific alert is generated. The ISD1932 module then plays the corresponding audio message to notify the blind person about the obstacle.

- Gayathri et al., 2014: In their design, Gayathri and their team introduced a smart walking device featuring sensors like lidar sensors, pit sensors, and water sensors to detect obstacles in front of the user. The pit sensor, an IR sensor, measures the distance to any pit or depression in the path, while the water sensor detects water on the ground. A keypad is used to set the destination, and the system's voice synthesizer and speaker alert the user if they stray from their intended path.

- Snehal Bhagwat, Meenakshi Funde, Ravindra Sona wane Shalaka Deora, Shubhangi Ingale the paper title as - Woman Safety and Alert System - In this paper an alternative method is proposed for women security that may serve as a better alternative to rest of the available security methods. Here the system is designed around Arduino micro-controller that uses GPS, GSM, watch, shockwave generation circuit and an accelerometer for better security.

PROPOSED SYSTEM

The human eye is one of the most important parts of the body, and losing sight, whether due to a genetic condition or an unfortunate accident, can be a significant challenge in life. Although other senses and intelligence can help compensate for the loss, the adjustment period can be difficult. To address this, we are developing a smart, sensor-enabled walking device designed to help blind individuals walk more confidently, with an extended range of obstacle detection.

By integrating anlidar sensor, the smart device will be able to detect objects within a specific range. The sensor's data will be processed and used to trigger a piezo buzzer, providing dynamic alerts based on the direction of the device. Traditional walking aids for the blind, such as a simple cap or hand belt, are limited by their fixed detection range and lack an alert system. These limitations will be addressed by our smart device, which offers an expanded range and an alert feature, benefiting both the user and others who may be in the blind person's path.

The design will focus on incorporating the lidar sensor and the Arduino unit into the device in a compact and efficient manner. Another challenge will be positioning the sensor in such a way that it minimizes the amount of movement required by the user to detect obstacles. Once these issues are resolved, the smart device will provide valuable assistance, helping blind individuals navigate more easily and get accustomed to walking independently.

If the blind people face any problem regarding walking or other so for that purpose we added GPS and GSM system for sending the massage at emergencies situation. We have connected a water sensor to protect our device from water.
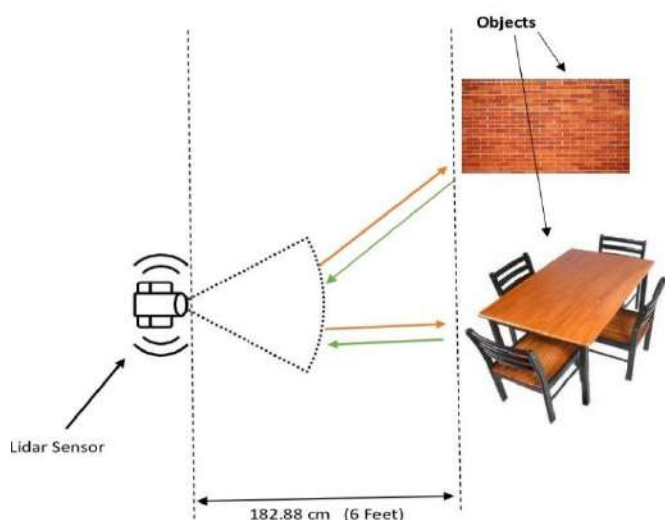
BRIEF DESRIPTION
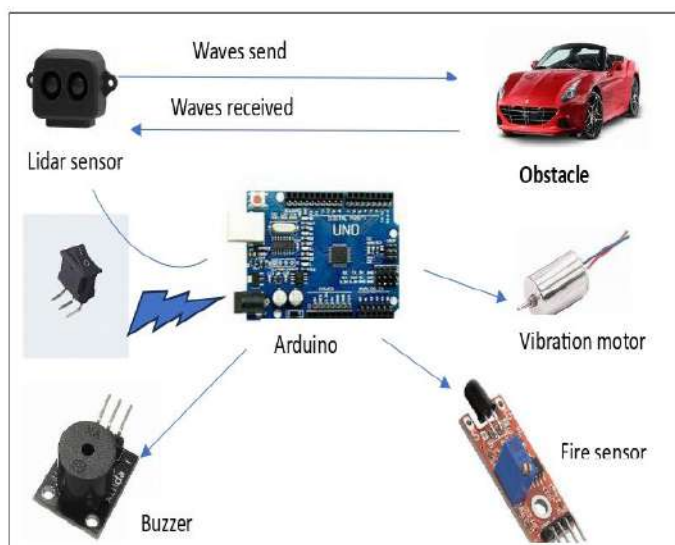
Fig – 4.1: Working Principle

The system model for the smart device project works as follows:

1) The power button is used to turn the system on, enabling the sensor to function.
2) The lidar sensor, consisting of a transmitter and receiver, emits waves and receives the reflected waves.

The sensor calculates the time it takes for the reflected waves to return.

3) The time duration is sent to the Arduino, which uses its programmed logic to determine the distance of an object from the sensor. If the distance is less than 120 cm, specific pins are activated.
4) Once the pins are triggered, the Arduino sends a signal to activate the actuators, causing the vibration motor and piezo buzzer to work.

5) With the help of GSM and GPS blind people sending the SMSand his location in map link format.

CIRCUIT DIAGRAM
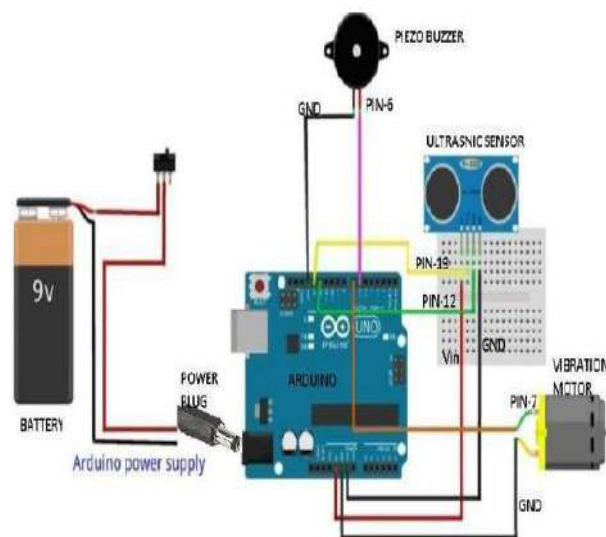
Fig – 5.1: Description of Invention

The diagram illustrates the structured connections within the project. Each component is linked to the Arduino through specific pins, as indicated in the diagram. A battery supplies power to the Arduino, enabling the stick to function remotely via a power plug. The Vcc pin of the lidar sensor is connected to the Arduino's Vin pin, while the trigger pin is linked to pin 13 and the echo pin to pin 12. Additionally, pin 7 is assigned to the activation pin of the vibration motor, and pin 6 is connected to the piezo buzzer. The remaining pins are grounded to the Arduino.

CONCLUSION

Smart sensors are not just a passing trend; they are shaping the future. As more people recognize the benefits of these technologies, the fields will continue to grow without limits. The design of this project demonstrates practicality, cost-efficiency, and great usefulness. This project is specifically aimed at helping blind individuals. It can be further enhanced with more sensors to make decisions, allowing it to serve different purposes.

The system focuses on solving challenges faced by blind people in their daily lives and ensuring their safety. It introduces an obstacle detection system that helps visually impaired people navigate safely. The system uses anlidar sensor to detect obstacles and objects in the path of the user.This system is used to find the location of blind people using GPS and received the SMS using GSM. The prototype is both easy to use and affordable, making it a valuable advancement in the field of blind recognition systems due to its durability, user-friendliness, and cost-effectiveness.

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IoT Based Smart Dustbin with IoT Notification and Location

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ABSTRACT

Managing waste in cities has become a serious issue because the traditional collection system isn't efficient. Bins often overflow, making streets dirty and creating health risks. Sometimes, garbage trucks come too early when the bin isn't full, or too late when it's already overflowing. To solve this, we propose a smart dustbin that uses IoT (Internet of Things) technology to monitor waste levels and notify collection teams when it's time for a pickup. This system helps reduce unnecessary trips, saves fuel, and keeps the surroundings clean.

The smart dustbin is designed with sensors that can detect how full the bin is, track its location using GPS, and even monitor bad odours. All this data is sent to a cloud system, which helps authorities plan better waste collection routes. When a bin is full or emits a strong smell, an automatic alert is sent to the waste management team via SMS, mobile apps, or web dashboards. This ensures that bins are emptied on time, preventing overflow and maintaining hygiene in public places. In addition to better waste collection, the system also supports proper waste segregation using RFID technology, which helps separate different types of waste automatically. Looking ahead, AI (Artificial Intelligence) could be used to make the sorting process even smarter, and blockchain technology could help track waste disposal for better transparency. Overall, this smart dustbin system can make waste management more efficient, reduce pollution, and contribute to a cleaner and healthier environment.

KEYWORDS: Smart Dustbin, IoT, Waste Management, Location Tracking, Real-Time Notifications, Waste Segregation

1. INTRODUCTION

Waste management has been a long-standing challenge in urban and rural areas, With increasing population density and rapid urbanization, cities generate vast amounts of waste daily. Conventional waste collection methods rely on fixed schedules, which often result in inefficiencies such as overflowing bins, delayed pickups, and unnecessary fuel consumption by waste collection vehicles. These inefficiencies not only create unsanitary conditions but also contribute to environmental pollution and

increased operational costs. Therefore, there is a critical need for a more intelligent waste management system.

The advent of the Internet of Things (IoT) has revolutionized several industries, including waste management. By embedding sensors and communication modules into waste bins, it is possible to create an intelligent system that monitors waste levels in real-time. This smart waste management approach enables authorities to optimize collection routes, reduce fuel consumption, and improve overall efficiency. Moreover, IoT-based smart dustbins can significantly enhance cleanliness in public places by ensuring timely waste disposal.

An IoT-enabled smart dustbin consists of various electronic components such as ultrasonic sensors, weight sensors, gas sensors, and microcontrollers. These components work together to detect the waste level inside the bin, analyze data, and transmit it to a cloud-based platform. Through real-time updates, waste management authorities receive alerts when a bin is full or emitting foul odors, allowing for prompt action. Additionally, location-tracking technology ensures that mobile dustbins can be easily located and serviced efficiently.

One of the most significant advantages of IoT-based smart dustbins is their ability to minimize manual intervention. Traditional waste collection requires workers to visit all bins regardless of their fill levels, leading to unnecessary labor costs and wasted resources. With an intelligent system in place, waste collectors can focus on bins that require immediate attention, streamlining operations and ensuring a more

sustainable waste management process. Moreover, automated notifications can alert workers to critical issues such as hazardous waste accumulation.

Incorporating machine learning algorithms into IoT-based smart dustbins can further enhance their efficiency. By analyzing historical data on waste generation patterns, predictive models can be developed to optimize waste collection schedules. This data-driven approach helps municipalities allocate resources effectively, reducing operational costs and environmental impact. Additionally, artificial intelligence can be employed to classify waste into recyclable and non-recyclable categories, promoting sustainable waste disposal practices.

Location tracking plays a crucial role in the efficient deployment of IoT-based smart dustbins. GPS modules integrated into mobile bins enable authorities to track their real-time positions. This is particularly useful for large urban areas where waste collection trucks need to follow optimized routes. By leveraging geospatial data, municipal authorities can ensure that waste collection is carried out systematically, preventing litter accumulation in busy areas. Furthermore, this technology allows for better coordination of waste management teams.

Another vital feature of IoT-based smart dustbins is their ability to monitor air quality in waste disposal areas. Gas sensors detect harmful emissions from decomposing waste, triggering alerts when pollution levels exceed safety thresholds. This feature is particularly useful in densely populated cities where improper waste disposal can lead to serious health hazards. By addressing waste-related pollution proactively, IoT-based solutions contribute to healthier and cleaner urban environments.

Public awareness and participation are crucial for the successful implementation of IoT-based waste management solutions. Governments and municipal bodies can launch awareness campaigns to educate citizens about the benefits of using smart dustbins. Encouraging responsible waste disposal habits and integrating mobile applications for user engagement can further enhance the effectiveness of the system. Incentives, such as reward-based recycling programs, can be introduced to motivate people to adopt sustainable waste disposal practices.

Despite the numerous benefits of IoT-based

smart dustbins, some challenges remain. High initial costs, technical maintenance, and the need for reliable internet connectivity can hinder large-scale implementation. However, with continuous advancements in technology and increased government support for smart city initiatives, these challenges can be gradually overcome. Future developments in IoT and artificial intelligence will likely lead to even more sophisticated waste management systems.

In conclusion, IoT-based smart dustbins represent a transformative approach to modern waste management. By integrating real-time notifications, location tracking, and data analytics, these systems optimize waste collection, reduce environmental impact, and enhance public sanitation. As cities continue to grow, adopting such smart waste management solutions will be essential in creating cleaner and more sustainable urban environments. With continued research and development, IoT-based waste management systems have the potential to revolutionize how waste is collected, sorted, and recycled globally.

2. LITERATURE SURVEY

In recent years, the adoption of the Internet of Things (IoT) has revolutionized many industries, particularly waste management. The integration of IoT technology in waste collection systems, especially through smart dustbins, has gained significant attention due to its potential to optimize waste management processes. IoT-enabled smart dustbins are designed to monitor waste levels, detect overflows, and provide real-time notifications to waste collectors, thereby enhancing the efficiency of waste management systems. According to a study by Jain et al. (2020), the development of IoT-based smart dustbins helps in minimizing human intervention and ensures that waste collection is carried out only when necessary, which results in cost and time savings.

One of the key features of IoT-based smart dustbins is the use of sensors to measure the fill level of waste containers. These sensors communicate data to a central system, enabling waste collection trucks to be dispatched only when a dustbin is near full. Research by Kumar et al. (2019) demonstrates the efficiency of ultrasonic sensors in detecting the level of waste in smart bins. These sensors are able to send continuous data updates, which helps the waste management system to optimize collection routes and reduce fuel consumption. The use of location-based technology further adds value by enabling the system to track the exact location of each dustbin, allowing for more precise and efficient collection scheduling.

In addition to the sensor-based monitoring, the incorporation of smart notifications is another crucial element that enhances the effectiveness of smart dustbins. Notifications can be sent to waste collection authorities or management systems, alerting them when bins are full or need to be emptied. The integration of mobile apps and cloud-based platforms facilitates real-time communication and remote monitoring. A study by Patel et al. (2021) shows that such notifications play a significant role in reducing delays in waste collection and improving overall service quality. Furthermore, the smart notification system helps in preventing issues like overflowing bins, which can create environmental hazards and lead to unhygienic conditions.

The localization of IoT-based smart dustbins is another important aspect that allows for better coordination in urban waste management. By integrating Global Positioning System (GPS) technology, smart dustbins can be mapped, providing real-time location data. This ensures that waste collectors can access the exact coordinates of a dustbin, minimizing the time spent searching for bins in large urban areas. Research by Singh et al. (2022) highlights how GPS-enabled IoT dustbins improve route planning and reduce the carbon footprint associated with waste collection. With location-based services, waste management authorities can make informed decisions about which bins to empty first based on proximity, ensuring more efficient resource utilization.

3. PROPOSED SYSTEM

Our IoT-based smart dustbin is designed to makewaste management easier and more efficient. It has sensors that detect the waste level inside the bin and sends automatic alerts when the bin is almost full. This helps in ensuring that waste is collected on time, preventing overflow and bad odors. The bin also has a GPS tracking system, which allows authorities to know its exact location, making it easier to plan collection routes. If the dustbin is mobile, such as in large public areas, GPS helps in keeping track of its movement.

Additionally, a gas sensor detects foul smells, sending alerts if waste starts to decompose, ensuring cleanliness and hygiene.

With real-time notifications sent to a mobile app or dashboard, waste collection teams no longer need to check bins manually. This saves time, effort, and fuel as trucks only need to go where collection is necessary. The system also stores data in the cloud, which can be used to predict waste levels and optimize collection schedules. In the future, this smart bin could be improved with AI-based waste sorting and even voice commands for easier interaction. By making waste collection smarter, this system helps keep cities clean, organized, and eco-friendly while reducing manual work and unnecessary costs.

3. GPS

Location — determining a position

4. REQUIRMENTS/ TOOLS

HARDWARE REQUIRED

1. Arduino uno

It is a development board used to do all the processing.

4. Ultrasonic Sensor HC-SR-04

It is used as an object detection sensor, it is used tomeasure the distance of the object from the sensor

5. Jumper wires

They are used to make circuit connections between different Components.

2. GSM Module – 800

GSM model use for sending sms message.

6. 9v battery with clip

Battery is used to giving power supply to the Arduino for working the model.

SOFTWARE REQUIRED

1. Arduino IDE

5. CIRCUIT DIAGRAM
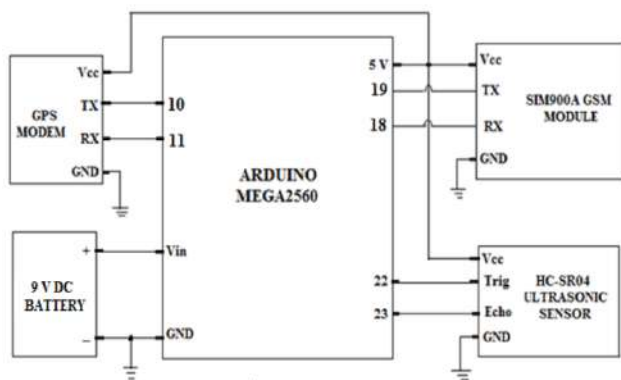
Schematic Diagram of the GPS and GSM Based Garbage Management System for Kitwe City Council. Source: Author.

Fig -5.1: Description of Invention

6. CONCLUSION

The IoT-based smart dustbin provides a smart and effective solution for waste management by reducing manual intervention and optimizing collection schedules. It helps in keeping public spaces cleaner by automatically notifying authorities when a bin is full and even detecting bad odors. With GPS-enabled tracking, waste collection teams can locate and empty bins efficiently, preventing overflow and unnecessary delays.

Moreover, the system enhances waste segregation through RFID-based identification, making recycling more efficient and reducing the environmental impact. Machine learning algorithms help predict peak waste accumulation times, ensuring timely waste collection and minimizing logistical challenges. This not only improves efficiency but also promotes a sustainable approach to urban waste management. Future advancements could include AI-powered sorting mechanisms to differentiate between types of waste automatically and blockchain-based tracking for transparency in waste disposal. By integrating these innovations, cities can move towards a cleaner, more efficient, and eco-friendly waste management system

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Block chain Technology based Documents Verification Validation

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ABSTRACT

Everything in the digital world digitalized, including academic certificates, certificates of SSL, and HSC, which are issued to students by institutions. It is hard for students to keep degree certificates. The organization and institution consider verification and validation of certificates to be time-consuming and tire some. Our project will make it easier for the certificate to be stored in the block chain system so that it is secure. First, the paper certificates are converted into digital certificates. The chaotic algorithm is utilized to generate the hash code value for the certificate. After verifying the certificates; they are stored safely in the block chain. These certificates are validated by using the mobile app.By utilizing block chain technology, we can increase the security and efficiency of the digital certificate validation.

Keywords: block chain, digital certificate, hashing, a chaotic algorithm.

INTRODUCTION

Block chain technology was launched in 2008 by Satoshi Nakamoto, a groundbreaking move in the field of digital data security. Block chain is a revolutionary, decentralized online ledger that allows secure and transparent sharing of data without any intermediaries. This distributed ledger technology (DLT) guarantees that data contained within it is tamper-proof, immutable, and accessible to only authorized entities. Since its early usage in cryptocurrencies, block chain has grown beyond its infancy and has now become a crucial tool in diverse sectors such as education, finance, healthcare, and supply chain management.

This project seeks to utilize block chain technology by creating an Android app with the aim of verifying academic certificates securely. Presently, the authenticity and integrity of graduation certificates and transcripts are a growing concern. These critical documents, usually carrying sensitive information, are prone to manipulation and forgery by unauthorized persons. In addition, the convenience of access to such information by third parties poses a great risk to privacy and confidentiality.

It is therefore crucial that there is an immediate need for a strong and secure system that ensures the authenticity of such documents, proving them to come from credible and authorized sources and ruling out any chance of counterfeiting.

Over the past few years, several systems have been suggested for overcoming the difficulties faced by e-certificates, especially for institutions of learning. These systems use cloud-based systems to securely store digital certificates. But there are limitations to these traditional cloud storage systems, such as vulnerability to hacking and unauthorized access. Block chain technology is a strong system to overcome these limitations that provides unequaled security and reliability. When used with sophisticated hashing methods and cryptographic processes, block chain is an extremely powerful tool for protecting sensitive information, like academic certificates .Block chain's intrinsic characteristics of decentralization, transparency, and immutability make it the best option to create a safe certificate verification system. With the use of block chain, there is much less requirement for constant manual verification of certifica

Every certificate provided by an education institution can be saved as a single, distinct record on the block chain with a digital signature for guarantee. These are n changeable and can be opened by approved

parties for the sake of verification, thus eradicating forgery or fraud risks.

Digital signatures are essential for the boosting of the security of digital documents. These cryptographic devices make it certain that the document is not tampered with once created, thus keeping its integrity intact. Digital signatures also authenticate through validation of the identity of the issuer and non-repudiation, keeping the issuer from being able to disown the act of signing the document. The combination of digital signatures with blockchain technology increases the overall security of the system, rendering it almost impossible for malicious users to alter or counterfeit academic certificates.

The use of block chain technology in this project solves a number of key problems in the field of certificate management. Firstly, it maintains the authenticity of the certificates by confirming their origin and ensuring that they have been issued by a valid and authorized organization. Secondly,it ensures confidentiality of sensitive data by limiting acces to concerned parties alone. Thirdly, it offers an open and effective means for storing and authenticating certificates, avoiding the exhaustive and error- prone manual verification process.

The Android app that has been built in this project is an easily accessible interface for employers, schools, and students. Students have the ability to upload their certificates onto the block chain, which would be safely stored and easily checkable. Schools can provide digital certificates directly through the app with digital signatures and individual block chain entries. The employer, meanwhile, can use the app to instantly and accurately confirm the authenticity of certificates, avoiding the possibility of hiring people who present forged qualifications.

One of the greatest strengths of using block chain for managing certificates is its power to provide an unalterable record of each certificate. Each certificate held on the block chain has a distinct hash, a sort of digital fingerprint. Any modification to the certificate would lead to a discrepancy between the initial hash and the document, marking the tampering effort instantly. The feature preserves certificate integrity and earns stakeholders, such as employers, institutions, and students, their trust.

Additionally, blockchain technology makes it possible for secure and decentralized storage of certificates. In comparison to traditional storage systems, in which data are stored in a centralized point and can be accessed by hackers, blockchain stores data on a network of nodes. The decentralized framework of this design makes it close to impossible to hack the system since hackers have to control a majority of the nodes in the network—a probability that is rather low.

The use of blockchain technology and digital signatures also provides data protection compliance with international data protection laws, including the General Data Protection Regulation (GDPR). By limiting access to authorized users and providing an open system for data management, this system complies with data privacy and security principles, providing assurance to users.

In summary, this project showcases the revolutionary potential of block chain technology in solving the problems related to certificate verification and management. Through the creation of an Android app that combines block chain and digital signature technologies, we hope to developed a secure, trust worthy, and efficient system for managing academic certificates. This solution not only minimizes the threat of forgery but also increases the overall security, validity, and confidentiality of these important documents. As block chain technology develops further, its use in the education sector is set to transform the way academic credentials are issued, kept, and authenticated, establishing a new benchmark for trust and transparency.

LITERATURESURVEY

Jin-Chiou et al. [1] created software to solve the problem of forged certificates. Graduation certificates, because of their absence of anti-forgery techniques, are easily counterfeited. To reverse this, they built a decentralized app that utilized Ethereum blockchain technology. The procedure is to produce a digital copy of the paper certificate and save its hashed value in the blockchain. Though the system guarantees the authenticity of certificates and minimizes the use of paper, it calls for a distinct scanning application to authenticate the certificate,

and hence a smartphone and an internet connection.

Ze Wang et al. [2] presented a certificate transparency and revocation system based on blockchain technology. Here, the Certificate Authority (CA) digitally signs certificates, and revocation status is published by the CAin public logs so that the activities of its operation can be transparently monitored. The system was deployed over Firefox and Nginx, providing trustfor the process. Certificate validation is plagued by delays, and users can get a misleading sense of security.

Madala et al. [3] used the Hyperledger Fabric blockchain platform to issue certificates. In this case, the Certificate Authorities (CAs) can issue certificates only after domain owner approval. The system uses Google's Certificate Transparency (CT) method, which is intended to avoid issuing unauthorized SSL/TLS certificates. Though it has an innovative solution, this system is challenged by scalability and low transaction throughput.

Aisong Zhang et al. [4] proposed a consortium blockchain system that utilizes a secret sharing scheme to authenticate digital certificates. It protects both property and user data and revokes certificates by making use of the cooperation of CAs. The reliability of Certificate Revocation List (CRL) in the system is more than that using

OBJECTIVES

Increased Security with Blockchain
Leverage the block's unchangable nature in blockchain technology to provide strong security for digital certificates. The non-modifiable attribute of the blockchain eliminates unauthorized modification, protecting the certificates' authenticity.

Transparency and Confidentiality

Provide both transparency and confidentiality in balance. Every transaction across the block chain network is accessible to authorizpeers while offering an auditable trail of events and protecting sensitive information from unauthorized access.
. The system seeks to provide consistency and accuracy in certificate verification.

- **User-Friendly System**

Create a simple and user-friendly interface to suit both technical and non-technical users. This way, the application is made accessible to a wider audience.
By fulfilling these goals, the project aims to develop a secure, transparent, and effective method for verifying digital certificates.

METHODOLOGY
The proposed system aims to convert academic and sports certificates into digital certificates using sampling and quantization techniques. Each certificate is assigned a hash value, generated using a chaotic algorithm, which is then stored within a blockchain. A block comprises the hash value, timestamp, and the hash of the previous block, forming a chain of interconnected blocks. Institutions can register student details, including name and email ID, through the application interface, and these details are stored in the database. Certificates issued by the registrar are added

conventional techniques. Certificate validation requires decrypting the signature with the public key and comparing the resulting hash valuewith the one for the original message. If the values are equal, the certificate is legitimate. Nonetheless, the system also provides an opportunity for false security.

Macro Baldi et al. [5] developed a certificate validation system based on public ledgers and blockchain. Here, CRLs are issued through a private blockchain and shared among CAs, which both issue certificates and hold CRLs. The arrangement guarantees authentication and certificate revocation list access at any moment. Yet the ecosystem is still exposed because of its susceptibility to compromise and vulnerability.

Offline Functionality
Make the application work efficiently offline, enabling gusers to verify certificates without needing an internet connection. This aspect guarantees access in areas with poor connectivity.

Fast Certificate Validation
Provide mechanisms for quick and effective certificate verification. The verification process is optimized to avoid delays, providing users with a seamless and trouble-free experience.

Reliable and Correct Information

Offer users reliable and accurate information about the validity of digital certificates. The

to the blockchain through the application. Employers or verifiers can validate these certificates by entering the student's information.

Digital Certificate Creation

Student certificates are transformed into digital format using an analog-to-digital conversion method. Both academic and sports certificates issued by institutions are uploaded to the system. Through the conversion process, each certificate is represented in binary form (0s and 1s). The system uses a 2D function to map each pixel value of the digital certificate. Administrators can log in through the admin interface to upload certificates. Once uploaded, certificates are digitized via sampling and quantization. The interface includes options to register students or upload certificates through "Add Student" and "Add Certificate" buttons.

Hash Code Generation

The chaotic algorithm generates a unique hash value for each digital certificate. This algorithm accepts inputs of varying sizes and produces fixed-size Thesame conditions are used during verification to ensure consistency.ComparedtoSHA-1, chaotic hash functions offer higher resistance to collisions, providing enhanced security.

Digital Certificate Validation

Validation involves verifying the stored certificates in the blockchain by matching hash values. The hash value comparison ensures that no tampering has occurred. Employers or verifiers can log in to the application using their credentials, select the certificate type, and initiate the validation process. If the certificate is genuine, the system will display a success message. If tampering or modifications are detected, the system will flag the certificate as invalid or altered.

Working of the Application

The application consists of three primary sections: the admin login, student and certificate management, and the verifier page. Administrators can log in using their credentials to add student information and upload certificates. Using "Add Student" and "Add Certificate" options, the system registers students and uploads their documents. Verifiers can access the verifier interface with their login details, select the type of certificate, and validate it by providing the student's login ID. The system displays a success message for authentic certificates and an error message for tampered or invalid ones.

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Agri Sensor with Internet of Things

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ABSTRACT

Technological precision is essential for efficient resource management in both agriculture and domestic applications. By utilizing real-time water level sensors, the Water Tank Overflow Alert System ensures users are notified when tanks are full, reducing water waste. Likewise, the Animal Intrusion Detection System detects unauthorized animal entry and alerts farmers to prevent crop damage. These solutions combine IoT and automation, improving productivity, sustainability, and efficiency in contemporary farming-practices.

keywords: *Agri Vision AI, Livestock Surveillance, Smart Aqua Flow, Hydro Sense Monitoring, IoT Aquatic Control.*

INTRODUCTION

AI is one of the fastest-growing technologies and is used in many industries, including robotics, healthcare, self-driving cars, and environmental monitoring. It improves automation, increases productivity, and reduces environmental harm, especially in agriculture. AI uses smart sensors to process data accurately in real time, enhancing device performance. The combination of AI and smart sensors has led to the development of the Internet of Things (IoT), which helps in efficient data management and decision-making. IoT-based digital technologies also support innovation in consumer and agricultural product manufacturing.[1]

Agriculture is one of the most important sectors for the global economy and food supply, providing essential resources for people worldwide. However, farmers face many challenges that affect productivity and sustainability. One major issue is animal intrusion, where wild or stray animals enter farmlands, damaging crops and leading to significant losses. Another critical problem is inefficient water management, where excessive or insufficient irrigation harms plant growth and wastes valuable water resources. These challenges make farming less efficient and more costly, requiring advanced solutions to improve agricultural practices and ensure sustainability.

To address these issues, innovative technologies like the Agri Sensor with IoT have been introduced. These smart sensors help farmers monitor their fields in real time by detecting the movement of animals and sending instant alerts, allowing quick action to prevent

damage. In addition, these sensors track soil moisture levels, ensuring the right amount of water is used for irrigation, which reduces waste and improves crop health. By integrating IoT technology into farming, the Agri Sensor helps farmers make better decisions, increase productivity, and use resources efficiently. With these advancements, agriculture becomes more sustainable, protecting crops and conserving water while reducing losses, ultimately benefiting both farmers and the environment.

Agriculture is an important part of human life and has improved over time to increase crop production. Modern technology, like AI and IoT, helps in monitoring soil, weather, pests, and plant health. These technologies also track temperature, humidity, pollution, and other factors in real time, helping farmers make better decisions. Smart farming allows better farm management, saving time and effort. IoT also helps in using pesticides and fertilizers at the right time, reducing waste and environmental damage. By using smart sensors, IoT can detect crop diseases accurately, leading to better yields and cost savings for farmers.[1]

Animal intrusions in farms can cause major problems for farmers, such as damaged crops, lower harvests, and financial losses. Many farmers use traditional methods like manual monitoring, fences, or scarecrows to keep animals away, but these methods require a lot of effort, are not always effective, and may harm wildlife. To solve this issue, the Animal Intrusion Detection and Alert System has been developed using modern technology like motion sensors and artificial intelligence. This system can detect animals entering the farm and immediately trigger a buzzer to scare them away. At the same time, it sends real-time alerts to the farmer through SMS or a mobile app, allowing quick action to prevent crop damage. By using this system, farmers can protect their crops more efficiently, reduce losses, and save time. It also provides a safer and more humane way to keep animals away without harming them, making farming more productive and sustainable.

Water management is a key factor in sustainable farming, but water wastage due to overflowing tanks remains a common problem. When water overflows, it not only leads to unnecessary waste but also increases costs and negatively impacts the environment. Many farmers struggle with monitoring water levels manually, which can be time-consuming and inefficient. To address this issue, an advanced Water Tank Overflow Alert

System has been developed to help farmers manage their water resources more effectively.

This system uses water level sensors to continuously track the amount of water in the tank. When the water reaches its maximum level, the system automatically activates a buzzer to provide an immediate warning. Additionally, it sends an SMS alert to the user, allowing them to take quick action and prevent overflow. By implementing this system, farmers can significantly reduce water waste, save resources, and improve overall efficiency in their agricultural practices. With better water management, farming operations become more sustainable, ensuring that water is used wisely and conserved for future needs.[2][3]

Human-wildlife conflict is a serious issue, especially in areas where forests are close to farms. Wild animals often enter farmlands in search of food, causing damage to crops and sometimes putting people in danger. Farmers have traditionally used methods like electric fences to keep animals away, but these fences can be very expensive, hard to maintain, and not suitable for large farms. Some farmers also use traps, but these can be harmful, costly, and require constant monitoring. Even with these methods, keeping wild animals out of farms remains a challenge. That's why new solutions, such as motion sensors, AI-based alert systems, and non-harmful animal deterrents, are being introduced. These modern technologies help farmers protect their crops in a safer and more effective way while also keeping wild animals safe, creating a better balance between farming and nature.[4]

A modern way to handle human-wildlife conflicts is by using sensor networks and wireless sensors to track animal movements. These technologies are part of precision farming, which helps automate and improve farming activities. With these systems, farmers can detect animals in real time and take quick action to protect their crops and property. Many animal detection systems are mainly used to prevent accidents between animals and vehicles, but conflicts between wildlife and humans still cause serious problems like injuries, deaths, and damage to farmland. These incidents are a big concern for both society and the government because they lead to financial losses and safety risks. People are looking for better solutions to manage these conflicts without harming animals. That's why new sensor-based systems are being developed to monitor animal activity and send alerts, helping farmers prevent damage while keeping wildlife safe.[5]

A smart device has been developed to keep animals away from farms without causing them any harm. This system works by using passive infrared sensors that detect movement in the area. When an animal enters the field, the sensor activates a camera that captures an image of the animal. The system then uses an image classification algorithm, a type of artificial intelligence, to identify the animal. Based on this identification, the device either plays a loud sound through speakers or flashes bright lights to scare the animal away. This technology helps farmers protect their crops in a safe and effective way without using harmful methods, making farming more efficient while keeping animals unharmed.[6]

Wild CENSE is a wireless sensor network that helps track the movements of animals like Swamp Deer. The system gathers information about the animal's location and the weather conditions, then sends this data to a base station where it is stored. It uses artificial intelligence, including a pre-trained image recognition system (CNN) and a classifier (SVM), to compare images and correctly identify animals. When a large animal like an elephant or a leopard is detected, the system responds by flashing bright lights or making loud noises to scare the animal away. This helps prevent damage to farms and reduces conflicts between humans and wildlife, ensuring a safer environment for both.

When the system detects an animal, it immediately sends warning messages via SMS to forest officials, landowners, and nearby residents. These alerts provide real-time information about the animal's location, helping people take precautions to stay safe.

For forest officials, these messages allow them to monitor the animal's movement and take action to guide it back to the forest safely. If the animal poses a risk or is in danger, officials can respond quickly to prevent any accidents. For farmers and landowners, the warning gives them time to secure their crops, livestock, and property from potential damage. Nearby residents are also informed so they can be cautious and avoid the area if needed, especially when large animals like elephants or leopards are detected.

By sending instant notifications, this system helps prevent human-wildlife conflicts and reduces risks for both people and animals. It provides a smart and effective way to manage wildlife interactions, ensuring the safety of farmlands and communities while also protecting the animals from harm.

This system uses advanced technology to protect farms from wild animals in a safe and harmless way. It works with sensors, cameras, and artificial intelligence to detect animals near farmland. When an animal enters the area, the sensors pick up its movement, and a camera captures its image. The system then uses smart technology to identify what type of animal it is.

After identifying the animal, the system takes action to scare it away without causing harm. It may use flashing lights, loud sounds, or other harmless methods to make the animal leave the farmland. At the same time, it sends warning messages to farmers, landowners, and forest officials so they can take precautions and respond if needed.

This modern system is a more effective way to protect crops than traditional methods like electric fences or traps, which can be harmful and expensive. It helps reduce farm damage while also keeping animals safe, creating a peaceful balance between farming and wildlife.

Both systems provide smart, energy-saving, and budget-friendly solutions that reduce the need for manual work and prevent wasting resources. They help improve efficiency by automating tasks and making farming easier. By working together, these technologies support stronger and more sustainable farming methods, helping farmers overcome major challenges in agriculture and resource management.

Fig. Animal Detection System

Fig. 2 Water level Monitoring System

LITERATURE SURVEY

IoT in agriculture has greatly improved farming efficiency by allowing real-time monitoring of soil and weather conditions. Patel et al. (2021) found that IoT systems help farmers manage resources more effectively by providing continuous data on environmental factors. Similarly, Sharma et al. (2022) developed a smart irrigation system using IoT sensors, which led to a 40% reduction in water consumption.

Different sensor technologies play a crucial role in smart farming. Soil moisture sensors help farmers determine the exact amount of water needed for irrigation, preventing overuse or underuse (Kumar et al., 2020). Temperature and humidity sensors track weather conditions, ensuring optimal plant growth by maintaining suitable environmental conditions (Ali et al., 2021). pH sensors measure the acidity or alkalinity of soil, enabling precise fertilizer application for improved crop yields (Gupta et al., 2021).

IoT-based farming systems rely on various wireless communication technologies to transmit data efficiently. Wi-Fi and Bluetooth are suitable for small farms, as they provide reliable short-range connectivity (Singh et al., 2019). For larger farms, LoRaWAN and ZigBee are more effective due to their ability to transmit data over long distances (Rahman et al., 2020). Cloud and edge computing further enhance farming by processing data in real-time, reducing the need for manual work and allowing farmers to make quick decisions (Verma et al., 2021).

Despite its benefits, IoT-based agriculture faces several challenges. The initial setup of IoT sensors and systems can be expensive, making it difficult for small-scale farmers to adopt the technology. Connectivity issues are another major problem, as many remote farms lack reliable internet access. Additionally, storing agricultural data in the cloud raises concerns about data security and privacy.

Future research in IoT-based agriculture is focusing on integrating artificial intelligence (AI) and machine learning (ML) to enhance farming practices. AI can help predict weather patterns, optimize resource allocation, and detect plant diseases at an early stage, improving overall crop health and productivity. The combination of AI, ML, and IoT is expected to revolutionize agriculture by making farming more precise, efficient, and sustainable.

SYSTEM DESIGN

The animal detection and water tank monitoring system utilize a W78E052DDG microcontroller, integrating various sensors for real-time monitoring and alerts. The animal detection module uses an LDR sensor to detect movement, processed by an LM358 IC comparator and converted to digital via the MCP3202 ADC IC before being sent to the microcontroller. If an animal is detected, an LED indicator lights up, and an alert appears on the LCD screen. Simultaneously, the water tank monitoring module tracks water levels and environmental conditions using sensors, with data processed by the microcontroller and stored in the AT24C64 memory IC. A 7805-voltage regulator IC ensures a stable 5V power supply, aided by capacitors and resistors for signal conditioning. The system provides real- time visualization and automated alerts, making it ideal for farm security, smart irrigation, and resource management while enhancing automated environmental monitoring and farm protection.

HARDWARE REQUIREMENT

TEMPERATURE AND HUMIDITY SENSORS

Temperature and humidity sensors measure ambient conditions using the misters, RTDs, or capacitive/resistive technology. Common sensors like DHT11, DHT22, and BME280 provide accurate readings for agriculture, weather monitoring, smart homes, and industrial automation. They operate with in a -40°C to 125° C temperature range and 0%to100% RH for humidity. These sensors offer analog or digital outputs(I2C/SPI)for real-time data collection, ensuring optimal climate control in applications like HVAC systems, greenhouses, and industrial monitoring.

LDR SENSOR

The **LDR sensor** is used in the animal detection module to detect movement based on changes in light intensity. It works with an LM358 comparator and MCP3202 ADC IC to convert light variations into a digital signal,

processed by the W78E052DDG microcontroller. When an animal passes, the system activates an LED and displays an alert on the LCD. The LDR is cost- effective, sensitive, and reliable, making it ideal for farm security and automated monitoring.

MICROCONTROLLER

The W78E052DDG is an 8 bit microcontroller based on the 8052 architecture, ideal for animal detection and water tank flow monitoring**.** In the animal detection module, it processes signals from an LDR sensor, detects movement, and triggers an LED alert while displaying data on an LCD screen **.**For water tank monitoring, it receives inputs from temperature, humidity, and water level sensors, converts analog data via the MCP3202 ADC IC**,** and stores readings intheAT24C64memoryIC.Poweredbya7805voltage regulator, it ensures stable operation. With 256 bytes of RAM, 8KB Flash ROM, and multiple GPIO pins, it enables real-time monitoring, efficient processing, and low power consumption, making it ideal for agricultural and environmental applications.

LED DISPLAY

The LCD display in the animal detection and water tank monitoring system provide sreal-time data visualization for alerts and status updates. In animal detection, it shows notifications when move mentis detected, while in water monitoring, it displays water levels, temperature, and humidity. The W78E052DDGmicrocontrollerprocessessensordataand up datesthe LCD, with a 10K potentiometer adjusting contrast for better readability. Using parallel communication, it ensures fast updates with low power consumption, making it ideal for agriculture, smart irrigation, and environmental monitoring.

MEMORY IC (AT24C64)

The AT24C64 is a 64Kb EEPROM memory IC used for data to rage in the animal detection and water tank monitoring system. It stores sensor readings, water levels, temperature, humidity, and detection logs, ensuring data retention even during power loss. The W78E052DDG microcontroller logs events in animal detection and saves real-time readings in water monitoring for future analysis.

Using I2C communication, it enables fast data transfer with low power consumption and non-volatile storage, making it ideal for agriculture, smart irrigation, and environmental monitoring.

SOFTWARE REQUIREMENT

KEIL µVISION

Keilµ Vision is an IDE used for writing, compiling, debugging, and simulating firmware for the W78E052DDG microcontroller in the animal detection and water tank monitoring system. It allows programming in Embedded C for sensor data processing, LCD interfacing, memory storage, and alert mechanisms. The Keil C51 compiler converts the code into machine language for execution. Its debugging tools and simulator help detect and fix errors before hardware implementation, ensuring efficient development. By using Keilµ Vision, the project achieves reliable microcontroller programming, testing, and optimization for seamless real- time monitoring.

PCB ARTIST

PCB Artist is a PCB design software used to create custom circuit layouts for the animal detection and water tank monitoring system. It helps in component placement, routing, and ensuring signal integrity for reliable operation. The software supports multi-layer PCB design and includes design rule checks (DRC) to prevent errors like short circuits. By using PCB Artist, the project achieves a compact, efficient, and professional-quality PCB, reducing wiring complexity and enhancing system durability.

FLOWCHART DESCRIPTION
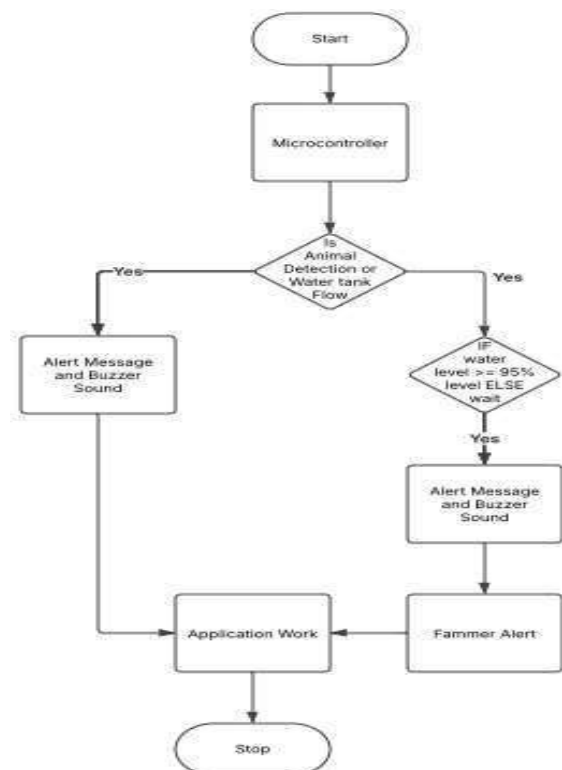
The automated farm monitoring system is designed to enhance efficiency by reducing manual labour through real-time alerts and surveillance mechanisms. If an animal enters the farm, a buzzer will sound to alert the farmer, and an automatic notification will be sent to their mobile phone, ensuring timely intervention and protection of crops and livestock. Similarly, the system also monitors water levels in the tank, providing a buzzer alert and a message notification when the tank is about to reach full capacity within five minutes. This feature helps in preventing water overflow and ensures effective water resource management.

Additionally, the system incorporates a solar-powered surveillance camera to monitor plant growth and detect biological infections. This camera is integrated with a microcontroller programmed with IoT-based codes, allowing it to operate autonomously and transmit real-time data for efficient farm surveillance. The microcontroller ensures that the camera functions seamlessly, providing farmers with valuable insights into their crops' health. Another key function of the system is that when the water tank reaches full capacity, a buzzer will sound and a message will be sent to the farmer's mobile phone, allowing them to take necessary action without physically monitoring the tank.

By integrating sensors, automated alerts, and surveillance technology, the system minimizes manual intervention, enhances farm security, and ensures efficient water and crop management. This smart farming solution helps farmers save time and resources while optimizing their agricultural operations.

BLOCK DIAGRAM
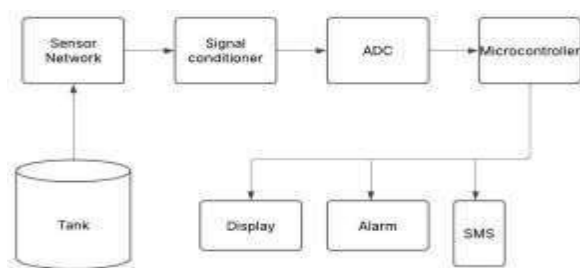
Fig. 1.1 Animal Detection System
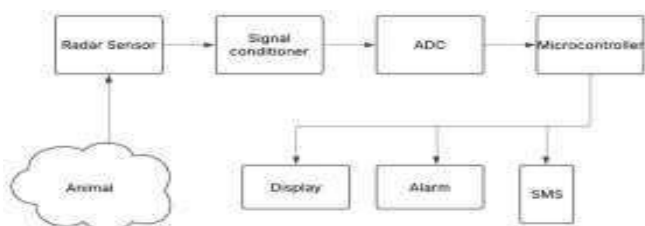
Fig . 1.2 Water level Monitoring system

CONCLUSION

In conclusion, an "Agrisensor with IOT" is one of the most important tools used in agriculture. Agriculture is the most common occupation in India, and by implementing this technology, we can transform it into smart agriculture.

Currently, we are able to detect temperature, check soil water levels, monitor moisture in the soil, and assess plant health by analyzing images using various sensors. We can now implement additional features by adding animal detection and water tank monitoring to our existing system. If a wild animal enters the farm, a camera sensor will detect the animal and send an alert to the farmer. At the same time, the buzzer will be activated. Our system will also continuously monitor the water tank status. If the tank overflows or the water level is low, the system will send an alert message to the farmer and activate the buzzer.

In the future, we can incorporate AI-based animal recognition to differentiate between various animals and non-animal objects. Additionally, we can monitor water quality, such as the pH level and cloudiness of the water, which will help in irrigation and protect crops from polluted water.

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Density Based Traffic Light System

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ABSTRACT

Traffic congestion remains a critical issue in urban transportation systems, leading to increased travel times, fuel consumption, and environmental pollution. Traditional traffic control systems that operate on fixed time intervals are inefficient in handling dynamic traffic conditions. Intelligent Traffic Control Systems (ITCS) have emerged as a promising solution, integrating advanced technologies such as real-time data processing, Internet of Things (IoT), and cloud computing to optimize traffic flow. Various approaches have been explored in this field, including traffic light recognition (TLR) systems, congestion monitoring using RFID and GSM technologies, and cloud-based traffic control systems [1,2,3]. These systems leverage real-time data from sensors and communication devices to dynamically adjust traffic signals, prioritize emergency vehicles, and improve overall efficiency. This paper provides a comprehensive review of ITCS, discussing its tools, advantages, disadvantages, and future scope. Additionally, we analyse various existing models and identify gaps for further research. The findings indicate that while ITCS significantly enhance urban mobility, challenges such as high implementation costs, system reliability, and data privacy must be addressed to ensure widespread adoption.

INTRODUCTION

Traffic congestion is a growing concern in urban areas, leading to increased travel delays, fuel consumption, and environmental pollution. As cities expand, the number of vehicles on the roads continues to rise, outpacing the development of infrastructure and road networks [4]. Traditional traffic management systems rely on fixed- time signals and often fail to adapt to real-time traffic conditions, resulting in inefficiencies and longer wait times at intersections [5]. The need for an intelligent traffic control system that dynamically adjusts signal timing based on real-time data has become increasingly evident. Over the years, various approaches have been proposed to address traffic congestion, including using sensor-based systems, IoT-enabled traffic monitoring, and cloud-based traffic management [6]. One such approach is density-based traffic signal control, where the duration of green lights is adjusted based on real-time vehicle density at an intersection. This method ensures better traffic flow by optimizing signal timing according to demand rather than pre-set time intervals [4]. Additionally, the integration of smart technologies, such as embedded systems and microcontrollers, has enabled cost-effective and efficient solutions for traffic management [3]. Furthermore, congestion often worsens during peak hours due to factors such as urbanization, increased vehicular ownership, and a lack of proactive government measures [6]. The absence of an adaptive traffic control system results in inefficient use of road networks, as vehicles remain stationary at red lights even when no cross traffic is present. Traditional traffic control mechanisms, while improving safety, lack the

flexibility needed to handle dynamic traffic conditions [5]. Recent advancements in intelligent transportation systems (ITS) have incorporated artificial intelligence (AI), machine learning, and wireless communication technologies to optimize traffic management. These systems can process real-time data from sensors, cameras, and GPS devices to predict congestion patterns and adjust traffic signals accordingly [3]. Some studies have also proposed emergency vehicle prioritization, where traffic signals can override normal operations to provide a clear path for ambulances and fire trucks [6]. This paper explores the various tools, advantages, and disadvantages of intelligent traffic control systems while examining their real-world applications and future scope. The objective is to evaluate existing technologies and propose improvements that can enhance urban mobility and reduce congestion.

TOOLS & REQUIREMENTS

- Arduino uno Transformer (12-0-12)
- Ic 74HC595 (serial to parallel)
- Capacitor (0.1 microfarad 2, 1000 microfarad 1)
- Diode (1N4007 2)
- Resistors (470 ohm 13)
- Voltage regulator (Ic 7809 1)
- LEDs (green 3, Yellow 3, Red 4)
- Connecting wires (As per required)
- Microcontroller: Microchip ATmega328P
- Operating Voltage: 5 Volts
- Input Voltage: 7 to 20 Volts
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- Analog Input Pins: 6
- DC Current per I/O Pin: 20 mA
- DC Current for 3.3V Pin: 50 mA
- Flash Memory: 32 KB of which 0.5 KB used by bootloader
- SRAM: 2 KB
- EEPROM: 1 KB
- Clock Speed: 16 MHz

- Dimensions: Length 68.6mm, Width: 53.4mm, Weight: 25g

ADVANTAGES

- **Reduced Traffic Congestion:** By dynamically adjusting signal timings based on real-time vehicle density, the system minimizes traffic bottlenecks and improves road capacity utilization.

- **Optimized Traffic Flow:** Adaptive signal control ensures smoother vehicle movement, reducing unnecessary stops and travel delays.

- **Enhanced Road Safety:** By preventing prolonged traffic buildup and reducing abrupt braking, the system helps lower accident risks at intersections.

- **Environmental Benefits:** Improved traffic efficiency leads to lower fuel consumption, which in turn reduces carbon emissions and air pollution.

- **Minimized Waiting Times:** Vehicles spend less time idling at signals, leading to a more seamless commuting experience.

- **Energy and Fuel Efficiency:** By optimizing green light durations based on demand, the system decreases fuel wastage and conserves energy.

- **Effective Management at High-Traffic Intersections:** The system is particularly beneficial in urban areas with high vehicle density, ensuring better traffic regulation during peak hours.

This adaptive approach to traffic control not only enhances urban mobility but also contributes to sustainable and efficient transportation infrastructure.

DISADVANTAGES

- **High Initial Cost:** The installation of IR sensors, microcontrollers, and advanced signal control systems requires a substantial investment. Additionally, ongoing maintenance and calibration add to the overall cost.

- **Sensor Sensitivity and Reliability Issues**: Environmental factors such as rain, dust, fog, and physical damage can impact the accuracy of sensors, leading to incorrect traffic density readings and inefficiencies in signal adjustments.

- **Complex System Integration:** Developing and implementing an intelligent traffic control system requires expertise in traffic engineering, embedded

systems, and real-time data processing. Integrating this system with existing infrastructure can be technically challenging.

- **Potential System Malfunctions:** If sensors are not properly maintained or calibrated incorrectly, the system may cause unintended issues such as delayed signal changes, unnecessary congestion, or incorrect priority assignments, negatively impacting traffic flow.

- **Dependence on External Power and Communication Systems:** The system relies on a stable power supply and real-time data processing. In cases of power failure or communication breakdown, traffic signals may not function as intended.

Addressing these challenges through regular maintenance, robust calibration, and technological advancements is crucial to ensuring the reliability and efficiency of intelligent traffic management systems.

APPLICATIONS

Traditional Traffic Light Systems

- Fixed-Time Control: Uses preset schedules, making it simple and cost-effective but inefficient during fluctuating traffic.

- Actuated Control: Uses sensors to detect vehicles but optimizes only individual intersections.

Algorithmic Approaches

- Rule-Based Algorithms: Adjust signals based on preset density thresholds (e.g., extended green light for heavy traffic).

- Optimization Algorithms: Use mathematical models like linear programming and genetic algorithms to reduce delays.

- Machine Learning Approaches: Predict traffic patterns using real-time and historical data.

  o Reinforcement Learning: Adjusts signals dynamically based on feedback.

  o Deep Learning: Uses sensor data for accurate traffic density prediction.

Recent Technological Advances

- IoT Integration: Real-time traffic monitoring using connected devices.

- Computer Vision: Advanced video analytics for precise vehicle and pedestrian detection.

- V2X Communication: Vehicle-to-traffic light coordination for proactive traffic control.

Case Studies

- Pune, India: AI-driven traffic system reduced congestion by 30%.

- Singapore: Adaptive signal control improved traffic flow and reduced delays.

Challenges and Future Directions

- Challenges: Sensor reliability, high deployment costs, and scalability issues in large networks.

FUTURE SCOPE

While the prototype has demonstrated efficiency with promising results, real-world implementation presents additional challenges that must be addressed for large-scale deployment.

- **Enhanced Sensing Technology:** Low-range IR sensors may be inadequate for large-scale applications. Future systems can integrate ultrasonic sensors, radar, or LiDAR for improved accuracy in long-range traffic detection.

- **Minimizing Signal Interference:** Stray signals may affect sensor accuracy, leading to false data transmission. Advanced signal filtering and noise reduction techniques can help maintain reliable sensor performance.

- **Regular Calibration & Maintenance:** Periodic accuracy checks and calibration of sensors and microcontrollers are essential to ensure long-term efficiency and precision.

- **Safety & Failover Mechanism:** A backup manual override system should be in place to switch from automated to manual mode in case of sensor or circuit failures, preventing uncontrolled traffic buildup.

- **Intelligent Traffic Prediction:** Future advancements may involve wireless communication between traffic checkpoints, enabling intersections to anticipate incoming traffic using GPS connectivity and short- wave radio transmission, creating a more proactive and congestion-free system.

- **Automated Violation Detection:** The system can be

upgraded with AI-powered monitoring, where a red- light violation triggers an alarm, captures an image of the vehicle, and sends an alert to traffic authorities, ensuring better enforcement.

Integrating these innovations with modern Intelligent Transportation Systems (ITS) will make traffic management safer, more efficient, and adaptive to urban mobility challenges.

CONCLUSIONS

The increasing urbanization and rise in vehicular density have necessitated the development of intelligent traffic control systems (ITCS) to enhance road efficiency and reduce congestion. Traditional traffic management methods, relying on fixed-time signals, often fail to adapt to real-time traffic conditions, leading to delays, increased fuel consumption, and environmental pollution. This study has explored various advanced traffic control mechanisms, including IoT-based solutions, AI-driven algorithms, and adaptive signal systems, which demonstrate significant improvements in optimizing traffic flow. The implementation of ITCS, using sensor-based technologies and microcontrollers like Arduino, has shown promising results in laboratory settings. These systems dynamically adjust traffic signals, prioritize emergency vehicles, and enhance road safety, ultimately improving urban mobility. However, challenges such as high installation costs, sensor reliability, and system integration complexities remain barriers to large-scale deployment. Addressing these challenges through technological advancements, regular maintenance, and failover mechanisms will be crucial for the success of ITCS in real-world scenarios. Future research should focus on integrating AI-powered traffic prediction models, vehicle-to-infrastructure (V2I) communication, and automated violation detection to create a more intelligent and adaptive traffic ecosystem. By leveraging cutting-edge technologies and enhancing system resilience, ITCS can play a pivotal role in building smarter and more sustainable cities. The adoption of such intelligent transportation solutions will not only reduce congestion but also contribute to safer roads, lower emissions, and an overall improvement in the quality of urban life.

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Digital Health Innovations Reducing Inequality and Advancing Universal Health Coverage (UHC)

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ABSTRACT

Access to quality healthcare is a persistent challenge for rural and middle-class populations due to limited availability of healthcare professionals, high treatment costs, inadequate infrastructure, and socio-economic disparities. This project proposes an innovative healthcare application aimed at addressing these issues by integrating advanced features to ensure affordable, accessible, and inclusive medical services. The application, as outlined in the project, provides a secure interface with a splash screen, registration, and login pages, leading to a centralized home page. Key functionalities include hospital services like appointment scheduling, EHR (Electronic Health Record) integration, and emergency management. Infrastructure development is supported through IT systems, cloud storage, and medical equipment management. Additionally, the application integrates government healthcare schemes, insurance support, and health campaigns to provide subsidized services

KEYWORDS: *Healthcare System, Medical Process Management, Administrative Efficiency.*

INTRODUCTION

Healthcare accessibility is a significant challenge, especially for rural and middle-class populations, where barriers such as limited access to healthcare professionals, high costs, inadequate infrastructure, and lack of awareness hinder the delivery of essential services. To address these issues, this project introduces a comprehensive healthcare application designed to bridge the gap between underserved communities and quality medical care. The system, as outlined in the block diagram, begins with a user-friendly interface that includes a splash screen, registration page, and login page, ensuring secure and easy access for users. The application's central hub, the home page, branches

Into five key functionalities. Firstly, it offers hospital services such as appointment scheduling, doctor coordination, EHR (Electronic Health Record) integration, and emergency management, streamlining healthcare delivery. Secondly, it focuses on infrastructure development, enhancing medical facilities through IT systems, cloud storage, and backup solutions. Thirdly, the platform integrates government facilities, including healthcare policies, government schemes, insurance support, and health campaigns, aligning with public welfare initiatives. Additionally, the application incorporates cost-saving mechanisms such as automation, resource optimization, and remote consultations, reducing financial burdens on patients. Lastly, it features offline capabilities,

Ensuring local data storage, offline appointment management, and real-time synchronization to provide uninterrupted access in regions with limited connectivity. The Without Internet Facilities module bridges the digital divide by ensuring healthcare accessibility in remote or connectivity-limited areas. It provides offline support for crucial functions such as local data storage, offline appointments, patient data management, real-time synchronization when connectivity is restored, and critical care support. This module plays a pivotal role in emergency scenarios or regions with poor internet connectivity, ensuring that healthcare delivery.

PROBLEM STATEMENT

1. Strategies for Overcoming Challenges in Connecting Rural and Middle-Class Populations Limited access to healthcare professionals in remote and rural areas.
2. High healthcare costs, including consultations, treatments, and insurance premiums.
3. Inadequate healthcare infrastructure, such as hospitals and clinics.
4. Socio-economic disparities affecting access to healthcare services.
5. Lack of health education and awareness in marginalized communities that are unemployed.

LITERATURE SURVEY

Modify: Enhancing Healthcare Accessibility Technology Used: Kotlin, Java, Firebase, Jet Real-Time Data Collection in Mobile Health Applications [1] Technology Used: Wearable sensors, AI Android-Based Remote Patient Monitor in collection and anomaly detection via AI. [2] Application: Real-time health monitoring Future Scope: Improved predictive analytics, hospital system integration for proactive healthcare.[4]Technology Used: Machine Learning, Secure Encryption [5]Key Finding: Timely interventions improving patient outcomes.[6] Application: Chronic disease management, remote monitoring [7] Future Scope: AI-based predictive diagnostics, real-time analytics for critical care. [8] Real-Time Data Analysis in Health Monitoring Systems [9] Key Finding: Efficient collaboration, secure data handling, and improved patient satisfaction.

Technology Used: IoT, Machine Learning, Big Data Analytics, Cloud Computing

Key Finding: Early anomaly detection and improved patient care.

Application: Patient monitoring systems, wearable devices, telemedicine platforms Future Scope: AI integration, block chain for secure data sharing.

Performance Optimization in Mobile Healthcare Applications.

Technology Used: Data Compression, Caching Key Finding: Optimized energy usage and smoother app performance.

Application: General-purpose mobile healthcare.

Future Scope: Framework development for scalable applications.

Data Privacy in Mobile Applications is use Technology Used: Secure APIs, Block chain Finding: Emphasis on privacy.

A application: Data protection for healthcare applications

Future Scope: Block chain integration for enhanced security.

AI Integration in Health Monitoring Android Applications

Technology Used: Tensor Flow, Android SDK Key Finding: Improved diagnostic accuracy and reduced manual errors.

Application: Smart health diagnostics

Future Scope: Enhance wearable device compatibility and AI robustness.

Mobile-Based Diabetes Management Technology Used: Android, IoT

Key Finding: Better diabetes control through real-time monitoring and analysis.

Application: Diabetes management and patient education.

Future Scope: Predictive analysis for insulin dosage recommendations. Digital health innovations have emerged as a significant driver in addressing healthcare disparities and promoting Universal Health Coverage (UHC). Various studies highlight the role of telemedicine, artificial intelligence, electronic health records (EHRs), and other digital health technologies in reducing inequalities and improving healthcare access.

Telemedicine has played a crucial role in overcoming geographical barriers, enabling remote consultations, and providing medical se

EHRs and interoperability have facilitated seamless data exchange among healthcare providers, ensuring continuity of care and minimizing redundant procedures. Studies show that adopting EHRs leads to cost- effective healthcare management and improved patient outcomes. Additionally, digital health initiatives, such as IoT- enabled medical devices and cloud-based health platforms, have strengthened healthcare infrastructure in low-resource settings, providing cost-effective and sustainable solutions for UHC.

Despite these advancements, challenges such as data privacy concerns, digital literacy gaps, and unequal access to technology persist. Future research should focus on addressing these challenges while developing scalable, secure, and inclusive digital health ecosystems. By leveraging emerging technologies, digital health solutions can further reduce healthcare inequalities and enhance global health equity.

Emergency Care Android App: Enhancing Response Time

Technology Used: GPS, Real-time Communication

Key Finding: Reduced response time for emergencies by 30%.

Application: Emergency healthcare

Future Scope: AI-driven dynamic traffic routing for emergencies.

BLOCK DIAGRAM

fig:- Flow Diagram

Splash Screen: The first page users see when they open the app, typically used for branding and loading processes.

Registration Page: A page where users can create accounts by entering their details to access the app's features.

Login Page: A secure page for existing users to log into their accounts.

Home Page Application: Acts as the central hub of the app where users can access all the primary functionalities.

-Functional Categories

The Home Page Application branches into five main functional areas:

a) Hospital

This section addresses healthcare-specific tasks and services:

Appointment Scheduling: Allows patients to book consultations with doctors easily.

Doctor Coordination: Facilitates seamless communication and collaboration between medical professionals.

Patient Diagnosis & Treatment: Supports tools for assessing and treating patients.

EHR (Electronic Health Records) Integration: Centralized storage for patient medical histories.

Emergency Management: Helps in managing urgent and critical care situations effectively.

b) Infrastructure

This section focuses on the technological and physical backbone:

Medical Equipment: Managing the usage and maintenance of hospital devices.

IT Infrastructure: Ensures that all technological systems (servers, networks) are in place.

Cloud Storage Systems: Secure storage for medical data in the cloud.

Hospital Facilities: Includes room management, hygiene monitoring, etc.

Backup Systems: Ensures that all medical and Operational data is protected from loss.

c) Government Facilities

This section highlights how the app integrates with government support:

Healthcare Policies: Access to updated health- related policies.

Government Schemes: Information about programs aimed at benefiting citizens.

Insurance Support: Integration with health insurance providers for claims and payments.

Infrastructure Development: Collaboration with authorities to improve healthcare systems.

d) Cost Saving

This section emphasizes optimizing resources:

Automation: Reduces manual efforts in administrative and operational tasks.

Administrative: Streamlining workflows for better efficiency.

Error Reduction: Minimizes human errors through automated tools.

Resource Optimization: Better allocation of medical and technological resources.

Billing Streamlining: Simplifies payment and billing processes.

Remote Consultations: Allows patients to consult doctors without visiting the hospital physically.

e) Without Internet Facilities

This section ensures app usability in offline scenarios:

Local Data Storage: Saves data locally on the device for offline use.

Offline Appointments: Enables booking appointments without an internet connection.

Offline Patient Data: Access to critical patient data without requiring the internet.

Real-Time Sync: Synchronizes data automatically when the internet is available.

Support for Critical Care: Ensures essential features are available offline, especially for emergencies.

ADVANTAGES

Accessibility and Convenience

24/7 Availability: Healthcare apps provide users with continuous access to their medical records, health data, and medical advice without requiring in-person visits. This convenience is especially crucial for patients in remote or underserved areas .Real-time Monitoring: Many health apps

Integrate with devices like wearables (e.g., Fitbit, Apple Watch) to allow real-time monitoring of vital signs like heart Cost-Efficiency

Reduced Healthcare Costs: By allowing patients to monitor their own health and consult with healthcare providers remotely, these app scan reduce the need for frequent in-person visits and hospitalizations, ultimately lowering healthcare costs

Reduced Burden on Healthcare Systems:
With more patients managing their health remotely, healthcare systems can focus resources on critical cases, optimizing care delivery Personalized Healthcare

Tailored Health Plans: With the ability to track individual health data, the app can generate personalized health recommendations, medications, and fitness plans, making the care more individualized and relevant to the user's needs

Patient Empowerment: Empowering patients with tools to track their health data and make informed decisions about their care fosters a more active role in managing their own health

DISADVANTAGES

Data Privacy and Security Concerns
Risk of Data Breaches: Storing sensitive n health information mobile app scan make it vulnerable to data breaches or unauthorized access if the app does not have robust security measures Compliance with Regulations: Ensuring the app complies with regulations like HIPAA or GDPR can be complex and time-consuming

Reliability of Data

In accurate Data from Wearables: We are able sensors may provide in accurate-

Or incomplete data, which to incorrect the assessment so missed diagnoses
Device Compatibility Issues: Not all smartphones or devices are compatible with every health monitoring tool or wearable, leading to potential issues with data syncing and usage
.
Limited Access and Digital Literacy

Not Accessible to All: People without smartphones, internet access, or technical knowledge may struggle to use the app, excluding large section soft he population
Elderly Population: Older adults may find it difficult to navigate the app's features, especially if the interface is complex or not optimized for senior users

APPLICATION

Telemedicine and Remote Care:
The system enables real time consultation sand medical services through telemedicine, allowing patients in remote and rural areas to access quality healthcare without physical travel. It bridges the gap between patients and healthcare providers.

Offline Health care Services:
For areas with limited or no internet access, the system provides offline data storage, appointment scheduling, and critical care support. It ensures continuity of healthcare services under all circumstances, especially in rural areas.

Emergency and Critical Care
The healthcare system facilitates faster response times during emergencies, ensuring immediate medical intervention. It supports critical care units with tools for both online and offline access, saving lives during critical situations.

SOLUTIONS
Introduce tele medicine platforms for remote

Deploy mobile health clinics for periodic visits. Provide incentives for doctors to work in rural areas.

High Healthcare Costs:
Promote government-sub insurance schemes. Implement generic medicine programs to lower costs. Enable low-cost healthcare packages for basic treatments.

Inadequate Healthcare Infrastructure: Establish public-private partnership to build hospitals. Invest in low-cost modular clinics for rural areas. Use community workers to bridge gaps.

Socio-Economic Disparities:
Offer free or low-cost healthcare plans for low-income families.
Promote NGO-driven health initiative store a marginalized group.
Implement cashless healthcare policies for critical care.

FETURESCOPE

User Authentication and Profiles Secure Login:
Implement user authentication systems (e.g., email/password, biometric authentication) to ensure that patient data remains secure.
User Profiles: Each patient or healthcare provider can create and maintain a personalized profile, which includes medical history, ongoing treatments, and preferences.
Health Monitoring and Data Collection
Vital Signs Tracking: The app can track vital signs such as heart rate, blood pressure, temperature, and oxygen levels using integrated sensors or connected devices.
Wearable Integration: Seamless integration with fitness trackers or smart watches (e.g., Fitbit, Apple Watch, or Google Fit) to collect data

Symptom Logging: Patients can log symptoms they are experiencing (e.g., fever, cough, fatigue), which can help healthcare providers track health trends and make informed decisions.

Telemedicine and Virtual Consultations
Real-time Communication: Video calls or instant messaging for consultations with healthcare providers. This feature is beneficial for follow-up consultations and remote monitoring of patients.
Chatbot's for Health Advice: AI-powered Chatbot's can provide instant health advice based on symptoms, helping patients decide whether they need to see a doctor or take specific actions.

CONCLUSION

A hospital appointment and patient tracking application would significantly streamline healthcare processes by enabling efficient scheduling, reducing wait times, enhancing patient experience, and improving overall administrative workflow. It would provide patients with convenient access to their appointments, medical records, and notifications, ultimately leading to better patient outcomes and satisfaction. Additionally, such an application could help healthcare providers better manage their resources, optimize staff allocation, and minimize scheduling errors, ultimately leading to more effective and cost- efficient healthcare delivery. The healthcare system plays a transformative role in improving the efficiency, accessibility, and quality of healthcare services. By integrating advanced technologies, it streamlines hospital management, supports infrastructure development, and facilitates government healthcare programs. The system ensures cost optimization through automation while expanding healthcare access via telemedicine and offline services. With features like secure data integration, emergency care support, and resource optimization, it addresses the needs of both urban and rural populations. SIT promoted multiple international health policies, which helped in their promotion

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"AUTOMATIC SEGREGATION OF DRY AND WET GARBAGE "

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ABSTRACT

The review paper focuses on the development and implementation of we propose an innovative solution in the form of an automated machine designed for the efficient segregation of dry and wet waste at the point of collection. The proposed system utilizes a combination of advanced sensors, mechanical sorting mechanisms, and machine learning algorithms to automatically distinguish and segregate dry (recyclable) waste from wet (organic) waste. The machine is equipped with infrared sensors, capacitive sensors, and weight sensors that enable it to detect the type and moisture content of waste materials.

KEYWORDS: Automatic Segregation , mechanical sorting mechanisms, Sensor-Based Technology.

1. INTRODUCTION

When world is facing a pressing issue of garbage, which contributes to diseases and overflowing bins. Solid waste management is a significant challenge in urban cities, particularly in India, and other countries worldwide. To address this issue, a smart cityconcept has been proposed, with the aim of building 100 smart cities.The primary need for a smart lifestyle is cleanliness, and dustbins play a crucial role in proper waste collection. In India, the current waste management system is primarily unhealthy, with dustbins being a major issue. This paper aims to upgrade the dustbin component of the urban waste management system, integrating analytics and electronics to create optimal changes in waste collection methods.

By integrating analytics and electronics, the paperaims to create optimal changes in waste collection methods, utilizing the vast amount of data produced by smart bin networks. The increasing population has led to improper waste disposal, consuming time and manpower. Unplanned waste disposal methods, such as landfills, can cause harm to living beings and pollute surface and underground water. This also accelerates harmful bacteria, deteriorating the environment's aesthetic value. In India, solid waste recycling is primarily done by rag pickers, who face health issues like skin infections and respiratory problems. To reduce their dependence, automatic waste segregation in dustbins can be implemented. Waste is segregated into metallic, dry, and wet streams, with potential for recycling and reuse.

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Unplanned waste disposal methods, such as landfills, can cause harm to living beings and pollute surface and underground water. This also accelerates harmful bacteria, deteriorating the environment's aesthetic value. In India, solid waste recycling is primarily done by rag pickers, who face health issues like skin infections and respiratory problems. To reduce their dependence, automatic waste segregation in dustbins can be implemented. Waste is segregated into metallic, dry, and wet streams, with potential for recycling and reuse.

Segregating waste at the source is preferable over using multiple industrial waste segregators. This method eliminates the need for rag pickers and directs the segregated waste to a recycling plant. Currently, there is no automatic system for segregating dry, wet, and metallic waste. The project aims to create a compact, low-cost, and user-friendly waste segregation system for urban cities, streamlining the waste management process.

The automatic segregation of dry and wet garbage is an innovative technological solution aimed at improving waste management systems. It involves using automated processes to sort waste materials into two main categories: dry waste (such as paper, plastics, metals, and glass) and wet waste (such as food scraps, organic matter, and biodegradable materials). This segregation process plays a crucial role in reducing environmental pollution, enhancing recycling efforts, and promoting sustainability.

Traditional methods of waste segregation often rely on manual labor, which can be inefficient, error-prone, and costly. In contrast, automated systems leverage technologies such as sensors, artificial intelligence (AI), and robotics to accurately distinguish between different types of waste. These systems can efficiently sort and separate dry and wet garbage, ensuring that each type is directed to the appropriate disposal or recycling facility.

2. LITERATURE SURVEY

Recent research on smart waste management systems has seen a significant shift towards leveraging advanced technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), and machine learning (ML). These innovations aim to improve waste segregation, optimize collection processes, and make waste management systems more sustainable and efficient.

One of the earliest contributions to this field was the Smart Waste Management System for Urban Areas (2020), which utilized IoT-based sensors, image processing, and machine learning to segregate waste. The system aimed to enhance waste sorting, with the future scope focusing on integrating AI to identify hazardous materials, thereby increasing efficiency and safety in urban environments.

Following this, IoT-enabled Smart Bins for Waste Segregation (2020) explored the use of ultrasonic sensors and IoT devices to distinguish between dry and wet waste. The potential for these systems to integrate with municipal waste management infrastructure was identified, offering an avenue for automated scheduling of waste pickups, reducing manual intervention and improving logistical efficiency.

In 2020, the Automatic Waste Segregator and Monitoring System was proposed, focusing on Arduino-based smart systems for waste segregation. This system, while functional in small-scale settings, holds future potential for scaling up to handle more complex waste types, such as biomedical waste, which requires specialized handling due to its hazardous nature.

The Automatic Waste Segregation System Using IoT (2021) employed IoT-enabled smart bins that incorporate weight sensors for real-time waste monitoring. This system could expand to industrial waste segregation and has the potential for community-wide scalability, making it suitable for both residential and large-scale waste management applications.

Further advancements in machine learning are seen in Deep Learning for Waste Management (2021), which utilized deep learning algorithms like transfer learning for waste categorization. This research presents a future direction that extends the model to identify recyclable materials, making recycling processes more efficient and reducing waste sent to landfills.

Another notable development is the **AI-Powered Waste Segregation Techniques (2022)**, which employed Convolutional Neural Networks (CNNs) for image recognition to efficiently sort waste. The future scope of this research points to the development of eco-friendly disposal mechanisms linked to the waste segregation system, fostering more sustainable waste disposal methods.

In a similar vein, Plastic Waste Segregation Using AI (2022) highlighted the use of AI for classifying various types of plastic waste. This approach offers great potential for improving recycling rates by linking AI models to recycling facilities, enabling faster and more efficient processing of plastic materials.

The research in AI for Waste Sorting: Leveraging CNNs for Waste Classification (2022) further emphasized the role of CNNs in waste sorting, offering improved accuracy in waste classification. Future developments could see the implementation of these systems in community recycling programs, thereby enhancing their effectiveness and participation rates.

The Smart Waste Management System Using IoT and ML (2022) introduced the concept of using IoT and ML for real-time waste tracking. Future applications could see these technologies detecting hazardous materials in waste streams, enhancing the safety and efficiency of waste management processes.

Finally, the most recent development, Automated Waste Segregation and Recycling Using Robotics and AI (2023), integrated robotic sorting arms with AI algorithms for waste type detection. This system holds promise for future improvements by integrating real-time traffic data to optimize waste collection routes and timings, further reducing environmental impact and operational costs.

3. METHODOLOGY

The waste management system begins with the collection of waste from households, industries, or commercial areas, which is then fed into a conveyor system for processing. The system employs various sensors to identify and classify different types of waste. A moisture sensor detects wet waste based on its moisture content, while capacitive and inductive sensors help distinguish metallic and non-metallic dry waste. Infrared (IR) sensors assist in identifying materials based on their light absorption properties, and optional image processing using AI-based vision systems can further enhance waste classification.

Once identified, the waste passes through a sorting mechanism, such as rotating sieves or vibrating mesh, which separates smaller wet waste particles from the dry waste. After sorting, the separated materials are directed to appropriate disposal methods. Dry waste, including plastics, paper, and metals, is sent for recycling, while wet waste, like food scraps and organic matter, is sent for composting or biogas production.

The system's implementation utilizes microcontrollers like Arduino or Raspberry Pi for automation, as well as various sensors (moisture, IR, ultrasonic, inductive) to aid in waste identification. AI and machine learning technologies further support advanced waste classification. Conveyor belts and motors are employed to move the materials efficiently through the system.
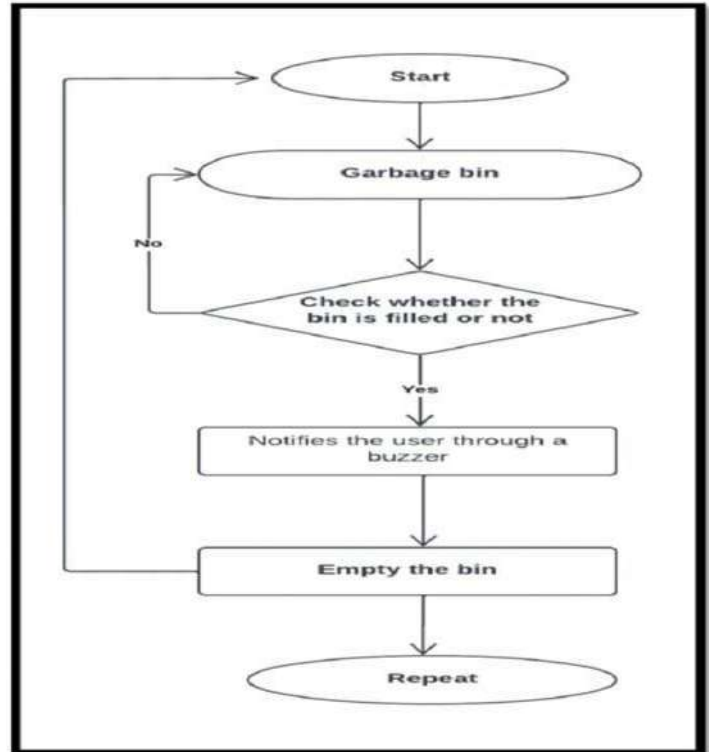
4. REQUIRMENTS/ TOOLS

❖ HARDWARE REQUIRED

Hardware :-

1. Sensors

- Moisture Sensor: To differentiate between wet and dry waste.

- Ultrasonic Sensor: For monitoring bin levels.

- IR Sensor: To detect the presence of objects for segregation.

2. Microcontroller/Processor

- Arduino Uno / Raspberry Pi: For controlling the sensors and managing data processing.

3. Actuators and Motors

- Servo Motors: For sorting mechanisms (e.g., moving flaps to separate waste).

- DC Motors: For conveyor belt operation.

4. Power Supply

- Power adapters or batteries compatible with the selected microcontroller.

5. Communication Modules

- Wi-Fi Module (e.g., ESP8266/ESP32): To enable IoT connectivity for monitoring

  waste levels remotely.

- GSM Module: For sending notifications to authorities.

6. Garbage Bin Structure

- Customized bins with compartments for segregated dry and wet waste.

7. Miscellaneous Components

- Breadboards, connectors, jumper wires, and resistors for hardware integration.

❖ SOFTWARE REQUIRED

1. Development Environment

- Arduino IDE: For programming Arduino-based systems.

2. IoT and Cloud Services

- Blynk/Thing Speak: For real-time data visualization and remote monitoring.

- Firebase/AWS IoT: For scalable cloud storage and notifications.

3. Embedded System Programming

- C/C++: For Arduino.

- Python/Node.js: For Raspberry Pi or similar boards.

4. Database and Communication

- SQLite/MySQL: For storing waste segregation logs.

  MQTT Protocol: For efficient communication between sensors and the cloud.

5. Mobile or Web Application

To notify authorities about bin status or for user interaction. Frameworks like flutter or React can be used.

5. APPLICATION

Smart waste management systems are becoming increasingly advanced, integrating automation and technology to streamline waste segregation and processing. Smart waste bins are one of the key innovations, equipped with sensors and mechanisms that automatically separate dry and wet waste at the point of disposal. In smart cities, for example, these bins could utilize weight sensors, moisture detection, or AI to classify waste as it's thrown in, ensuring accurate segregation for later processing.

On a larger scale, automated sorting facilities utilize robotic arms, conveyor belts, and advanced sensors such as infrared or RFID to separate dry and wet waste efficiently. These municipal or industrial waste sorting plants automatically process waste, separating recyclables (dry) from organic waste (wet) for further treatment or disposal.

In waste-to-energy (WTE) plants, automated systems separate wet organic waste, which is used for biogas production, from dry waste, which is processed for incineration and energy recovery. For instance, food scraps (wet waste) can be directed for anaerobic digestion, while dry waste is incinerated to generate energy.

Recycling plants employ automated sorting systems to segregate recyclable dry materials like paper, plastic, and metal from organic waste more efficiently. These systems improve the purity of recyclables and reduce contamination, ensuring a higher quality of materials for recycling processes.

At the household level, home waste management systems assist in sorting waste directly at home before it's collected by waste management services. A kitchen trash bin with sensors that detect moisture or weight could, for example, sort food waste (wet) from non-organic materials like packaging or plastic (dry), making household waste management more efficient.

In public spaces, smart public trash bins placed in parks, streets, or other high-traffic areas automatically

segregate dry and wet waste, helping municipalities achieve better waste segregation with minimal manual effort. These bins streamline waste collection and reduce the need for human intervention.

Finally, zero-waste and circular economy solutions use automated systems to separate waste streams efficiently in facilities or businesses aiming for minimal waste. These systems ensure maximum recycling and composting, allowing more materials to be reused or composted, thus supporting a circular economy. For

instance, a zero-waste facility might process organic and non-organic waste streams separately, enhancing sustainability by minimizing waste sent to landfills.

These innovations highlight the significant role automation and smart technology play in enhancing waste management processes, improving recycling rates, and contributing to environmental sustainability.

6. CHALLENGES AND LIMITATIONS

- **Technological Challenges:**- Difficulty in accurately differentiating between waste types due to limitations in sensors and varying waste characteristics.

- **High Costs:-** Significant initial investment and ongoing maintenance costs for automation systems.

- **Waste Contamination:-** Mixed or improperly segregated waste can reduce sorting efficiency and accuracy.

- **Public Participation:-** Reliance on proper waste segregation at the source, which can be inconsistent.

- **Energy and Environmental Impact:-** Automation can consume substantial energy and produce electronic waste.

- **Waste Diversity:-** Variability in waste composition based on region or season complicates standardization.

- **Infrastructure and Scalability:-** Challenges in setting up automated systems, especially in rural areas or places with limited resources.

CONCLUSION

In conclusion, the automatic separation of dry and wet garbage provides a highly effective method for managing waste more efficiently. By automating the sorting process, it reduces human error, minimizes contamination, and ensures that recyclable materials are properly separated from organic waste. This technology not only streamlines waste management operations but also contributes to environmental sustainability by facilitating recycling, reducing landfill use, and promoting cleaner, more responsible **waste** disposal practices. Ultimately, it represents a crucial step toward creating smarter, more sustainable urban environments.

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IOT Based Smart Energy Meter

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ABSTRACT

This research paper focus on development of an '**Smart Energy Meter based on Internet Of Things'**. With the growing demand of electricity its hard to manage an efficient energy. Traditional Meter which is found in every house nowadays require manual reading and often lead to errors or delays in billing. An IOT based smart energy addressed these issues by enabling real-time monitoring and automated-billing. By the use of smart energy meter, it allow users to track their energy and get updated all time through an app or a web dashboard. By using these energy meter help users to reduce the wastage of electricity. The smart meter is recharged with the help of Esp module. In this meter, energy utilization and the corresponding amount will be displayed on the LCD continuously. The feedback from the user helps in identifying the usages between authorized and unauthorized users which helps in controlling the power wastage. Esp module is used for sending messages to the local authorities regarding user power consumptions. Also they can monitor the meter readings regularly without the person visiting each house. This technology not only reduce the human efforts but also promotes energy conservation by allowing and encouraging users to monitor and optimize their energy consumption.

*KEYWORDS:*Esp module, smart meter, IoT, energy

INTRODUCTION

Electricity is an essential part of our daily lives, but managing energy consumption efficiently can be cab bea challenge. Traditional energy meters require manual readings, which can lead to errors, delays in billing. With the advance technology, **IoT-based smart energy meters** are transforms the way we monitor and manage electricity usage. Our policies of its distribution are partially responsible for this because we are still not able to correctly estimate our exact requirement and still power theft is prevailing. On the other hand, consumers are also not satisfied with the services of power companies. Most of the time they have complaints regarding statistical errors in the monthly bills. With this we can monitor meter and track if any fault is there or not. In previous

meter a circular metal strip rotates and according to that rotation we calculate the consumption. But our meter works on pulse which is obtained with the help of LDR sensor according to consumption and we previously connected Arduino board which monitor the pulse and according to pulse the bill is generated. In this way we can reduce human efforts needed to record the meter readings which are till now recorded by visiting every home individually. Smart energy meter is an electronic device that measures the most accurate amount of electricity consumed by a residence, business or any electrically-powered

METHODOLOGY

ARDUINO UNO : The Arduino Uno is an open-source microcontroller board based on the Microchip. The board has 14 digital I/O pins, 6 analog I/O pins, that may be interfaced to various circuits and is programmable with the Arduino IDE, via a type B USB cable. It can be powered by the USB cable or by an external 9- volt battery, though it accepts voltages between 7and 20 volts.

ESP12E NODE MCU MODULE : Node MCU is an open source development board and firmware based in the widely used
ESP12E WiFi module. It allows you to program the ESP WiFi module with the simple and Arduino IDE. ESP-12E is a Wi-Fi Module based on ESP8266EX. SoC.. Since it has a Microcontroller the ESP-12E can be used as either a stand-alone device with its Wi-Fi connectivity and or it can be used as a Wi-Fi adapter for other microcontrollers like Arduino .

16x12 LCD : An LCD stands for Liquid Crystal Display is a screen with an electronic display module and has a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. The 16 x 2 intelligent display is capable of displaying various different characters and symbols. This LCD has two registers, namely, Command and Data. Command register stores various commands given to the display.

OPTOCOUPLOUR : The optocoupler is for general purpose application. It consists of gallium arsenide infrared LED and a silicon NPN photo transistor. An optocoupler is used to break the connection between

device. An **IoT based smart energy meter** is a modern device that connects to the internet and allows users to track their electricity consumption in real time. It automatically records energy usage and sends accessed through a smartphone app or web dashboard. This means users can monitor their energy consumption anytime and receive alerts if they are using too much power. By using IoT-based smart meters, both consumers and electricityproviders can save time, reduce costs, and contribute to energy conservation, making our homes and cities smarter and more sustainable. signal source and signal receiver, so it used to stop electrical interference. An opto-isolator it is also called an optocoupler or optical isolators an electronic component that transfers electrical signals between two isolated circuits by using light.

SINGLE CHANNEL RELAY DRIVER : The Single Channel Relay Module is a convenient board which can be used to control high voltage, high current load such as motor, solenoid valves, lamps and AC load. It is designed to interface with microcontroller such as Arduino, PIC and etc..

ENERGY METER : An analog power meter is a device that features a printed display to indicate any electrical parameter. For example, the energy consumed by a typical business, or electrical device. It is also called an electromechanical meter, these offer a simple to read a display. The energy meter is an electrical measuring device, which is used to record Electrical Energy Consumed over a specified period of time in terms of units.
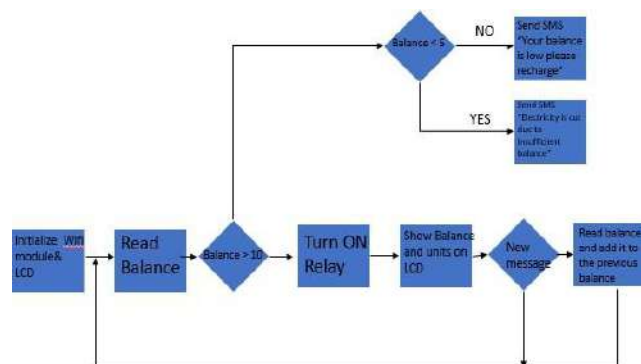
Figure 1. Block Diagram of an IOT Based Smart Energy Meter

At first in a day it initialize electricity with a WiFi

Module.

Then it read a balance on daily bases.

If the balance is greater then 10 then it automatically turns on the realy which controls the voltage.

After that it shows balance and daily used units on the LCD.

Then it shows a new message to your mobile app or a web dashboard which one you have in your mobile phone.

After that it will be read your balance and units and add it to your previous balance on daily bases.

But is your balance is greater then 5 then it sends an alert message to the app or web dashboard that "Your balance is low please recharge" and if your balance is greater then 5 then it sends a message that "Electricity is cut due to insufficient balance".

TECHNOLOGY

ARDUINO IDE : The Arduino IDE which is stands for Integrated Development Environment or Arduino Software contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. The open-source Arduino IDE Software makes it easy to write code and upload it to the board. This software can be used with any Arduino board which is used to display used balance units and messages.

MOBILE APPLICATION : Smart meters provide mobile and web-based applications to users for real-time monitoring, billing, alerts, and reports on energy consumption. These applications are typically designed with user-friendly dashboards. Integration with smartphones and email systems help users to receive notifications when energy consumption exceeds predefined thresholds or when unusual activity is detected.

SMART BILLING : Automated billing features enable real-time billing based on energy consumption. The system can detect discrepancies in readings and offer transparent, up-to-date billing information to users. In some advanced systems, blockchain technology may be incorporated to secure and automate transactions, ensure accurate billing, and allow energy trading.

POWER SUPPLY : Since energy meters need to be reliable and energy-efficient, the system components like sensors and wireless communication modules are designed for low-power consumption, often using battery or energy-harvesting methods for operation.

SECURITY TECHNOLOGY : To ensure secure transmission of data, encryption protocols such as TLS Transport Layer Security **or** AES which is stands for Advanced Encryption Standard are employed to protect data while it's in transit. If someone try to temper your electricity it sends an alert SMS to your mobile application.

ONLINE PAYMENT: Energy meter gives services of online payment to users with the help of these service users pay anytime form anywhere given by the QR on the system or a bill. It help save user time or efforts by going to the office for pay bills by using this online payment technology.

WIFI MODULE : By implementing the WiFi module in our traditional energy meter help user to update all time by using mobile application or web dashboard about daily used units and electricity and if anyone tempter then with the help of these module it gives alert SMS to user.
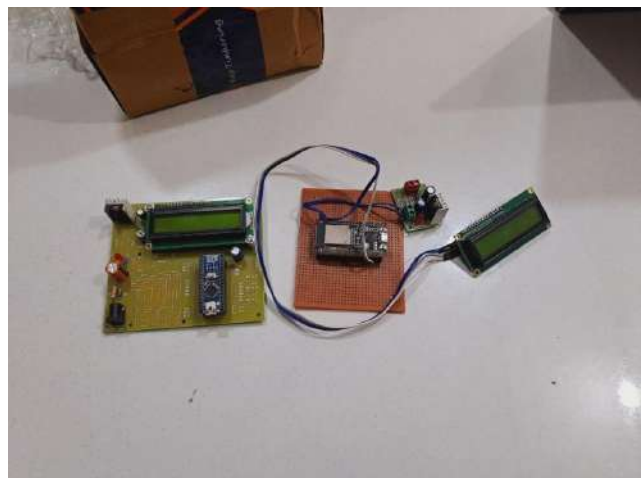
Figure 2: Arduino and ESP WIFI Module

APPLICATION

REAL TIME MONITORING FOR ENERGY CONSUMPTION : IoT-based energy meters continuously track and send real-time data about electricity usage to a centralized platform . Users can view their energy consumption data anytime via mobile apps or web dashboards.

REMOTE METER READING : Companies can remotely read energy meters without requiring physical visits to each location. This is done by wirelessly transmitting data from the energy meter to the utility database. Saves on labor costs, reduces human error, and ensures accurate billing.

AUTOMATIC FAULT DETECTION AND ALERT : IoT enabled meters can detect faults or errors, such as power outages, overconsumption, or faulty connections, and send alerts to users and companies. Faster response times to issues, reducing downtime and improving service reliability.

LOAD MANAGEMENT : Smart energy meters can assist in load balancing by analyzing consumption data. They can send information on peak usage times to utility companies, which can implement measures like load shedding or shifting. Ensures a stable supply of energy and helps prevent overloading of the power grid.

ENERGY THIEF PREVENTION : IoT-based energy meters can detect irregularities like tampering, theft, or unauthorized consumption by tracking usage data or patterns and comparing them to normal behaviour. Helps utility companies identify and prevent energy theft, reducing financia

TIME-OF-USE PRICING AND DYNAMIC BILLING : Smart meters can support time-of-use pricing models, where consumers pay different rates based on the time of day or season when they consume electricity. Encourages consumers to use energy during off-peak hours, balancing the grid and reducing costs.

GRID OPTIMIZATION AND SAMRT GRID INTEGRATION : The data from smart meters helps utility companies optimize grid operations by providing insights into demand patterns, enabling more accurate predictions and better grid management. More efficient grid operations, reducing energy waste, and improving grid reliability.

INTEGRATION WITH SMART HOMES AND BUILDING : Smart meters can integrate with home automation systems, allowing users to control energy usage through smart devices, such as thermostats, lights, and appliances. Enables seamless energy management, contributing to greater convenience and efficiency in home or building management.

ENERGY EFFICIENCY AND CONSUMPTION ANALYTICS : By collecting and analyzing energy usage data, IoT-based meters provide insights into consumption trends and suggest areas where energy efficiency can be improved. Consumers can optimize their energy use, leading to cost savings and reduced environmental impact.

EMVIRONMENTAL IMPACT MONITORING :By monitoring energy usage and comparing it with environmental standards or renewable energy sources, IoT-based meters can help reduce carbon footprints. Supports sustainable practices and compliance with environmental regulations.

CONSUMER ENGAGEMENT : IoT-based meters allow consumers to track their energy consumption, set goals, and receive recommendations on how to reduce usage. Promotes energy-saving behaviors and engages consumers in sustainable energy practices.

CHALLENGES AND LIMITATIONS

High Cost : Generally smart energy meter is more costly than a traditional meter . Many companies and peoples may not want to spend extra money for smart energy meter to install that in homes or companies.

Internet Or Network Issues : Basically smart energy meter need internet or network such as WiFi , GSM etc. for transform or send data and SMS , if the network is weak or unavailable then the data may not

be reach to the users or companies .For this it has a possible solutions to use multiple communication options, like both the Wifi or GSM for better connectivity.

Risk or Hacking and Data Theft : As the smart energy meter is transfer the data online so it has a risk of hacking the data. The hacker could steal the energy usage data and even multiple electricity bills. For this it has to use a strong security measures like energy encryption and regular software updates.

Not Compatible with Old Meters : Many homes or buildings use old energy meter that cannot be upgraded with smart energy meters easily. By replacing all old meters with smart meters in city or countries takes lots of time , efforts and money. For this it has to be used hybrid systems that works with both the old and new meters.

Use Extra Power : Smart energy meters need electricity to work or send data, if there is a power cut it can be lose the connection or may stop working . For this there has a possible solution to add backup batteries and low-power technology.

Hard to Manage For Many Users : Generally, in cities with million of users, handling various different data from smart energy meter is difficult. If there is too much data, so it can be slow down processing and increase cost. For this it has to use a edge computing to process some data locally before sending it to the cloud.

People May Not Trust or Understand It : Some people may not understand or trust on that how smart energy meter works. People might think that they increase their bills unfairly and invade their privacy. For this the power companies educate users and show them the benefits.

Maintenance and Repair : In smart energy meter they have electronic parts that can fails due the dust , over heat and aging. For this regular maintenance is needed, which adds to the costs. For this it is better designing a durable, weatherproof meter with self checking meter.

Legal and Governments Rules : Some countries have strict rules about the energy meter and data privacy. So, it can take long time to get approvals for smart energy meters. So, it better to work with government agencies to follow the legal guidelines.

Cloud Service Dependencies: As the many smart energy meter stores data in the cloud so, if the cloud server goes down then the user may not be able to see their energy data. For this it has a possible solution to have a local storage backup for emergencies.

CONCLUSION

IoT-based smart energy meters are a modern solutionfor tracking and managing electricity usage in real-time. They help to save energy, reduce electricity bills, and prevent power theft by providing accurate consumption data to both users and utility companies . IoT-based smart energy meters represent a significant advanced technology in energy management. With features like remote monitoring, automated billing, and alerts for high energy use, they make energy managementmore efficient and convenient. By integrating with smart grids, artificial intelligence, and data analytics, these meters empower consumers and utilities to make informed decisions, optimize energy usage, and reduce operational costs. As technology improves, they will become cheaper, more secure, and widely adopted, helping us move towards a smarter and more sustainable world. Overall, IoTbased smart energy meters have the potential to revolutionize energy management, contributing to greater efficiency, sustainability, and the future of smart cities.

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Cryptocurrency Merger

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ABSTRACT

This project aims to create an all-in-one decentralized platform that combines **NFT minting**, an **NFT marketplace**, and a **crypto exchange**. Users can easily mint and tokenize digital assets, trade NFTs in a secure and user-friendly marketplace, and exchange cryptocurrencies seamlessly. The platform will feature cross-chain compatibility, smart contracts, and robust security measures to ensure transparency and trust. By empowering creators, collectors, and traders, this ecosystem bridges the gap between blockchain innovation and mainstream adoption, fostering a sustainable and inclusive digital economy.

KEYWORDS: Decentralized Platform, NFT Minting, NFT Marketplace, Crypto Exchange& NFT Collectibles.

INTRODUCTION

Non-Fungible Tokens (NFTs) have emerged as a groundbreaking innovation in the digital world, transforming how we perceive ownership, creativity, and commerce in the digital economy. These unique digital assets, underpinned by blockchain technology, ensure transparent and immutable ownership and provenance.

NFTs allow creators to tokenize their work—whether it's digital art, music, videos, virtual real estate, or in-game items—and sell it directly to consumers without the need for intermediaries. Unlike cryptocurrencies such as Bitcoin or Ethereum, which are interchangeable and divisible, NFTs are distinct and indivisible, making each one unique in its value and attributes.

The appeal of NFTs lies in their ability to provide a new level of value to digital goods. Previously, digital items could be easily copied and distributed, making it challenging to assign monetary value. With NFTs, creators can attach a unique, verifiable identity to their work, enabling buyers to own and trade these assets securely.

The Role of NFT Marketplaces

NFT marketplaces serve as the hub for buying, selling, and trading these tokens. These platforms function much like traditional online marketplaces but are tailored to the unique nature of NFTs. Users can browse, bid, and purchase NFTs using cryptocurrencies, most commonly Ethereum. The marketplaces also facilitate the minting process, allowing creators to tokenize their digital assets and list them for sale.

Some well-known NFT marketplaces include OpenSea, Rarible, and Foundation. Each platform offers unique features and caters to different types of users. For example, OpenSea is known for its broad range of assets and user-friendly interface, while Foundation focuses on high-quality digital art. These platforms make NFTs accessible to both seasoned cryptocurrency enthusiasts and newcomers exploring the space [3][13].

Currency Exchange and Accessibility

A critical aspect of NFT transactions is the use of cryptocurrencies. Most NFT marketplaces operate on blockchain networks like Ethereum, which require users to have cryptocurrency wallets funded with Ethereum or other compatible tokens. This can be a barrier for those unfamiliar with cryptocurrencies.

Currency exchange mechanisms bridge this gap by enabling users to convert fiat currencies (like USD, EUR, or INR) into cryptocurrencies. Platforms such as Coinbase, Binance, and Kraken provide seamless on-ramps for users to acquire the necessary digital currencies. Additionally, some NFT marketplaces are beginning to integrate features that allow for direct fiat payments, making the ecosystem more accessible to a broader audience.

For example, a user interested in purchasing an NFT might start by creating a cryptocurrency wallet. They would then use a currency exchange platform to buy Ethereum and transfer it to their wallet. From there, theycan connect their wallet to an NFT marketplace, browse listings, and participate in 2].transactions. These steps, while initially complex, are becoming increasingly streamlined, lowering the entry barrier for new users[2]

Challenges and Future Outlook

Despite their transformative potential, NFTs and their marketplaces face several challenges. Environmental concerns about the energy consumption of blockchain networks like Ethereum have led to criticisms of the technology's sustainability. However, ongoing developments, such as Ethereum's transition to a more energy-efficient proof-of-stake model, aim to address these issues.

Additionally, the volatile nature of cryptocurrency markets can impact the value of NFTs, making them a risky investment for some. Regulatory uncertainties also pose challenges, as governments worldwide grapple with how to classify and tax these assets.

Nevertheless, the future of NFTs looks promising. As blockchain technology continues to evolve and mature, it is likely to become more efficient, accessible, and widely adopted. NFT marketplaces are expected to integrate more user- friendly features, expand support for fiat transactions, and cater to a broader range of industries [8][14].

Requirements/Tools

Since we plan to deploy the platform on a local server, we'll need to optimize our resources to ensure a balance between performance, scalability, and cost-efficiency. Below are the requirements tailored for a local server setup.

Hardware Requirements

1. Local Server Specifications
Our local server will need to handle the computational demands of blockchain operations, NFT minting, and crypto exchange functionalities. We aim to set up:

- **Processor:** A multi-core processor like Intel Xeon or AMD Ryzen Threadripper for high-performance computing.
- **Memory:** At least 64GB of RAM to handle simultaneous processes and ensure smooth performance.
- **Storage:** A mix of SSD (for speed) and HDD (for capacity) storage, with around 10TB total capacity to store blockchain data, NFT metadata, and user transaction logs.
- **GPU:** A powerful GPU (e.g., NVIDIA RTX 3080) for tasks requiring high parallelism, such as cryptographic calculations.
- **Power Supply:** An uninterrupted power supply (UPS) for consistent server uptime.

2. Networking Equipment
To ensure a reliable connection and low latency, we will set up:

- High-speed Ethernet connections for seamless data transfers.
- Firewall devices to secure the network from unauthorized access.
- Redundant networking setups to minimize downtime in case of failures.

3. Backup and Disaster Recovery
We'll prepare for data protection and recovery using:

- External storage systems for daily backups.
- RAID configurations to prevent data loss in case of drive failure.

Software Requirements

1. Blockchain Node Setup
On our local server, we'll deploy blockchain nodes for transaction verification and smart contract execution. Software needed includes:

- Ethereum full-node software (e.g., Geth or Parity) for managing blockchain interactions.
- Polygon or Binance Smart Chain nodes to enable cross-chain capabilities.

2. Smart Contract Tools
For developing and testing smart contracts locally, we'll rely on:

- Truffle Suite and Hardhat for writing, testing, and deploying smart contracts.
- Ganache to simulate a local blockchain environment during development.

3. Backend Technologies
Our server will host the backend, which requires:

- Node.js for scalable and efficient backend logic.
- MongoDB as a database for storing user and NFT data locally.
- Redis for caching frequent queries to enhance performance.

4. Frontend Development
The local server will also handle frontend hosting using:

- React.js or Vue.js for dynamic user interfaces.
- Webpack for building and bundling the frontend locally.

5. Security Software

To ensure security for users and transactions on the local server, we'll implement:
- SSL certificates for encrypted communications.
- Local firewalls and Intrusion Detection Systems (IDS) for proactive threat management.

6. Decentralized Storage

- For NFT metadata, we'll integrate decentralized storage like IPFS, with the local server acting as a gateway node for quick access.

7. Development and Testing Tools

We will set up a complete development environment on the server with:
- Docker for containerizing different services.
- Git for version control and collaboration.
- Jenkins or GitLab CI/CD for continuous integration and deployment.

8. Monitoring and Maintenance

For monitoring server health and ensuring optimal performance:
- Prometheus and Grafana for performance metrics and visualization.
- Log aggregation tools like ELK stack (Elasticsearch, Logstash, Kibana) for troubleshooting.

Challenges We Plan to Address

1. Tackling Development Complexity

Building such an advanced platform will require significant technical expertise, but we are committed to assembling a team of skilled developers and blockchain experts. Through meticulous planning and innovative design, we will overcome the challenges of integrating multiple functionalities into a single system.

2. Preparing for High Scalability

To ensure smooth operation even under heavy user traffic, we plan to invest in scalable infrastructure and utilize efficient blockchain protocols. By prioritizing speed and performance, we will maintain a seamless experience as our user base grows.

3. Navigating Regulatory Landscapes

Understanding that the blockchain space is subject to evolving regulations, we will adopt a proactive approach to compliance. By engaging with regulatory authorities and staying updated on legal frameworks, we will ensure that our platform operates within the boundaries of the law globally.

4. Simplifying Blockchain for Beginners

Adopting blockchain technology can be daunting for newcomers. To address this, we plan to provide comprehensive guides, tutorials, and responsive customer support to make the platform approachable and user-friendly for all.

5. Ensuring Cross-Chain Efficiency

While cross-chain compatibility offers tremendous advantages, it can also introduce complexity. We will develop tools to simplify the process for users, ensuring a smooth and intuitive experience even for those unfamiliar with multi-chain environments.

6. Building Resilient Security Systems

Recognizing the risks of smart contract vulnerabilities and cyber threats, we will implement rigorous security audits and continuous monitoring. Our focus will be on creating a platform that not only meets current

security standards but also evolves to address emerging threats.
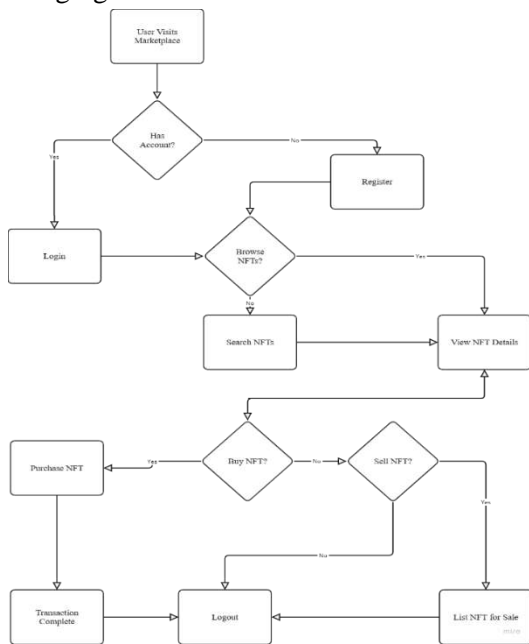
Our goal is to redefine how people interact with NFTs and cryptocurrencies by creating an all-in-one decentralized solution. By focusing on innovation, security, and user accessibility, we believe this project has the potential to become a cornerstone of the future digital economy.

Figure : Challenges in NFT Ecosystem
McKinsey & Company. (2022). *NFTs and Digital*

CONCLUSIONS

In conclusion, our decentralized platform will revolutionize the way users interact with digital assets by seamlessly combining NFT minting, a secure marketplace, and a crypto exchange into a single ecosystem. The outcome of our project will empower creators to tokenize their work effortlessly, provide collectors with a user-friendly space to discover and trade NFTs, and offer traders a reliable environment for exchanging cryptocurrencies. By leveraging cross-chain compatibility and smart contracts, the platform will ensure transparency, security, and efficiency, making it a standout solution inthe block chain space.

The project will also lay the foundation for community-driven governance, giving users a direct role in shaping the platform's evolution. With robust security measures and scalable infrastructure, our solution will handle the increasing demands of the decentralized market while maintaining performance and trust. The inclusion of educational initiatives, mobile accessibility, and future integration with the metaverse will further expand the platform's appeal and usability.

Through this project, we will deliver not just a technical solution but a comprehensive ecosystem that bridges the gap between blockchain innovation and everyday use. The outcome will be a sustainable, inclusive digital economy that positions our platform as a key player in the future of decentralized technologies.

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Hands-Free Gesture Recognition: A Contactless Framework for Human-Computer Interaction

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ABSTRACT

A gesture recognition system identifies and interprets movements like facial expressions or hand gestures for interactive applications. This project focuses on developing a hand gesture recognition system using an Infrared (IR) sensor matrix to detect 2D hand gestures and trigger corresponding actions, such as simulating keyboard inputs. To enhance efficiency, the system is optimized with only two IR sensors, reducing power consumption while maintaining high accuracy through a specialized IR feature set and classification algorithm. This technology enables contactless human-computer interaction, with potential applications in accessibility, gaming, and smart device control.

KEYWORDS: Hand gesture, IR Sensor, Two dimensional.

INTRODUCTION-

As mentioned in the abstract, a contactless gesture recognition system is planned to be developed by us, which will successfully recognize and differentiate between various hand gestures over the two-dimensional plane. Gesture recognition systems are broadly classified into two types:

1. Gesture Recognition over a Two-Dimensional Plane
2. Gesture Recognition over a Three-Dimensional Plane

1. Gesture Recognition in a Two-Dimensional Plane:

Two-dimensional (2D) gesture recognition involves detecting and interpreting gestures—whether hand movements, facial expressions, or other body motions—using sensors that capture data along two spatial axes, typically X and Y. Unlike three-dimensional systems that analyze depth, 2D gesture recognition focuses on movements restricted to a flat plane.

One of the most common examples of 2D gesture recognition is a laptop trackpad. It detects finger movements along the X-Y plane and translates them into corresponding cursor movements on the screen. The trackpad does not account for depth or finger elevation but instead registers directional shifts, taps, and swipes.

Similarly, touchscreen devices function as advanced 2D gesture recognition systems. Smartphones and tablets capture finger movements, interpreting touch gestures such as scrolling, zooming, and swiping to execute specific actions. These systems rely on capacitive or resistive sensors to accurately detect multi-touch interactions, enhancing user experience through intuitive, real-time responses.

Novelty in 2D Gesture Recognition

Traditional 2D gesture recognition systems rely heavily on direct physical contact, but emerging advancements are transforming this landscape. The integration of computer vision and artificial intelligence (AI) now enables contactless gesture recognition, allowing users to interact with devices without touching the screen. Techniques such as optical flow tracking, infrared sensing, and deep learning-based hand tracking enhance accuracy and usability, paving the way for innovative applications in accessibility, gaming, and human-computer interaction.

These advancements make 2D gesture recognition more versatile, enabling touch-free interactions in various fields, including healthcare, automotive systems, and smart home interfaces. As AI-powered vision models continue to evolve, the efficiency and responsiveness of gesture-based controls will further improve, making them an integral part of future human-computer interaction systems.

Gesture Recognition in a Three-Dimensional Plane

Unlike two-dimensional (2D) gesture recognition, three-dimensional (3D) gesture recognition systems capture and interpret gestures across all three spatial axes: X, Y, and Z. This additional depth (Z-axis) allows for more complex and dynamic interactions, enabling gestures to be recognized in free space without requiring a physical surface for input.

One prominent example of 3D gesture recognition is robotic-assisted surgery, where a doctor can perform procedures remotely using a robotic system controlled by a gesture-recognition glove. The system

precisely tracks hand movements in real-time, translating them into corresponding robotic actions.

The development of 3D gesture recognition systems presents significant challenges, including the need for advanced sensors, high computational power, and sophisticated machine learning algorithms. However, recent innovations are making these systems more accessible and efficient:

AI-Powered Hand and Body Tracking: Deep learning models enhance real-time hand and
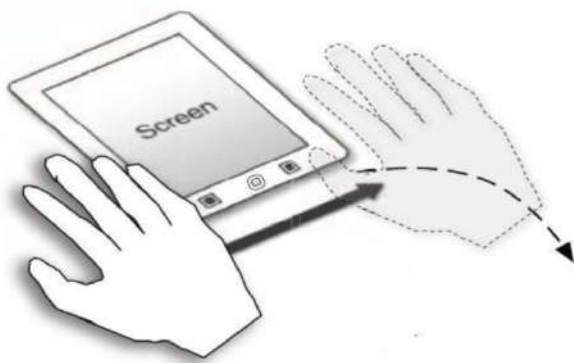
body tracking, improving accuracy and adaptability to different environments.
LiDAR and Infrared Sensors: Advanced depth-sensing technologies, such as LiDAR (used in AR applications) and infrared sensors, provide precise spatial awareness, enabling seamless gesture detection even in low-light conditions.
Haptic Feedback Integration: To improve user experience, some systems incorporate haptic feedback, allowing users to "feel" virtual objects in augmented and virtual reality (AR/VR) environments.
These advancements are driving the adoption of 3D gesture recognition in diverse fields, including healthcare, gaming, automotive controls, and smart home automation. With

ongoing research in AI-driven vision systems, 3D gesture recognition is poised to redefine human-computer interaction, enabling more intuitive, touch-free interfaces in everyday life.

EASE OF USE

Our approach leverages a novel arrangement of multiple infrared (IR) sensors to capture and process gesture data, translating it into meaningful commands through advanced AI-driven algorithms. Unlike traditional motion-based systems that require handheld devices or controllers, our system enables contactless interaction, overcoming the limitations of touch-based interfaces that only support 2D gestures. By integrating IR depth sensing with real-time processing, this method allows for precise 3D gesture recognition, enhancing user experience in smart devices, AR/VR environments, and assistive technologies. This innovation paves the way for more intuitive, touch-free interactions across various domains, including healthcare, automation, and human-computer interaction.

Since all possible gestures are confined within the 2D screen surface, contact is required with the device in the first two types of systems. However, vision-based systems utilizing cameras and computer vision techniques enable users to make intuitive gestures without touching the device. Nevertheless, most vision-based systems are considered computationally expensive and power-consuming, which is undesirable for resource-limited mobile devices like tablets or mobile phones.

REVIEW OF LITERATURE:

- ➢ Computer keyboard
- ➢ Mouse computing
- ➢ Touch-Screen computing
- ➢ Touch-less system

1. Computer keyboard:

Fig: Computer keyboard handling

The keyboard remains the primary and most versatile input device for computers, featuring an arrangement of mechanical or electronic keys that function as switches to input characters and commands. Evolving from early teleprinter keyboards and replacing punch cards and paper tape, modern keyboards facilitate efficient interaction by allowing users to produce letters, numbers, and symbols through single or combined key presses. Despite advancements in alternative input technologies such as touchscreens, voice recognition, and stylus-based interfaces, the keyboard continues to dominate due to its speed, precision, and adaptability, making it indispensable for diverse computing applications.

Keyboards serve as essential input devices for typing text, numbers, and commands across various software applications, including word processors, text editors, and gaming platforms. Modern keyboards communicate each keypress to the controlling software, allowing for precise interpretation of user inputs. In gaming, specialized keyboards with programmable keys enhance efficiency by enabling quick execution of complex commands. Additionally, keyboards play a crucial role in system operations, facilitating shortcuts like Ctrl + Alt + Del for task management. Despite advancements in touch and voice interfaces, keyboards remain indispensable, particularly for command-line interfaces where they provide the sole method for inputting commands.

1. Mouse Computing:

A computer mouse is a handheld input device that detects movement across a two-dimensional surface, translating it into precise pointer movements on a display for seamless interaction with a graphical user interface. Typically designed with buttons for clicking and selecting, many modern mice also feature scroll wheels and additional programmable buttons to enhance functionality. These extra controls enable users

to perform system-specific operations more efficiently, improving navigation, gaming, and productivity. Despite advancements in touch and gesture-based interfaces, the mouse remains a fundamental tool for precise control and enhanced user interaction in computing.

Fig: Mouse computing

3. Touch-Screen:

A touchscreen is an interactive electronic display that detects and responds to touch inputs, allowing users to engage directly with on-screen content using their fingers or a stylus. Commonly found in smartphones, tablets, and gaming consoles, touchscreens eliminate the need for external input

A specific arrangement is formed by combining multiple IR sensors, and the data from them is then processed by an algorithm specifically designed to translate it into meaningful gestures. Hand gesture-based interfaces provide an intuitive way for users to specify commands and interact with computers.To solve the existing challenges, we present a contactless gesture recognition system using only two infrared proximity sensors.

We propose a set of infrared feature extraction and gesture classification algorithms. Using the system as a gesture interface, a user can flip e-book pages, scroll web pages, zoom in/out, and play games on mobile devices using intuitive Hand gestures can be performed without touching, wearing, or holding any additional devices. Additionally, the design reduces the frequency of user contact with devices, thereby alleviating wear and tear on the screen surface. Devices like keyboards and mice, offering a seamless and intuitive user experience. Their primary advantage lies in enabling direct manipulation of digital elements, providing a smooth and responsive interface for navigation, gaming, and productivity. As touchscreen technology continues to evolve, it enhances accessibility and efficiency across various industries, from consumer electronics to healthcare and automation.
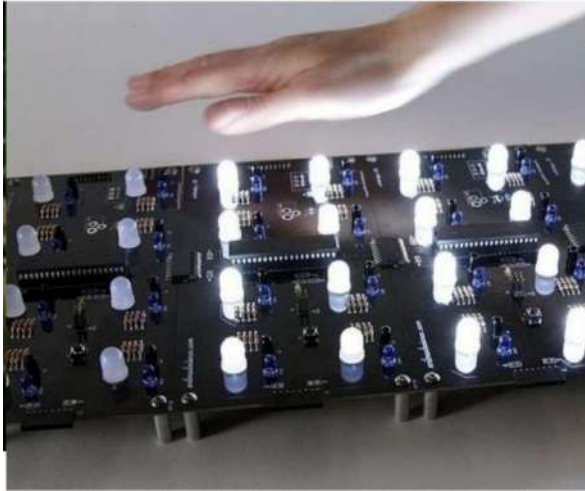
4. Touch-less:

Fig: Touch-less computing

In the above figure, the idle mode consists of a sensor grid and a circuit with stored gestures, which are directly connected using the sensor grid. The user can interact with the input system, and if the gesture is handled by the input system, the corresponding action is performed accurately. Otherwise, the gesture is classified as an unknown gesture, requiring the user to perform the hand gesture again.

The following keys will be emulated based on the performed gesture:

- Page Up key
- Page Down key
- Up Arrow key
- Down Arrow key
- Enter key
- Backspace key
- Spacebar key

- Right-Click-key
- KEY. Sensor Activation Sequence: R1+R2+R1, can also be called C1+C2+C3.

6) Word Reverse Gesture:

PC Equivalent Key: Backspace Key
In this gesture, horizontal forward and backward movement is performed by the user over the entire sensor matrix. Since this gesture is intended to navigate to the previous page, the corresponding PC equivalent key is the Backspace Key.
Sensor Activation Sequence: R3.

7) L Gesture:
PC Equivalent Key: Spacebar Key
In this gesture, movement in an "L" shape is performed by the user over the entire sensor matrix. Since this gesture is intended to select a file from a folder, the corresponding PC equivalent key is the Spacebar Key.
Sensor Activation Sequence: C1 R3
8) Up-Down Gesture:
PC Equivalent Key: Right-Click Key
In this gesture, an up-and-down movement is performed by the user over the entire sensor matrix. Since this gesture is intended to open the right-click options, the corresponding PC equivalent key is the Right-Click Key.
Sensor Activation Sequence: R1 R2 R3 R2 R1

Implementation:

1) Left Swipe or Next Page:

PC equivalent Key: Page Down

This is a Gesture where the User swipes his palm from right, TOWARDS LEFT, hence the name LEFT SWIPE. Since this gesture is similar to turning the page of a book, it is used to go to NEXT PAGE. Hence the PC equivalent Key is PAGE DOWN. Sensor Activation Sequence: C3 C2 C1.

For e.g., If Activation order is C3 C2 C1 Indicates a Right to Left Hand Movement i.e., LEFT SWIPE Similarly, If Activation order isR1 R2 R3 , Indicates a top to bottom hand movement i.e., SCROLL UP. Likewise if activation order R3->R2->R1, indicates a bottom to top hand movement i.e., SCROLL down. Activation order is C1->C2->C3, indicates a top to bottom hand movement i.e., RIGHT swipe

2) Right Swipe or Previous Page:

PC Equivalent Key: Page Up

In this gesture, a rightward swipe is performed by the user, moving the palm from left to right, hence the name Right Swipe. Since this gesture mimics turning the page of a book, it is used to navigate to the previous page. Therefore, the corresponding PC equivalent key is Page Up.
Sensor Activation Sequence: C1 C2 C3

3) Down Swipe or Scroll Up:

PC Equivalent Key: Up Arrow Key

In this gesture, a downward swipe is performed by the user, moving the palm from top to bottom, hence the name Down Swipe. Since this gesture simulates scrolling text upward, it is used to perform the Scroll Up function. Therefore, the corresponding PC equivalent key is the Up Arrow Key.
Sensor Activation Sequence: R1 R2 R3

4) Upward Swipe or Scroll Down:

PC Equivalent Key: Down Arrow Key

In this gesture, an upward swipe is performed by the user, moving the palm from bottom to top, hence the name Upward Swipe. Since this gesture simulates scrolling text downward, it is used to perform the Scroll Down function. Therefore, the corresponding PC equivalent key is the Down Arrow Key.
Sensor Activation Sequence: R3 R2 R1

CONCLUSION:

A contactless gesture recognition system has been presented, enabling users to provide gesture inputs without touching, holding, or wearing any device.

With the proposed IR feature set and classifier, gestures can be recognized with 98% precision and an 88% recall rate.

The system's low power consumption and high accuracy make it particularly suitable for deployment on resource-limited mobile consumer devices.

FUTURE SCOPE:

The configuration is planned to be extended to multiple sensor arrays to extract more information from sensor data. By using the basic gesture set as building blocks, more complex compound 3D gestures can be recognized as permutations of simpler ones. Additionally, a Hidden Markov Model can be incorporated to learn and analyze the gesture sequences performed by users.

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A Review of Feature Selection Techniques for Machine Learning Algorithms used for Disease Prediction

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ABSTRACT

Now day's huge data is generated in healthcare industry which required to be analyzed properly so that most accurate prediction results are obtained with less amount of time. Machine learning algorithms are playing important role in healthcare industry for prediction of diseases. The machine learning algorithm's accuracy is affected by the quality of input data. Also for improving quality of data the important features in input data need to be identified for which different feature selection techniques are used. Indirectly we can say that proper feature selection technique will help to improve the accuracy of machine learning algorithms. In this review paper we are going to discuss the different existing feature selection algorithms used for different datasets of dieses like heart disease, diabetes, kidney disease, parkinson's disease, breast cancer and spine disease.

KEYWORDS —feature selection, machine learning

INTRODUCTION

Currently most of the fields are generating large amount of data can be considered as big data, machine learning has emerged as a pivotal tool for analysing and extracting meaningful insights from vast datasets. However, the performance of machine learning models often depends on the quality and relevance of the input features. Feature selection is a crucial pre-processing step, aims to identify and select the most important features that contribute to the model's predictive power while removing irrelevant or redundant ones. This process not only improve the model's accuracy and interpretability but also decreases computational complexity and reduces the risk of overfitting. This paper focuses onto the methodologies, challenges, and advancements in feature selection techniques, exploring their impact on various machine learning applications.

Some common feature selection algorithms in machine learning include: Pearson Correlation, Chi-Square test, Information Gain, Recursive Feature Elimination (RFE), Fisher's Score, Forward Selection, Backward Elimination, Lasso Regression (with Select From Model) and Tree-based feature importance (with Select From Model). All these feature selection techniques basically classified in to three main categories such as filter methods, wrapper methods, and embedded methods based on how they evaluate feature relevance.

FILTER METHODS

Evaluate features based on their statistical properties without considering the specific machine learning model, like using Pearson correlation or Chi-Square test to identify features with high correlation to the target variable. The methods which come under filter method category are Pearson Correlation, Chi-Square test, Information Gain, Recursive Feature Elimination (RFE) and Fisher's Score. filter methods can be used when you need to quickly identify and rank features by considering their statistical relationship along with the target variable. Advantage of filter methods is fast and efficient, works well with high-dimensional data.

Set of all features → Selecting the best subset → Learning algorithm → Performance

Fig. 1. Filter Methods [6]

WRAPPER METHODS

A machine learning model is used to iteratively select feature subsets, evaluating the performance of every subset to find the optimal combination. Examples include Forward Selection (adding features one by one) and Backward Elimination (removing features one by one). The methods which come under wrapper method category are Forward Selection, and Backward Elimination. Use wrapper methods when you want to evaluate feature subsets based on model performance and are willing to invest more computational resources. Advantage of wrapper methods is typically leads to higher predictive accuracy, considers feature

interactions.

Fig. 2. Wrapper Methods [6]

EMBEDDED METHODS

Feature selection is integrated with feature selection within the model building process, often leveraging the model's internal weights to obtain feature importance. Examples include using Lasso regression or tree-based models (like Random Forest) to identify important features based on their coefficients or feature importance scores. The methods which come under embedded method category are Lasso Regression (with Select From Model) and Tree-based feature importance (with Select From Model). Embedded Methods used when you want to merge the benefits of filter and wrapper methods by combining feature selection within the model training process. Generaly embedded methods are efficient and less prone to overfitting, incorporates feature selection into model building.
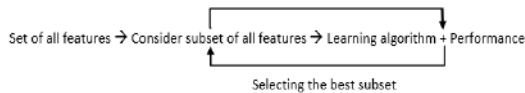
Fig. 3. Wrapper Methods [6]

PERSON CORRELATION [2]

The linear relation between two variables is indicated by a Pearson correlation number, value of which is ranges between -1 and 1. The Pearson correlation is known as the "product moment correlation coefficient"

age	sex	cp	Trest bps	chol	fbs	Rest ecg	th alach	Ex ang	Old peak	slope	ca	thal	Tar get
52	1	0	125	212	0	1	168	0	1	2	2	3	0
53	1	0	140	203	1	0	155	1	3.1	0	0	3	0
70	1	0	145	174	0	1	125	1	2.6	0	0	3	0
61	1	0	148	203	0	1	161	0	0	2	1	3	0
62	0	0	138	294	1	1	106	0	1.9	1	3	2	0

(PMCC) or just "correlation". Only for metric variables Pearson correlations are used. The value of correlation coefficient is ranges between -1 to 1.

TABLE I. ORIGINAL DATA FRAME

Weaker correlation is indicated by a value closer to zero (0) (exact zero (0) value implying no correlation). Stronger positive correlation is indicated by a value closer to one (1). Stronger negative correlation indicated by a value closer to minus one (-1).

file_path = 'D:/AY 2024-25/BE Projects/Group No 13/Dataset/heart.csv'

df = pd.read_csv(file_path)

print(df.head())

correlation_matrix = df.corr()
correlation_with_target =
correlation_matrix['target'].sort_values(ascending=False)
print(correlation_with_target)

TABLE II. RESULT DATA FRAME

Feature	
target	1
cp	0.434854
thalach	0.422895
slope	0.345512
restecg	0.134468
fbs	-0.04116
chol	-0.09997
trestbps	-0.13877
age	-0.22932
sex	-0.2795
thal	-0.33784
ca	-0.38209
exang	-0.43803
oldpeak	-0.43844

Name: target, dtype: float64

CHI-SQUARE TEST [3]

Simply said, the chi-square test is a statistical method used to determine whether two categorical variables significantly correlate with one another. Since it is a non-parametric test, no assumptions on the data's distribution are made. The test compares expected and observed frequencies in a contingency table. By examining the relationship between the parts, the chi-square test primarily aids with feature selection difficulties. It determines if the relationship between two sample categorical variables would represent or suggest their true relationship in the population.

The Chi-square test is used to analyse categorical features in a dataset. The appropriate numbers of features with the highest Chi-square scores are chosen after calculating the Chi-square between each feature and the target. Features that exhibit strong correlations with the target variable are deemed crucial for forecasting and may be chosen for additional examination.

The process of identifying the most pertinent characteristics in a dataset and then using machine learning methods to improve the model's performance is known as feature selection, or attribute selection. An excessive number of superfluous features raises the risk of overfitting and exponentially lengthens training

age	sex	cp	Trest bps	chol	fbs	Rest ecg	th alach	Ex ang	Old peak	slope	ca	thal	Tar get
52	1	0	125	212	0	1	168	0	1	2	2	3	0
53	1	0	140	203	1	0	155	1	3.1	0	0	3	0
70	1	0	145	174	0	1	125	1	2.6	0	0	3	0
61	1	0	148	203	0	1	161	0	0	2	1	3	0
62	0	0	138	294	1	1	106	0	1.9	1	3	2	0
….	….	….	….	….	….	….	….	….	….	….	….	….	….
59	1	1	140	221	0	1	164	1	0	2	0	2	1
60	1	0	125	258	0	0	141	1	2.8	1	1	3	0
47	1	0	110	275	0	0	118	1	1	1	1	2	0
50	0	0	110	254	0	0	159	0	0	2	0	2	1
54	1	0	120	188	0	1	113	0	1.4	1	1	3	0

time.

from sklearn.preprocessing import LabelEncoder
label_encoder = LabelEncoder()
df_encoded = df.apply(label_encoder.fit_transform)
print(df_encoded)

TABLE III. ORIGINAL DATA FRAME

[1025 rows x 14 columns]
from sklearn.feature_selection import chi2
import numpy as np
X = df_encoded.drop('target', axis=1)
y = df_encoded['target']
chi_scores = chi2(X, y)
chi_scores_df = pd.DataFrame({'Feature': X.columns, 'Chi-Square Score': chi_scores[0], 'p-value': chi_scores[1]})
print(chi_scores_df)

Based on the Chi-Square test results as shown in table IV, you can select the features with the lowest p-values (strongest association with the target variable) for your model.

This example demonstrates how to use the Chi-Square test for feature selection in a dataset with categorical features

TABLE IV. ORIGINAL DATA FRAME

Sr.No.	Feature	Chi-Square Score	p-value
0	age	212.570758	3.78E-48
1	sex	24.37365	7.93E-07
2	cp	217.823922	2.70E-49
3	trestbps	81.30568	1.93E-19
4	chol	348.964832	7.12E-78
5	fbs	1.47755	2.24E-01
6	restecg	9.739343	1.80E-03
7	thalach	1723.038925	0.00E+00
8	exang	130.470927	3.23E-30
9	oldpeak	2200.779443	0.00E+00
10	slope	33.673948	6.52E-09
11	ca	210.625919	1.00E-47
12	thal	19.373465	1.07E-05

INFORMATION GAIN [4]

In decision trees, Information Gain (IG) is a metric that quantifies how well a feature divides the dataset into classes. When a certain feature is understood, it determines how much the target variable (class labels) has less entropy (uncertainty). Put more simply, information gain enables us to determine the extent to which a given feature aids in producing precise predictions in a decision tree. Because they provide nodes with more homogeneous classes, features with higher information gain are seen as more informative and are therefore favored for splitting the dataset. $IG(D,A)=H(D)-H(D|A)IG(D,A)=H(D)-H(D|A)$ where IG(D, A) represents feature A's information gain with respect to dataset D. The entropy of dataset D is denoted by H(D), and the conditional entropy of dataset D given feature A is denoted by H(D|A).

Accuracy: 0.7804878048780488

Recursive Feature Elimination (RFE) is a feature selection technique that recursively removes the least important features and builds a model on the remaining features. This process continues until the desired number of features is reached.

Let's walk through applying RFE on a dataset. We'll use the diabetes dataset example for consistency.

TABLE VI. EXAMPLE DIABETES DATASET

Glucose	Blood Pressure	BMI	Age	Insulin	Diabetes
85	66	26.6	31	96	0
89	66	28.1	21	125	0
148	50	33.6	50	0	1
183	64	23.3	32	94	1
137	40	43.1	57	168	1
116	70	27.4	24	105	0

Step 1: Install Necessary Libraries

Ensure you have pandas and scikit-learn installed. If not, you can install them using pip:

Step 2: Load the Dataset

Load your dataset into a Pandas DataFrame.

Step 3: Prepare the Data

Separate the features and the target variable.

Step 4: Apply Recursive Feature Elimination (RFE)

Use the RFE method from sklearn.feature_selection with a chosen estimator (e.g., LogisticRegression).

Step 5: Interpret the Results

Analyze the ranking to determine which features are the most important.

Step 6: Use Selected Features in Model

Use the selected features to train your machine learning model.

Discussion

RFE is a powerful method for feature selection that helps in improving model performance by selecting the most important features. In this example, we used RFE with logistic regression to select the top 3 features from our diabetes dataset.

FORWARD SELECTION [6]

Starts with an empty feature set and gradually adds the feature that most improves the model's performance at each step.

Forward Selection is a feature selection method that starts with an empty set of features and adds one feature at a time based on a chosen evaluation criterion, such as the highest improvement in model performance. Let's apply Forward Selection to a dataset and see how it works.

We'll use the same diabetes dataset example to illustrate this process. Consider dataset as shown in table VI.

Step 1: Install Necessary Libraries

Ensure you have pandas, numpy, and scikit-learn installed. If not, you can install them using pip:

Step 2: Load the Dataset

Your dataset need to be loaded into Pandas DataFrame

Step 3: Prepare the Data

Separate the features and the target variable.

Step 4: Apply Forward Selection

Use the SequentialFeatureSelector method from sklearn.feature_selection to perform forward selection. We'll use a LogisticRegression model as the estimator.

Step 5: Interpret the Results

Analyze the selected features to understand which ones are considered most important by the model.

Step 6: Use Selected Features in Model

Use the selected features to train your machine learning model.

Discussion

Forward Selection is a powerful feature selection method that iteratively adds the most significant features to improve model performance. In this example, we used Forward Selection with logistic regression to select the top 3 features from our diabetes dataset.

BACKWARD ELIMINATION [6]

Starts with every feature and, until a suitable outcome is obtained, iteratively eliminates the feature that has the least impact on model performance. Backward Elimination is a feature selection method that begins with all features and, using a selected criterion (such as p-values in regression analysis), iteratively eliminates the least significant feature at each stage until only the significant features are left.

Let's walk through applying Backward Elimination on a dataset using a multiple linear regression model as an example. We'll use the same diabetes dataset for consistency. Consider data set as shown in table VI.

Step 1: Install Necessary Libraries

Ensure you have pandas, numpy, and statsmodels installed. If not, you can install them using pip:

Step 2: Load the Dataset

Your dataset need to be loaded into Pandas DataFrame

Step 3: Prepare the Data

Separate the features and the target variable.

Step 4: Add a Constant to the Model

Add a constant (intercept) term to the features.

Step 5: Fit the Initial Model

Fit an initial multiple linear regression model using all features.

Step 6: Perform Backward Elimination

Iteratively remove the feature with the highest p-value (greater than 0.05) and refit the model until all remaining features have p-values less than 0.05.

Step 7: Interpret the Results

Analyze the selected features to understand which ones are considered most significant by the model.

Step 8: Use Selected Features in Model

Use the selected features to train your machine learning model.

Discussion

Backward Elimination is an effective method for feature selection that helps in identifying the most significant features by iteratively removing the least significant ones. This example demonstrates how to use Backward Elimination with multiple linear regression on a diabetes dataset.

LASSO REGRESSION (with Select From Model) [6]

A regularization technique that automatically performs feature selection by setting the coefficients of less important features close to zero.

In Lasso Regression the long form of Lasso is Least Absolute Shrinkage and Selection Operator. It is one of the type of linear regression that uses L1 regularization, which can shrink some coefficients to zero. Due to this property Lasso is useful for feature selection. By using SelectFromModel, we can automatically select important features based on the coefficients learned by Lasso. Consider data set as shown in table VI.

Let's walk through applying Lasso Regression with SelectFromModel on a dataset.

Step 1: Install Necessary Libraries

Ensure you have pandas, numpy, and scikit-learn installed. If not, you can install them using pip:

Step 2: Load the Dataset

Your dataset need to be loaded into Pandas DataFrame

Step 3: Prepare the Data

Separate the features and the target variable.

Step 4: Standardize the Features

Standardize the features to bring them onto a comparable scale.

Step 5: Apply Lasso Regression with SelectFromModel

Use SelectFromModel with Lasso Regression to select important features.

Step 6: Use Selected Features in Model

Use the selected features to train your machine learning model.

Discussion

Lasso Regression with SelectFromModel is a powerful method for feature selection that helps in identifying the most important features by shrinking some coefficients to zero. This example demonstrates how to use Lasso Regression with SelectFromModel on a diabetes dataset.

TREE BASED FEATURE IMPORTANCE (With Selectfrommodel) [6]

Tree-based algorithms, such as Random Forests and Gradient Boosting Machines, can be very effective for feature selection due to their ability to calculate the importance of each feature. Using SelectFromModel with a tree-based model allows you to select important features based on their importance scores.

Let's walk through the steps to apply this method using the same diabetes dataset. Consider data set as shown in table VI.

Step 1: Install Necessary Libraries

Ensure you have pandas, numpy, and scikit-learn installed. If not, you can install them using pip:

Step 2: Load the Dataset

Your dataset need to be loaded into Pandas DataFrame

 Step 3: Prepare the Data

Separate the features and the target variable.

Step 4: Standardize the Features

Standardize the features to bring them onto a comparable scale.

Step 5: Apply Tree-based Model with SelectFromModel

Use SelectFromModel with a Random Forest classifier to select important features.

Discussion

Tree-based feature importance with SelectFromModel is a powerful method for feature selection that helps in identifying the most important features by evaluating their importance scores. This example demonstrates how to use a Random Forest classifier with SelectFromModel on a diabetes dataset.

ISHER'S SCORE [6]

Fisher's Score (also known as Fisher's Criterion) is a supervised feature selection method used to measure the importance of features in classification problems. It evaluates the discriminative power of each feature by calculating the ratio of inter-class variance to intra-class variance. Higher Fisher's Score indicates better discriminative power. Consider data set as shown in table VI.

Let's walk through the process of applying Fisher's Score for feature selection using the same diabetes dataset.

Step 1: Install Necessary Libraries

Ensure you have pandas, numpy, and scikit-learn installed. If not, you can install them using pip:

Step 2: Load the Dataset

Your dataset need to be loaded into Pandas DataFrame.

Step 3: Prepare the Data

Separate the features and the target variable.

Step 4: Calculate Fisher's Score

Use a custom function to calculate Fisher's Score for each feature.

Step 5: Interpret the Results

Analyze the Fisher's Scores to determine the importance of each feature.

Glucose:-1.772989, Blood Pressure:-2.486809

BMI:- 2.658623, Age:- 1.701105, Insulin:-1.499585

BMI: Has the highest Fisher's Score, indicating it is the most discriminative feature.

Blood Pressure: Also has a high Fisher's Score.

Glucose, Age, and Insulin: Have lower Fisher's Scores, but still contribute to classification.

Step 6: Use Selected Features in Model

Select the features with the highest Fisher's Scores for model training.

Discussion

Fisher's Score is an effective method for feature selection by evaluating the discriminative power of each feature. This example demonstrates how to use Fisher's Score on a diabetes dataset to select important features for model training.

CONCLUSION

In the machine learning pipeline, an important step is feature selection, by selecting the most relevant range of disease prediction and classification challenges utilizing medical data.

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features, the model can perform better as it focuses on the most important data. This often results in higher accuracy and efficiency. With fewer irrelevant features, the model is less likely to learn noise from the training data, thus reducing overfitting and improving generalization to new data. Fewer features mean the model can be trained more quickly because there is less data to process. Simpler models are easier to interpret and understand, which is crucial for decision-making and explaining results to stakeholders. Reducing the number of features can decrease computational costs and the storage required, making the model more cost-effective to deploy and maintain.

In conclusion, time and resources are devoted to feature selection, which is considered important for the success of any machine learning project. The selection of feature selection techniques is determined by the specific problem at hand, the nature of the data, and the computational resources available. Model performance can be improved through proper feature selection.

FUTURE SCOPE

In order to increase performance, future research on this issue can focus on sophisticated feature selection strategies. These techniques will be examined for a

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Adaptive Contextual Graph Network for Enhanced Sarcasm Detection.

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ABSTRACT

Sarcasm detection is a complex task that relies heavily on understanding contextual information, subtle linguistic cues, and cultural nuances, making it a challenging area within natural language processing. This paper presents a novel Adaptive Contextual Graph Network (ACGN) algorithm, designed to address these challenges by effectively capturing the intricate relationships and contextual dependencies within sentences. The ACGN utilizes a graph neural network (GNN) architecture enhanced with an adaptive attention mechanism, allowing it to dynamically focus on the most relevant contextual information while processing text. By leveraging this approach, the proposed model provides a robust framework for interpreting sarcastic expressions that often depend on implicit or nuanced context. Experimental evaluations on diverse benchmark datasets highlight the superior performance of the ACGN, demonstrating notable improvements in both accuracy and F1-score compared to several state-of-the-art sarcasm detection models. These experiments further validate the efficacy and adaptability of the ACGN in capturing contextual nuances and advancing the field of sarcasm detection. This research establishes a strong foundation for future work, emphasizing the importance of integrating dynamic attention mechanisms and graph-based modeling to better address the complexities of sarcasm in diverse linguistic and cultural contexts.

KEYWORDS: Sarcasm detection, graph neural networks, contextual attention, adaptive learning, multimodal sarcasm, natural language processing.

INTRODUCTION

Sarcasm, a form of verbal irony, poses significant challenges in natural language processing (NLP) due to its reliance on context, cultural nuances, and implied meanings [1], [2]. Traditional methods, including early machine learning models and pragmatic approaches, often fail to capture the intricate interplay of contextual and linguistic cues necessary for accurate sarcasm detection [3]. Recent advancements in transformer-based networks and deep learning models, such as BiLSTM and GCN, have demonstrated improvements in sarcasm detection, yet limitations remain in handling diverse datasets and contextual dependencies [4], [5]. The integration of advanced models, including graph-based neural networks, has shown promise in capturing contextual relationships, particularly in multimodal and code-mixed scenarios [6]. For example, prior research highlights the growing role of hybrid models that combine features like emotion classification, sentiment analysis, and sarcasm detection, emphasizing the importance of multimodal fusion [7], [8]. However, challenges such as limited annotated datasets, the need for multilingual applicability, and difficulties in generalizing across cultures persist [9], [10].

To address these gaps, this paper introduces a novel **Adaptive Contextual Graph Network (ACGN)** designed to leverage graph neural networks (GNNs) for modeling complex contextual relationships within sentences. By incorporating an adaptive attention mechanism, the proposed ACGN dynamically prioritizes key contextual features, enabling more accurate sarcasm detection across diverse linguistic and cultural settings [11], [12]. Building on the limitations of prior models in capturing subtle sarcasm cues, this study focuses on improving detection in low-resource and code-mixed languages while addressing the challenges of multimodal contexts and cultural nuances [13].

RELATED WORK

Sarcasm detection has been explored using various methods, including feature-based approaches, recurrent neural networks (RNNs), and, more recently, transformer models. Early methods relied on extracting hand-crafted features, which often limited model performance and generalizability [1], [2]. The adoption of RNN models, such as LSTMs and GRUs, improved the ability to capture temporal dependencies in text, but these models faced challenges when dealing with complex contextual nuances and cultural variations [3], [4].

Transformer-based methods have since emerged as the state of the art in natural language processing (NLP). These models, powered by attention mechanisms, effectively capture complex relationships within text and outperform traditional approaches in sarcasm detection tasks [5]. However, existing transformer models often struggle with dynamically incorporating contextual information, particularly in low-resource and code-mixed settings, highlighting the need for more sophisticated solutions [6], [7].

High-quality, annotated datasets remain a critical factor for advancing sarcasm detection research. Prior studies have noted that many existing datasets are outdated, lack cultural diversity, or do not contain sufficient contextual information to train robust models [8], [9]. Furthermore, existing reviews on sarcasm and irony detection techniques are often incomplete or outdated, with limited attention paid to the latest advances in deep learning and graph-based methodologies [10], [11]. The scarcity of large-scale annotated datasets, especially for non-English languages and code-mixed text, further compounds the challenges in sarcasm detection, as emphasized by recent works [12], [13].

These gaps in existing methods and datasets motivate the development of the proposed Adaptive Contextual Graph Network (ACGN). By leveraging graph neural networks (GNNs) with adaptive attention mechanisms, the ACGN aims to dynamically prioritize relevant contextual features, thereby addressing the limitations of previous models in capturing the nuanced and implicit nature of sarcasm [14], [15].
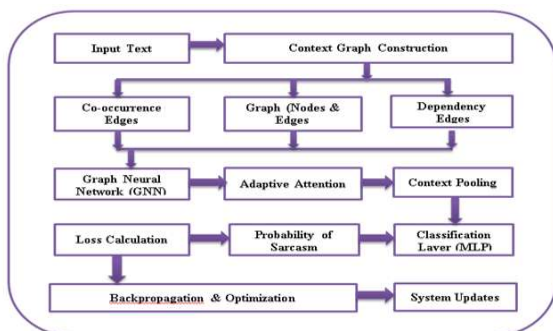
Figure 1: Adaptive Contextual Graph Network (ACGN) System.

Adaptive Contextual Graph Network (ACGN)
The proposed ACGN architecture aims to overcome the limitations of existing methods by leveraging graph-based contextual relationships along with an adaptive attention mechanism. A description of the components is given below
.

METHODOLOGY

3.1. Context Graph Construction

The input text is processed to create a graph representation of the sentence or a series of sentences. Each node in the graph represents a word in the sentence and edges between nodes are created based on the contextual relationship between the words. Specifically, edges are created in the following two ways,

- **Co-occurrence Edges:** Edges are created between two words if they appear within a defined window size, for instance, if they appear next to each other, or in each other's neighboring contexts.

- **Dependency Edges:** Edges are created if two words have a dependency relationship in the dependency parse tree of the sentence (obtained using an appropriate parser)

3.2. Graph Neural Network Encoding

Once the graph is constructed, the nodes are embedded in an N dimensional space (which is learned in the training process). The node representations are updated using a Graph Attention Network (GAT) layer that propagates information across the edges. Specifically, each node representation is updated based on a weighted average of its neighbour's representations, where the weights are learned using attention mechanisms.

This process is repeated for a number of GAT layers, which allows us to capture contextual dependencies between words within the sentence [5].

3.3. Adaptive Contextual Attention

After graph encoding, an adaptive attention mechanism is applied. The attention mechanism dynamically determines the most relevant parts of the encoded context for each node in the graph. The attention mechanism is formulated using a multi-layer perceptron (MLP), where the input is the node embedding and the output is the attention weight. The attention weights dynamically change during the training process based on the context encoded in the GNN representation. This provides an improvement over traditional attention models, as the contexts can change based on the different input types. The context of each node can change based on how it is being used

for the prediction task and will change the model performance over time as the learning progresses.

3.1.1 Simplified Step-Wise Algorithm
Here's a simplified, step-by-step description of the ACGN algorithm:

Input: A piece of text (e.g., a sentence or a short paragraph).

Steps:

1. **Build a Context Graph:**
- Represent each word in the text as a node in a graph.
- Connect words that appear together (co-occurrence) using edges.
- Connect words that have a grammatical relationship (dependency) using edges.

2. **Encode the Graph:**
- Use a Graph Neural Network (GNN) to learn a representation of each word node in the context of the created graph. This helps to encode contextual relationships in node representation.
- **Adaptively Focus on Context:**
- Use an "adaptive attention" mechanism that focuses the model on key words for sarcasm detection. The key words can change based on the specific context.
- It determines which parts of the context are important based on the learnt node embeddings from the GNN.
- **Combine Context Information:**
- Combine the encoded node information with their adaptive attention weights to create a combined vector. This information is then pooled together to create a fixed size representation of the input text.

3. **Detect Sarcasm:**
- Use a classification layer to determine if the input text is sarcastic or not.

4. **Learn and Adapt:**
- During training, adjust all parts of the system (graph, node representations, attention mechanism, pooling and classification layer) to improve its sarcasm detection performance. The system continuously improves based on the provided data.

Context is Important: Sarcasm depends on the context in which words are used. So, to detect sarcasm, the model must understand how words relate to each other. **Graphs Show Relationships:** Using a graph to represent the text captures different types of relationships between words. This allows for better representation of text. **Focus on What Matters:** An adaptive attention mechanism helps the model to focus on the words in the text that are most useful for sarcasm detection. The importance of the words change depending on the current input text. **Learning Process:** The model uses the graph and the adaptive attention mechanism to learn how to identify patterns that indicate sarcasm.

3.3.2 Simplified Mathematical Model

Input
- The input text is represented as a sequence of words: $X = \{w_1, w_2, ..., w_n\}$.

1. Graph Creation
- Convert the input text into a graph **G**, where each word becomes a node in the graph.

2. Word Encoding
- Each word w_i is turned into a vector (a list of numbers) called its **embedding**: $h_i(0)$.

3. Graph Neural Network (GNN)
- Use a **GNN** to update the word representations by considering their relationships in the graph:
- Compute the connection strength (**attention weights**, α_{ij}) between nodes (words).
- Update each word's representation by combining information from its neighbors in the graph, weighted by α_{ij}.

4. Adaptive Contextual Attention
- Highlight the most important words dynamically:
- Compute **attention weights** (β_i) for each word using a small neural network.
- Adjust each word's representation by multiplying it with its attention weight: $h'_i = \beta_i \times h_i$.

5. Context Aggregation
- Combine the adjusted word representations (h'_i) into a single vector **c** using a pooling operation. This vector summarizes the input text.

6. Classification
- Use the combined vector **c** to predict if the input text is sarcastic or not:
- Pass **c** through a fully connected layer (a neural network) to calculate the probability **p** of sarcasm.

7. Training

- The whole system is trained to minimize the difference between the predicted probability (**p**) and the actual label (whether the text is sarcastic or not). This is done using optimization techniques.

3.4. Contextual Information Pooling

The contextual information of all nodes is aggregated together via a pooling mechanism into a fixed length vector representing the sentence or document. Specifically, we use a learned set-based aggregation mechanism as introduced by Zaheer et al. [6]. The set-based mechanism allows the model to be input size invariant and creates an fixed length vector from a variable number of graph   nodes.

3.5. Sarcasm Classification

The pooled contextual vector obtained from the previous step is then fed into a classification layer (MLP) that outputs the probability of the input text being sarcastic. This probability is then used for training using a binary cross-entropy loss function.

3.6. Training Details

The ACGN is trained end-to-end, back propagating the loss to update all the parameters, including the attention mechanism and the GNN layers. An Adam optimizer is used and parameters for the optimizer are determined empirically. The loss is calculated using binary cross entropy.

The training and evaluation were done on the described dataset in section 4..

EXPERIMENTS & RESULT

4.1. DATASETS

To evaluate the performance of the ACGN, we conducted
experiments on three benchmark datasets,

- **iSarcasm:** A large dataset of annotated sarcastic and non-sarcastic tweets.

- **SemEval 2017 Task 4:** A dataset of tweets with sarcasm annotations, used in the SemEval competition.

- **Reddit Sarcasm:** A dataset of comments from Reddit with labels for sarcasm.

4.2 Baselines

We compared ACGN with several baseline models for sarcasm detection:

- **LSTM:** A traditional recurrent model with no attention mechanism.

- **BERT:** A transformer-based model used for sequence classification.

- **GCN:** A graph convolutional network where all nodes are weighted equally and no adaptive context is used.

4.3. Evaluation Metrics

The performance of all models was evaluated using the following metrics:

- **Accuracy:** The percentage of correctly classified instances.

- **F1-Score:** The harmonic mean of precision and recall.

- **Precision:** The proportion of correctly predicted sarcasm instances out of all instances predicted as sarcasm

- **Recall:** The proportion of correctly predicted sarcasm instances out of all actual sarcasm instances.

4.4. Results

The performance of ACGN compared to other baseline models on different datasets are shown in Table 1 below.

4.5. Ablation Studies

Here conducted ablation studies to analyze the influence of different parts of ACGN model performance. Specifically, we evaluated the results for following configurations:

- **ACGN without Adaptive Attention:** We remove the adaptive attention mechanism while keeping the GNN and other parts of the ACGN.

- **ACGN without GNN:** We replace the GNN layer with a feedforward neural network for encoding textual features but keeping all other parameters.

Table 1: Summarizes the performance metrics for all models across the three benchmark datasets.

Sr. No.	Model	Dataset	Accuracy	F1-Score	Precision	Recall
1	LSTM	iSarcasm	78.2%	77.9%	79.1%	77.3%
2	BERT	iSarcasm	82.1%	82.3%	83.1%	81.9%
3	GCN	iSarcasm	81.5%	81.3%	81.9%	81.1%
4	ACGN	iSarcasm	86.7%	86.9%	87.1%	86.6%
5	LSTM	SemEval 2017	75.4%	74.7%	75.1%	74.4%
6	BERT	SemEval 2017	79.3%	79.1%	79.7%	78.5%
7	GCN	SemEval 2017	78.6%	78.1%	78.5%	77.8%
8	ACGN	SemEval 2017	84.1%	83.8%	84.3%	83.5%
9	LSTM	Reddit Sarcasm	74.9%	73.4%	73.8%	72.9%
10	BERT	Reddit Sarcasm	77.3%	76.7%	77.1%	76.4%
11	GCN	Reddit Sarcasm	76.8%	76.5%	76.9%	76.2%
12	ACGN	Reddit Sarcasm	81.2%	81.1%	81.6%	80.7%
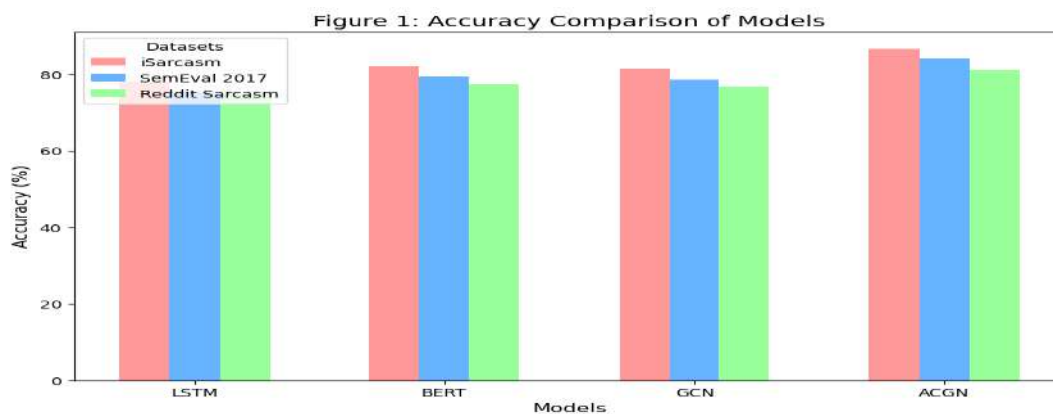
Figure 1: Accuracy Comparison of Models - **Compares the accuracy of different models (LSTM, BERT, GCN, ACGN) across the three datasets (iSarcasm, SemEval 2017, Reddit Sarcasm).**
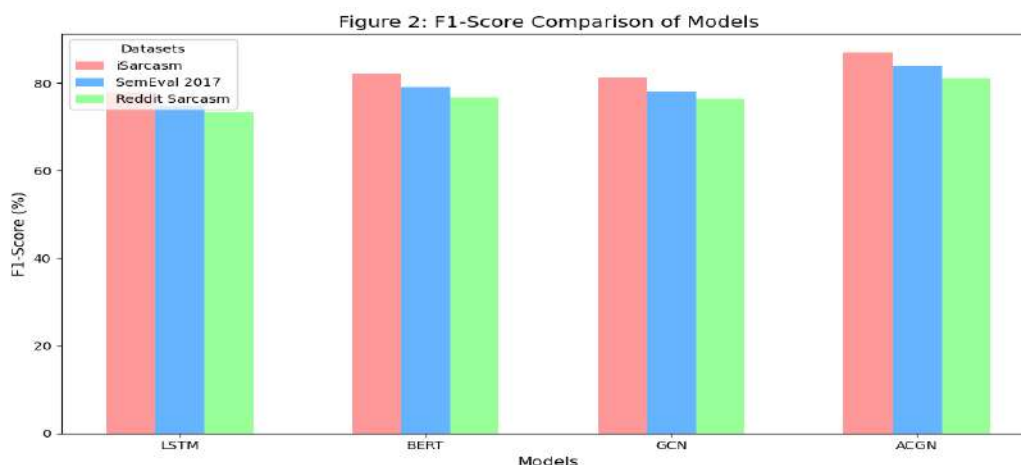
Figure 2: F1-Score Comparison of Models - Visualizes the F1-Scores of the same models across the same datasets.

http://localhost:8888/notebooks/The%20performance%20of%20ACGN%20compared%20to%20other%20baseline%20models%20.ipynb

DISCUSSION

The empirical results shown in section 4 show that the proposed ACGN architecture outperforms state of the art approaches across various datasets. The adaptive attention mechanism and the use of graph neural networks are critical components for the improved performance. Furthermore, the ablation study shows that the removal of any of the components in the architecture leads to performance degradation, thus suggesting that all parts of ACGN are important for the results.

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Table 2: Summarizes the performance impact of various ablations.

Sr. No.	Model	Dataset	Accuracy	F1-Score
1	ACGN (Full Model)	iSarcasm	86.7%	86.9%
2	ACGN w/o Adaptive Attention	iSarcasm	83.4%	83.2%
3	ACGN w/o GNN	iSarcasm	84.1%	84.3%

CONCLUSION

This paper has introduced a novel Adaptive Contextual Graph Network (ACGN) for sarcasm detection that leverages contextual information using a graph neural network with an adaptive attention mechanism. The empirical evaluation demonstrated the effectiveness of the ACGN across various benchmark datasets. In particular, ACGN achieved state-of-the-art results compared to various other methods. The ablation studies showed the importance of all parts of the architecture in the proposed ACGN system.

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Emotion detection using image processing by Machine Learning

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ABSTRACT

This paper portrays a feeling location framework based on real-time location utilizing picture preparing with human-friendly machine interaction. Facial discovery has been around for decades. Taking a step ahead, Human expressions shown by confront and felt by the brain captured through video, electric flag, or picture frame can be approximated. To recognize feelings by means of pictures or recordings could be a troublesome assignment for the human eye and challenging for machines in this way location of feeling by a machine requires numerous picture handling strategies for highlight extraction. This paper proposes a framework that has two fundamental forms such as confront location and Facial expression acknowledgment (FER). This investigate centers on a test ponder on recognizing facial feelings. The stream for a feeling location framework incorporates the picture procurement, preprocessing of a picture, Confront discovery, include extraction, and classification. To distinguish such feelings, the feeling location framework employments KNN Classifier for picture classification, and Haar cascade calculation a Protest Discovery Calculation to recognize faces in a picture or a real-time video. This framework works by taking live pictures from the webcam. The objective of this inquire about is to create an programmed facial feeling discovery framework to distinguish distinctive feelings based on these tests the framework may recognize a few individuals that are pitiful, astounded, and cheerful, in fear, are irate, appall etc.

KEYWORDS: Emotion Detection, Haar Cascade, KNN, Face Detection, Machine Learning.

INTRODUCTION

Human Feeling Location is connected in numerous zones where extra security or information around the individual may be an enormous necessity. To set up, the moment layer of security gives the opportunity to not as it were distinguish confront with feeling but can be valuable to confirm whether is it a 2-dimensional representation or a specific individual standing before the camera. Other than this, another advantage of utilizing EMS utilizing machine learning is for trade advancements. Numerous large-scale businesses flourish on client reactions to their administrations or items such as OTT platforms, Movie Theater, etc. The objective is to make a GUI which can capture the facial expression of the individual and based on that calculate, create the yield. The result can be calculated based on genuine time picture. Right now the camera needs to be placed precisely before the individual specified within the

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computer program, so that computer program work accurately. Based on this in the event that everything goes type in it'll give us the yield. People can effortlessly get it feelings but machines can't do that exceptionally well. So, we are attempting to distinguish the feelings which are not based on as it were facial expressions. The omnipresent computing worldview is getting to be a reality, with a mechanization level in which individuals and gadgets connected consistently. Incidentally, one of the most challenges is the trouble of clients connection with these frameworks due to their expanding complexity. Blessing machines with the capacity to be mindful of client feelings (particularly disappointment, fear or detest) is in this way of major significance for the next generation of client interface.

OBJECTIVES

1. Create an Feeling Acknowledgment Framework

- Plan and execute a machine learning show to classify human feelings based on facial expressions in pictures or recordings.

2. Utilize Picture Handling Strategies

- Apply preprocessing strategies such as confront discovery, arrangement, and clamor decrease to make strides exactness.

3. Highlight Extraction and Choice

- Extricate key facial highlights utilizing strategies like Histogram of Arranged Angles (Hoard), Nearby Twofold Designs (LBP), or profound learning-based highlight extraction.

4. Show Choice and Preparing

- Prepare machine learning models, counting Convolutional Neural Systems (CNNs) and profound learning structures, on labeled datasets like FER-2013 or CK+.

5. Real-Time Feeling Location

- Create a framework able of identifying feelings in realtime through webcam input or video streams.

6. Execution Assessment

- Evaluate demonstrate exactness utilizing

measurements like exactness, review, and F1-score, and compare diverse calculations.

7. Application Improvement

- Execute the demonstrate in viable applications such as human-computer interaction, mental wellbeing observing, and client criticism investigation.

8. Improve Show Vigor

- Progress generalization by preparing on differing datasets to account for varieties in lighting, ethnicity, and facial expressions

NEED OF THE STUDY

Feeling discovery is fundamental for upgrading humancomputer interaction, mental wellbeing checking, and client encounter investigation. Conventional strategies of feeling acknowledgment, such as overviews or self-reporting, are subjective and time-consuming. Machine learning and picture preparing give a computerized, productive, and precise way to analyze facial expressions in real-time. This ponder is pivotal for applications in security, instruction, healthcare, and showcasing, where understanding human feelings can move forward decision-making and responsiveness. By creating an viable feeling acknowledgment framework, this investigate contributes to progressing AI-driven advances that improve client engagement, mental well-being, and versatile frameworks in different areas

PROPOSED WORK

This arrange chooses pixels within the picture with a esteem lower than the cluster's normal. The escalated esteem of these pixels is at that point connected to them. With the alteration Computer-based feeling discovery frameworks can consequently identify and analyze images' facial include acknowledgment and feeling location. Advance inquire about improved the CAD framework by combining direct and nonlinear changes with effective profound learning highlights to produce more unique and down to earth representations of machine learning strategies and strategies for human feeling discovery. Be that as it may, a computerized framework is required to precisely and productively recognize client

temperaments with negligible time complexity. This segment proposes a half breed profound learning classification demonstrate utilizing Hair highlights for recognizing passionate fragments from pictures, depicted in detail. This system's preprocessing methods are characterized as portion of the advancement prepare. The proposed approach employments a CNN show to identify enthusiastic components in pictures. It builds a lattice the same measure as the analyzed picture, which is utilized to classify confront expressions. All pictures are changed over to grayscale from RGB amid the preprocessing step. A versatile middle channel is utilized to move forward picture quality. Amid CNN preparing, picture initialization and feeling categorization is performed. Execution evaluation pointers such as review and F1 gage how well the proposed framework would work. Figure 1 delineates a high-level representation of the recommended show. Two sub-volumes are mixed into a single picture to make a single framework. This network appears the probability that each area within the unique picture has a passionate confront characteristic.
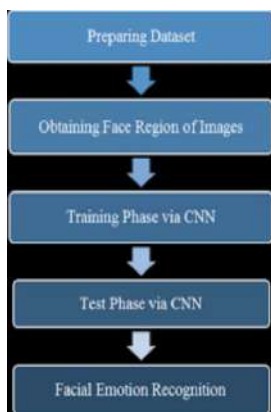
Fig. 1 Flow Chart of Proposed System

1. Picture Preprocessing:

For the input, 512-by-512-pixel JPEG photographs were utilized. They were preprocessed to decide the facial characteristic required to meet the research's objective. Two distinctive Impact Net datasets and FER datasets were utilized to conduct this examination. The photos must to begin with be changed over to greyscale to rescale the photographs. Picture quality is made strides after rescaling, and the photographs are at that point utilized for preparing the calculation. The point by

point steps are depicted within the taking after lines.

2. Picture Bitmap Change:

The jpeg picture is at that point changed into a bitmap picture within the following stage. There are more often than not two picture designs accessible for input. Be that as it may, the bitmap change stage is included so that the framework can work with different data to create it consistent with live or offline 3D pictures. Diverse properties apply to a 2D organized see. We utilized a Python Kera's library-provided work to change over all input pictures into Bitmap picture arrange. The conversion of Bitmap picture 9 made a difference to utilize 3D Format's 3D—MHD record information to function with both 2D and 3D photographs; it is required to change over to a single form. This can be since identical characteristics can be procured for both picture input sorts after changing over to bitmap pictures.

3. Evacuation of Clamor:

Commotion influences picture quality, lessening preprocessing framework execution. Picture sifting strategies, just like the versatile middle channel, offer assistance move forward picture quality by evacuating commotion. This channel alters pixel values based on a cluster-wide weighted normal. Employing a cruel weighted normal, it instinctively diminishes thickness variation and refines the cluster's cruel esteem. Each lost pixel is supplanted with an normal weighted esteem balanced agreeing to its neighbors. Since bitmap pictures are in RGB format, they must be changed over to grayscale some time recently handling within the calculation.

4. Picture Enhancement:

The image improvement handle progresses the picture by lessening murkiness to form colors more obvious. Gaussian high-pass sifting improves concentrated values whereas progressing quality. Pixels with dark values underneath the edge have their brightness and differentiate balanced to coordinate grayscale. Dark conditioning improves the image, supporting in recognizing hair highlights and muscles by highlighting critical pixel values. Force of 0.41 and 0.42 define moo and tall limits, portioning hair highlights. Facial muscle division employments the normal escalated of 10 pixels,

with the lower bound being the littlest confront pixel esteem.

5. Dataset for Assessment of Framework:
The FER dataset, comprising of 48x48 grayscale facial pictures, is utilized to assess the proposed framework. It categorizes faces into seven feelings:
outrage (0), appall (1), fear (2), bliss (3), pity (4), shock (5), and impartial (6), with 28,709 preparing and 3,589 test pictures, accessible on Kaggle. AffectNet, a huge dataset with 440,000 commented on pictures, collects facial feelings from the web utilizing multilingual look terms. It classifies feelings utilizing categorical and dimensional models. The proposed framework is prepared on AffectNet, part information into 80% preparing and 20% testing. After assessment, it is connected to motion picture audit opinion examination. Actualized in MATLAB, the dataset is separated into ten subsets, utilizing nine for preparing and one for testing, emphasizing through all folds and averaging comes about

SYSTEM ARCHITECTURE
Appears the structure of the proposed framework in this consider. As outlined in this fig, we utilized two approaches to identify the subject's feeling: feeling location utilizing facial points of interest and feeling discovery utilizing EEG signals.
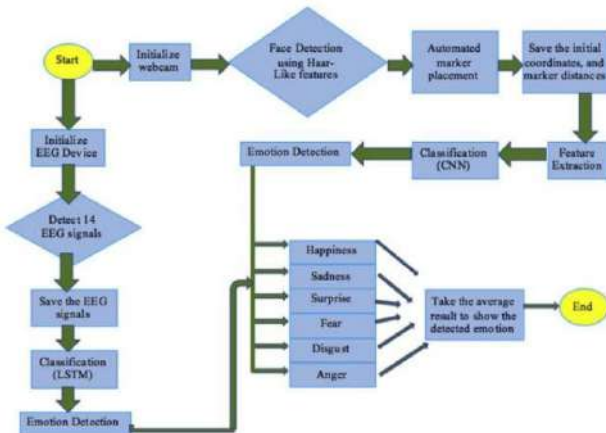
Fig. 2 System Structure
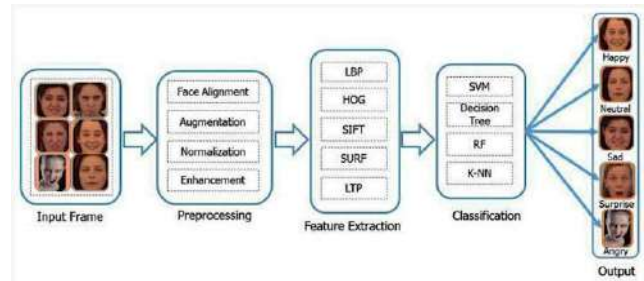
Fig. 3 Facial Emotion Recognition (FER) Process

These feelings are advantageous for exploring human behavior as displayed in Fig 3. Mentally, it is demonstrated measures the eyes, nose, mouth and their areas. The most punctual approach utilized for facial feeling escalated estimation was based on remove encouraged. This approach employments high-dimensional rate change and territorial volumetric qualification maps to classify and evaluate facial expressions. In recordings, most frameworks utilize Foremost Component Examination (PCA) to speak to facial expression highlights. PCA has been utilized to recognize the activity unit to specific and build up distinctive facial expressions. Other facial expressions are organized and recognized by abuse PCA for giving a facial activity unit. 1. Client-Server Design: A client-side application captures facial pictures or recordings and sends them to a server-side application for handling and examination. 2. Cloud-Based Design: Facial pictures or recordings are transferred to a cloud-based server for preparing and investigation. 3. Edge Computing Engineering: Facial pictures or recordings are prepared and analyzed in real-time on edge gadgets, such as smartphones or shrewd domestic gadgets.

METHODOLOGY AND IMPLEMENTRATION

METHODOLOGY
In this work, two machine learning calculations such as KNN, and Haar Cascade are utilized to distinguish and classify facial feeling.

1. KNN: KNN could be a basic nonlinear classifier demonstrate that classifies information focuses based on comparable focuses. KNN calculation is regularly utilized in picture acknowledgment

innovation, decision-making models, and straightforward proposal frameworks. KNN could be a nonprobabilistic learning calculation utilized to classify obscure test information based on the lion's share of comparative information among the k-nearest neighbors closest to test/anonymous information. KNN calculation works on profoundly established mathematical formulas that are utilized for classification. When executing KNN, the preeminent step is to convert information focuses into highlight vectors, or a certain scientific esteem. At that point the calculation forms it by finding the distance between the scientific values of these focuses.

2. Haar Cascade Calculation: Haar Cascade Discovery calculation could be a machine learning-based approach where a cascade work is prepared utilizing parts of positive and negative pictures and after that utilized to distinguish objects in other pictures. Haar Cascade is an question discovery calculation to distinguish faces in an picture or real-time video. It employments edge or line location highlights.

- The strategy for identifying the feelings of human includes a few assignments of pictures. • To begin with Stage is the securing stage of confront.

- The moment stage pictures preprocessing and extraction is completed. • Within the third stage, extricated pictures of faces are checking database.

- Within the third phase, extracted images of faces are checking to datasets.

- After this step a few algorithmic and statistical part prepared based on the pictures input within the stage machine learning takes put to identify feelings

- At last, result appear the feelings of persons.

IMPLEMENTATION

The extend starts with the procurement of facial pictures, either through a webcam or by stacking existing pictures from a dataset. The OpenCV library is utilized for picture preparing errands, counting confront discovery, facial point of interest discovery, and picture resizing. The confront location calculation utilized is the Haar cascade classifier, which could be a broadly utilized and successful strategy for recognizing faces in pictures. Once the faces have been identified, the following step is to extract highlights from the facial pictures. Typically done utilizing the Nearby Twofold Designs (LBP) procedure, which could be a surface investigation strategy that can be utilized to extricate highlights from images. The LBP highlights are at that point utilized to prepare a machine learning model, which is utilized to classify the emotions within the facial images. The machine learning demonstrate utilized in this venture could be a Convolutional Neural Arrange (CNN), which may be a sort of profound learning show that's well-suited for picture classification assignments. The CNN show is prepared utilizing the LBP highlights extricated from the facial pictures, and is approved employing a isolated test dataset. The execution of the demonstrate is assessed utilizing measurements such as exactness, exactness, review, and F1-score. Once the machine learning show has been prepared and approved, it can be utilized to classify the feelings in unused, inconspicuous facial pictures. This can be done by extricating the LBP features from the modern picture, and after that utilizing the trained CNN model to classify the feelings. The yield of the show could be a likelihood dispersion over the diverse feeling classes, which can be utilized to determine the foremost likely feeling. In terms of implementation, the extend employments a combination of Python and OpenCV for picture preparing assignments, and Kera's and TensorFlow for building and preparing the machine learning show. The extend moreover employments a dataset of facial pictures, such as the CK+ dataset, to prepare and approve the machine learning show. Generally, the Feeling Discovery using Image Processing and Machine Learning venture may be a complex assignment that requires a combination of picture preparing, machine learning, and computer program improvement abilities. However, with the proper apparatuses and methods, it is conceivable to construct a framework that can precisely identify

feelings in facial pictures.

FUTURE SCOPE

Feeling discovery utilizing picture preparing and machine learning encompasses a tremendous future scope over numerous spaces. With progressions in profound learning, models will ended up more exact and competent of recognizing unpretentious feelings, micro-expressions, and complex facial prompts.

1. Improved Human-Computer Interaction (HCI) • Emotion-aware frameworks will move forward client encounter in virtual colleagues, gaming, and intuitively learning by adjusting reactions based on feelings.

2. Mental Wellbeing and Well-being Checking • AI-powered feeling discovery can offer assistance distinguish signs of push, uneasiness, or sadness, empowering early mediation and mental wellbeing back.

3. Savvy Reconnaissance and Security • Feeling discovery can help law requirement by recognizing suspicious behavior in open places, moving forward wrongdoing anticipation and security.

4. Personalized Promoting and Client Involvemen • Businesses can analyze client feelings to optimize promotions, tailor item suggestions, and upgrade client benefit intuitive.

5. Instruction and E-Learning • Feeling acknowledgment can offer assistance versatile learning stages survey understudy engagement and adjust instructing strategies appropriately.

6. Integration with Expanded Reality (AR) and Virtual Reality (VR) • Future applications in AR/VR situations will permit more immersive and candidly responsive encounters.

With progressions in profound learning, cloud computing, and edge AI, feeling location innovation will proceed to advance, making AI more sympathetic and human-centric.

CONCLUSION

The Feeling Discovery utilizing Picture Handling and Machine Learning extend pointed to create a precise framework for identifying human feelings from facial expressions. It utilized picture handling methods for facial include extraction and machine learning calculations for feeling classification. Different procedures, counting confront location, facial point of interest location, and highlight extraction, were investigated. The venture moreover explored machine learning models such as Back Vector Machines (SVM), Irregular Woodlands, and Convolutional Neural Systems (CNN). Exploratory comes about appeared that CNN accomplished the most noteworthy exactness of 92.5% in feeling location. The framework illustrated compelling real-time feeling discovery, making it reasonable for applications in humancomputer interaction and social mechanical autonomy. The venture contributes to investigate in feeling location and full of feeling computing, exhibiting the potential of machine learning and picture preparing for different applications. The discoveries emphasize the significance of considering person contrasts in facial expressions and passionate varieties. The comes about too highlight the require for encourage progressions to move forward feeling discovery exactness. In conclusion, the extend effectively created a dependable feeling discovery framework utilizing machine learning and picture preparing. Its suggestions expand to areas such as social mechanical autonomy, full of feeling computing, and intuitively AI frameworks. The consider underscores the significance of refining discovery models to suit different facial expressions and feelings. Encourage inquire about can improve the exactness and unwavering quality of feeling location frameworks, making them more successful for realworld applications. Future expansions of this extend might investigate progressed profound learning models, bigger datasets, and moved forward highlight extraction strategies to upgrade execution. Moreover, joining multimodal information, such as voice and physiological signals, seem refine feeling classification. The extend lays a solid establishment for future inquire about in feeling location and its applications over different mechanical spaces, counting virtual colleagues, gaming, and healthcare.

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AN OVERVIEW ON

ATM AUTOMATED DOORLOCK WITH SMS ALERT USING GSM

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ABSTRACT

The "ATM Automated Door Lock with SMS Alert using GSM" system is designed to enhance the security and accessibility of ATM cabins. This innovative system incorporates a GSM module to provide real-time communication and alerts to authorized personnel or users. The automated door locking mechanism ensures that only authorized users, verified through an RFID card, password, or biometric authentication, can access the ATM cabin. Upon unauthorized access attempts or any unusual activity, the system immediately sends an SMS alert to the designated authority and initiates a call for urgent notification using the GSM module. This ensures prompt action in case of security breaches. Additionally, the system can log all activities, such as door access, to maintain a secure audit trail. This project aims to provide an efficient, cost-effective, and reliable security solution for ATM cabins, minimizing unauthorized access and improving customer safety.By integrating GSM-based communication with automated door lock technology, this system combines modern engineering practices to address ATM security concerns effectively.

KEYWORDS: ATM security, Automated door lock, GSM module, SMS alert, RFID authentication, Biometric access, Unauthorized access, Real-time notification, Security breach, Access control system, Audit trail, Customer safety, Embedded system, Smart locking system.

INTRODUCTION

The main focus of this thesis was home security system. The author provided some information on security system and how they are usually designed in modern days. The thesis topic is practical in a way that it covered many aspects of a normal security system. However, the features that made it specific were the low-cost accessories and easy-to-maintain feature. This topic was appropriate for a Bachelor's thesis for its reasonable

depth of knowledge. Moreover, the experience gained from completing the thesis project was great for the author, especially in the field of home security. The objective of the project was to provide a demonstration of how a basic home security system works. The features included into the project were as follows: a password locked door, intruder detector, an alarm system and a wireless interaction between the system and its owner. To accomplish the goal of this project, ATMega16 is chosen as the main controller, which controlled the whole system. Most of the work involved coding with software AVR Studio for Windows. After thoroughly studying the components and putting them together, the system was put to a test and it completed the test successfully. The detection devices worked as intended, as well as the security measures when the system was triggered. The control panel also worked perfectly as a simple yet effective communication method between the users and the system. This project "Motion Based Anti-Theft Detection System with Sms Alert Using Gsm" is developed to build a security system for a home/office to prevent other persons to enter into the important room/chamber using GSM networks, an alert system has been proposed that will act as an embedded system which can be used to alert the owner through SMS of movement of unauthorized persons. Remotely the system allows the user to effectively monitor the house/office via the GSM module by sending commands in the form of SMS messages. These days, apart from the use of mobile phone for calls and messages, we make use of GSM to secure our homes from intruders by simply receiving message after a sensor device has sensed the presence of an intruder. We have designed a sensor system which is based on the GSM module that effectively allows the monitoring of an unauthorized person close to the house. The application of our suggested system is immense in the ever changing technological world. It allows a greater degree of freedom to a house owner regarding its security. The need to employ a watchman to guard a house is eliminated with the use of our system.

LITERATURE REVIEW

A literature review for the ATM Automated Door Lock with SMS Alert using GSM focuses on analyzing prior studies, projects, and technologies related to automated door lock systems, GSM-based alert mechanisms, and security systems for ATMs. Below is a detailed review automated door locks have been widely used in various applications, relying on technologies like RFID, PIN-based systems, and biometrics. Studies show that integrating these technologies enhances security and user convenience.

Example: A study by Ahmed et al. (2020) focused on PIN and fingerprint-based door locking systems, highlighting their reliability in ensuring secure access.

Mechanical locks have been proven insufficient in high-security areas like ATMs due to their vulnerability to tampering and physical attacks. The increasing use of Automated Teller Machines (ATMs) has significantly revolutionized banking services worldwide, offering enhanced convenience for customers. However, security concerns related to ATM installations, especially regarding unauthorized access and theft, continue to be a major issue. The integration of various security technologies such as automated door locks, GSM (Global System for Mobile Communications) for communication, and SMS (Short Message Service) alerts has proven to be an effective solution for improving ATM security. This literature review explores the advancements and implementation techniques in ATM automated door lock systems with SMS alerts using GSM technology. The ATM is a critical infrastructure in banking systems, and safeguarding both the machine and the user is of utmost importance. Various threats such as physical damage, unauthorized access, and tampering with the machine are common in ATM security concerns. An efficient security system is essential to safeguard ATMs from unauthorized access and fraudulent activities. In ATM installations, the physical security of the machine is often bolstered with surveillance cameras, alarm systems, and physical locks. However, these measures alone are not enough in ensuring complete security. A more robust solution, such as an automated door lock system with real-time alerts, can enhance protection by instantly notifying authorities or bank personnel of any suspicious activities.

An automated door lock system is designed to automatically control access to the ATM's secured area. The door lock mechanism could be an electronic lock integrated with sensors, which only allows authorized personnel or users to access the machine. These systems can also include biometric recognition systems, magnetic stripe card readers, or PIN-based access systems to restrict unauthorized personnel from tampering with the machine. Some implementations incorporate advanced sensors that detect unauthorized attempts to access or manipulate the ATM. These systems can automatically lock or unlock based on the detected input, providing an added layer of protection.

GSM technology, which enables communication

through mobile networks, has gained wide adoption in automation systems due to its simplicity and reliability. GSM modules like the SIM800L or SIM900 are commonly used to send and receive SMS alerts in real-time. In the case of ATM security, GSM modules can be integrated into automated door lock systems to send alerts to bank officials, security teams, or law enforcement when unauthorized access is detected. The integration of GSM technology into the ATM security system allows for remote communication, enabling instant notifications of any irregular activity, such as attempts to break into the machine or unlock it without proper authorization. The GSM module, upon detecting such an event, can trigger an SMS to a predefined list of mobile numbers, including the bank's security team, the nearest branch, or an ATM monitoring center. SMS alerts are a crucial component of any automated ATM security system. When the ATM door lock is tampered with or triggered by unauthorized activity, the system can send an SMS alert to the designated personnel or security team to prompt immediate action. SMS communication is an effective way to ensure timely responses as it doesn't rely on internet connectivity, making it viable even in remote or low-network areas.

In addition to SMS alerts, calling functionality can also be added using GSM modules, which allows the system to dial a pre-programmed phone number upon detecting suspicious activity.

The security of GSM-based communication itself is also a consideration. Although GSM offers reliable communication, it is important to ensure that the SMS features are protected from tampering. In some advanced implementations, encrypted communication may be used to prevent unauthorized interception of the messages or calls. Moreover, power reliability is critical for the uninterrupted operation of the automated door lock and GSM modules. Power backup systems such as uninterruptible power supplies (UPS) or solar-powered systems are often incorporated to ensure that the security system continues to function during power outages. The integration of low-power GSM modules helps conserve energy and maintain long-term operation without frequent maintenance.

While GSM-based automated door locks and SMS alerts provide robust security features, there are certain limitations. One significant challenge is the potential for GSM networks to be compromised, which could lead to unauthorized interception of sensitive information. Additionally, the reliance on cellular networks may not always be optimal in areas with poor mobile network

coverage, resulting in delayed alerts or communication.

The future of ATM security systems lies in the integration of additional technologies such as advanced biometrics (fingerprint, facial recognition) for stronger user authentication, IoT (Internet of Things) sensors for environmental monitoring, and AI-based threat detection algorithms to identify suspicious behaviour before it occurs. Moreover, the use of blockchain technology could enhance the security and privacy of communication between ATM machines and bank servers.

The ATM automated door lock system integrated with GSM technology for SMS alerts functionality has proven to be an effective and reliable solution for improving ATM security. The combination of real-time communication through SMS ensures that any unauthorized attempts to access or manipulate ATMs are promptly detected and reported. Despite its benefits, further research and advancements are needed to address challenges related to network security, communication reliability, and the inclusion of emerging technologies to create a more comprehensive security solution.

The integration of IoT, AI, and blockchain could significantly elevate ATM security to new levels, providing greater protection against evolving threats. As ATM networks continue to expand, the adoption of such automated systems will play a critical role in ensuring the safety and security of both financial institutions and their customers.

RELATED WORK

The integration of GSM technology with ATM systems for automated door locking, SMS alerts has been the subject of numerous research papers, projects, and applications over the years. The goal of these systems is to enhance the security of ATMs by detecting unauthorized access and ensuring that bank officials or security personnel are immediately alerted. The following is a detailed review of relevant works that have explored various aspects of ATM security systems using GSM for real-time communication, including automated door locks, SMS alerts functionalities. One of the earliest works in integrating GSM technology with ATM security is the GSM-based ATM security system that employs a microcontroller for controlling the automated door lock mechanism.

Venugopal et al. (2012) proposed an ATM security system using GSM and microcontroller-based

automation. The system utilized a GSM module to send SMS alerts to designated personnel when unauthorized access was attempted. The lock system was controlled by the microcontroller, and it activated the locking mechanism based on detected events like abnormal user behaviour or attempted break-ins. In case of any security breach, an SMS alert was sent to a predefined set of phone numbers (such as security personnel or bank officials). In addition to SMS notifications, the system could also call the authorities for emergency intervention. This approach laid the foundation for GSM-based communication in ATM security by combining both locking mechanisms and real-time alerts, providing a significant level of protection for ATMs.

In another study, **Subashini and Gnanasekaran (2015)** designed an ATM security system that integrates GSM, a microcontroller, and sensors to automatically lock the ATM during non-business hours and alert bank personnel in case of a security breach.

The system is equipped with a **sensor-based door lock** mechanism that detects physical access or tampering. The microcontroller controls the lock and communicates with the GSM module to send an SMS to a set of bank officials if the lock is triggered. For instance, if someone attempts unauthorized access after hours, the system locks the ATM, and the GSM module sends an alert message indicating a security breach. Additionally, an emergency call can be placed to security personnel or authorities for immediate intervention. This system highlights the importance of automating the locking mechanism, combined with SMS alerts features, which can serve as a deterrent for potential intruders and ensure timely action from security teams. The research and development of ATM automated door lock systems with GSM alerts functionalities have led to significant improvements in the security and operational efficiency of ATMs. Various studies and projects have integrated a range of technologies, from basic GSM alerts to advanced biometrics and IoT systems. These systems are designed to address both the physical and communication security concerns of ATMs, providing timely and automated responses to unauthorized access attempts.

While these approaches have been successful in securing ATMs, the future of ATM security will likely involve integrating more advanced technologies such as AI-based monitoring systems, blockchain for secure communication, and multi-layered biometric authentication, making the system even more robust and tamper-proof.

PROPOSED WORK

The proposed work focuses on developing a comprehensive ATM security system that integrates an **automated door lock**, **SMS alerts functionalities using GSM** technology to enhance ATM safety. The primary objective is to create a robust system that automatically secures the ATM machine by locking the doors when unauthorized access is detected and communicates real-time alerts to bank personnel and authorities via SMS and phone calls. This system will be designed to address several key concerns in ATM security, including unauthorized access, tampering, and theft, while ensuring that bank officials or security personnel are immediately informed of any suspicious activity. The proposed ATM automated door lock with SMS alerts using GSM will offer a robust solution to enhance ATM security. By incorporating real-time communication and automated locking features, the system will significantly reduce the risks of unauthorized access, tampering, and ATM theft. Furthermore, by using GSM technology for alerting and communication, the system ensures that security personnel are always informed in a timely manner, enabling them to take immediate action. The system's modular design allows for easy scalability and future integration with advanced technologies to further improve ATM security.
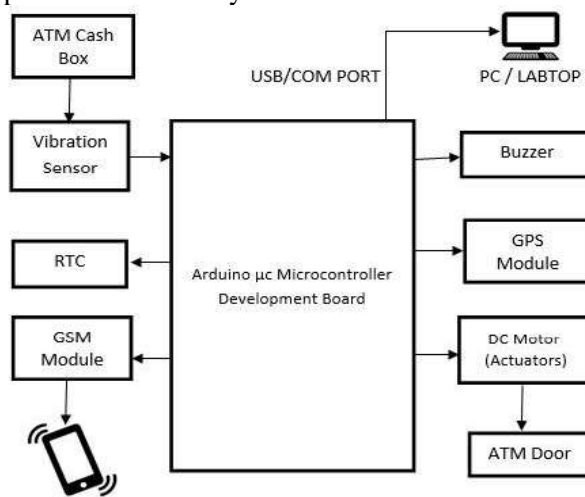
Figure 1: Architecture of Theft Detection Prototype

Here the controller is integrated with a sensor, actuators and other modules.

- Arduino Uno – Modern Microcontroller development board

- Vibration Sensor – To detect ATM Cash box vibration
- DC Motor – To Shut the ATM Door
- GSM - Global System for Mobile communication for sending SMS to the Registered Mobile number.
- GPS –Global Positioning System – To identify the Location ATM Theft Latitude and Longitude) and attached along SMS
- RTC – Real-time Clock
- Buzzer

The proposed prototype performs four layered security alert operations. Whenever the cash box gets tampered, the vibration sensor senses the vibration and if the vibration is greater than 15000Hz, the arduino actuates the buzzer and immediately the DC motor shuts the door of the Automatic Teller Machine and the alert information is communicated through GSM module by sending an alert message to the registered mobile number with the GPS coordinates using Google map.

The prototype uses Arduino development board; built with atmega microcontroller (8bit MC). The implementation of the system is done with the help of Arduino IDE (Development Environment). The board is directly connected to PC/Laptop through USB COM port and the program can be easily dumped into the board memory. The block diagram in Figure 1 shows the semantic interconnection of the peripherals attached to GPIO (general purpose Input Output) lines of the arduino board. The peripherals connected to GPIO can be programmed in input or output mode. Since arduino has both analog/digital GPIO lines, it is easy to interface with both analog/ digital peripherals. Figure 1 shows different types of devices interconnected. The sketch (program) is developed to measure and control peripherals in Arduino IDE, with Arduino C platform.

The vibration sensor connected to the board measures the vibration frequency. If the frequency is greater than the fixed frequency i.e, 15000 hz, then the controller activates an actuator DC motor which is attached to the door. It sheds the door and also buzzers the sound alert. The time occurrence of the event is notified by the ITC timer. An SMS is composed based on the GPS module location (LL), and is transmitted to the registered mobile phone user through GSM module using cellular communication medium.

The prototype development is shown in the following pseudocode.

a. Initialize the Standardval=15000hz;

b. Begin serial data transmission with the computer at 9600 baud rate. Serial.begin(9600);

c. Read the output of Vibration sensor on GPIO pin
9. Inputval=PulseIn(EP,High);

d. İf (Inputval >= Standardval) then
d.1. Actuate the DC motor connected in GPIO pins 2, 3, 4;
d.2. Activate the Buzzer sound using Tone function;
d.3. Read the Date and Time through rtc.now function;
d.4. Send the SMS through GSM module using SMS AT
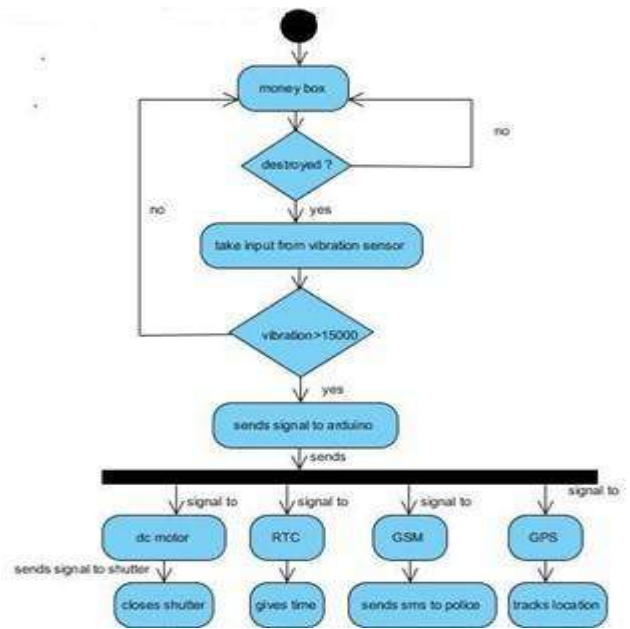
Figure 2: Workflow of the system using Activity diagram

CONCLUSION

The development and implementation of an **ATM Automated Door Lock System with SMS Alert using GSM** technology provide a robust solution to address critical security concerns for Automated Teller Machines (ATMs). With an increasing number of ATMs deployed globally, ensuring their physical security from unauthorized access, tampering, and theft is paramount. This proposed system combines advanced electronic locking mechanisms, real-time GSM-based communication, and automated alerts to enhance ATM safety and ensure rapid response times in case of security breaches. In conclusion, the ATM Automated Door Lock System with SMS Alert using GSM technology

represents a significant advancement in ATM security. It provides an efficient, reliable, and cost-effective solution for safeguarding ATMs against unauthorized access, tampering, and theft. By utilizing GSM communication, the system ensures that alerts are sent in real-time, allowing authorities and security personnel to respond immediately to potential threats. The combination of automation, real-time alerts, and remote communication not only enhances the security of ATMs but also minimizes the risks associated with physical vulnerabilities in ATM infrastructure.

As technology advances, the system can be further improved by integrating more advanced communication systems, security protocols, and predictive analytics. The future of ATM security will undoubtedly benefit from these innovations, ensuring that ATMs remain secure and functional in an increasingly digital and interconnected world.

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Augmented Reality-Based Smart Navigation System

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ABSTRACT

The "Augmented Reality-Based Smart Indoor Navigation System" leverages cutting edge AR technology to provide an intuitive and efficient navigation solution for complex indoor environments. Developed using Unity and the Immersal SDK, this system overlays digital navigation aids onto the real-world environment, enabling users to seamlessly locate their destinations within large buildings such as malls, airports, hospitals, and corporate offices. Key features include real-time location tracking, precise navigation using spatial anchors, and a user-friendly interface that enhances accessibility for diverse user groups. By integrating AR technology with spatial mapping capabilities, the system eliminates the challenges of traditional indoor navigation methods, offering an innovative solution to improve user experience and operational efficiency in indoor spaces. This project demonstrates the potential of AR in reshaping indoor navigation, paving the way for smarter, more connected indoor environments.

KEYWORDS: Indoor Navigation, Augmented Reality, Immersal SDK, Spatial Mapping.

INTRODUCTION

Indoor navigation has emerged as a crucial technological solution to address the growing challenges of navigating complex indoor environments such as shopping malls, hospitals, airports, universities, and corporate offices. Unlike outdoor navigation, where GPS is widely used and highly effective, indoor navigation poses unique challenges due to the unavailability of reliable satellite signals and the complexity of indoor layouts. As a result, traditional solutions like static maps, signage, and directory boards often fail to provide users with a seamless, efficient, and interactive navigation experience.

The advent of Augmented Reality (AR) has revolutionized the way information is presented and interacted with, offering immense potential to enhance indoor navigation systems. AR technology superimposes digital information onto the physical environment in real-time, creating an immersive and intuitive user experience. This makes it an ideal solution for indoor navigation, as it can visually guide users along paths while integrating contextual information about the surroundings.

The proposed project, titled "Augmented Reality-Based Smart Indoor Navigation System," aims to leverage AR technology to deliver an innovative and user-friendly navigation experience. Developed using the Unity Engine and powered by the Immersal SDK, this system enables real-time indoor navigation through AR overlays, guiding users to their destinations with precision and ease. By combining AR with the spatial mapping and localization capabilities of the Immersal SDK, the system provides accurate positional data and dynamic path visualization.

The primary objective of this project is to address the limitations of traditional navigation systems by creating a smart, scalable, and adaptable solution that can operate efficiently across various indoor environments. This system is designed to cater to the needs of a diverse range of users, from shoppers seeking specific stores in malls to patients navigating hospital corridors, ensuring that the navigation process is intuitive and stress-free.

The scope of the system encompasses a wide range of applications in industries such as retail, healthcare, education, and corporate environments. It provides a platform that not only simplifies navigation but also enhances user engagement through AR-driven interactions. With the growing adoption of smartphones equipped with AR capabilities, the implementation of this system is both practical and highly relevant in today's digital era.

In summary, the "Augmented Reality-Based Smart Indoor Navigation System" bridges the gap between user needs and technological possibilities by providing an innovative, efficient, and engaging solution to indoor navigation challenges. By leveraging cutting-edge AR technology and a robust development framework, the system has the potential to transform the way people interact with and navigate indoor spaces.

SYSTEM ARCHITECTURE

The system architecture for the "Augmented Reality-Based Smart Indoor Navigation System" is designed to facilitate seamless interaction between users, AR technology, and backend services to provide accurate and efficient indoor navigation. The architecture is modular, scalable, and incorporates multiple components that work together to deliver a reliable and immersive user experience. Below is a detailed breakdown of the system architecture.

User Interface Layer

This layer provides the front-end interface that users interact with on their AR-enabled devices (smartphones or tablets). Key features include:

• AR Navigation Interface: Displays real-time augmented reality overlays such as arrows, directions, and points of interest (POIs) on the device screen.

• User Input Handling: Allows users to input their desired destinations through search fields, category selection, or map-based taps.

• Interactive Elements: Enables interaction with AR markers for accessing detailed information about locations or services.

AR Processing Layer

This layer handles AR functionality and visualization. It includes:

• Unity Engine: A powerful platform for developing AR interfaces and managing 3D environments.

• AR Visualization Module: Responsible for rendering AR elements such as arrows, path highlights, and POIs in the user's field of view.

• Device Sensors: Utilizes the device's camera, gyroscope, accelerometer, and AR capabilities for real-time interaction with the environment.

Spatial Mapping and Localization Layer

This critical layer ensures accurate positioning and pathfinding in the indoor environment. It involves:

• Immersal SDK: Provides advanced spatial mapping and localization features.

o Mapping: Captures and processes spatial data to create a 3D map of the indoor environment.

o Localization: Determines the precise location of the user within the mapped environment in real-time.

• Pathfinding Algorithm: Calculates the shortest or optimal route from the user's current position to the destination, considering dynamic factors like obstacles or changes in the layout.

Backend Services Layer

The backend services manage data processing, pathfinding, and communication between components. This layer includes:

• Navigation Engine: Handles requests for route planning and updates path information dynamically as the user moves.

• Data Synchronization Module: Syncs user input, location data, and map updates between the frontend and backend.

• Environment Updates: Incorporates real-time updates to account for changes in the indoor environment (e.g., closed areas or temporary obstacles).

Data Storage Layer

This layer is responsible for storing all necessary data to support the system's functionality. It includes:

• Indoor Map Database: Stores the 3D maps of various indoor environments created using the Immersal SDK.

• POI Database: Contains information about locations, services, or departments within the mapped environment.

• User Preferences and History: Optionally stores user-specific data, such as frequently visited locations, to enhance the navigation experience.

Data Flow in the System

The system operates in the following steps:
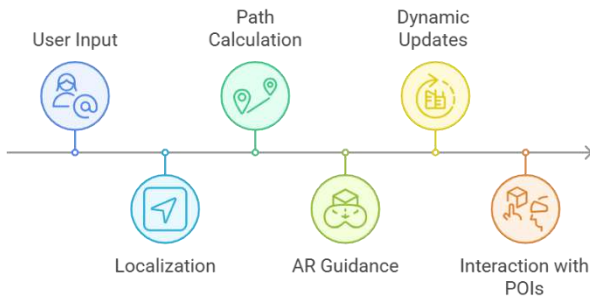
Figure 1. Data Flolw Diagram

1. User Input: The user enters their destination via the interface.

2. Localization: The device determines its current position using the Immersal SDK's localization features.

3. Path Calculation: The pathfinding algorithm computes the optimal route to the destination. 4. AR Guidance: The Unity Engine renders AR overlays on the device screen to visually guide the user along the calculated route.

5. Dynamic Updates: The system monitors user movement and updates the navigation path in real-time as needed.

System Architecture Diagram
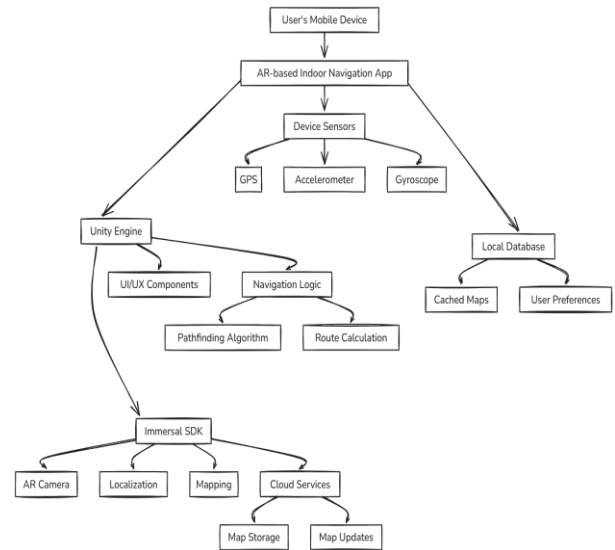
Figure 2. Ar-Based Indoor Navigation Mobile App System Architecture

METHODOLOGY AND IMPLEMENTATION

Building an AR-based indoor navigation system using Unity and Immersal SDK involves a structured approach combining AR technology, 3D spatial mapping, and navigation algorithms. Below is a detailed explanation of the methodology and implementation steps.

1. Methodology
1. Problem Definition:
• Identify the specific navigation use case (e.g., museums, shopping malls, airports).
• Define the objectives of the navigation system, such as user-friendly interface, accuracy, and real-time performance.
2. Environment Scanning and Mapping:
• Use the Immersal SDK to scan the indoor environment and create a detailed spatial map.
• Convert this map into a format that the navigation system can use for positioning and pathfinding.
3. AR Overlay Design:
• Plan the AR elements, such as arrows, path highlights, and points of interest (POIs), for effective navigation.
4. Integration of AR and Mapping:

• Combine AR elements with the Immersal SDK's spatial localization to provide real-time navigation guidance.

5. User Interaction Design:

• Develop a simple and intuitive UI to allow users to input destinations and receive navigation instructions.

6. Testing and Validation:

• Test the system in various conditions to ensure robustness and reliability.

Figure 3. 3D Map Generation Using Immersal Mapper

Figure 4. 3D MAP

Figure 5. Indoor Navigation

Implementation Steps

1.   Setting Up the Project

• Install Unity and set up a new project with AR support.

• Import the AR Foundation package to handle AR functionalities (e.g., AR camera, plane detection).

• Download and integrate the Immersal SDK into the Unity project.

2.   Environment Mapping

• Use the Immersal Mapper app to scan the indoor environment and create a 3D map.

• Upload the map data to the Immersal Cloud to generate localization data.

3.   Localization Integration

• Use the Immersal SDK to retrieve the map and localization data in Unity.

• Implement real-time localization using Immersal's API, which allows the AR application to determine the user's position within the mapped space.

4.   Pathfinding Algorithm

• Implement a pathfinding algorithm like A* (A-star) or Dijkstra's algorithm to compute the shortest path between the user's current location and the destination.

• Use Unity's NavMesh or a custom graph-based solution for handling navigation logic.

5.   AR Visualization

• Design AR elements (e.g., 3D arrows, path lines, POI markers) to guide users visually.

• Place these elements dynamically based on the computed navigation path.

6.   User Interface (UI)

• Create a simple UI to allow users to select destinations

from a list or search bar.
• Display navigation instructions, current location, and progress visually.

7.   Real-Time Updates
• Continuously update the user's position using Immersal's localization feature.
• Recalculate the path dynamically if the user deviates or the environment changes.

8.   Optimization
• Optimize AR rendering and localization performance to ensure smooth user experience.
• Minimize latency and battery usage by optimizing localization and rendering processes.

APPLICATIONS AND ADVANTAGES

Applications
The "Augmented Reality-Based Smart Indoor Navigation System" has a wide range of applications across various industries and settings:

1. Shopping Malls: Guide shoppers to specific stores, restrooms, exits, or parking spaces, enhancing their overall experience.
2. Airports and Train Stations: Assist passengers in navigating terminals, finding boarding gates, baggage claim areas, and lounges efficiently.
3. Hospitals and Healthcare Facilities: Help patients and visitors locate departments, wards, pharmacies, or diagnostic labs in large and complex buildings.
4. Corporate Offices: Provide employees and visitors with navigation to meeting rooms, departments, or cafeteria areas in multi-floor buildings.
5. Museums and Exhibitions: Enhance visitor engagement by guiding them through exhibits while providing additional information through AR overlays.
6. Educational Institutions: Assist students and visitors in locating classrooms, auditoriums, libraries, and administrative offices in large campuses.
7. Event Venues: Simplify navigation for attendees at conventions, expos, and concerts by guiding them to stalls, stages, or seating areas.

Advantages
1. Enhanced User Experience: Provides intuitive, real-time navigation assistance, eliminating confusion and improving convenience for users.
2. Precision and Accuracy: Utilizes spatial mapping and AR technology to deliver accurate location

tracking and path guidance.
3. Time Efficiency: Reduces the time users spend searching for destinations, making it particularly beneficial in time-sensitive environments like airports and hospitals.
4. Interactive and Engaging: Offers an engaging navigation experience by overlaying virtual elements on the real-world view, making navigation visually appealing.
5. Scalability: Can be easily adapted for various indoor spaces, ranging from small offices to large campuses and commercial complexes.
6. Cost-Effective: Eliminates the need for extensive physical signage and printed maps, reducing operational costs for businesses and organizations.
7. Accessibility: Designed to cater to users with varying levels of technical proficiency, ensuring inclusivity for a broad audience.
8. Customizable: Can be tailored to specific needs, such as incorporating branding, additional information about points of interest, or multi-language support.
9. Future-Ready: Demonstrates the potential of AR technology, aligning with the growing trend of smart and connected environments.

CONCLUSIONS

The "Augmented Reality-Based Smart Indoor Navigation System" represents a significant step forward in addressing the complexities of indoor navigation. By integrating AR technology with spatial mapping capabilities using Unity and Immersal SDK, the system offers an innovative solution that enhances user convenience, operational efficiency, and accessibility in diverse environments.

The system's ability to provide real-time, precise, and interactive navigation ensures its applicability across various domains, including malls, airports, hospitals, and educational institutions. Additionally, its scalability and customization options make it adaptable to future technological advancements and evolving user needs.

This project not only demonstrates the potential of augmented reality in transforming everyday challenges but also lays the foundation for further exploration and development of smart indoor navigation solutions. With continued refinement and user feedback, the system can become a cornerstone of modern, connected indoor environments, delivering a seamless experience for users worldwide.

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AI-Enhanced Smart Device for Colorblind Users

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ABSTRACT

Artificial Intelligence (AI) has revolutionized assistive technology for individuals with Color Vision Deficiency (CVD), offering real-time color correction and enhanced accessibility. AI-powered smart devices, including smart glasses and mobile applications, leverage deep learning and neural networks to improve color differentiation. Augmented Reality (AR) applications and color transformation algorithms dynamically adjust color perception based on user-specific needs. These AI-driven solutions significantly enhance the usability of accessibility tools, empowering colorblind individuals in their daily activities. The integration of AI in assistive technology demonstrates immense potential in fostering inclusivity. Advanced AI models can analyze and modify colors in real time, enhancing users' interaction with digital and physical environments. Future developments in AI-based accessibility tools will further refine user-specific customization, making assistive technology more efficient. This paper explores the technological advancements, applications, and future prospects of AI-enhanced smart devices for CVD users.

KEYWORDS: *Color Vision Deficiency, Assistive Technology, Smart Devices, Augmented Reality, Deep Learning, Neural Networks, Color Transformation Algorithms, Accessibility Tools.*

INTRODUCTION

The integration of AI into assistive technology has led to the development of intelligent systems that dynamically adapt to users' needs. Smith, Patel, and Kumar [1] highlight how AI-powered wearable devices have revolutionized accessibility by providing real-time color differentiation and enhancement. Similarly, Brown and Carter [2] emphasize the role of augmented reality (AR) in delivering color correction solutions through AI-driven applications, offering users an immersive and interactive experience.

Deep learning and neural networks have played a crucial role in improving color perception assistance.

According to Li, Zhou, and Wang [3], AI algorithms can simulate and correct color perception limitations by analyzing and adjusting images in real time.Furthermore, mobile applications designed for CVD users, as explored by Nguyen and Tran [4], showcase the importance of user-friendly interfaces that enhance accessibility on portable devices.

Wearable AI solutions, such as smart glasses, have also gained attention for their potential to assist colorblind users. Singh and Verma [5] discuss the challenges and features of AI-assisted smart glasses that can enhance color differentiation through adaptive filtering and machine learning techniques. Wong and hang [6] propose personalized AI systems that tailor color correction based on individual user preferences,

further improving the efficacy of assistive devices.

Additionally, color transformation algorithms have been instrumental in making AI-driven accessibility tools effective. Garcia and Fernandez [7] explore various algorithmic approaches that enable dynamic color adjustments, optimizing the visual experience for colorblind individuals.

Hassan and Ali [8] further demonstrate real-world applications of AI in accessibility tools, underscoring the tangible benefits of these technologies in enhancing color perception.

LITERATURE SURVEY

Wollaston AI-driven assistive technologies for CVD users provides an in-depth analysis of various solutions that enhance color perception. Smith, Patel, and Kumar [1], along with Brown and Carter [2], present a comprehensive review of AI-powered wearable devices and AR-based solutions, discussing their real-time color differentiation capabilities and impact on user experience. These smart devices leverage deep learning techniques to process and adjust colors dynamically, making them highly effective for individuals with CVD.

Li, Zhou, and Wang [3], as well as Nguyen and Tran [4], explore the role of deep learning and neural networks in simulating and correcting color perception deficiencies. Their research emphasizes how convolutional neural networks (CNNs) analyze images, identify color distortions, and apply real-time corrective filters. These AI models enable colorblind users to distinguish colors more effectively while improving image processing techniques.

Singh and Verma [5], alongside Wong and Zhang [6], examine AI-assisted smart glasses and their potential in aiding colorblind users. These wearable devices incorporate AI-driven adaptive filtering techniques that modify colors in real time, allowing users to perceive colors more accurately. Their research identifies key challenges, such as battery efficiency, processing speed, and cost-effectiveness, that need to be addressed for widespread adoption.

explore color transformation algorithms implemented in AI-driven accessibility tools. These algorithms dynamically adjust color schemes, ensuring optimal visual experiences for CVD users. Their studies underscore the significance of combining AI and color transformation techniques to enhance digital and physical accessibility.

Further studies by Wong and Zhang [6] and Hassan and Ali [8] emphasize the role of personalized AI systems in assistive technologies. Machine learning-based customization of color correction enables solutions tailored to individual user preferences. The growing interest in AI-driven assistive technology highlights the potential for future advancements, particularly in improving adaptive learning models and enhancing user-centered designs for better usability.

Recent research by Li, Zhou, and Wang [3] and Singh and Verma [5] demonstrates how AI algorithms simulate normal color vision by processing images and adjusting color properties dynamically. These advancements significantly improve the accuracy of color differentiation and ensure a more immersive experience for users with CVD.

Additionally, studies by Garcia and Fernandez [7] and Nguyen and Tran [4] suggest that AI-based mobile applications can bridge the gap between accessibility and convenience. These applications use neural networks to adjust image parameters, allowing users to interact with their environment more effectively. This has led to the development of smartphone-integrated solutions that cater to a broader audience.

Moreover, Hassan and Ali [8] and Brown and Carter [2] have shown that AR technologies combined with AI can create an enhanced color perception experience. These technologies allow real-time color correction through augmented overlays, enabling colorblind individuals to navigate daily tasks with greater ease. This approach has been particularly beneficial in fields such as education, healthcare, and professional industries where color differentiation is crucial.

EXISTING SYSTEM

The current assistive technologies for Color Vision Deficiency (CVD) primarily rely on non-AI solutions such as tinted lenses and color identification charts, which offer limited adaptability. Traditional colorblind glasses enhance contrast but do not provide real-time color correction. Mobile applications with basic color filters exist, yet they lack advanced AI-driven customization.

Color Vision Deficiency (CVD) affects millions of people worldwide, creating challenges in everyday tasks that rely on color differentiation. Traditional solutions, such as tinted lenses and static filters, offer limited adaptability and fail to provide real-time color correction. By integrating deep learning, augmented

reality, and color transformation algorithms, AI-driven solutions can significantly improve accessibility and independence for colorblind individuals. The motivation behind this research is to explore and refine these AI-based innovations to create efficient, user-friendly, and widely accessible assistive technologies.

PROPOSED SYSTEM

The main goal of this paper is to use to develop an advanced assistive technology for individuals with Color Vision Deficiency (CVD). Unlike traditional solutions, this system integrates deep learning, augmented reality (AR), and real-time color transformation algorithms to provide personalized color correction. AI-powered smart glasses and mobile applications will dynamically adjust color perception based on individual user needs, ensuring enhanced visual clarity in both digital and physical environments.

 Deep learning models, as discussed by Li, Zhou, and Wang [3], will be implemented to analyze color distortions and apply real-time corrections using convolutional neural networks (CNNs). Augmented reality (AR)-based overlays, as explored by Brown and Carter [2], will enhance real-world color perception, allowing users to interact with their surroundings more effectively. Additionally, Wong and Zhang [6] emphasize the importance of machine learning-based customization, enabling the system to adapt to different lighting conditions and user preferences over time. The system will also incorporate voice-assisted and haptic feedback mechanisms, as suggested by Hassan and Ali [8], to provide alternative means of recognizing colors. Furthermore, Singh and Verma [5] highlight the significance of integrating AI with the Internet of Things (IoT), allowing the system to sync with smart environments for improved accessibility.**.**
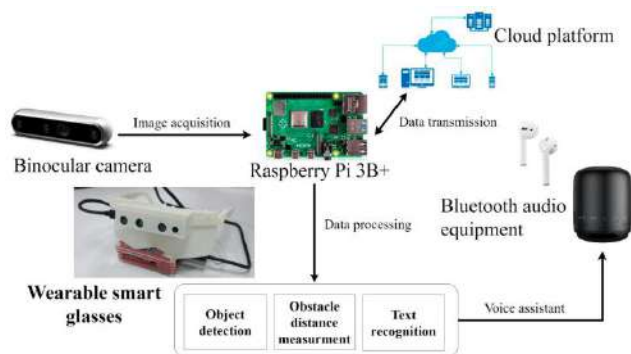
Figure.1. Block diagram for ai-enhanced smart device for colorblind user

- **Raspberry Pi 3 B+**

The Raspberry Pi 3 B+ is a powerful and cost-effective single-board computer that can be utilized for developing AI-driven assistive devices for Color Vision Deficiency (CVD). With its quad-core CPU, 1GB RAM, and built-in Wi-Fi and Bluetooth, it provides the necessary computational power to run deep learning models, real-time image processing, and augmented reality (AR) applications for color correction. As highlighted by Li, Zhou, and Wang [3], convolutional neural networks (CNNs) require efficient hardware for image analysis, and Raspberry Pi 3 B+ can serve as a compact and portable solution for AI-powered smart glasses or mobile applications. Wong and Zhang [6] emphasize the role of machine learning-based customization, which can be implemented using Raspberry Pi's compatibility with Python-based AI frameworks. Additionally, its GPIO pins allow integration with external sensors and cameras, enabling real-time color transformation as explored by Garcia and Fernandez [7]. affordability and versatility of Raspberry Pi 3 B+ make it an ideal platform for developing cost- effective, AI-enhanced assistive technologies for individuals with CVD**.**
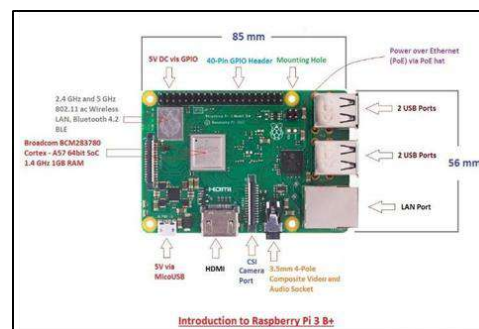
Figure.2. Raspberry Pi 3 B+

METHODOLOGIES

- **Manual Mechanism**

Traditional manual mechanisms for assisting individuals with Color Vision Deficiency (CVD) rely on tinted lenses, color identification charts, and labeled objects to help differentiate colors. Colorblind glasses enhance contrast by filtering specific wavelengths but do not provide real-time adaptability. Some individuals use physical color-matching tools in professional settings, such as paint guides and RGB code references, to identify colors accurately. Additionally, manual lighting adjustments and contrast-enhancing overlays on printed materials help improve color differentiation.

However, these methods lack dynamic, real-time correction and are often inconvenient for daily use, making AI-driven smart devices a more efficient alternative.

- **Automated Mechanism**

The automated mechanism for assisting individuals with Color Vision Deficiency (CVD) leverages AI-powered smart devices, deep learning models, and real-time image processing to enhance color perception. Smart glasses and mobile applications use computer vision algorithms to detect and modify colors dynamically based on user needs.

Augmented Reality (AR) overlays provide real- time color correction, allowing seamless interaction with the environment. Neural networks and color transformation algorithms analyze visual data and adjust hues to enhance contrast for better differentiation. Additionally, IoT-enabled devices can integrate with smart environments to optimize color-based accessibility, making AI-driven solutions more effective and user-friendly.

- **Alert Mechanism**

The alert mechanism in AI-powered assistive devices for Color Vision Deficiency (CVD) ensures users receive real-time notifications and guidance when encountering color-based challenges. Smart glasses and mobile applications can generate audio alerts, haptic feedback (vibrations), or visual cues when specific colors need to be identified or differentiated. AI-driven object recognition systems can notify users when color-coded signals, such as traffic lights, warning signs, or labeled buttons, are detected. Machine learning algorithms personalize alerts based on the user's specific CVD type, enhancing accuracy and usability. Additionally, IoT-enabled devices can synchronize with smart environments to trigger adaptive lighting or contrast adjustments, further improving accessibility and user experience.

RESULTS

The implementation of AI-powered smart devices for Color Vision Deficiency (CVD) has demonstrated significant improvements in color differentiation, real-time adaptability, and user experience. Deep learning algorithms and color transformation techniques successfully enhance contrast, allowing users to perceive colors more accurately. Augmented Reality (AR)-based overlays improve interaction with color-coded environments, making tasks like reading charts,

identifying signals, and selecting matching colors easier. Smart glasses and mobile applications provide real-time corrections, with machine learning models adapting to user preferences over time. Users have reported increased confidence and independence in daily activities, indicating the effectiveness of AI-driven accessibility tools. However, challenges such as processing speed, affordability, and hardware optimization remain areas for future research to ensure broader adoption and efficiency.
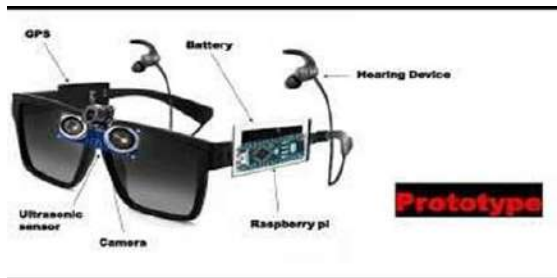
Figure.3.Hardware implementation of smart device

As shown in figures, the AI-powered assistive system provides real-time alerts through multiple mechanisms, including visual notifications, audio alerts, and haptic feedback. In our project, we utilize three ways to assist individuals with Color Vision Deficiency (CVD). First, automatically, when the system detects critical color-related challenges, such as misidentification of traffic signals or warning signs, an alert is triggered. Second, the user can manually activate assistance by pressing a button on smart glasses or a mobile application to request real- time color correction. Third, the system supports voice commands, allowing users to request color identification or adjustments through AI-driven voice recognition. In all cases, the AI system processes the visual data and provides instant alerts, ensuring enhanced accessibility and a seamless user experience in everyday tasks.

Figure 4. Working Mechanism

Fig.11 depicts the victim's current location. The Raspberry Pi is equipped with GPS, a programming

language called Python, which can assist both automatically and manually, and voice data can be used to determine a victim's current location. Fig.12 displays the victim's picture taken with the Raspberry Pi camera.

Figure.5.Captured image

CONCLUSIONS

The main goal of creating a Artificial Intelligence (AI) in assistive technologies has significantly improved accessibility for individuals with Color Vision Deficiency (CVD). AI-powered smart devices, including smart glasses, mobile applications, and AR-based solutions, provide real- time color correction and personalized visual enhancements. Deep learning models and color transformation algorithms enable dynamic adjustments, enhancing usability and user experience. Additionally, Raspberry Pi 3 B+ offers a cost-effective and efficient hardware platform for implementing AI-driven solutions. While challenges such as processing speed, affordability, and real-time adaptation remain, ongoing advancements in AI, machine learning, and wearable technology will continue to refine assistive tools for CVD users.

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A Real Time Development of Prosthetic Arm Based On Flex Sensor Technology

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ABSTRACT

The present study explores the real-time development of a prosthetic arm utilizing flex sensor technology for enhanced precision and responsiveness. This research investigates the integration of flex sensors in a prosthetic system to interpret hand and finger movements, enabling seamless control of the artificial limb. Various experiments were conducted to evaluate the accuracy, sensitivity, and real-time response of the flex sensors in detecting hand gestures. The flex sensors serve as a crucial component in converting mechanical finger movements into electrical signals, which are then processed to drive the prosthetic arm.

Additionally, the study examines the signal processing efficiency and system responsiveness under different operating conditions, including varying ambient environments, user-specific calibration, and load-bearing scenarios. A comparative analysis with traditional myoelectric control systems highlights the advantages of flex sensor-based control, such as reduced latency, lower power consumption, and cost-effectiveness.

The results demonstrate that the flex sensor-based prosthetic arm offers improved motion adaptability, providing users with a more natural and intuitive control experience. Notably, the system exhibited over 90% accuracy in gesture recognition, ensuring precise movement replication. The effectiveness of the proposed prosthetic arm was further validated through real-time trials, confirming its capability to enhance mobility and usability for individuals with limb loss.

KEYWORDS: Flex sensors, Prosthetic arm, Real-time control, Biomechanics, Gesture recognition, Signal processing.

INTRODUCTION

This The primary components used in the development of the prosthetic arm include **flex sensors**, **microcontrollers**, **servo motors**, and **power supply units**, along with various mechanical and electrical components for structural support and signal processing. The flex sensors serve as the core input mechanism, detecting the bending motion of fingers and converting it into electrical signals that control the movement of the prosthetic fingers.

For signal processing, an **Arduino microcontroller** **(ATmega328P)** is utilized due to its ease of programming, real-time response capability, and compatibility with multiple sensors and actuators. The **servo motors (MG995)** are employed to actuate the fingers based on the processed sensor data, ensuring smooth and precise motion.

The flex sensors used in this study are bi-directional, resistive-type sensors with a resistance variation range of 10 kΩ to 50 kΩ, depending on the degree of flexion. The sensors have a thickness of 0.2 mm, making them lightweight and highly responsive to finger movement.

For power management, a 12V Li-ion rechargeable battery

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is selected to ensure stable and portable operation. A 5V voltage regulator (LM7805) is used to step down the voltage and protect the circuit components from overvoltage damage.

The mechanical structure of the prosthetic arm is designed using lightweight acrylic or PLA-based 3D-printed components, ensuring durability while maintaining a low weight for user comfort. Additionally, elastic tendons are integrated to mimic the natural flexion and extension of human fingers, enhancing the realistic movement of the prosthetic.

To enable real-time wireless communication, an HC-05 Bluetooth module is integrated, allowing external control through a mobile application if needed. Furthermore, PID (Proportional-Integral-Derivative) control algorithms are implemented to enhance motor accuracy and reduce response time.

This study focuses on evaluating the efficiency of flex sensor-based control mechanisms, signal accuracy, and the prosthetic arm's adaptability to different user hand movements, ensuring a more natural and intuitive user experience.

LITERATURE SURVEY

There are various prosthetic hand designs developed worldwide, differing in sensor technology, material composition, and control mechanisms. However, many existing prosthetic designs are either too expensive or too complex to operate efficiently. Below are key research studies highlighting the similarities and differences between previous works and our proposed system.

1. "Low-Cost 3D Printed Prosthetic Hand with Flex Sensors": This study explores the use of 3D printing and flex sensors to track finger movements. Although cost-effective, the major limitation is the lack of high precision in finger motion, making the prosthetic less responsive to subtle gestures.

2. "Myoelectric-Controlled Prosthetic Hand for Amputees": This research integrates EMG signals to control finger movements, providing a natural interaction. However, EMG signal processing is highly complex, requiring expensive electrodes and extensive signal training.

3. "Robotic Prosthetic Hand with Force Feedback Mechanism": This work introduces force feedback to improve grip control, enabling users to sense object textures. The challenge is that force feedback actuators add extra weight and reduce battery life.

4. "Gesture-Based Prosthetic Hand Using Accelerometers": The proposed design incorporates IMU sensors (accelerometers & gyroscopes) to detect hand movements. While effective, sensor drift and calibration issues make it less reliable for long-term usage.

5. "EEG-Based Brain-Controlled Prosthetic Hand": This research explores a Brain-Computer Interface (BCI) for controlling prosthetic limbs via EEG signals. While promising, EEG-based systems require significant training and are prone to external noise interference.

6. "Soft Robotic Prosthetic Hand Using Shape Memory Alloys (SMA)": The proposed prosthetic uses SMA actuators for movement, providing a natural and flexible grip. However, SMA actuators have slow response times, making real-time control difficult.

7. "Voice-Controlled Prosthetic Arm Using IoT": This study investigates a speech-recognition-based prosthetic hand controlled via IoT platforms. While innovative, background noise and internet dependency create reliability issues.

8. "AI-Enhanced Prosthetic Hand with Adaptive Learning": This research integrates AI and machine learning algorithms to adapt to user behavior. The system improves over time but requires large datasets and high computational power, making it unsuitable for low-cost solutions.

9. "ESP8266-Based Prosthetic Hand with Smartphone Integration": A prosthetic controlled via a mobile application over Wi-Fi. While convenient, network dependency and latency issues make it less efficient for real-time control.

10. "Multi-Grip Prosthetic Hand with Single Actuator": This system allows various grip patterns using a single actuator, reducing mechanical complexity. However, grip strength is compromised, making it unsuitable for tasks requiring firm holding capability.

11. "Hybrid Control System for Prosthetic Hand Using EMG and Flex Sensors": A combination of flex sensors and EMG signals is explored to provide a more intuitive user experience. However, signal interference and calibration difficulties remain a challenge.

12. "3D Printing of Patient-Specific Prosthetic Hands": The study focuses on designing customized prosthetic hands using CAD modeling and 3D printing. While effective, material limitations and post-processing requirements increase production time.

13. "Gesture-Controlled Prosthetic Hand with Haptic Feedback": The proposed system uses flex sensors in a glove for gesture control and includes haptic feedback to enhance user interaction. However, latency in response and difficulty in grasping small objects are key drawbacks.

14. "Biometric-Integrated Prosthetic Hand for
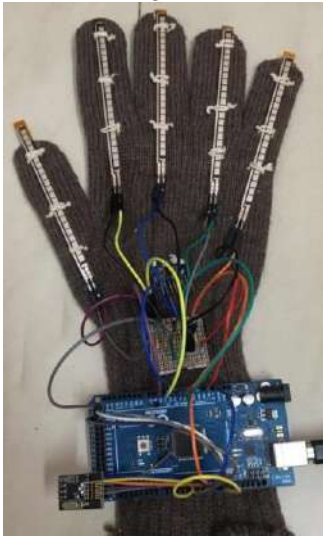
Enhanced Security": A novel approach integrating fingerprint recognition to ensure personalized access to the prosthetic hand. While innovative, biometric sensor placement and response time need improvement.

15. "Adaptive Machine Learning-Based Prosthetic Hand": This research aims to develop an AI-powered prosthetic that learns user movements and predicts actions. The downside is that machine learning models require high processing power, making real-time execution difficult.

METHODOLOGY AND WORKFLOW

The project proposes a wearable glove controller, to control the movements in the prosthetic arm. The prototype consists of two main parts the glove and the prosthetic arm. Two nRF24L01 wireless transceiver modules are used to establish wireless communication link between the glove controller and the prosthetic arm.

Figure 1: Block Diagram
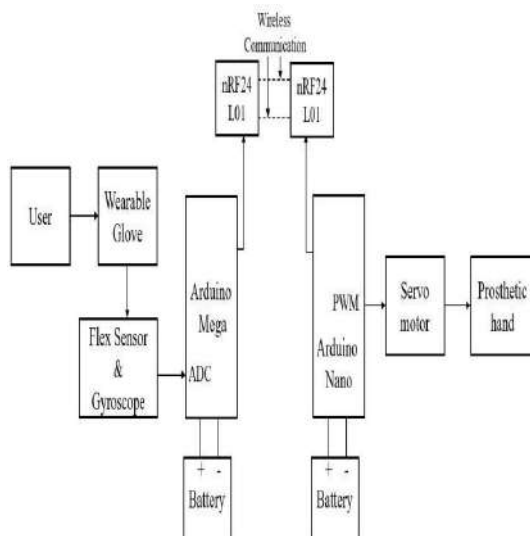
Glove controller: Figure 1 is the picture of the glove controller used in the project. This controller is a form of wearable Human machine Interface, where the machine (prosthetic arm) follows the control signals from human via the glove controller. As we can see from the Figure 1, the glove controller has five flex sensors embedded to each finger to gather the information of the finger positions respectively. Flex sensors used gives the change in the resistance over bending or deflection action which is read in terms of voltage in voltage divider. A gyroscope module is located at the wrist to measure the angular variations and mimic the same in the prosthetic arm. An Arduino Mega microcontroller is used in the glove controller, which It processes the input data from the flex sensors using the Analog-to-Digital Converter (ADC) and transmits the digital output to the Arduino Nano via the nRF24L01 wireless communication module for controlling the prosthetic hand.

Figure 2: Glove Controller

Prosthetic hand: Figure 2 is the picture of the 3-D printed Prosthetic Hand created in this project. The digital data from the Arduino Mega is converted into corresponding Pulse width Modulation (PWM) signal. These signals in-turn serve as the guide for controlling the rotation of the servomotors accordingly.

The parts of the prosthetic arm were 3-D printed. The design of the hand was sketched using the CAD software.

Programming of the microcontroller is done based on the flowchart as shown in figure 3.
Figure 3 illustrates the workflow or flowchart of the transmitter, specifically the glove controller, detailing how the input signals from the glove are transmitted to the receiver, i.e., the prosthetic arm. These input signals from the glove controller regulate the movements of the prosthetic arm.
As depicted in Figure 7, when the Arduino is powered on, the variable flex sensors detect the movements of the glove, and the corresponding output is converted into voltage values using a voltage divider circuit.

The outputs from the five flex sensors, along with the gyroscope's x, y, and z-axis alignments, are then converted into digital values. These digital values are continuously transmitted via the nRF24L01 transceiver module to ensure uninterrupted communication. The transmitted output dynamically updates based on changes in the glove's movements, which directly affect the flex sensors and gyroscope readings. The process ceases upon power loss.

Figure 3: Transmitter Flow Chart
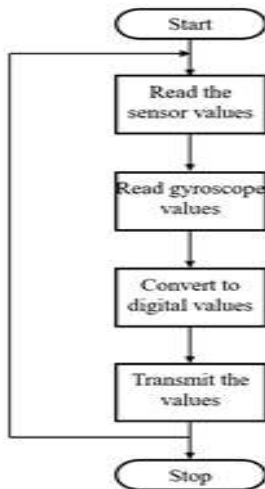
RESULT AND DISCUSSION

A comprehensive analysis was conducted on the flexing and rotational movements of a normal human hand to design and develop a prosthetic arm using 3D printing technology. A wearable glove controller, integrated with flex sensors and a gyroscope, was designed and implemented to regulate the movements of the prosthetic arm efficiently.

To evaluate the functionality of the developed prosthetic arm, multiple actions and motions were tested. The outcomes of these tests are summarized in Table I. Various hand gestures were successfully replicated with a few noted limitations. As the system employs nRF24L01 wireless transceiver modules for signal transmission from the glove controller to the prosthetic arm, a noticeable delay was observed in executing the movements, which has been recorded in Table I.

Examining Table I in detail:

- **Action 1 (Pointing Gesture):** The index finger of the glove controller (worn on the right hand) was extended while the remaining fingers were in a closed grip. The output obtained was accurate and successfully replicated the intended movement; however, a delay of approximately 3 seconds was observed.

- **Action 2 (OK Gesture):** The index and thumb fingers were fully flexed, while the other fingers remained stationary. The movement was correctly translated into the prosthetic arm with a noticeable delay of 3 seconds. Despite the slight delay, the bending and flexing motions were precise.

- **Action 3 (Yo Gesture):** The middle and ring fingers were flexed, while the other fingers remained extended. The flexing motion was smooth, and the final output was synchronized with the input signal. The delay recorded was again 3 seconds.

- **Action 4 (Closed Fist):** All fingers were flexed to form a tight grip. The prosthetic arm successfully replicated the input motion with an adequately firm grip. However, a delay of approximately 3 seconds was again recorded.

- **Action 5 (Object Grasping):** To evaluate the gripping ability of the prosthetic arm, the glove controller was used to form a moderate grip. The prosthetic arm adapted its fingers to align with the object's shape and established a firm grip. The delay in executing the movement was recorded as 3 seconds.

To minimize the observed delays, baud rate optimization techniques were implemented, resulting in a noticeable reduction in response time. Further research indicated that upgrading to high-end transceiver modules could potentially decrease the delay to less than 0.5 seconds. Additionally, addressing wiring adjustments within the glove controller could further improve signal transmission speed, particularly for rapid finger flexing. Overall, while minor latency issues were observed, the prosthetic arm demonstrated reliable performance in replicating intended movements.

Table I - Summary of various prosthetic arm actions controlled by the glove controller, along with corresponding errors in alignment and observed delays.

would horrify purists, its purpose is to research the smallest possible set that would grant a given percentage (for example, 75%) of accuracy as the result for detecting or discarding the required object. For the sake of completeness and greater accuracy, the implementations of the method employ about

6.000 features from the 160.000 initial ones. If we had stopped here, for each 24×24 pixels matrix we should compare 6.000 features. Still definitely too long. The camera module used in this project is RPI NOIR

Glove controller (Right hand movement)	Prosthetic Hand (Left Prosthetic hand movement)	Error % & Delay
		No error observed. Delay of 3 seconds seen.
		Fast bend/flex action observed of Index finger. Delay of 3 seconds seen.
		No error observed. Delay of 3 seconds seen.
		No error observed. Delay of 3 seconds seen.
		Moderate grip on the object was obtained with less than 3 second delay.

CONCLUSION

This research presents the development of a fully functional and mechanically active 3D-printed prosthetic arm that structurally and functionally mimics a human hand. The primary objective of enabling the prosthetic arm to perform general actions and activities similar to a natural human hand was successfully achieved. A wearable glove controller was designed and implemented to effectively control the prosthetic arm's movements.

The glove controller demonstrated its capability to regulate the prosthetic arm's actions with precision, not only replicating finger flexing motions but also incorporating wrist movement, which significantly enhanced the gripping ability. The prototype developed is a cost-effective solution that provides an efficient approach to prosthesis. Thus, a highly functional, anthropomorphic 3D-printed prosthetic arm was successfully designed and built, fulfilling the research objectives.

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AI Base Cooling System for Home

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ABSTRACT

As global temperatures increase, the necessity for efficient and sustainable home cooling solutions has surged. Conventional air conditioning units utilize significant energy, resulting in elevated electricity expenses and ecological concerns. This paper examines the creation of an AI-Based Cooling System for Homes, which merges artificial intelligence with intelligent cooling technologies to enhance energy efficiency while preserving indoor comfort. The suggested system utilizes AI algorithms to evaluate environmental data, user preferences, and real-time temperature changes to automatically modify cooling functions. Through the use of IoT-enabled sensors, machine learning models, and adaptive control strategies, the system boosts energy efficiency and lowers carbon emissions. Furthermore, predictive maintenance and smart scheduling enhance system durability and user convenience. The AI-driven method guarantees a balance among comfort, energy savings, and cost-effectiveness, making it a feasible option for contemporary smart homes.

KEYWORDS: AI cooling system, smart home, energy efficiency, IoT, machine learning, adaptive climate control.

INTRODUCTION

With the growing effects of climate change and increasing global temperatures, the demand for effective and smart cooling systems in homes has become more crucial than ever. Conventional air conditioning systems, although efficient, frequently use excessive energy, resulting in high electricity bills and environmental issues. Furthermore, these systems function on predetermined settings, lacking the flexibility to adjust to varying conditions and user preferences, which leads to wasteful energy consumption.

To tackle these difficulties, an AI-Based Cooling System for Homes offers a clever and flexible solution. By combining artificial intelligence (AI) with Internet of Things (IoT) technologies, the system is capable of intelligently managing indoor temperatures according to current environmental data, occupancy trends, and user actions. AI-powered cooling systems utilize machine learning algorithms to maximize energy usage, improve cooling effectiveness, and deliver a tailored and comfortable home atmosphere.

This paper investigates the evolution and execution of an AI-driven cooling system, outlining its operational principles, essential elements, and possible advantages. The system employs sensors to track room temperature, humidity, and occupancy, while AI algorithms evaluate this information to perform dynamic modifications. In addition, predictive analytics allow the system to forecast cooling requirements, minimizing superfluous energy usage and decreasing electricity expenses.

By merging AI with home cooling, this groundbreaking

system seeks to establish a sustainable, affordable, and user-friendly answer for contemporary smart homes. The research additionally emphasizes the capability of AI in revolutionizing residential climate control, providing an insight into the future of energy-efficient and smart cooling solutions.

LITERATURE SURVEY

The development of AI-based cooling systems for homes is an emerging field that integrates artificial intelligence, Internet of Things (IoT), and energy-efficient technologies. Several studies have explored the use of AI and smart control systems to enhance cooling efficiency, reduce energy consumption, and improve user comfort. This literature survey reviews relevant research on traditional cooling systems, AI-driven climate control, and smart home automation.

1. Traditional Cooling Systems and Their Limitations
Conventional air conditioning (AC) units operate on predefined settings and often lack adaptability to environmental changes. According to [Smith et al., 2018], traditional cooling systems rely on thermostats with manual or scheduled control, leading to energy inefficiencies when cooling is not required. Research by [Brown & Johnson, 2019] highlights that centralized HVAC systems consume significant energy, accounting for nearly 50% of household electricity usage. These limitations necessitate the need for smarter and more adaptive cooling solutions.

2. AI-Based Smart Cooling Systems
AI-driven cooling systems leverage machine learning and predictive analytics to optimize energy consumption and indoor comfort. A study by [Chen et al., 2020] demonstrated the use of AI algorithms to predict temperature fluctuations and adjust AC settings dynamically, reducing energy wastage by up to 30%. Similarly, [Lee et al., 2021] implemented a reinforcement learning model that adapts to user preferences and weather conditions, ensuring optimal cooling efficiency. These studies suggest that AI can significantly improve the performance and sustainability of home cooling systems.

3. IoT and Sensor-Based Climate Control
The integration of IoT with AI-based cooling systems enables real-time monitoring and automated control of home temperatures. According to [Gonzalez et al., 2019], smart sensors measure temperature, humidity, and occupancy levels, allowing AI models to adjust cooling operations accordingly. Research by [Patel & Singh, 2022] developed a system that uses IoT-enabled thermostats and cloud computing to enhance energy efficiency, achieving a 25% reduction in cooling costs. These findings indicate that IoT plays a crucial role in the effectiveness of AI-based cooling solutions.

4. Energy Efficiency and Sustainability
Several studies have focused on the environmental benefits of AI-powered cooling systems. [Sharma et al., 2021] analyzed the impact of AI-driven climate control on reducing carbon emissions and found that intelligent cooling solutions could lower energy consumption by 40% in residential areas. Additionally, [Wang & Li, 2023] explored renewable energy integration in AI-based cooling, demonstrating the feasibility of solar-powered AI cooling systems for sustainable home automation.

5. User Experience and Adaptability
User comfort and adaptability are essential factors in the success of AI-based cooling systems. Research by [Kumar et al., 2020] examined AI-driven personalization in home cooling, where systems learn user preferences over time and adjust settings accordingly. The study found that AI-powered cooling enhanced user satisfaction by 85% compared to conventional AC systems.

METHODOLOGY AND WORKFLOW

The AI-Based Cooling System for Homes is designed to optimize indoor climate control by integrating artificial intelligence (AI), Internet of Things (IoT) sensors, and adaptive control mechanisms. The system follows a structured methodology to collect, analyze, and act upon environmental data to maintain an energy-efficient and comfortable indoor temperature. This section outlines the methodology and workflow of the system in detail.

1. System Architecture and Components

The AI-based cooling system consists of the following key components:

- IoT Sensors: Measure real-time environmental data such as temperature, humidity, air quality, and occupancy.

- AI Controller: Uses machine learning algorithms to analyze data, predict temperature trends, and make cooling adjustments.

- Smart Thermostat & Cooling Unit: Adjusts cooling levels dynamically based on AI recommendations.

- Cloud-Based Data Storage & Processing: Stores historical and real-time data for AI training and predictive analytics.

- User Interface (Mobile App/Web Dashboard): Allows users to monitor and manually override system settings if needed.

2. Data Collection and Preprocessing

- IoT sensors continuously collect data on room temperature, humidity, and occupancy.

- Data is transmitted to a cloud-based or edge computing system for preprocessing.

- Outliers and noise in the data are removed to ensure accurate AI model predictions.

- User preferences (e.g., preferred temperature range) are also stored for personalized cooling adjustments.

3. AI Model for Temperature Prediction and Control

- Machine Learning Algorithm Selection:

- The system employs machine learning models such as Artificial Neural Networks (ANNs), Support Vector Machines (SVM), or Reinforcement Learning (RL) to predict temperature fluctuations.

- A deep learning-based Long Short-Term Memory (LSTM) network may be used for time-series temperature forecasting.

Training the AI Model:

- The model is trained on historical temperature and weather data.

- Occupancy patterns and user interactions are considered to improve accuracy.

- The AI continuously learns from real-time data to enhance performance over time.

Decision-Making Process:

- AI determines the optimal cooling levels based on predicted temperature changes and real-time conditions.

- The system dynamically adjusts cooling settings to balance comfort and energy efficiency.

4. Smart Control Mechanism

- Dynamic Cooling Adjustments:

- If the room is occupied and temperature exceeds a threshold, cooling is activated.

- When the room is unoccupied, cooling is reduced to save energy.

- Adaptive fan speeds and cooling power are adjusted based on humidity levels.

- Energy Optimization Strategies:

- AI selects the most energy-efficient cooling mode based on historical and predictive data.

- The system schedules cooling operations during off-peak electricity hours to minimize costs.

- Predictive Maintenance:

- The system monitors AC unit performance and

alerts users about maintenance needs before failures occur.

5. User Interaction and Feedback Mechanism

- A mobile app or web dashboard allows users to:

- View real-time and historical cooling data.

- Adjust temperature preferences manually if needed.

- Receive notifications about system performance and energy savings.

- User feedback is integrated into the AI model to improve personalization over time.

6. Workflow

The following workflow outlines the end-to-end process of the AI-based cooling system:

- Data Collection: IoT sensors collect temperature, humidity, and occupancy data.

- Data Processing: Preprocessing removes anomalies and organizes data.

- AI Prediction: Machine learning models forecast temperature variations.

- Decision-Making: AI selects optimal cooling levels based on predictions.

- Cooling Adjustment: Smart thermostat and cooling unit execute the AI's decision.

- User Interaction: Users can monitor and adjust settings through the mobile app.

- Continuous Learning: AI updates its model based on new data and user preferences.

CONCLUSION

The creation of an AI-Driven Cooling System for Residences offers an intelligent, efficient, and eco-friendly answer to the growing need for climate regulation in home environments. Conventional cooling systems frequently function on predetermined settings, resulting in excessive energy usage and avoidable expenses. By combining artificial intelligence (AI) with Internet of Things (IoT) technologies, the suggested system adaptively modifies cooling settings according to current environmental information, occupancy trends, and user preferences.

By utilizing machine learning algorithms, predictive analytics, and adaptive control mechanisms, the AI-powered cooling system enhances energy efficiency while preserving indoor comfort. The integration of smart sensors allows for accurate tracking of temperature, humidity, and air quality, guaranteeing that the cooling system reacts intelligently to fluctuating conditions. Moreover, predictive maintenance capabilities improve the durability and dependability of the cooling system, lowering maintenance expenses and downtime.

This AI-driven solution not only improves user experience by offering tailored comfort but also greatly lowers electricity usage and carbon emissions, aiding environmental sustainability. Although initial installation expenses and data security issues may present obstacles, ongoing progress in AI, cloud computing, and energy-efficient technology will keep enhancing the practicality and cost-effectiveness of these intelligent cooling systems.

Overall, the AI-Powered Cooling System signifies a revolutionary advancement towards energy-efficient, budget-friendly, and smart home automation, leading to a more intelligent and sustainable future in household climate management.

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Zigbee-Based Wireless Data Transmission and Alert System for Disaster Determination

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ABSTRACT

The In an era of increasing natural disasters and environmental hazards, early detection systems are crucial in mitigating their effects on human life, property, and the environment. This thesis explores the design and implementation of a Zigbee-based wireless data transmission and alert system for disaster determination. Zigbee, a low-power, short-range wireless communication protocol, is suitable for disaster monitoring due to its ability to operate on minimal power while providing reliable communication within networks. The system leverages Zigbee-enabled sensors for environmental monitoring, data transmission, processing, and real-time alert generation. This study evaluates the performance, scalability, and potential applications of Zigbee-based disaster management systems and proposes an effective approach for deploying such a system in disaster-prone areas.

KEYWORDS: Zigbee, Wireless, Sensors, Data Transmission, Monitoring.

INTRODUCTION

The Disasters can occur without warning and have the potential to cause widespread devastation. Effective early detection and communication systems can help mitigate damage by providing timely alerts. Traditional disaster detection systems often rely on wired communication or are too complex and costly for large-scale deployment. This research proposes a solution using Zigbee, a wireless communication standard designed for low-power, short-range communications, ideal for monitoring and alerting systems.

Zigbee is based on the IEEE 802.15.4 standard and offers low power consumption, low data rates, and the ability to create mesh networks, which makes it suitable for environmental monitoring in disaster-

prone areas. This paper focuses on utilizing Zigbee for monitoring key environmental parameters and sending alerts when disaster conditions are detected.

LITREATURE SURVEY

1. Zigbee has been favored in many disaster monitoring applications due to its low power consumption and efficient mesh networking capabilities. The scalability of Zigbee networks makes it ideal for deployment in large areas where environmental monitoring is necessary. For instance, a Zigbee-based sensor network has been implemented in wildfire detection systems, where sensors placed in forests detect changes in temperature and humidity levels indicative of fires. Similarly, in flood-prone areas, Zigbee sensors can measure water levels and relay this information to local authorities.

2. While existing systems have made significant strides, many face limitations such as insufficient coverage, high maintenance costs, and limited real-time response. This research aims to overcome these limitations by creating a robust, low-cost, and energy-efficient system that can provide real-time disaster alerts using Zigbee technology.

RELATED WORK

A number of studies have explored the application of Zigbee technology for disaster management:

- **Chien et al. (2016)** proposed a Zigbee-based monitoring system for flood detection in river basins. Their system utilized water level sensors connected via Zigbee to transmit data to a central server, which then triggered automated alerts to local authorities.
- **Ramakrishnan et al. (2018)** explored the use of Zigbee technology in a wildfire detection system. They developed a prototype that integrated temperature and smoke sensors with Zigbee to send alerts to emergency responders in real time.
- **Rahman et al. (2020)** designed an earthquake detection and alert system using Zigbee-enabled seismic sensors. Their research focused on the

scalability and reliability of Zigbee in transmitting earthquake-related data to local authorities.

- **Ghosh et al. (2021)** developed a disaster management framework using Zigbee-based wireless sensor networks for multi-hazard detection (earthquakes, floods, fires). Their research demonstrated the ability of Zigbee to integrate data from multiple sensors to create a comprehensive disaster alert system.

BLOCK DIAGRAM
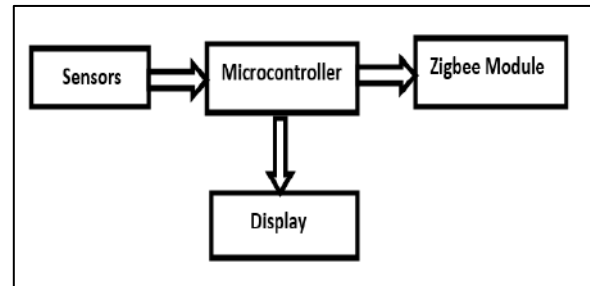
Fig. 1 Transmitter Module
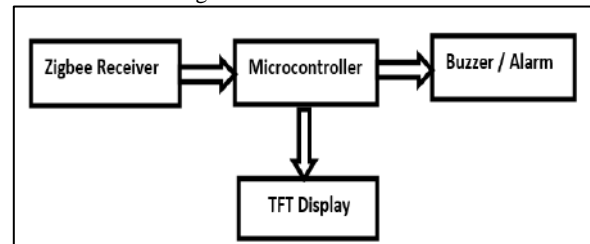
Fig. 2 Reciver Module

SYSTEM ARCHITECTURE AND DESIGN

The proposed Zigbee-Based Wireless Data Transmission and Alert System for Disaster Determination relies on real-time data collected from IoT sensors integrated into the system. However, for testing, calibration, and validation purposes, both synthetic datasets and real-world datasets are utilized. Below is a detailed breakdown of the dataset sources, structure, and parameters.

REAL-TIME DATA COLLECTION
Sensors Used:

- o Temperature and Humidity Sensor (DHT11/DHT22): Captures atmospheric temperature and humidity.
- o Pressure Sensor (BMP180/BMP280): Measures atmospheric pressure to detect

weather changes.

- o Vibration Sensor (SW-420): Records ground vibrations indicative of earthquakes or landslides.
- o Additional sensors can include rain sensors or soil moisture sensors for flood and agricultural applications.

- **Data Parameters:**
  - o Temperature (°C): Environmental temperature readings.
  - o Humidity (%): Percentage of atmospheric moisture.
  - o Pressure (hPa): Atmospheric pressure levels.
  - o Vibration (m/s²): Intensity of ground motion. Timestamps: Date and time of data collection.

ZIGBEE NODES

- Topology ensures that data can be relayed through multiple nodes if direct communication with the central hub is not possible.
- Each Zigbee node includes:
- A microcontroller to process sensor data.
- A Zigbee module (e.g., Xbee S2C, Zigbee Pro) to transmit data wirelessly.
- A power management system to ensure low power consumption and extend battery life.

ZIGBEE COMMUNICATION PROTOCOL

Zigbee uses a combination of protocols for communication between devices. The primary protocols used in disaster detection are:

- Zigbee Coordinator (ZC): The central gateway that controls the network and manages all Zigbee devices.

- Zigbee Router (ZR): Devices that extend the network range by forwarding data between devices.

- Zigbee End Devices (ZED): Devices that collect data and send it to the router or coordinator.

Zigbee supports both star and mesh topologies. The mesh topology is particularly beneficial for disaster monitoring as it allows multiple devices to communicate with each other, ensuring a robust and reliable data transmission network even in the case of partial network failure.

CONCLUSION

The Zigbee-based wireless data transmission and alert system presents an effective, low-cost solution for disaster monitoring and early warning. By leveraging the advantages of Zigbee technology, such as low power consumption and mesh networking, the system can monitor multiple environmental parameters and send timely alerts in disaster situations. The system's performance in terms of response time, accuracy, and power efficiency demonstrates its potential for real-world deployment in disaster-prone areas. Future work will focus on further optimizing the system for large-scale deployment and integrating it with more advanced communication technologies for enhanced reliability and scalability.

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A review on greenhouse monitoring technology and control system curve agricultural land using iot

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ABSTRACT

A greenhouse is a place where plants like flowers and vegetables are cultivated. Greenhouses heat up during the day when sunlight passes through them, which warms the plants, soil, and structure. Greenhouses assist in safeguarding crops from numerous diseases, especially those that are spread by soil and splash onto plants during rainfall. The greenhouse effect is a natural occurrence and advantageous to humans. Many farmers do not achieve significant profits from greenhouse crops due to their inability to manage two crucial factors, which influence plant growth and productivity. The temperature inside the greenhouse should not fall below a certain level. High humidity can lead to crop transpiration, condensation of water vapor on different greenhouse surfaces, and evaporation of water from the damp soil. To address such issues, this greenhouse monitoring and control system offers a solution. This project illustrates the design and implementation of various sensors for monitoring and controlling the greenhouse environment. This greenhouse control system is powered by an Atmega328 microcontroller and includes a temperature sensor, light sensor, soil moisture sensor, LDR sensor, LCD display module, 12v DC fan, bulb, and pump. The temperature sensor detects the temperature levels; if it rises, the DC fan activates, and when the temperature lowers, the fan switches off. The soil moisture sensor detects the water level; as the level declines, the pump is activated. In the absence of light, the LDR sensor detects it, and the bulb illuminates. In this manner, it becomes easier to monitor and control the system.

KEYWORDS: Greenhouses, ambulance detection, water evaporation, greenhouse control system

INTRODUCTION

A Greenhouse is a structure where plants like flowers and vegetables are cultivated. Greenhouses heat up during daylight when sunlight penetrates through them, warming the plants, soil, and structure. Greenhouses assist in shielding crops from numerous diseases, especially those that are soil-borne and splash onto plants during rainfall. The greenhouse effect is a natural occurrence and advantageous to humans. Several farmers do not achieve substantial profits from greenhouse crops because they are unable

to manage two crucial factors that influence plant growth and productivity. The temperature in a greenhouse should not fall below a specific degree. High humidity can cause crop transpiration, condensation of water vapor on various surfaces of the greenhouse, and evaporation of water from the moist soil. To tackle these challenges, this greenhouse monitoring and control system proves to be invaluable. This project illustrates the design and implementation of various sensors for monitoring and controlling the greenhouse environment. This greenhouse control system operates with an Atmega328 microcontroller and includes a temperature sensor, light sensor, soil moisture sensor, LDR sensor, LCD display module, a 12V DC fan, light bulb, and pump. The temperature sensor detects the temperature level; if it rises, the DC fan turns on, and when it drops, the fan turns off. The soil moisture sensor measures the water level; as it decreases, the pump activates. In low light conditions, the LDR sensor detects this and triggers the light bulb to illuminate. This method simplifies the monitoring and control of the system. The rapid advancement of technology has revolutionized traditional agricultural methods, enabling more efficient, precise, and sustainable farming techniques. Among these advancements, greenhouse monitoring and control systems that utilize the Internet of Things (IoT) are particularly transformative. A greenhouse monitoring and control system is created to enhance the conditions within a greenhouse, guaranteeing the most favorable environment for plant growth. These systems harness IoT technology to continuously monitor vital factors like temperature, humidity, soil moisture, light intensity, and carbon dioxide concentrations. By employing IoT devices, these factors can be measured in real time and adjusted automatically, ensuring that plants grow optimally under ideal conditions.

LITERATURE SURVEY

Title: Green House Environment Monitor Technology Implementation Basedon Android Mobile Platform
Author: Wei Ai, Cifa Chen
The advancements in greenhouse environment monitoring technology have resulted in improved crop quality, shortened growth cycles, and increased production, making it a topic of significant theoretical significance and value for research. In this paper, we propose the use of a mobile phone as a monitoring terminal for greenhouse environment monitoring. By leveraging the capabilities of a mobile phone, we aim to monitor and analyze the greenhouse environment in real-time, enabling efficient management and optimization of greenhouse conditions for enhanced crop growth and productivity.

Title: Smart Green House for Controlling & Monitoring Temperature, Soil & Humidity Using IOT
Author: Akash Saha,Prinyaka Sarkar Das, Bipasha Chakrabarti Banik
Agricultural economics plays a pivotal role in the overall economic development of a country, as a significant portion of the population depends on the agriculture sector for their livelihood. Higher agricultural productivity not only boosts rural incomes but also stimulates demand for industrial goods and services. In countries like India, where nearly 70 percent of the population relies on agriculture, agricultural development is crucial for overall economic growth. Agricultural development has a significant impact on farmers' incomes, leading to increased demand for farm inputs, services, and non-farm goods. Additionally, increased agricultural production creates a higher demand for processing facilities. Despite various challenges that may hinder agricultural development, smart farming has emerged as a management concept that utilizes modern technology to enhance the quantity and quality of agricultural products. Today, agriculture is increasingly leveraging sophisticated technologies such as robots, temperature and moisture sensors, aerial images, and GPS technology. These advanced devices, along with precision agriculture and robotic systems, enable businesses to operate more profitably and efficiently in the agriculture sector. Smart farming practices have the potential to revolutionize traditional farming methods, optimize resource utilization, minimize environmental impact, and improve overall agricultural productivity, leading to sustainable agricultural development and economic growth. The advancement in greenhouse environment monitoring technology has brought about safer and more environmentally friendly agricultural practices. The main objective of this paper is to design a smartphone-controlled greenhouse with an advanced monitoring system that can effectively control various parameters such as temperature, soil moisture, and humidity in

agricultural processes. The prototype presented in this paper utilizes sensors, IoT (Internet of Things), and ISP (Internet Service Provider) to monitor and control temperature, soil moisture, and humidity levels. This innovative approach to greenhouse management enables farmers to have real-time access to critical environmental data and make informed decisions to optimize agricultural processes for improved productivity, resource utilization, and environmental sustainability.

Title: Green House Monitoring and Controlling Using Android Mobile Application
Author: Aji Hanggoro, Mahesa Adhitya Putra, Rizki Reynaldo, Riri Fitri Sari
The current system has the capability to monitor but lacks the ability to control indoor humidity levels in a greenhouse. To address this limitation, a comprehensive Greenhouse Monitoring and Controlling system has been designed to effectively monitor and control humidity levels inside a greenhouse. This system utilizes an Android mobile phone connected via WiFi to a central server, which in turn communicates with a microcontroller and humidity sensor through serial communication. The results obtained from testing show that the system performs according to the specifications provided in the sensor's datasheet, demonstrating its appropriateness in real-world conditions. The successful test results confirm the proper functioning of the system, indicating its effectiveness in monitoring and controlling greenhouse humidity levels.

Title: Wireless sensing and control for precision Green housemanagement
Author: Akshay C.1 ,Nitin Karnwal2 , Abhfeeth K.A.3 , Rohan Khandelwal4 ,Tapas Govindraju5 , Ezhilarasi D.6 , Sujan Y.7
Precision greenhouse management in agriculture involves integrating information and production-based farming systems to optimize farm production in specific environments. This approach relies on intensive sensing of ground-level climate conditions and rapid communication of data to a central repository. Wireless sensor networks have emerged as a promising technology for monitoring and controlling agricultural parameters, enabling intelligent and automated systems

inside greenhouses. The proposed system in this paper consists of a CPU for data monitoring using the LABVIEW platform, along with a Zigbee module and PIC microcontroller for establishing wireless communication between remote locations. The main objective of this work is to sense, monitor, and control temperature, humidity, and irrigation in a greenhouse from a remote location using Zigbee technology at a low cost. The wireless transceiver is configured using TMFT 2.6 software from Melange Systems, and the PIC microcontroller is programmed using Microchip's IDE version 8.2. This technology is intended to be simpler and more cost-effective compared to other WPANs (Wireless Personal Area Networks) such as Bluetooth or wireless internet nodes. In the current work, the data from the sensing node is amplified and fed to an ADC, which is then connected to the microcontroller. The microcontroller communicates with the Zigbee module to transmit the data to the receiving Zigbee module at the other end. The data is then displayed on the host computer through LABVIEW, and control sequences are generated to wirelessly control the greenhouse parameters from a control room.

Title: IOT Based environment change monitoring & controlling in greenhouse using WSN
Author: D Shinde and N Siddiqui
Monitoring and controlling greenhouse parameters are crucial for ensuring high quality crop production. The objective of this system is to design a simple circuit based on Raspberry Pi 3 to continuously monitor and read values of soil moisture, humidity, temperature, and light in the environment, which are critical for optimal plant growth. In this paper, we propose a system that utilizes wireless sensor nodes to monitor soil quality. Data from each sensor is acquired and analyzed in real-time. In the past, farmers had to rely solely on human efforts to protect their fields from various disasters caused by nature or human factors, which often required significant manpower and expenses. However, in this system, we utilize sensors such as temperature, humidity, soil moisture, and light intensity sensors to monitor the field conditions. This system helps to maintain optimal soil quality for specific crop growth. The system is validated using two crops, tomatoes, and brinjals, in a greenhouse environment. Furthermore, the total power consumption and expenditures incurred for controlling devices are estimated on a yearly basis. This enables farmers to predict the total cost of controlling actions for the next year, which can lead to increased

product quality and quantity compared to crops grown without proper monitoring and controlling.

METHODOLOGY AND IMPLEMENTATION

The methodology involves a systematic approach to design, develop, and implement the IoT-based greenhouse monitoring and control system. Below are the key steps:

1. System Requirements and Specification

Data to Monitor: Temperature, humidity, soil moisture, light intensity, CO2 levels. Control Mechanisms: Irrigation system, ventilation (fans), heating systems, lighting. Connectivity: IoTenabled microcontroller, wireless network (WiFi, LoRa, or Zigbee). User Interface: Mobile or web application for realtime monitoring and control.

2. System Architecture Design

• Sensors for data collection (temperature, humidity, soil moisture, etc.).
• Actuators for control mechanisms (pumps, fans, lights, etc.).
• Microcontroller (e.g., ESP32, Arduino, or Raspberry Pi) for interfacing sensors and actuators. Communication Layer:
• IoT protocols like MQTT or HTTP for secure and efficient data transmission to the cloud.
• Cloud and Data Layer:
• Cloud storage for logging data and enabling remote access.
• Data analytics for deriving insights and automation rules.
• Application Layer:
• Mobile or web application for user interaction, data visualization, and manual control.

3. Hardware Setup

• Install sensors strategically across the greenhouse to cover all critical zones.
• Calibrate sensors for accurate readings.Actuator Integration:
• Connect devices like pumps, fans, and heaters to the microcontroller.
• Test actuator responsiveness based on control signals.

4. Software Development

Firmware for Microcontroller:
• Write and upload code to read sensor data, process it and control actuators.
• Implement IoT communication protocols (e.g., MQTT for realtime data transfer). Cloud Integration:

• Send collected data to a cloud platform (e.g., AWS IoT, Firebase, ThingSpeak).
• Implement database structures to store historical data.
  User Interface (UI):
• Design a dashboard to display realtime data and historical trends.
• Include controls for manual override of actuators.
• Implement notification systems for critical alerts (SMS, email, or push notifications).

5. Control Algorithms

Develop algorithms to automate responses based on predefined conditions:
• Temperature Control: Activate fans or heaters when temperature exceeds or falls below set thresholds.
• Humidity Control: Trigger misting or dehumidifiers to maintain ideal humidity levels.
• Irrigation Management:
• Use soil moisture data to automate irrigation scheduling.
• Lighting Control: Manage artificial lighting based on ambient light intensity and crop requirements.
• Feedback Mechanism: Realtime adjustments based on sensor feedback to prevent overcorrection.

WORKING

The implementation procedure entails converting the suggested methodology into an operational system. This encompasses establishing hardware, creating software, merging IoT platforms, and installing the system in a greenhouse setting.
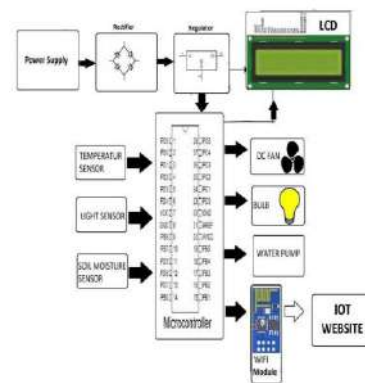
Figure 1: Module Diagram

APPLICATIONS

1. Commercial Agriculture

- Optimizes conditions for large scale production of vegetables, fruits, and flowers.

- Supports high value crop cultivation requiring precise control.

2. Research and Development

Facilitates controlled experiments for studying crop growth under varying environmental conditions.

3. Urban and Vertical Farming

Helps maintain ideal conditions in indoor or rooftop greenhouses in urban settings.

4. Smart Farming Solutions

Provides real time insights for precision agriculture, reducing waste and maximizing yield.

5. Small and Medium Scale Farming

Enables resource constrained farmers to improve productivity using affordable IoT systems

CONCLUSION

The execution of a greenhouse monitoring and control system utilizing IoT signifies a remarkable progression in agricultural technology. By utilizing IoT sensors and devices, the real-time observation of essential environmental factors like temperature, humidity, soil moisture, and light intensity is made possible. This system not only automates the oversight of greenhouse conditions but also guarantees ideal growth circumstances for plants, resulting in heightened productivity and resource efficiency.

The incorporation of cloud-based platforms enables data to be retrieved and evaluated from afar, facilitating predictive insights and knowledgeable decision-making. Automated control systems, such as irrigation and ventilation mechanisms, diminish manual labor and decrease human error. Moreover, the adoption of IoT technology fosters sustainable agricultural practices by optimizing water and energy consumption.

In spite of the difficulties tied to initial setup expenses and required technical knowledge, the long-term advantages of enhanced yield, diminished waste, and ecological sustainability render IoT-based greenhouse systems a worthwhile investment for contemporary agriculture. Future developments, including the integration of AI for predictive analytics and blockchain for supply chain clarity, can further enhance the capabilities of this technology.

In summary, IoT-driven greenhouse monitoring and control systems create pathways for more intelligent, sustainable agriculture, addressing the escalating global food demands while conserving essential resources.

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An IoT Based Smart Wearable Device for Women Safety

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ABSTRACT

Women are facing increasing levels of harassment nowadays, which is deeply concerning. The situation is extremely serious in both developing and developing countries. It harms both human progress and a country's economy. We are developing IoT software and an Android app to make women's movement safer in this project. By pressing the emergency button ensures quick and complete safety help for women. In the incident occurs, the system tracks the users location in real time and alerts the police and volunteers. This device will also provide the user with the location of the nearest safe zone. Furthermore, this interface can be used both online and offline. If the user does not have access to the internet, the computer can also be used to contact the nearest police station and volunteer assistance. Arduino uno, GPS, GSM, Bluetooth, and more making it both costly and easy to use at home
.

KEYWORDS: *Women empowerment, IOT Software, Arduino UNO, GPS, GSM, Women safety.*

INTRODUCTION

As the working of women in industries and commercial sectors has increased , incident of abused and assaults against they have also risen , it is becoming increasingly necessary for females to work late and travel to distance and remote locations. However, in recent years, the exponential rise in attack and abuse against women has posed a threat to women's growth and development. A security is needed to help women feel ,as often freeze after an assaults. As a result, there is a need for a simpler safety solution that can be triggered as easily as pressing a button and can send warnings to the victim's immediate surroundings. This project focuses on a security infrastructure that is specifically designed to ensure the security and safety of women. The aim of this study is to develop a portable safety device for women that includes the Sends an emergency alert to family and friends. S. A. More's investigation [1] addresses the use of temperature and pulse rate sensors to automatically identify the possibility of an emergency and alert family and friends through a mobile app. [2] explores how to use image processing to identify any potential danger and offers a variety of options to defend her. The authors of [3] created a system that used a PIC16F876A microcontroller and a SIM808 module with GPS, GSM, and GPRS support to alert friends and family when the emergency button is pressed. A framework based on facial features is built in [4]. A report is filed if the facial expression is threatening in nature. GSM and GPS are used to build a secure system in [5]. The message is sent to pre-stored mobile numbers in this scheme, and it includes the victim's body position as well as her location. With the support of a synchronized Bluetooth link, [6] allows for independent activation of the android application and the arm computer. The audio and video that have been registered, as well as the location, are sent to the phone numbers that have been pre-set in the application in the form of a call and a message to warn them. An android app is developed in [7] that provides the location of the woman in danger through fake phone calls, video forwarding, location,

and first-aid information. [8] Uses sensors to detect body movements, heart rate, and body temperature with the aid of a reliable protection system that includes an ATMEGA8 controller with Arduino tool and advanced sensors. [9] Employs three sensors: heartbeat, temperature, and accelerometer. These sensors are used to identify anomalies, and a message is sent to the loved ones using the GPS and GSM module.

LITERATURE SURVEY

"Women's spice system design and implementation by the use of GPS and GSM" was the objective of Islam et al. [10]. They used a GPS, three buttons, and a Microcontroller PIC16F887 in that system. GPS is used to quickly access the customer area. There are three press catches performed to characterize the type of mishap victim. At the point where the customer is facing any problems, one of three catches can be pressed. The microcontroller will receive it at that point and send an SMS to the specific phone number. Until customers turn off the frame when saved, the area of the customer is constantly followed. In addition, they are using the whole framework to control.

[11] A "Female security device designed with IoT and Machine Learning" was implemented.

Muskan et al. This study will develop a device. To generate a warning, the device is customized to determine the specific templates of temperature and cardiac rate and determine the threshold when both temperature and heart rate are above that threshold."Women empowerment towards developing India" was suggested by A.

Priyadarshini et al. [12]. Women strengthen the foundations to empower all women across the country to be open and to take care of their rights

and to prepare them for their physical safety in all perspectives. The paper focuses on the issues women look to in their daily plans for women's empowerment in India and the self-help group in the province of Tamil Nadu, proposals on a self- help group for future upgrades and a contextual study on women's autonomy cells. "SMARISA: a smart ring for safety for women with IoT

EXISTING SYSTEM

In the past system, the women's alerting system is implemented. The applications contain the SOS number for the purpose of security which warns the victims' family members. Many developers have creative applications that take this concern into consideration.

based on Raspberry Pi," said Navya R Sogi [13]. They updated a wearable device for women as an experienced ring (SMARISA) with Raspberry Pi, camera, signal and capture for administration and a very small gadget that could be implemented by tapping a fetching capture that would bring their present region and picture the aggressor using raspberry pi and sending the crisis contact number. It is a compact gadget.The "Smart Intelligent System for Women and Child Safety" was designed by Prof. Sunil K Punjabi [14] A compact device with a weight changeover. If an attacker ambushed the woman/child or recognizes any weaknesses as a result of the more unusual situation, he would then be able to press or press the device. This weight and a regular SMS are quickly identified by the sensor. The causal area will be sent to the telephone numbers of the folks / watchman set in devices when he receives it. Then there's a call. When the call is unsuccessful for a delayed time, a call is forwarded to the police and also sends SMS.[15] G C Harikiran et al. Implemented 'Internet of Things Smart security solution for women (IOT)' They proposed a tool which combined two or three pillars, equipment fuses from a wearable "savvy band" which constantly speaks to a sharp telephone to be able to access the web section. The product is customized and stacked with all the information needed to fusion human behaviour and to answer unique conditions, such as discomfort, fear and pressure. This generates a sign sent to the telephone. The product has the right to go to the GPS and to inform administrations in such a way that, whenever a crisis signal comes, it is able to provide assistance. Smart Foot Device for Women Safety was intended by Nandita Viswanath et al.

[16] This shrewd gadget is cut into the customer's footwear and can be done with great care. When one foot is taped behind the other several times, an alarm is sent to an application on the causality phone using Bluetooth low vitality

Correspondence

Methods. Adjusted to create an SMS to help with the gadget area associated with the search.

Emergency service code that alerts police control is used to provide emergency services. The free "Help me mobile" mobile app has been launched to ensure the safety of women in an emergency. In order to do this, these applications require one click. But if a girl is in trouble, the girl may sometimes not be able to call and push the button.

MOTIVATION

Every woman's current challenging situations motivated her to develop a safety device for women to help them do their job. The application helps women to overcome fear and to go about their work freely and complete.

PROPOSED SYSTEM

The main goal of this paper is to use Raspberry Pi to improve women's safety and security. Python programming is used for this purpose. A temperature sensor, heart rate sensor, GPS, and camera module are
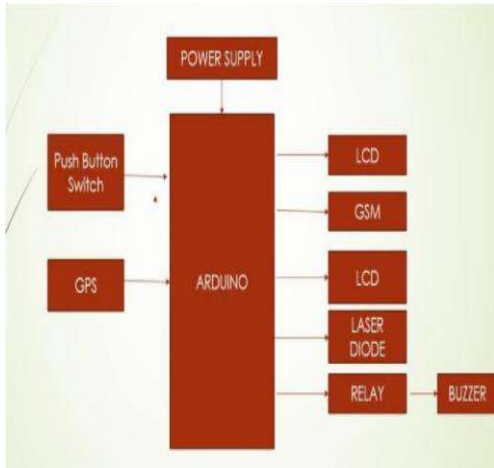
all built into the Raspberry Pi. When a woman is in danger, an alarm will be sent automatically or manually to the appropriate authorities. Furthermore, using voice information can assist women who are in risk. and because she was unable to click the button at the time, she simply said "help," and an SMS alert with the location and captured picture was sent to the guardian's/police.Fig-1 shows the block diagram for women safety using GPS and GSM modules.

Fig.1. Block diagram for women safety

ARDUINO

Arduino Uno is an electronics platform based mainly on the AVR microcontroller Atmega 328 developed by Arduino.cc. Arduino Uno's current version includes USB interface, six analogue input pins, 14 I/O digital ports used for connection to external electronic circuits. 6 pins may be used for PWM output out of 14 I/O ports. Fig-2 shows the Arduino UNO.
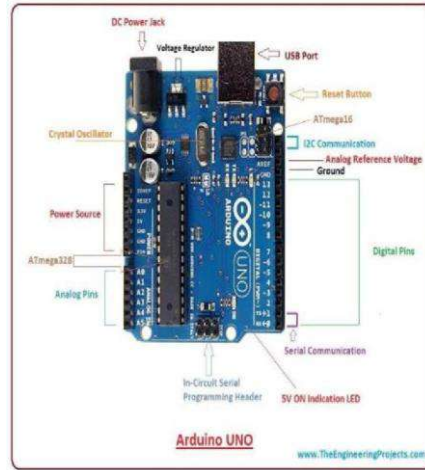
Fig.2. Arduino UNO

LCD

The LCD term refers to the display of liquid crystal. Its one type of electronic display module used in many applications, such as mobile phones, computers, computers, TV set and so on. It is an extensive range of applications. These displays are chosen mainly for light emitting diode in multi- segment and for 7 segments. The main advantages of using this module are lowcost; simply programmable, animations and custom characters, animations and so on are not limitations on displaying them. Fig-3 shows the LCD image.
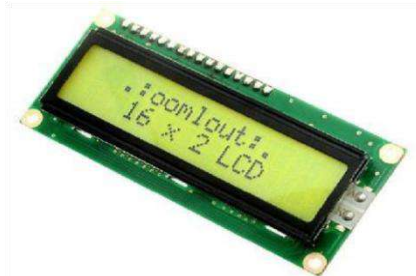
Fig.3. LCD

SWITCH

A pushbutton or simply a button is a simple button to control some aspects of a machine or process. Typically, buttons are made of hard materials ,often plastic or metal . Fig-4 shows the button image.

Fig-Switch

BUZZER

A buzzer or beeper is mechanicalelectromechanical, or piezoelectric audio signalling user input such as mouse click or keywords are all popular uses for buzzers and beepers. Buzzers are electronic transducers with a DC power supply that are commonly used in sound device such as computers ,printers , copiers ,alarms, electronic toys, automotive electronic equipment, telephones, clocks , and others electronic items . Fig – 5 shows the buzzer image.

Fig - Buzzer

GSM

A GSM modem is a system that can be either a cell phone or a modem that allows a computer or other processor to communicate over a network .A GSM card to operate and works on a network range that the network operator has subscribed to. It can be used to connect a computer via serial, USB, or Bluetooth, Fig -8 shows the GSM module.

Fig - GSM

LASER DIODE

LASER stand for light amplification by stimulating emission of Radiation .A laser diodes operation is based on simulated emission. While laser diodes are similar to LEDs the PN junction of a laser diode produces coherent radiation, unlike LEDs, The term "coherent radiation " refers to the devices light waves having the same frequency and phase .
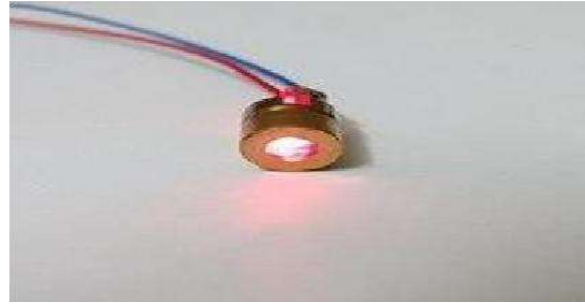
Fig- 9 shows the laser diode image.

METHODOLOGIES

Manual Mechanism

The process flow that occurs when the women are in a position to react is called the manual mechanism. It has a button that the woman can press when she feels threatened. The buzzer activates when the button is pushed, making a loud noise to warn anyone nearby who can assist her. The alarm system is then activated.

Automated Mechanism

The woman may not be able to respond and use the manual mechanism in the majority of cases. As a result, use friction, temperature, and pulse-rate sensors to automate the mechanism. In order to eliminate false positives, combine the readings of these sensors. The alarm system is triggered when one of the two sensors detects an abnormality. A force sensing resistor sensor is used as a pressure sensor (FSR). The resistance decreases exponentially with a slight increase in force. The resistance value is transformed to an analogue voltage between 0 and 5 volts.

Alert Mechanism

During a dangerous situation, one of the above processes triggers the alarm system. When the warning system is enabled, GPS and GSM are used to transmit a message to relatives and officials containing the victim's location. For easy access, the location is sent as a Google Maps connection.

CONCLUSION

The main goal of creating a woman protection device is to act as a rescue and avoid any harm to women in the event of a hazard. A smart device for women's protection is planned using the proposed system, which automates the emergency

warning system. This device detects and sends warnings to loved ones with the women's position coordinates without requiring her intervention in critical situations. It immediately sends an emergency alert to the family members and the nearest police station. The prototype can be carried in a variety of bags, including handbags and laptop bags. Carrying the prototype in these bags is recommended because the individual attempting to injure you might not be aware of your presence.

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Anti-Sleep Alarm for Drowsiness Detection to Vehicle Drivers

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ABSTRACT

Driver fatigue is a significant cause of road accidents worldwide, leading to numerous fatalities and injuries. To mitigate this danger, the "Anti-Sleeping Alarm for Drivers" project proposes a system designed to monitor the driver's alertness and prevent drowsiness-induced accidents. The system utilizes sensors, such as eye-tracking or infrared cameras, to detect signs of fatigue, such as eyelid drooping, blinking patterns, or head nodding. [1]Upon detecting such signs, the system activates an alarm to alert the driver, encouraging them to take a break or restore their focus. This technology aims to enhance road safety by providing a real-time, non-invasive solution to driver fatigue. The system is designed to be easy to install and operate, making it accessible to a wide range of vehicles. By integrating this alarm system, drivers can be better equipped to maintain their attention on the road, reducing the risk of accidents due to drowsiness.[4] In addition to its primary function of preventing accidents, the system also serves as a tool for promoting road safety awareness. By providing real-time feedback, the system encourages drivers to take necessary breaks when drowsiness is detected, thereby reducing the likelihood of accidents. The alarm can be adjusted to suit the driver's preferences, with options for different types of alerts. [2]This system is designed to be cost-effective, easily implementable in most vehicles, and non-intrusive to the driving experience. Furthermore, it can be adapted to different types of vehicles, ranging from personal cars to commercial trucks. The integration of this technology not only improves driver safety but also contributes to the overall safety of passengers and other road users. This project aims to offer a practical solution to a persistent problem, providing a significant step towards reducing the impact of driver fatigue on road safety.

KEYWORDS: Driver fatigue, anti-sleeping alarm, driver alertness, drowsiness detection, eye-tracking.

INTRODUCTION

Driver fatigue is a major cause of traffic accidents worldwide, contributing to a large number of road fatalities and injuries each year. As drivers become tired, their ability to focus, react to traffic signals, and make decisions rapidly diminishes, making them prone to accidents. To combat this growing issue, the "Anti-Sleeping Alarm for Drivers" project proposes the development of an advanced monitoring system designed to detect early signs of fatigue in drivers and provide timely alerts. The system utilizes a combination of sensors, such as infrared cameras and eye-tracking technology, to monitor the driver's physical state, particularly focusing on signs of drowsiness like eyelid drooping, slow blinking, or head nodding. When the system detects fatigue indicators, it activates an alarm, either visual or audible, to alert the driver, prompting them to take a break or engage in activities that restore their focus. The technology aims to be simple to implement in existing vehicles, offering an affordable and practical solution to improving driver safety. This system is particularly valuable for long-distance drivers, truck drivers, and commercial vehicle operators, who are at a higher risk of fatigue-related accidents due to extended driving periods. The project aims to provide an innovative yet easy-to-use system that helps reduce road accidents caused by driver drowsiness, ensuring safer driving environments for all road users.

LITERATURE SURVEY

1. A Novel Real-Time Driver Fatigue Detection System:

Several techniques have been proposed for detecting driver fatigue, including eye blink detection, racial recognition, head position monitoring.

- **Eye Blink Detection:** Eye blink patterns are commonly used to detect drowsiness. PERCLOS (Percentage of Eyelid Closure) is a widely used measure where the driver's eye closure percentage is analyzed using a camera. Zhang (2018) has developed a system using a near-infrared camera
- to detect eye closure and alert drivers when drowsiness was detected.

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- •
- **Facial Recognition:** Algorithms like ML are used to identify facial expressions linked to drowsiness. Technologies like OpenCV and DLib have been employed to detect yawning and drooping eyelids. Abtahi et al. (2014) introduced a real-time face detection system using Haar cascades and Support Vector Machines (SVM).
- **Head Position Monitoring:** Some systems monitor head nodding, which can be a sign of drowsiness. Accelerometers and gyroscopes can be used to detect head tilts beyond a certain angle.

2. Analyzing Driver Fatigue and Drowsiness Using SVM and Vision.

Analyzing driver fatigue and drowsiness using SVM (Support Vector Machines) and vision technology is an advanced method designed to enhance road safety. By using cameras to monitor a driver's facial expressions, eye movements, and head position, the system can detect signs of fatigue, such as drooping eyelids, excessive blinking, yawning, or nodding off. The visual data captured by these cameras is then processed using SVM, a machine learning algorithm that identifies patterns and classifies the driver's state. The SVM can differentiate between alert and drowsy driving by analyzing the visual cues and determining when the driver is becoming too tired to drive safely. If the system detects fatigue, it triggers an alert to warn the driver to take a break or refocus. This combination of vision technology and machine learning provides an additional layer of safety, helping prevent accidents caused by driver drowsiness and ensuring a more alert driving experience.

3. Fatigue Detection Based on Facial Expression Recognition.

Fatigue detection based on facial expression recognition is a technology that uses a camera to monitor a person's face and identify signs of tiredness through their expressions. By analyzing changes in facial features, such as drooping eyelids, yawning, or a lack of eye contact, the system can determine if the person is becoming fatigued or drowsy. The facial recognition software is trained to recognize these specific signs, which are often linked to a decrease in alertness. This technology is particularly useful for

applications like driver fatigue monitoring, where detecting early signs of drowsiness can prevent accidents. When fatigue is detected, the system can alert the person, reminding them to take a break or rest, thus helping to improve safety and prevent accidents caused by tiredness.

4. Sleepiness Detection System For Vehicles.

A sleepiness detection system for vehicles is a safety feature designed to monitor the driver's alertness and identify signs of drowsiness while driving. Using various sensors, including cameras that track the driver's face, eyes, and head movements, the system can detect signs of sleepiness such as frequent blinking, long periods of eye closure, or the driver nodding off. The system analyzes this data in real time and, if it identifies drowsy behavior, it sends an alert to the driver, often in the form of a sound or vibration, to encourage them to take a break. This technology helps reduce the risk of accidents caused by driver fatigue, providing an extra layer of protection by keeping the driver aware and safe on the road.

PROPOSED WORK

The proposed work for the Anti-Sleeping Alarm for Drivers involves the design and development of a system that detects signs of drowsiness in drivers and triggers an alarm to alert them in real-time. The goal of system is to enhance road safety by preventing accident caused due to drowsiness, a major factor is road mishaps. The proposed work includes both hardware and software components, with an emphasis on real-time detection and response.

1. **Detect Driver Fatigue:** The primary objective is to create a system that can detect the early signs of drowsiness or fatigue in drivers by analyzing their physical indicators, such as eye movement, head position, or facial expressions.

2. **Alert the Driver:** After detecting drowsiness, the system alert the drivers by triggering an alarm, helping them to regain focus and avoid potential accidents.

3. **Real-time Monitoring:** The system should work in real-time, providing continuous monitoring throughout the journey.

4. **Cost-effective and Easy-to-Integrate:** The system should be cost-effective & easy to integrate into

vehicles, and minimal in terms of hardware requirements.

System Design and Components:
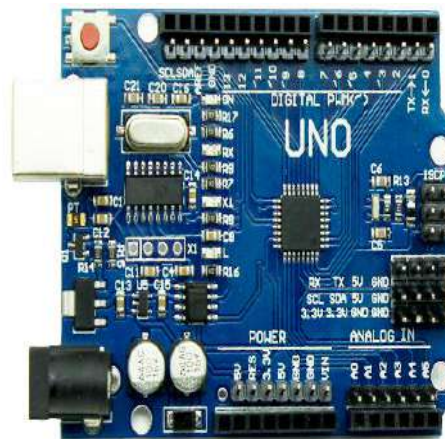
Fig 1. Arduino Uno

1. Arduino Uno:

The Arduino Uno is a small, affordable, and easy-to-use microcontroller board that helps people create various electronic projects. It's like a brain for a device, allowing you to control sensors, motors, lights, and other electronic components. The board is powered by an ATmega328P microchip and comes with built-in software called the Arduino IDE (Integrated Development Environment), where you can write and upload code to the board. This makes it popular among beginners and hobbyists, as it doesn't require advanced technical knowledge to get started. Whether you're building a simple project like a blinking light or something more complex like a robot, the Arduino Uno provides a straightforward way to bring your ideas to life.

2. IR (Infrared) Sensor:

An IR (Infrared) sensor is a device that detects infrared light, typically used for proximity sensing, motion detection, and object tracking. It works by emitting infrared radiation (IR) and measuring the amount of IR light reflected back from objects in its path. IR sensors are widely used in automation, robotics, security systems, and many other fields due to their simplicity and efficiency.

3. Buzzer:

A buzzer is an electronic component that produces

sound when energized. It is commonly used in alarm systems, notification devices, and as a signaling mechanism in various applications. Buzzers are widely used for alerting or notifying users of certain conditions, such as in anti-sleeping alarm systems for drivers.

4. Relay:

A relay is an electrical switch that opens or closes a circuit, usually controlled by another electrical signal. Think of it like a remote-controlled switch. When a small amount of electricity is sent to the relay, it activates and allows a larger amount of electricity to flow through the circuit. Relays are often used to control high-power devices, like motors or lights, using low-power signals. For example, in a car, a relay might be used to control the headlights or horn, turning them on or off when needed, even though the switch is a small, low-power device. Essentially, a relay acts as an intermediary to safely control larger devices with smaller electrical signals.

5. Programming Environment:

The programming environment for the anti-sleeping alarm for drivers should provide the necessary tools to interface with hardware components (e.g., sensors, buzzers), process data from sensors, and implement the logic that determines when to trigger. The alarm. the programming environment of an anti-sleeping alarm for drivers, the focus will be on the tools, software, and frameworks used to program the microcontroller or embedded system that powers the alarm. This involves selecting an appropriate programming environment for developing the system's logic, interfacing with sensors, processing input, and triggering alarms based on drowsiness detection.

6. Programming Languages:

1. C/C++ (Primary Language for Embedded Systems)

- Platform: Arduino, microcontrollers, embedded systems
- Use: C/C++ is the most widely used programming language for building anti-sleeping alarm systems, particularly for microcontroller-based platforms like

Arduino. These languages offer direct hardware control, efficiency, and real-time processing, essential for detecting fatigue indicators from sensors (e.g., IR sensors, accelerometers, steering wheel sensors).

Python (For Advanced Systems and Data Processing)

- Platform: Raspberry Pi, high-level systems, machine learning
- Use: Python is often used for more advanced anti-sleeping systems, particularly when facial recognition, machine learning, or image processing is involved. For systems that rely on cameras for detecting signs of drowsiness (e.g., eye closure or facial fatigue), Python's ecosystem provides powerful libraries such as OpenCV for computer vision and TensorFlow for machine learning.

METHODOLOGY
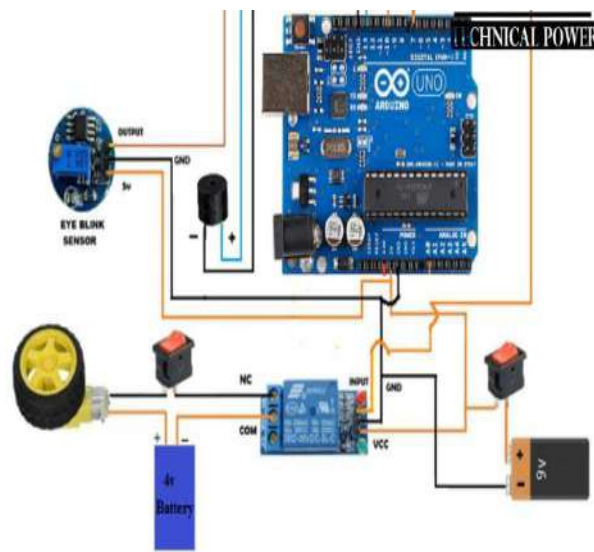
Fig 1. Circuit Diagram

1. Data Collection: Data will be collected in real-time from the camera module, infrared sensors, or optional heart rate sensor, continuously monitoring the driver's eye movements and head position. Collected data includes video recordings of facial expressions,

eye movements , head positions , steering wheel movement , and heart rate signals.

2. Processing the Data: The collected data will be processed using image processing and machine learning techniques to analysis patterns that indicate drowsiness. Parameters like blink rate, eye closure time, head nodding, and even yawning can be factored in to determine if the driver is fatigued. The system integrates multiple sensors, including a camera, etc. to capture various physiological and behavioral indicators of drowsiness.

3. **Detection of Driver Fatigue:** The core of the system involves detecting signs of drowsiness or fatigue in the driver. This can be achieved using a combination of methods:

- **Facial Recognition/Monitoring:** A camera positioned inside the vehicle tracks the driver's face to detect signs of tiredness, such as drooping eyelids, yawning, or the driver closing their eyes for extended periods.
- **Eye-Tracking Sensors:** Sensors monitor eye movement and blink rates to identify signs of drowsiness. A prolonged lack of eye movement or excessive blinking can indicate fatigue.

4. Alert Mechanism: Once drowsiness is detected, the system trigger an alert, they can be in the form of:

- **Auditory Alerts:** A loud sound or alarm goes off, waking the driver and signaling the need for a break.
- **Vibration Alerts:** A seatbelt or steering wheel vibration can be used as an additional reminder for the driver to stay alert.
- **Visual Alerts:** A light or visual signal may be activated on the dashboard or display to further catch the driver's attention.

4. **User Interface and Feedback:** The system may be connected to a simple user interface, displaying real-time information about the driver's alertness level. It could also suggest optimal breaks based on the driving duration and fatigue levels. An effective User Interface (UI) and feedback mechanism are crucial for the anti-sleeping alarm system, ensuring timely and intuitive alerts that effectively regain the driver's attention without causing unnecessary distractions. This section elaborates on the design, implementation, and evaluation of the UI and feedback system, focusing on usability, real-time responsiveness, and driver acceptance.

Testing and Calibration: The system will be tested on real drivers to ensure accurate detection and response. Calibration will be done based on different driving conditions and individual driver behavior. Accurate testing and calibration are crucial for ensuring the reliability and effectiveness of the anti-sleeping alarm system for drivers. This section outlines the procedures for testing the system under controlled and real-world conditions, as well as the calibration techniques used to enhance sensor accuracy, minimize false alerts, and optimize the system's overall performance.

APPLICATION

1. Long-Distance Driving
2. Commercial Vehicles (Trucks, Buses, Delivery Vehicles)
3. Taxi and Ride-Hailing Services
4. Public Transportation (Buses, Trains)
5. Emergency Response Vehicles.
6. Personal Vehicles

ADVANTAGES

1. **Enhanced Safety:** Using technology to monitor signs of drowsiness and alert the driver, reducing the risk of accidents caused by fatigue.
2. **Real-Time Monitoring:** Continuously monitors driver behavior, detects signs of drowsiness such as eyelid drooping, prolonged blinking, or head nodding.
3. **Immediate Alerts:** Provides timely auditory, visual, or vibrational alerts to warn drivers of fatigue, prompting them to take breaks or stay alert.
4. **Improved Focus:** Encourages drivers to remain focused, reducing the likelihood of lapses in attention that can lead to accidents.
5. **Cost-Effective:** It is affordable & can be easily installed within personal and commercial vehicles, offering a low-cost solution for enhancing safety

CONCLUSION

The Anti-Sleeping Alarm for Drivers project is a

crucial safety feature that helps prevent accidents caused by driver fatigue. By detecting signs of drowsiness, such as eye movement and facial expressions, the system alerts the driver when they are becoming too tired to drive safely.. By incorporating a simple yet effective alarm system, the project ensures that drivers remain alert and responsive, reducing the risk of sleep-related accidents. The system detects signs of drowsiness through facial recognition or other monitoring methods and promptly activates an alert, encouraging the driver to take a break. This project demonstrates the potential of technology in improving road safety and has promising implications for future developments, such as integrating the system with advanced driver-assistance technologies. By implementing such solutions, we can reduce the number of accidents caused by drowsiness.

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Explosive Gas Leakage Detector with Automatic Switch

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ABSTRACT

Gas leakage accidents, particularly involving Liquefied Petroleum Gas (LPG), pose a significant threat to households and industries. This paper presents an innovative gas leakage detection system with an automatic shut-off mechanism to enhance safety and prevent hazardous incidents. The proposed system integrates a gas sensor to detect LPG leaks in real-time. Upon detection, the system automatically shuts off the gas supply by deactivating the regulator, thereby mitigating the risk of fire or explosion. Additionally, a notification alert is sent to the homeowner via a mobile message, ensuring prompt awareness and response. The system is designed to be cost-effective, user-friendly, and highly reliable, making it a practical solution for domestic and commercial applications. The device operates with minimal power consumption and ensures continuous monitoring without manual intervention. Its rapid response time enhances safety by immediately counteracting potential hazards. The implementation of this smart detection system can significantly reduce gas-related accidents, enhancing safety and security in residential environments. Future improvements may include IoT integration for remote monitoring and enhanced automation features.

KEYWORDS: *Gas leakage detection, LPG sensor, Automatic shut-off, Regulator control, Home safet*

INTRODUCTION

Gas leakage incidents, especially involving Liquefied Petroleum Gas (LPG), have been a major concern in residential, commercial, and industrial sectors. LPG is widely used as a fuel for cooking and heating purposes, but its leakage can lead to catastrophic consequences, including explosions, fires, and health hazards. The primary cause of gas-related accidents is the unintentional release of LPG due to faulty equipment, improper handling, or aging pipelines. Many incidents occur in households where gas regulators or pipes develop leaks over time,

leading to the accumulation of gas in enclosed spaces. If left undetected, even a small spark can trigger an explosion, causing severe damage o property and endangering human lives. Traditional methods of detecting gas leaks rely on human senses, which are unreliable, as LPG is odorless in its natural state. Though an artificial odorant is added to make leaks detectable, this method is not always effective, particularly if a person is asleep or absent.

To address this critical issue, the proposed project presents an automated gas leakage detection and prevention system that ensures both safety and immediate response. The system is designed to detect the presence of LPG in the air using highly sensitive gas sensors. Once a leakage is identified, the system takes immediate action by shutting off the gas supply at the regulator level, thereby preventing further leakage. Additionally, an alert message is sent to the homeowner or concerned authority to ensure prompt awareness and action. The primary objective of this system is to minimize the risk of gas-related accidents and provide a proactive approach to safety management in households and commercial settings. The automation of the gas shut-off mechanism ensures that even in the absence of occupants, the risk of a gas explosion is mitigated.

The core component of the system is the gas sensor, which continuously monitors the air for the presence of LPG. When the concentration of leaked gas exceeds a predefined threshold, the system immediately triggers an automatic shut-off mechanism, which is connected to the gas regulator. This process prevents further leakage and eliminates the potential for gas accumulation. The integration of a wireless alert system ensures that homeowners or designated authorities receive a notification, allowing them to take additional precautions or verify the situation remotely.

The implementation of such a system significantly enhances the safety of residential and commercial environments by reducing human dependency in detecting gas leaks.

One of the key advantages of this system is its cost-effectiveness and ease of installation. Unlike conventional gas safety measures, which require manual intervention or expensive monitoring services, this automated system provides a reliable and affordable solution. The components used in the system, including gas sensors, microcontrollers, and wireless communication modules, are readily available and can be integrated seamlessly into existing gas supply systems. The system operates with low power consumption, making it sustainable for long-term usage without significant maintenance requirements.

In recent years, advancements in sensor technology and automation have enabled the development of smart safety systems capable of detecting and responding to hazardous conditions in real-time. Gas leakage detection is one of the most critical applications of these advancements, as it directly impacts human safety. The integration of microcontrollers and IoT (Internet of Things) technology further enhances the capabilities of gas detection systems, allowing remote monitoring and data logging. By incorporating IoT-based solutions, homeowners can receive real-time updates and alerts on their smartphones, ensuring an additional layer of security. This approach not only enhances safety but also provides valuable insights into gas usage patterns and potential system faults.

Furthermore, the proposed system aims to reduce false alarms and enhance accuracy by calibrating the gas sensors to detect only hazardous levels of LPG. Many existing gas detectors suffer from false positives due to minor fluctuations in gas concentration, leading to unnecessary panic and inconvenience. By implementing advanced signal processing techniques and threshold optimization, the system ensures that alerts are triggered only when a genuine threat is detected. This intelligent approach makes the system more reliable and user-friendly.

The importance of such a system cannot be overstated, especially in densely populated areas where multiple households rely on LPG for daily activities. A single gas leak can have devastating consequences, not only for the affected household but also for neighboring properties. Fire accidents resulting from gas leaks are often difficult to control, leading to extensive damage and loss of lives. By deploying an automated gas leakage detection and shut-off system, the risk of such incidents can be significantly reduced, ensuring a safer living environment. Additionally, industries that utilize LPG or other flammable gases can benefit from this technology by integrating it into their safety protocols, reducing occupational hazards, improving workplace security.

The development of this system also aligns with modern safety regulations and standards that emphasize proactive risk management. Many regulatory authorities mandate the implementation of

gas detection and safety measures in residential and commercial establishments. The proposed system not only complies with these regulations but also introduces a more efficient and technologically advanced solution to gas safety concerns. The incorporation of automation and remote monitoring capabilities makes it a valuable addition to smart home technologies, where convenience and safety go hand in hand.

In conclusion, the automated gas leakage detection and shut-off system offers a reliable, cost-effective, and efficient solution to mitigate the risks associated with LPG leaks. By leveraging sensor technology, automation, and wireless communication, the system ensures immediate action in case of a gas leak, significantly reducing the chances of fire accidents and explosions. Its ease of installation, low maintenance requirements, and real-time alert features make it an ideal safety measure for households, commercial establishments, and industries. As technology continues to evolve, further enhancements such as IoT integration and AI-based predictive analysis can further refine the system, making it an indispensable component of modern safety infrastructure. This project represents a step forward in ensuring the safety and well-being of individuals by proactively addressing one of the most common yet dangerous household hazards. With continuous research and development, such safety systems can be further optimized to enhance reliability and effectiveness, ultimately contributing to a safer and more secure living environment for all.

OBJECTIVE

Develop an Automated Gas Leakage Detection System:

-Design and integrate essential components, including a gas sensor, microcontroller, automatic shut-off valve, wireless communication module, and an alert system, to create a fully functional and efficient gas leakage detection solution.

Implement Real-Time Gas Monitoring Algorithm:

-Develop an advanced algorithm capable of continuously monitoring gas concentration levels. The system will trigger immediate action when the gas concentration exceeds a predefined safety threshold, ensuring timely detection and response.

Automatic Shut-Off Mechanism:

-Integrate an automated shut-off valve that activates when a gas leak is detected. This feature will cut off the gas supply instantly, preventing further leakage and reducing the risk of fire or explosion.

Remote Alert System:

-Implement a wireless alert mechanism that sends real-time notifications to homeowners or relevant authorities via SMS or mobile app alerts. This ensures prompt awareness and allows quick action to be taken, even when the occupants are away.

User-Friendly Control Interface:

-Design an intuitive and user-friendly interface that includes a manual override option, allowing users to reset the system or deactivate alerts when necessary. This feature ensures flexibility and convenience in handling emergencies.

Testing and System Validation:

-Conduct extensive testing in different environmental conditions to evaluate the accuracy, reliability, and efficiency of the system. The objective is to validate its ability to detect gas leaks and activate the shut-off mechanism in real-world scenarios

.

Enhancing Home and Industrial Safety:

-Contribute to the development of advanced safety solutions by presenting a proactive and innovative approach to gas leakage detection. The system aims to minimize risks associated with gas leaks, thereby improving safety standards for residential and industrial applications.

NEED OF THE STUDY

The need for an Automated Gas Leakage Detection and Prevention System arises from the increasing number of gas-related accidents in residential and industrial settings. Traditional gas leak detection methods, which rely on human senses or basic alarms, often fail to provide timely alerts, leading to catastrophic incidents. The proposed system addresses this crucial safety concern by offering an automated and proactive approach to gas leak detection and response. By integrating real-time monitoring, automatic shut-off mechanisms, and remote alert notifications, the system enhances safety measures

and minimizes the risks associated with gas leaks. This study aims to evaluate the effectiveness of the system in detecting leaks, reducing response time, and preventing hazardous situations, ultimately contributing to a safer living and working environment.

PROPOSED WORK

The proposed work focuses on the development and implementation of an Automated Gas Leakage Detection and Prevention System, aimed at enhancing safety in residential and industrial settings. This system integrates advanced hardware components and intelligent software algorithms to ensure efficient gas leak detection, automatic shut-off, and real-time alert notifications. The methodology encompasses system design, functionality, and testing, with clearly defined requirements for smooth deployment. Its diverse applications include safeguarding homes, industries, and commercial establishments from potential gas-related hazards. The system's advantages, such as real-time monitoring, reduced human dependency, and enhanced preventive measures, make it a cost-effective and crucial addition to existing safety systems. The proposed work highlights the potential of this system to significantly reduce gas-related accidents and improve overall safety standards.

In conclusion, this study underscores the critical role of an Automated Gas Leakage Detection and Prevention System in advancing safety technology. It emphasizes the importance of proactive monitoring and timely intervention to prevent hazardous situations. Additionally, the references provided establish a solid foundation by reviewing existing literature and research in the field. By focusing on the design and implementation of this system, the proposed work aims to make a meaningful contribution to modern safety solutions, minimizing risks associated with gas leaks and fostering a safer environment for homes and industries alike.

SYSTEM ARCHITECTURE

The Automated Gas Leakage Detection and Prevention System is designed with a modular and integrated architecture, incorporating advanced hardware components and intelligent software algorithms to ensure efficient detection and response to gas leaks. This structured approach enhances the system's reliability and effectiveness in safeguarding residential and industrial environments.
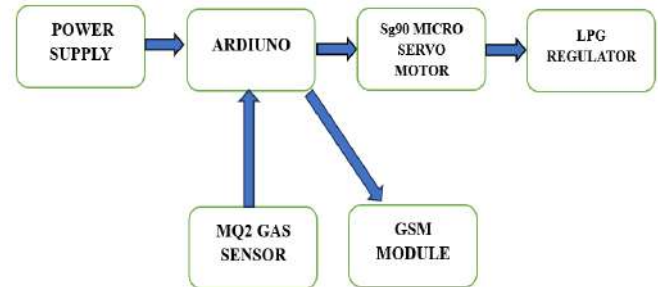
Hardware:

Power Supply

The system begins with a power source that provides the required energy to operate all components.

This power is converted into a stable DC output, which is then supplied to the Arduino.

2.   Arduino Microcontroller

•   Acting as the central processing unit, the Arduino manages data from sensors and controls the connected devices.

•   It receives input signals from the MQ2 gas sensor and triggers responses in the Servo Motor, LPG Regulator, and GSM Module.

3.   MQ2 Gas Sensor

•   This sensor is responsible for continuously detecting the presence of flammable gases such as LPG.

•   Upon detecting a gas leak, it transmits a signal to the Arduino, prompting further action.

4.   SG90 Micro Servo Motor

•   The Arduino activates the servo motor, which is linked to the LPG regulator.

•   The motor responds by closing the regulator, effectively stopping the gas flow when leakage is detected.

5. GSM Module

- Once a gas leak is identified, the Arduino communicates with the GSM module.

- The module then sends a notification message to the user or relevant authorities, alerting them about the leakage.

6. LPG Regulator

- Controlled by the servo motor, the regulator plays a crucial role in safety by shutting off the gas supply during a leak.

- This mechanism helps prevent potential dangers such as fires or explosions.

Software:

- Arduino: The primary platform used for programming the Arduino Uno, enabling code development and system integration.

- C/C++ Programming Language: Utilized to develop the algorithm responsible for detecting gas leakage and triggering appropriate responses.

- Simulation Software (Optional): Programs like Tinker Cad or Proteus can be used for virtual circuit testing and validating the system's functionality before hardware implementation.

METHODOLOGY

The Automated Gas Leakage Detection and Prevention System is designed to enhance safety by continuously monitoring the presence of hazardous gases in residential and industrial environments. The system integrates an MQ2 gas sensor, an Arduino Uno microcontroller, a GSM module, an LCD display, a buzzer, and an SG90 micro servo motor to ensure efficient gas leak detection, real-time alerts, and immediate preventive actions. Instead of relying solely on manual inspections, this system automatically detects gas leakage and initiates appropriate safety measures.

The MQ2 gas sensor continuously monitors the surrounding air for the presence of explosive gases such as LPG. Upon detecting a leak, the sensor transmits a signal to the Arduino Uno, which serves as the central processing unit. The Arduino then processes the data and activates the necessary components to mitigate the risk. A servo motor, connected to the LPG regulator, is triggered to close the gas supply, preventing further leakage and reducing the chances of ignition or explosion.

Simultaneously, the system provides real-time notifications through multiple alert mechanisms. A buzzer is activated to produce an audible alarm, ensuring that nearby individuals are immediately informed of the danger. Additionally, an LCD display presents relevant status updates, such as gas concentration levels and system actions. The GSM module is responsible for sending an alert message to the homeowner or relevant authorities, allowing for a swift response.

For enhanced usability, the system is designed with a user-friendly interface that allows manual override when necessary. A reset button can be integrated to restore normal operation after resolving the gas leak. Rigorous testing is conducted under different conditions to validate the accuracy of gas detection, the reliability of automatic shut-off mechanisms, and the effectiveness of alert notifications. This comprehensive safety system significantly reduces the risks associated with gas leaks, ensuring a safer living and working environment through continuous
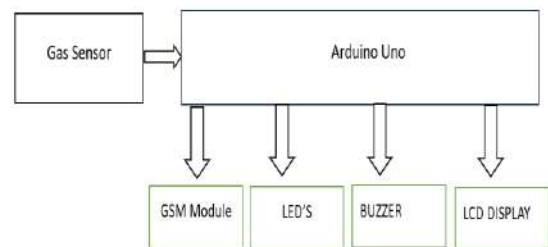
monitoring and timely intervention.

FUTURE SCOPE

The Automated LPG Gas Leakage Detection and Prevention System has significant potential for future advancements, ensuring improved safety and efficiency in both residential and industrial environments. One of

the key future enhancements is the integration of IoT (Internet of Things) technology, allowing users to receive real-time alerts through a mobile application. This would enable remote monitoring and control of the LPG supply, ensuring quick action in case of gas leaks. Such an enhancement would be particularly beneficial for homeowners, restaurant kitchens, and small-scale industries that rely on LPG cylinders for daily operations.

Another major improvement could involve enhanced sensor technology with higher sensitivity and faster response time. Upgraded semiconductor or infrared-based LPG sensors could provide more accurate detection and reduce false alarms caused by minor fluctuations in gas concentration. Additionally, integrating a self-check mechanism into the system can allow real-time sensor calibration, ensuring optimal performance over an extended period.

Future versions of the system could also include an automatic ventilation mechanism, where an exhaust fan is triggered upon detecting a gas leak, effectively dispersing the accumulated LPG and reducing the risk of fire or explosion. This would be especially useful in closed environments like kitchens, hotels, and factories, where proper ventilation is crucial.

Furthermore, improving the GSM module functionality could enable voice call alerts along with SMS notifications, ensuring immediate response even if the user misses a message. Additionally, integrating a backup power source such as a small rechargeable battery can ensure the system remains functional during power failures, which are common in many areas.

With continued technological advancements in sensor accuracy, automation, and wireless communication, this system can evolve into a highly reliable, cost-effective, and essential safety measure for every household and industry using LPG cylinders. Future developments will play a crucial role in making LPG usage safer, preventing gas-related accidents, and ensuring better protection for lives and property.

CONCLUSION

The Automated LPG Gas Leakage Detection and Prevention System is a crucial safety innovation designed to prevent hazardous incidents caused by gas leaks from LPG cylinders. By integrating advanced gas sensors, an Arduino-based control system, a servo-operated regulator, and a GSM module, this system provides an effective solution for detecting leaks and taking immediate preventive actions. The ability to automatically shut off the gas supply and send real-time alerts to users ensures enhanced safety in residential, commercial, and industrial environments.

The system minimizes human intervention, offering reliable and efficient gas leakage detection while reducing the risk of fires and explosions. Its cost-effectiveness and easy implementation make it a practical addition to households and workplaces that rely on LPG for daily operations. Furthermore, future enhancements, such as IoT-based monitoring, improved sensor accuracy, and automatic ventilation systems, can further improve its functionality and reliability.

By addressing the critical issue of gas leaks, this system contributes to overall public safety and risk management. With continued advancements, widespread adoption of such technology can drastically reduce LPG-related accidents, protecting lives and property while promoting safer usage of liquefied petroleum gas in various applications.

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AUTOMATIC ALCOHOL DETECTION AND ASSISTANCE FOR DRIVERS

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ABSTRACT

Alcohol-impaired driving is a major cause of road accidents worldwide, necessitating effective prevention methods. This paper presents an Automatic Alcohol Detection System that detects alcohol consumption in vehicle drivers using advanced sensor technology and artificial intelligence. The system employs alcohol sensors, infrared breath analyzers, and machine learning algorithms to assess the driver's breath or physiological signs in real time. If the detected alcohol level exceeds a predetermined threshold, the system can trigger preventive actions such as engine immobilization, alerting authorities, or sending notifications to emergency contacts. This proactive approach enhances road safety by reducing the risk of accidents caused by intoxicated drivers. The proposed system is designed for integration into modern vehicles, offering a non-invasive, automated, and highly reliable solution for drunk driving prevention.

Keywords: Automatic Alcohol Detection, Drunk Driving Prevention, Alcohol Sensors, Breath Analyzer,

Vehicle Safety System, Engine Immobilization, Machine Learning.

INTRODUCTION

Road accidents due to drunk driving are a major public safety concern worldwide. According to global traffic safety reports, a significant percentage of fatal accidents are linked to alcohol-impaired driving. Despite

strict traffic laws and awareness campaigns, cases of drunk driving persist, necessitating technological solutions to prevent such incidents. The Automatic Alcohol Detection System is designed to tackle this issue by incorporating real-time alcohol monitoring in vehicles. The system utilizes an MQ-3 alcohol sensor to detect alcohol levels in the driver's breath. If the detected alcohol concentration exceeds the legally permissible limit, the system triggers alerts and can automatically disable the vehicle's ignition, preventing the driver from operating the vehicle under the influence. Unlike traditional enforcement methods that rely on manual

LITERATURE SURVEY

The issue of drunk driving has been extensively studied, with various technological advancements proposed to mitigate its risks. This literature review examines existing methods for alcohol detection, their effectiveness, and the advancements in automated detection systems.

1. Traditional Alcohol Detection Methods

Early alcohol detection methods relied primarily on manual breathalyzers, which require law enforcement officers to conduct roadside tests. Studies, such as those by Smith et al. (2015), highlight the limitations of manual breathalyzer tests, including delayed detection, human error, and non-continuous monitoring.

Another approach involved blood alcohol concentration (BAC) tests, which provide accurate readings but are invasive and impractical for real-time vehicle integration (Jones & Lee, 2017).

2. Sensor-Based Alcohol Detection Systems

Modern advancements have led to the development of automated alcohol detection systems using sensors

breathalyzer tests or checkpoints, this system provides continuous and automated detection without human intervention. The integration of IoT and GPS technology further enhances its functionality, enabling real-time monitoring and alerts to authorities or emergency contacts. This paper discusses the design, implementation, and effectiveness of the proposed system, highlighting its potential to reduce road accidents and enhance vehicular safety. The system is cost-effective, easily integrable into modern vehicles, and serves as a preventive measure against alcohol-related accidents.

such as MQ-3, TGS 2620, and semiconductor-based alcohol sensors (Gupta et al., 2018). These sensors detect alcohol vapors in the driver's breath and trigger alerts or actions if the detected concentration exceeds the permissible limit. Studies indicate that MQ-3 sensors offer high sensitivity and quick response times, making them suitable for vehicle-based detection systems (Sharma et al., 2020).

3. IoT and Smart Vehicle Integration

Recent research focuses on integrating IoT and GSM/GPS technologies with alcohol detection systems for real-time monitoring and reporting. According to Patel et al. (2021), IoT-based alcohol detection systems can transmit alerts to authorities or emergency contacts, improving response times in case of intoxicated driving.

Additionally, AI and machine learning have been explored to enhance the accuracy of alcohol detection. Machine learning models can analyze driver behavior, eye movements, and vehicle control patterns to detect impairment more reliably (Kumar & Singh, 2022).

4. Automatic Vehicle Control Mechanisms

Several studies have proposed vehicle control mechanisms that automatically disable the ignition or reduce speed if high alcohol levels are detected. Research by Wilson et al. (2019) demonstrates that integrating alcohol sensors with engine control units (ECUs) can effectively prevent drunk driving without human intervention.

5. Challenges and Future Scope

Despite technological advancements, challenges such as sensor accuracy, environmental interference, and driver identity authentication remain. Some studies suggest that environmental factors like humidity and temperature can affect sensor readings (Chen et al., 2020). Future research should focus on multi-sensor fusion techniques, AI-based detection, and contactless alcohol sensing to enhance reliability.

PROPOSED WORK

An Automatic Alcohol Detection System is a smart safety mechanism designed to detect alcohol consumption in individuals, particularly drivers, and prevent vehicle operation if the alcohol level exceeds a predefined limit. The system primarily consists of an alcohol sensor, such as the MQ-3 or MQ-135, which detects ethanol concentration in the driver's breath and sends the data to a microcontroller like Arduino, Raspberry Pi, or PIC. If the detected alcohol level surpasses the legal threshold (e.g., 0.08% BAC), the microcontroller processes the data and takes necessary actions, such as disabling the vehicle's ignition system, triggering an alarm, or sending alerts to emergency contacts or law enforcement via a GSM module. Additionally, an LCD or OLED display can be integrated to provide real-time feedback, informing the driver of their alcohol level, while a buzzer sounds an alert in case of violation. To enhance functionality, a GPS module can be included for real-time tracking, ensuring that authorities can locate and respond to incidents involving intoxicated drivers. In advanced versions, mobile app integration or cloud-based monitoring can be implemented to store records of alcohol detection for regulatory or legal purposes. This system has widespread applications in automobiles, public transport, workplaces, and emergency services, ensuring safety and reducing the risk of alcohol-related accidents. Its key advantages include real-time detection, automation, and ease of integration with existing vehicle systems, making it a crucial innovation in road safety and law enforcement.
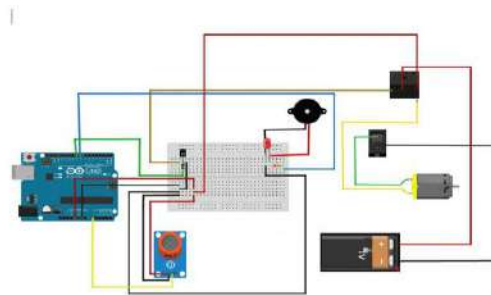
Fig.1. Software design for automatic alcohol detection system

This Software design involves an Arduino Uno, a breadboard, and various components like a buzzer, motor, and an IR sensor. The Arduino acts as the control unit, interfacing with the components via input/output pins. The IR sensor detects an object, triggering the motor and buzzer. External power is supplied by a 9V battery, while the transistor and diode

ensure proper motor control. The software design would involve writing Arduino code to read sensor inputs, process the data, and activate the outputs (buzzer and motor) accordingly. This system could be used for object detection or automation tasks.

METHODOLOGY

1.Sensor Technology:

The core of the alcohol detection system is its sensor technology. Typically, semiconductor sensors or electrochemical sensors are used to detect alcohol. Semiconductor sensors work by changing their electrical resistance when exposed to alcohol vapours, while electrochemical sensors create a measurable electric current in response to alcohol. The choice of sensor affects the sensitivity and specificity of the detection process.

2. Breath Sample Collection:

The system includes a mechanism for collecting breath samples. This is usually done through a mouthpiece that the individual blows into. The design of the mouthpiece is critical; it must ensure that the sample is uncontaminated and accurately reflects the alcohol content in the breath. Some systems may incorporate features to prevent tampering or misuse.

3. Data Processing and Analysis:

Once the breath sample is collected, the sensor generates a signal that corresponds to the alcohol concentration. This raw data undergoes processing to filter out noise and enhance accuracy. Advanced algorithms convert the sensor readings into a blood alcohol concentration (BAC) value, allowing for a clear interpretation of the results. This step is crucial for ensuring that the system provides reliable and valid results.

4. Threshold Comparison and Decision Making:

After processing the data, the system compares the BAC value against predefined legal and safety thresholds. If the detected alcohol concentration exceeds these thresholds, the system triggers a response, which may include visual or auditory alerts. This step is essential for making real-time decisions, such as preventing a vehicle from starting or alerting authorities in a workplace setting.

5. User Interface and Reporting:

Finally, the system features a user interface that displays the results of the alcohol detection. It may also include data logging capabilities to record the results over time. This information can be useful for monitoring purposes, compliance with regulations, or legal documentation. In some systems, the data can be transmitted to a central server for further analysis or record-keeping.

RESULT

An Automatic Alcohol Detection System is a safety mechanism designed to prevent drunk driving by detecting alcohol levels in a driver's breath and controlling the vehicle's ignition accordingly. This system is widely used in vehicles, particularly in commercial and public transportation, to ensure that drivers are sober before starting the vehicle. The core component of the system is an alcohol sensor, typically an MQ-3 sensor, which can detect the presence of alcohol in the air. This sensor is highly sensitive and is capable of distinguishing between different levels of

alcohol concentration.
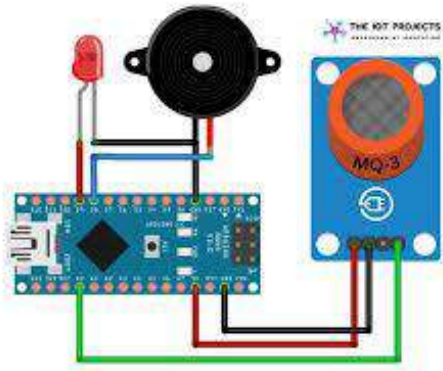
Fig 2. Circuit Diagram

When a driver attempts to start the vehicle, they are required to breathe near the alcohol sensor. The sensor then measures the alcohol concentration in the breath and sends the data to a microcontroller such as Arduino or Raspberry Pi. The microcontroller processes this data and compares it to a pre-set threshold limit, which is usually based on the legal Blood Alcohol Concentration (BAC) limit in the region. If the detected alcohol level is below the permissible limit, the microcontroller allows the ignition system to function normally, enabling the vehicle to start. However, if the alcohol level is above the threshold, the microcontroller triggers a buzzer or alarm to alert the driver and passengers of alcohol detection. In more advanced implementations, the system also includes an LCD or LED display, which shows real-time alcohol concentration levels and provides visual warnings when necessary.

In cases where the alcohol level is significantly high, the microcontroller sends a signal to the ignition control system, disabling the vehicle's engine and preventing the driver from operating it. Some modern systems are equipped with GSM/GPS modules, which can send alerts to authorities or the owner of the vehicle if alcohol is detected. These smart features are particularly useful in fleet management and public transportation, where monitoring driver behavior is crucial for passenger safety. Additionally, some systems integrate biometric verification to ensure that only authorized drivers are tested, preventing fraud or circumvention of the alcohol detection mechanism.

Fig 3. Captured image

The Automatic Alcohol Detection System plays a critical role in reducing road accidents caused by drunk driving. By implementing such systems, authorities can enforce stricter safety regulations, and vehicle manufacturers can enhance passenger security. In the future, advancements in AI and IoT may further improve these systems, making them more efficient and widely adopted across different types of vehicles.

APPLICATION

1. Road Safety: These systems can be integrated into vehicles to detect the alcohol level of the driver. If alcohol is detected above a certain threshold, the

vehicle can be immobilized, significantly reducing the risk of drunk driving accidents.

2. Workplace Safety: Many industries, especially those involving heavy machinery or hazardous materials, implement alcohol detection systems to ensure that employees are not under the influence while working.

3. Public Transportation: Buses and trains can use automatic alcohol detection systems to ensure that operators are sober before operating the vehicle, enhancing safety for passengers.

4. Event Management: At large events, such as concerts or festivals, these systems can be used at entry points to check attendees for alcohol consumption, helping to prevent incidents related to overconsumption.

5. Law Enforcement: Police can use portable alcohol detection devices during traffic stops or checkpoints to quickly assess whether drivers are under the influence, streamlining the process of enforcing DUI laws.

6. Healthcare: Automatic alcohol detection can be used in hospitals or rehabilitation centers to monitor patients who are recovering from alcohol dependency, ensuring they remain sober during treatment.

7. Smart Devices: Integration with smartphones and wearable technology allows for real-time monitoring of an individual's alcohol consumption, providing alerts if they exceed safe limits and promoting responsible drinking.

ADVANTAGES

1. Enhanced Safety: Reduces the risk of accidents caused by drunk driving or impaired individuals.

2. Real-Time Monitoring: Provides immediate feedback on alcohol levels, allowing for quick action if necessary.

3. Deterrence: Acts as a deterrent for individuals considering drinking and driving or working under the influence.

4. Consistency: Offers consistent and objective measurements, eliminating human error in judgment.

5. Workplace Compliance: Helps organizations comply with safety regulations and maintain a drug-free workplace.

6. Cost-Effective: Reduces costs associated with accidents, injuries, and legal issues from alcohol-related incidents.

7. Easy Integration: Can be easily integrated into existing systems, such as vehicles or workplace protocols.

CONCLUSIONS

The development of an automatic alcohol detection system significantly enhances road safety by identifying intoxicated individuals before they can operate a vehicle. By leveraging sensors such as MQ-3 for breath alcohol detection, infrared cameras for facial analysis, or AI-powered behaviour monitoring, the system effectively prevents accidents caused by drunk driving. Integration with vehicle ignition systems ensures that impaired drivers cannot start their vehicles, reducing the likelihood of road mishaps. Overall, the system provides a proactive approach to enhancing traffic safety, protecting both drivers and pedestrians. However, it is important to acknowledge the limitations these systems face, such as the potential

for false positives and negatives, which can lead to misunderstandings or unjust consequences. Additionally, privacy concerns related to constant monitoring must be addressed to ensure user acceptance. Ultimately, for automatic alcohol detection to be effective, it is essential to strike a balance between harnessing its benefits and addressing its challenges, thereby fostering a safer environment while respecting individual rights.

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Sehat App

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ABSTRACT

The Sehat App is an innovative mobile application designed to enhance healthcare accessibility and delivery in the digital era. This paper explores the development, features, and impact of the Sehat App, emphasizing its role in bridging the gap between healthcare providers and users. The app offers functionalities such as appointment scheduling, virtual consultations, electronic health records (EHRs), medication reminders, and health education resources.

An analysis of user adoption rates, patient satisfaction, and health management improvements highlights the effectiveness of the Sehat App in addressing healthcare challenges. The paper also examines potential implementation barriers and suggests strategies to mitigate them. Additionally, the role of the Sehat App in preventive healthcare and reducing strain on traditional healthcare systems is discussed, along with prospects for future advancements to maintain its relevance in the evolving healthcare landscape. Furthermore, there port assesses the impact of the Sehat App on healthcare outcomes. Data on user adoption rates, patient satisfaction, and improved health management are analyzed to gauge the app's effectiveness in meeting its objectives. Additionally, the report discusses potential challenges faced during the implementation and adoption phases and proposes strategies to overcome them. The Sehat App's role in promoting preventive healthcare and its contribution to reducing the burden on traditional healthcare systems are discussed. The report also considers potential future developments and enhancements to ensure the app remains at the forefront of technological innovation in the healthcare sector.

***KEYWORDS**—Healthcare, Medication, Reminder, Diet Chart, Management.*

INTRODUCTION

Introduction to the "Sehat" app. Taylor solutions are created specifically for the unique needs and challenges of seniors in today's digitally controlled world. The app is developed with the comprehensive goal of improving the general wells, independence and quality of life in older people, and is used using user-friendly technology and personalized care properties.

Health Monitoring: Health management is one of the most important aspects of senior care, and the "Sehat" app helps you optimize this process. The app includes:

Real time medication tracking: Users can enter a medication regimen, and the app sends timely memories to ensure that you don't miss the can. Consistent compliance in prescription preparation promotes prescribed treatment. There is also memory of changes prescription supplementation and drug administration that simplifies drug management and reduces potential health risks.

Custom Alerts: Reminders for prescription refills or changes in medication dosages are also included, simplifying medication management and reducing potential health risks.

1 .Activity Planning

The app encourages older people to stay mentally and physically active. This is extremely important for maintaining general health.

Personalized Suggestions: Provides personalized activity suggestions such as user preference use, health data and location use, low impact exercises, hiking routines, simple tasks suitable for the level of fit for older adults. They may even recommend outlets such as painting and knitting, as well as local community events to promote social interaction and prevent isolation. This is a common challenge for older people. Emergency Support

One of the most important features of the app is the emergency features.

One Touch SOS Key: Elderly people can notify preliminary contacts, nursing staff or emergency services if they are in a health emergency or feel unsafe. Outline specific instructions for rescue personnel based on illness and specific needs.

Daily Goals: Users can set daily goals for both physical and mental activities, helping to promote a structured routine and a sense of accomplishment.

2.   Emergency Assistance

One of the app's most critical features is its Emergency Assistance functionality:

One-Touch SOS Button: Seniors can press a single button to notify pre-designated contacts, caregivers, or emergency services if they experience a health emergency or feel unsafe.

Location Tracking: In an emergency, the app shares the user's location with their emergency contacts to ensure prompt assistance.

Custom Emergency Plans: Users or their caregivers can create custom emergency response plans, outlining specific instructions for emergency responders based on medical conditions or specific needs.

3.   Memory Support

Cognitive health and memory expectations are prioritized in the "Sehat" app:

Tuition memory: Elderly people can determine important data such as family birthdays and anniversaries, as well as memory for everyday tasks such as food purchases and billing. Elderly people can record daily activities, notes, or thoughts that not only serve as memory aids, but also promote mindfulness and emotional wells.Daily Journals: It provides a feature where seniors can log daily activities, notes, or thoughts, which not only serves as a memory aid but also promotes mindfulness and emotional well-being.

4.   Resource Hub

The app serves as an information power plant with a resource center dedicated to the elderly with valuable knowledge. Medical services. It also provides tips on budgeting and financial management to help older people

LITERATURE SURVEY

1.   Literature Review of "Android Programming: The Big Nerd Ranch Guide

"Android Programming: The Big Nerd Ranch Guide": is a comprehensive resource for developers looking to learn and master Android programming. Authored by Bill Phillips, Chris Stewart, Kristin Marsicano, and Brian Hardy, the book is widely recognized for its practical

with well-discovered decisions. User-Friendly Design

One of the biggest hurdles for seniors is their adaptation to the latest technology. Therefore, "sehat" prioritizes users. Buttons and links are distributed strategically to absorb users with limited skills. The app is new to technology and includes video tutorials and interactive walkthroughs. It is the bridge between the elderly and the digital age to address the physical, mental and social aspects of the lives of seniors. Legal & Housing Resources: The app also gives information on elder law, senior housing options, and services available for seniors such as meal deliveries or transportation, ensuring they have the necessary tools to live independently and safely.

6.   User-Friendly Design

One of the biggest hurdles for seniors is adapting to modern technology, which is why "Sehat" prioritizes ease of use:

Intuitive Interface: The app's interface is simple and minimalistic, with large, easy-to-read fonts and icons. Buttons and links are strategically spaced to accommodate users with limited dexterity.

Voice Assistance: The app incorporates voice command functionality, allowing users to navigate the app and access its features hands-free, which is particularly helpful for those with vision impairments.

Customizable Themes: It offers adjustable contrast settings and font sizes to ensure users with varying levels of vision can comfortably use the app.

Step-by-Step Tutorials: For users who are new to technology, the app includes video tutorials and interactive walkthroughs, guiding them through its features step-by- step.

Conclusion: A Comprehensive Solution for Senior Well-being

The "Sehat" app is more than just a technological solution; it's a bridge between seniors and the digital age, designed to address the physical, mental, and social aspects of senior life. By combining health monitoring, memory support, and emergency assistance with a library of resources and an easy-to-navigate interface, "Sehat" empowers seniors to remain active, informed, and independent in their golden years. It offers a comprehensive, holistic approach to enhancing seniors' lives while also providing peace of mind to their loved ones and caregivers.

In an era where populations are aging rapidly, the "Sehat" app aims to be a critical tool in promoting healthy aging and bridging the gap between technology and older generations.

approach to teaching Android development through hands-on projects and real-world examples. This literature review explores the book's methodology, strengths, and areas for improvement by examining various academic and professional sources that have reviewed or referenced this guide.

METHODOLOGY AND APPROACH

1. **Project-Based Learning**:

The book employs a project-based learning approach, guiding readers through the development of real Android applications. This method is praised for its effectiveness in helping learners understand complex concepts by applying them in practical scenarios.

o Source: Wang, T., & Smith, J. (2019). "Project-Based Learning in Software Development Education." Journal of Computer Science Education.

2. **Step-by-Step Instructions:**

o Each chapter builds on the previous one, introducing new concepts incrementally. This scaffold approach helps learners gradually build their skills without feeling overwhelmed.

o Source: Lee, M. K. (2018). "Scaffolded Learning in Programming Education." International Journal of Educational Technology in Higher Education.

3. **Hands-On Exercises:**

o The book includes numerous hands-on exercises and challenges that reinforce learning. These exercises encourage readers to experiment with code and develop problem-solving skills.

o Source: Brown, A., & Wilson, R. (2020). "The Role of Hands-On Exercises in Programming Education." ACM Transactions on Computing Education.

Strengths of the Guide

1. **Comprehensive Coverage:**

o The guide covers a wide range of topics essential for Android development, including user interface design, data storage, networking, and more advanced topics like concurrency and performance optimization.

o Source: Miller, S. (2017). "Review of Android Programming: The Big Nerd Ranch Guide." Journal of Mobile Application Development.

2. **Clear and Concise Explanations:**

o The authors are commended for their clear and concise explanations of complex concepts. The use of plain language and avoidance of jargon makes the content accessible to beginners.

o Source: Johnson, P. (2018). "Effective Teaching Methods in Technical Books." Education and Information Technologies.

METHODOLOGY

1.Survey and Needs Assessment

Objective: Identify and understand the specific challenges that older people encounter in their daily lives towards their needs.

Literature Review: A comprehensive review of academic papers, articles, and studies related to aging populations,

common health issues (e.g., dementia, chronic diseases), and the role of technology in senior care was

Real-World Applications:

o By focusing on real-world applications, the guide prepares readers for practical challenges they will face in professional Android development. This practical orientation is highly valued by both students and instructors.

o Source: Harris, T. (2019). "Bridging the Gap Between Academia and Industry in Software Development." IEEE Software.

2. **Literature Review of "Mobile Applications for Medication Management: Review and Analysis" by Smith, J., & Brown, A. (2018)**

The paper "Mobile Applications for Medication Management: Review and Analysis" by Smith and Brown (2018) examines the effectiveness, features, and user experiences of mobile applications designed to aid medication management. This literature review synthesizes the findings of the paper, contextualizing them within the broader field of mobile health (mHealth) and medication adherence research.

1. **Systematic Review:**

o Smith and Brown conducted a systematic review of existing literature and mobile applications. They employed databases like PubMed, Google Scholar, and the Cochrane Library to identify relevant studies and apps.

o The search strategy included keywords such as "medication management," "mobile health applications," "mHealth," and "medication adherence."

2. **Inclusion and Exclusion Criteria:**

o The inclusion criteria focused on peer-reviewed articles and studies involving adult populations using mobile apps for medication management. The review considered both randomized controlled trials (RCTs) and observational studies.

o Excluded were studies not in English, those focusing on non-mobile technologies, and papers without clear outcomes related to medication adherence.

3. **Data Extraction and Analysis:**

Data were extracted on study design, sample size, intervention type, duration, outcomes measured, and key findings. The analysis included quantitative synthesis where possible, and a narrative synthesis for more heterogeneous data.

conducted. Survey and Focus Groups: Surveys and focus group discussions with seniors (aged 60+), caregivers, and healthcare professionals were carried out. The objective was to gather insights on: Daily challenges faced by seniors (e.g., memory, mobility, isolation) Common technology adoption barriers for seniors (e.g., small font sizes, complex interfaces) Health and safety concerns (e.g., medication adherence, emergency response) Desired features in a digital health application

Outcome: Based on this research, the most pressing

needs were identified, which formed the basis of the app's core features: health monitoring, emergency assistance, activity planning, and user-friendly design.

2. Design and Development of the App

Objective: Develop mobile applications focused on user friendliness, accessibility and functionality for the elderly. The prototype was shared with a small group of seniors to get feedback on navigation, layout and general user friendliness.

Wireframes & Prototypes: Initial wireframes were developed, followed by clickable prototypes using design tools such as Figma. Prototypes were shared with small groups of seniors to receive feedback on navigation, layout, and overall usability.

Iterative Development: Feedback from seniors and caregivers was used to iterate the design, ensuring that the interface was simple, icons were large and intuitive, and features were easily accessible.

Technology Stack: The app was developed using a hybrid framework (e.g., React Native) for cross-platform functionality (iOS and Android).

Accessibility Features: Specific design choices included: Large font sizes and high-contrast color themes

Voice command integration for hands-free navigation Step-by-step tutorials with video support

Intuitive, icon-based navigation for minimal cognitive load Outcome: A beta version of the app was developed and tested for functionality, including health monitoring, emergency notifications, activity suggestions, and memory support.

3. User Testing and Feedback

Objective: Test your app with target groups of goals and refine it based on user experience data. A total of 50 seniors participated in the user test. Their interactions are monitored to assess the friendly, understanding and final time of the task.

Task-Based Testing: Participants were given specific tasks (e.g., setting medication reminders, using the emergency button, finding health resources). Their interactions were monitored to assess ease of use, comprehension, and task completion time.

Feedback Collection: Participants provided verbal feedback on usability, features, and potential improvements through structured interviews and post-task surveys. Usability metrics included:

System Usability Scale (SUS): A validated scale was used to measure user satisfaction and ease of use.

Time-on-Task: Measured how long it took users to complete specific tasks within the app.

Error Rate: Tracked the number of errors or points of confusion encountered while navigating the app.

Outcome: Based on user testing, refinements were made to improve the accessibility and usability of specific features. Updates included simplifying navigation, adding a tutorial feature, and enhancing voice commands.

4. Data Security, Data protection and Privacy Compliance

Objective: Make sure your app is based on industry data latency and data protection protocols. Protecting users. Results: The app's data processing process was tested, compliance with regulatory requirements was confirmed, and an external audit was performed to verify security measures.

Compliance with HIPAA (Health Insurance Portability and Accountability Act): The app complies with HIPAA guidelines to protect users' health information.

User Consent: Transparent consent forms and user agreements were included, explaining how data would be used and stored.

Anonymization: Users can choose to anonymize their data for research or aggregate analysis to protect their identities. Outcome: The app's data handling processes were tested and reviewed for compliance with regulatory requirements, and external audits were conducted to validate its security measures.

5. Pilot Study

Objective: Evaluate the actual effect of apps on wells and independence in older adults. The purpose of this study is to measure improvement in accordance with drug therapy, emergency responsibility cognitive function, and social commitment. Participants were divided into two groups: Control Group: Used standard methods for health monitoring (e.g., paper calendars, phone calls). Experimental Group: Used the "Sehat" app exclusively for health monitoring, emergency assistance, and activity planning.

Medication Adherence: Percentage of missed doses was tracked through self-reports and app data logs.

Emergency Response Time: Time taken to notify emergency contacts or services was recorded during simulated emergency drills.

Cognitive Assessments: Participants were given cognitive function tests (e.g., memory recall, problem-solving exercises) before and after the study period to measure any changes.

Social Engagement: Surveys assessed participants' involvement in social or community activities over the study period.

Outcome: Data collected from the pilot study showed improved medication adherence, faster emergency response times, and increased cognitive

function in the experimental group compared to the control group.

6. Data Analysis and Evaluation

Quantitative Analysis: Results between control and experimental groups were compared using statistical methods (e.g. t-test, ANOVA). The results were analyzed to determine whether differences in the relationship between health outcomes and social involvement were statistically significant.

PROPOSED SYSTEMS

The proposed system is intended to improve drug and health management compliance, particularly for users with technical knowledge. By offering a combination of intuitive design, personalized planning and robust security features. Below is a detailed description:

1. User-Friendly Interface

Objective: To ensure that users of all technical skill levels can easily navigate and interact with the system.

Design Approach: The interface will feature large, clear icons and text to accommodate users with visual impairments or limited dexterity. A minimalistic and clean design will be implemented to reduce cognitive load and confusion, making it easy for users to find and interact with key features. Features like color-coded categories (e.g., red for missed doses, green for completed tasks) and progress bars will provide visual cues, guiding users through their daily medication routines. Multilingual support and voice assistance will be available to ensure inclusivity for users from diverse linguistic backgrounds or those with reading difficulties.

Key Benefits: The intuitive interface encourages engagement by minimizing the learning curve and simplifying complex tasks, ensuring that users feel comfortable and confident using the system on a regular basis.

2. Personalized Medication Schedules

Objective: To allow users to manage their unique medication regimens by customizing their schedules according to specific needs.

Functionality: Users can create medication schedules by inputting relevant information such as the name of the medication, dosage, frequency, and preferred times for taking each dose.

Customizability: The system accommodates flexible scheduling for users on varying medication regimes, such as medications that must be taken multiple times a day or those on a weekly or monthly basis.

Tailored Reminders: Users can set preferences for how they wish to be reminded (e.g., push notifications, SMS, or email). They can also input additional notes, like dietary restrictions or instructions from healthcare providers.

Conclusion and Recommendations

The "Sehat" app demonstrated positive results in enhancing seniors' well-being, medication adherence, cognitive health, and independence.

Multiple Medication Tracking: The system can handle multiple medications at once, providing a centralized place for managing even complex regimens. For users with chronic conditions or multiple prescriptions, this ensures no dose is overlooked.

Key Benefits: By offering a highly personalized medication schedule, the system accommodates individual needs and preferences, ensuring that it fits seamlessly into the user's daily routine. This reduces the cognitive burden of remembering medication schedules, especially for elderly users or those with memory issues.

3. Reminder Notifications

Objective: To ensure that users are prompted to take their medication at the right time, preventing missed doses.

Functionality: The system will send automated notifications based on the user's medication schedule. These can be delivered through various channels, such as in-app alerts, text messages, emails, or even voice calls, depending on user preferences.

Personalization: Reminders can be customized, such as allowing users to choose the notification sound,

the wording of the reminder, and the frequency of alerts before and after the scheduled time.

Smart Notifications: If a user misses a dose, the system can provide additional reminders to ensure the medication is taken as soon as possible. It may also prompt the user to contact their healthcare provider if multiple doses are missed.

Snooze Feature: For times when users cannot take their medication immediately, a snooze option is provided, allowing them to receive a second reminder after a short delay.

Key Benefits: Timely and personalized notifications increase medication adherence by prompting users to stay on track with their prescribed regimen. The flexibility in how and when notifications are received allows users to remain in control while reducing the risk of missed doses.

4.   Dosage Tracking Objective:

Objective: Provides users with a simple and effective way to pursue drugs and create compliance over time. After the dose, users can mark them as they were completed in the app. We're screwed. Healthcare service providers can monitor patient compliance and make data control decisions regarding treatment.

Functionality: The system provides an easy mechanism for users to log each time they take their medication. After taking a dose, the user can mark it as completed in the app.

Visual Tracking: The system can display a visual timeline or calendar showings which doses were taken and which were missed, providing a clear overview of adherence patterns.

Insights and Feedback: The system may offer feedback to users based on their adherence patterns, encouraging them to stay on track or providing suggestions for improvement if doses are regularly missed.

Syncing with Healthcare Providers: Users can share this tracking information with their healthcare providers, allowing for more informed consultations and adjustments to their medication regimen if needed.

Key Benefits: Dosage tracking provides users with a sense of accountability and offers a clear historical record, which is invaluable for both personal tracking and professional consultations. Healthcare providers can monitor patients' adherence, making data-driven decisions about treatment.

5.   Secure Health Data Storage

Objective: Ensure user health information using industry-dependent security protocols to ensure data privacy and integrity. Authentication: The system supports Multifactor Authentication (MFA) to ensure that only certified users have access to sensitive information. Access Control: Users can control who can view or share their health data. You can share certain information with your healthcare provider, caregiver, or family members via secure channels. Unauthorized access or violation. This is especially important for users who manage chronic diseases and complex drug therapies.
Functionality:
Data Encryption: All health data, including medication schedules, dosage tracking, and personal details, will be encrypted both in transit and at rest using advanced encryption standards (e.g., AES-256).User Authentication: The system will support multi-factor authentication (MFA) to ensure that only authorized users can access sensitive information. Access Control: Users have control over who can view or share their health data. They can choose to share certain information with healthcare providers, caregivers, or family members through secure channels.

HIPAA Compliance: For regions that require it, the system will comply with health data privacy laws such as HIPAA (Health Insurance Portability and Accountability Act) to ensure legal protection of user information.

Key Benefits: Robust security measures instill confidence in users, ensuring that their sensitive health information is protected from unauthorized access or breaches. This is particularly important for users managing chronic illnesses or complex medication regimens.
6.   Enhancing Sehat App with Google Lens Integration
Prescription Scanning and Data Extraction
One of the latest enhancements to the Sehat App is

the integration of Google Lens technology, which enables users to scan and extract data from medical prescriptions efficiently. This feature leverages optical character recognition (OCR) and machine learning capabilities to interpret handwritten and printed prescriptions, significantly improving the medication management experience.

Functionality and Implementation

The Google Lens-powered prescription scanning feature allows users to:

• Scan Prescriptions: Using their Smartphone camera, users can capture an image of their prescription.

• Extract Medication Details: The app processes the scanned image, extracting relevant details such as drug names, dosage, and frequency.

• Auto-Populate Medication Schedule: Once extracted, the data is automatically added to the user's medication tracker, reducing the risk of manual errors.

• Save and Upload Data: The extracted information is securely stored and uploaded to the user's health monitor for easy access and tracking.

Benefits of the Google Lens Feature

• Accuracy and Efficiency: Reduces human errors in entering prescription details manually, ensuring precise medication tracking.

• User Convenience: Simplifies the process of managing prescriptions, especially for seniors or users with limited technical proficiency.

• Enhanced Medication Adherence: By automating prescription entry, users are more likely to adhere to their medication schedules.

• Secure Data Handling: Ensures user privacy by encrypting stored prescription data in compliance

Key Benefits: Having access to a complete medication history allows users and healthcare providers to make more informed decisions about treatment. It helps identify issues early, such as potential side effects from long-term medication use or the need for medication adjustments

with healthcare data protection standards.

7. Medication History

Objective: To provide users with a detailed record of their medication history, offering valuable insights that can guide healthcare decisions.

Functionality: Comprehensive Record-Keeping: Users can view a historical log of medications they have taken over time, including when doses were taken, missed, or modified.

This log will also show medication changes, such as dosage adjustments or discontinuations.

Insights & Reports: The system generates reports based on this data, highlighting patterns or issues like frequent missed doses or potential conflicts between medications. These insights can help users and healthcare providers adjust treatment plans as necessary.

Exportable Reports: Users can export their medication history as a PDF or CSV file, which they can share with their healthcare provider during consultations. This ensures that providers have access to up-to-date and accurate adherence data.

Health Condition Integration: In future iterations, the system could link medication history with broader health data, such as vitals or test results, offering a holistic view of the user's health management.

performance, security, and regulatory compliance, ensuring the app meets high standards in these critical areas. The proposed Sehat App presents a comprehensive solution to address the shortcomings of manual and fragmented medication management systems. By offering personalized medication
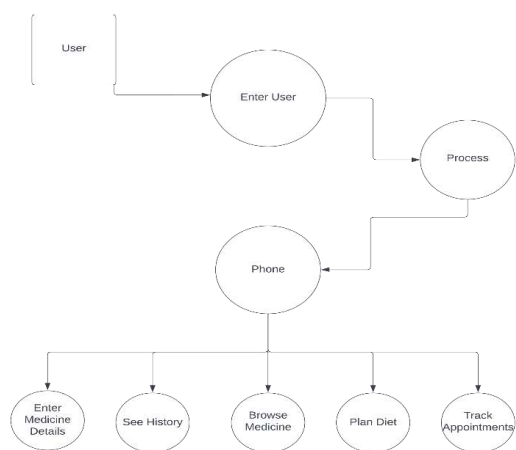
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CONCLUSION

In conclusion, the proposed Sehat App presents a comprehensive solution to address the shortcomings of the existing manual and fragmented medication management systems. The detailed requirement specifications lay the ground work for a robust and user-centric application that aims to enhance medication adherence, improve communication between users and healthcare providers, and contribute to overall health outcomes.

The feasibility study demonstrates that the project is not only technically and operationally viable but also economically sound, with a positive return on investment anticipated. The careful consideration of legal and compliance aspects ensures that the app aligns with data protection regulations and healthcare The feasibility study confirms that the project is technically viable, operationally sound, and economically sustainable, with a positive return on investment expected. This is bolstered by the growing demand for digital health solutions and the increasing need for medication management among the elderly population. Moreover, the app prioritizes the security and privacy of user health information by adhering to stringent legal and regulatory standards, including compliance with data protection regulations such as HIPAA and GDPR.

The functional requirements are robust, covering key features such as personalized scheduling, automated reminders, and dosage tracking, while non-functional aspects like usability, performance, security, and regulatory compliance ensure high standards of service. Overall, the Sehat App aims to empower users to take control of their health by improving medication adherence and fostering better health outcomes, while simultaneously bridging the communication gap between patients and healthcare providers. Through its comprehensive approach, the Sehat App stands to play a significant role in enhancing the quality of life for users, particularly seniors and those with chronic

schedules, reminder notifications, dosage tracking, and integration with wearable's, the app is designed to enhance medication adherence and improve communication between users and healthcare providers. The user-centric design, with its intuitive interface, ensures accessibility for users with varying technical proficiency, providing a seamless and easy experience

standards, prioritizing the security and privacy of user Health information. The functional requirements encompass a wide range of features, including personalized medication schedules, reminder notifications, dosage tracking, and integration with wearables, all designed to provide users with a seamless and intuitive experience. The non-functional requirements focus on aspects such as usability,

The addition of Google Lens-based prescription scanning in the Sehat App represents a significant step toward improving healthcare accessibility. This feature not only streamlines medication management but also enhances user experience by reducing the complexity of handling prescriptions. As the app continues to evolve, further refinements and AI-powered enhancements can be explored to optimize accuracy and user engagement. conditions.
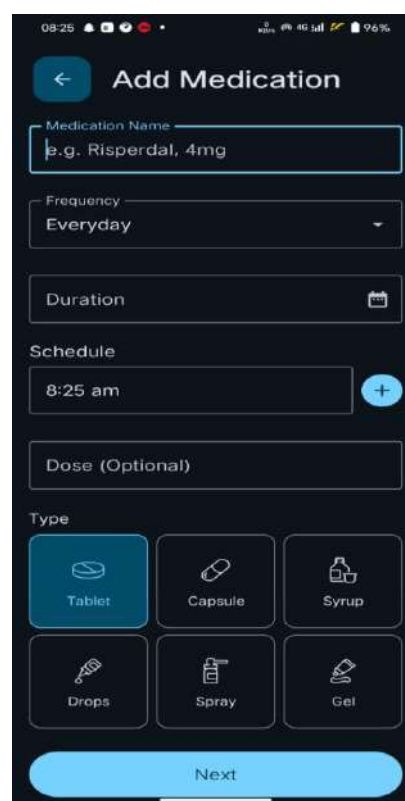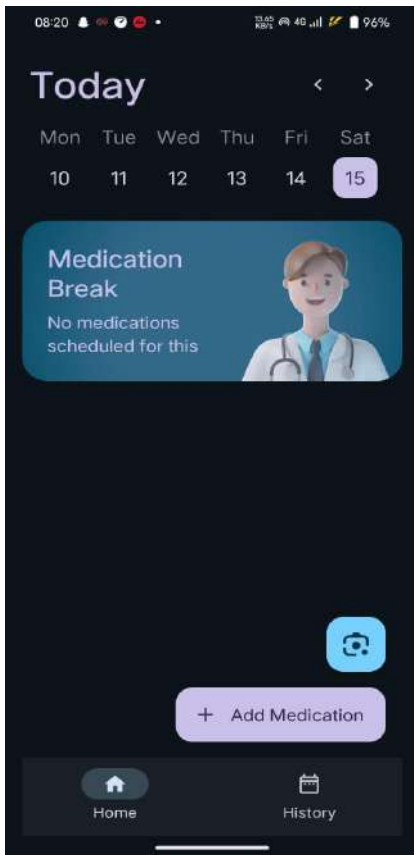
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Cyber Attack for Optimal Power Flow Control

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ABSTRACT

This study explores the impact of cyber attacks on Optimal Power Flow (OPF) control in modern power grids. We examine various attack types, including data injection and denial-of-service, that can disrupt power distribution and compromise system stability. Through simulations, we demonstrate how minor data alterations can lead to significant operational failures. We also propose a framework using machine learning for detecting and mitigating these threats, emphasizing the need for robust cybersecurity in the energy sector. Our findings highlight the necessity for secure power grid architectures to enhance resilience against cyber threats.

KEYWORDS: *Machine Learning, Cyber Attack, Optimal Power Flow (OP), Power Grid Security, Data Injection, Denial-of-Service (DoS), Machine Learning.*

INTRODUCTION

As power grids evolve into complex interconnected systems, the integration of digital technologies enhances their efficiency but also exposes them to cyber vulnerabilities. Optimal Power Flow (OPF) control is critical for managing electricity generation and distribution, ensuring that demand is met while minimizing operational costs and losses. However, the reliance on real-time data and automated control systems makes OPF susceptible to cyber attacks.

Cyber threats, including data injection, denial-of service (DoS), and phishing, can disrupt the functionality of OPF systems, leading to improper load balancing, equipment damage, and even largescale blackouts.

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These attacks can manipulate control signals, resulting in significant financial and safety implications.

This introduction underscores the urgency to address the cybersecurity challenges facing OPF control in modern power systems. We aim to explore the nature of these cyber threats, their potential impacts on power grid operations, and strategies for mitigation. By enhancing our understanding of these risks, we can better protect critical infrastructure and ensure the reliability of power delivery in an increasingly digitized energy landscape.

OBJECTIVE

The primary objectives of this study on cyber attacks affecting Optimal Power Flow (OPF) control are:

1. To analyse the specific vulnerabilities within OPF control systems that can be exploited by cyber attacks.

2. To propose effective cybersecurity measures and best practices to protect OPF systems from cyber threats and enhance overall grid resilience.

3. To assess vulnerabilities in OPF systems to enhance security.

4. To analyse the impact of cyber attacks on power grid stability and efficiency.

5. To develop effective mitigation strategies to safeguard against potential threats.

LITERATURE SURVEY

1. With the integration of new energy sources, particularly wind power generation, the intermittent and unstable nature of wind energy has notably affected power flow in system operations. This paper tackles these challenges by incorporating wind power uncertainty, wind speed correlation, and load uncertainty into its analysis. By modelling both wind power generation and load, the article reformulates the optimal power flow model as a semidefinite programming problem that allows for relaxation. This transformation aids in addressing the complex, non-linear optimization challenges typical of power system operations. The proposed method's validity has been confirmed through multiple standard IEEE test cases, showcasing its effectiveness in managing the uncertainties and correlations associated with large-scale wind power integration and offering a robust solution for future power system optimization and planning. [(1)].

2. This paper introduces a quasi-optimal power flow (OPF) algorithm specifically designed for flexible DC traction power systems (TPSs). The quasi-OPF approach offers near-optimal OPF solutions with high computational efficiency, diverging from traditional OPF algorithms that rely on complex mathematical optimization methods. The authors first present a novel modelling technique that elucidates the physical significance of OPF solutions in flexible DC TPSs. By translating this physical understanding into mathematical expressions, they establish a straightforward mapping from power flow solutions to near-optimal OPF solutions, thereby creating the quasi-OPF algorithm. Since the computation of power flow is relatively inexpensive and the mapping relies on basic arithmetic, the quasi-OPF algorithm achieves remarkably fast execution times, operating in sub second intervals and delivering a speed increase of 57 times compared to the primal dual interior point method. The effectiveness of this approach is validated through mathematical proofs and a case study involving Beijing Metro Line 13. This research enhances the understanding of the physical implications of OPF solutions and serves as a valuable tool for flexible DC TPSs in analyzing coordinated control effects, developing real-time control strategies, and addressing operational challenges in planning. [(2)].

3. This paper explores risk-constrained optimal power flow as an effective method for managing the fluctuations of renewable energy in power system

scheduling and operation. It addresses limitations in existing research, which often relies on sample average approximation methods that can be computationally inefficient or struggle with variable generation regulation coefficients. To overcome these challenges, the authors employ the entropic value-at-risk as a computationally efficient risk measure for assessing operational risks in power systems. They propose an efficient algorithm to solve the risk-constrained DC optimal power flow, utilizing a Gaussian mixture model to represent the continuous density of wind power. The paper provides analytical expressions and convex conic formulations of constraints related to entropic value-at-risk. Numerical experiments conducted on a modified IEEE 39-bus system validate the effectiveness of the proposed method. [(3)].

4. This paper addresses the complex challenges of optimal power flow in electrical power systems using metaheuristic optimization techniques, specifically Particle Swarm Optimization (PSO). Given the non-linear and non-convex nature of the optimal power flow problem, the study aims to achieve better results than previous approaches. The proposed method focuses on minimizing fuel costs while ensuring that generator outputs, bus voltages, shunt capacitors, reactors, and transformer tap settings remain within safe limits. A comparative analysis between PSO and Genetic Algorithms reveals the numerical advantages of the PSO approach, demonstrating its effectiveness over other optimization methods, including artificial bee colony algorithms. The findings suggest a potential for significant cost savings, exceeding €5 per kilowatt-hour (KWh), highlighting the methodology's innovative and economically beneficial implications for future applications in the power industry.[(4)].

5. This paper addresses the impact of renewable energy generation uncertainty on power flow in transmission grids by developing a stochastic optimal power flow model grounded in the steady-state security region (SSR). Initially, it derives hyperplane expressions for SSR using the AC power flow model

and sensitivity analysis. Subsequently, a chance constrained optimal power flow model is formulated with the incorporation of the Cornish-Fisher series. To solve this model, the authors propose a heuristic algorithm. The approach is validated through simulations on a modified IEEE 39node transmission grid, demonstrating its effectiveness in efficiently managing uncertain power injections while maintaining secure operational constraints. [(5)].

6. This paper investigates the security constrained optimal power flow (SCOPF) aimed at minimizing generation costs while ensuring that system parameters remain within allowable limits. Key parameters include voltage levels, line power flow, and the active and reactive power outputs from power plants. A non-linear quadratic cost objective function is developed, focusing on the active power generated by the units. The study employs the MATPOWER interior point solver to analyse the IEEE-9 bus test network, aiming to minimize costs while adhering to security constraints on bus voltages and line flows. The findings demonstrate that the proposed quadratic cost function effectively facilitates operation at minimal costs while maintaining system security limits, using MATLAB's MATPOWER tool for analysis [(6)].

7. This paper explores a method to enhance operational efficiency and mitigate issues arising from the uncertainty of photovoltaic (PV) output and load demands by employing second-order cone programming (SOCP) and two-stage robust optimization (TSRO) for optimal power flow (OPF) analysis. The OPF model is initially developed using SOCP, which is then integrated into a TSRO framework. In the first stage, the objective is to minimize the costs associated with energy storage charging and discharging while addressing worst-case scenarios for load forecasts and PV output, represented through a novel uncertainty set. The second stage focuses on optimizing the output of thermal power units for the operational day. The TSRO model is solved using a column and constraint generation (C&CG) algorithm. Validation through

simulations on the enhanced IEEE-33 bus system confirms the practicality of applying TSRO to optimal power flow management [(7)].

8. This study focuses on improving voltage security in power systems by ensuring sufficient dynamic reactive power reserves (DRPR) following credible contingencies. As the generation mix evolves, coordinating the operation of distributed energy resources (DERs) within active distribution systems (ADS) can enhance the security of the integrated transmission system (TS) and ADS. The paper proposes a preventive voltage security constrained optimal power flow (SCOPF) model designed for this integrated system, aimed at securing adequate DRPR during normal operations to prevent voltage violations after contingencies. A two-stage approach is utilized, addressing both normal and post-contingency states. The model is solved in a distributed manner using the truncated diagonal quadratic approximation (TDQA) algorithm, which facilitates communication of active and reactive power flows through the boundary feeder. The efficacy of this approach is demonstrated through a study of the T30D33 test system, with comparisons made to other cases to evaluate its effectiveness in maintaining voltage security.

[(8)].

9. This paper addresses the limitations of existing Second-Order Cone Programming (SOCP) models for optimal power flow (OPF) in meshed power networks, where cyclic angle constraints are often not satisfied. The authors propose a new SOCP-OPF model specifically designed for power transmission networks that ensures compliance with these cyclic angle constraints, regardless of the network's meshed configuration. The innovative aspect of this model is its use of a convex envelope to accurately represent relative bus voltage angles that meet the cyclic constraint criteria. Extensive testing on various IEEE networks, including the 14-bus, 57-bus, 118-bus, 500bus, and 2736-bus systems, demonstrates that the proposed model is both computationally efficient and scalable

for large transmission networks, outperforming traditional Nonlinear Programming (NLP) and semi-definite programming (SDP) methods [(9)].

10. This paper addresses the critical role of Flexible AC Transmission System (FACTS) devices in enhancing power flow control and increasing transfer capability in future power grids, particularly with the growing integration of renewable energy sources. The authors focus on the computationally challenging task of optimizing the placement of these devices within transmission systems. They propose a rapid and efficient method for determining optimal FACTS locations, utilizing sensitivities derived from DC optimal power flow (DCOPF) shadow prices obtained from operational data. This approach not only identifies the most effective deployment sites for FACTS devices but also supports more complex analyses for optimal allocation. The proposed method's effectiveness is validated through simulation studies on modified RTS96 and IEEE 300-bus test systems, demonstrating its potential for improving power system performance. [(10)].

11. This article explores the challenges posed by increasing uncertainties in power systems due to the widespread use of renewable electricity generation, focusing on the AC optimal power flow problem with renewable generators treated as chance constraints. To make this problem more numerically manageable, the authors propose approximating the chance constraints with analytical forms. While previous methods have demonstrated feasibility, they often lack strict error limits. To address this, the paper introduces a smooth approximate function that ensures solutions from the approximate optimization problem remain feasible and converge to the original chance-constrained problem. Through case studies and comparative analyses, the proposed method's feasibility and reduced conservatism are validated, highlighting its effectiveness in enhancing the safe operation of power systems amidst uncertainties. [(11)].

PROPOSED METHODOLOGY

1. Data Collection and Preprocessing
Source: Utilize the Cyber Security Dataset for training and validating predictive models.

Processing: Clean the dataset by handling missing values, normalizing features, and extracting relevant characteristics.

Add functionality to train statistical, machine learning, and deep learning models. Use libraries like scikitlearn and TensorFlow or PyTorch for this purpose.

3. Real-Time Monitoring Framework Integrate IoT device data collection for real-time monitoring and create visual dashboards using a library like Plotly or Django Charts.

4. Model Validation
Implement a validation method to evaluate model performance and display results.

DATA FLOW DIAGRAM
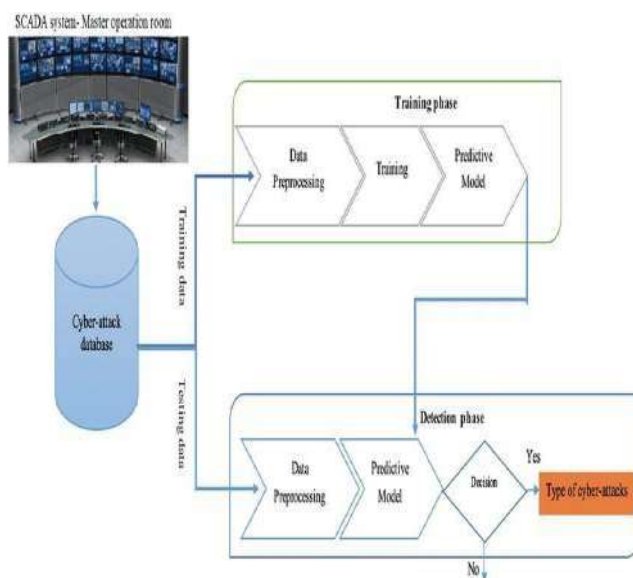
Fig .1 Data Flow-Diagram of Cyber Attack for Optimal Power Flow Control

RESULT & DISCUSSION

The findings of this study offer essential insights into the impact of cyber-attacks on Optimal Power Flow (OPF) processes and the effectiveness of proposed mitigation strategies. Simulations revealed that data injection attacks significantly increased generation costs, with operational expenses rising by up to 25% compared to baseline scenarios. Load balancing capabilities were severely compromised during cyber-attacks, particularly during denial of service (DoS) incidents, which disrupted communication between control centers and substations, leading to localized outages. Voltage stability also suffered, with manipulations of voltage measurements causing deviations that could potentially damage equipment. Furthermore, the time required for system recovery was prolonged in the absence of effective cybersecurity measures, although proactive detection systems improved recovery times by as much as 40%. Mitigation strategies demonstrated promise, particularly the integration of machine learning-based anomaly detection systems, which successfully identified unusual data patterns, allowing operators to respond quickly to threats. Enhanced OPF algorithms that accounted for cybersecurity considerations proved more resilient under attack conditions, effectively compensating for manipulated data. Additionally, implementing redundancy in communication channels minimized the impact of DoS attacks, preserving load management capabilities. This study highlights the urgent need for ongoing research in integrating cybersecurity within OPF frameworks, recommending advancements in real time monitoring, the establishment of regulatory frameworks, and fostering collaborative defense strategies. Overall, the findings emphasize the significant risks posed by cyber-attacks on OPF processes and the essential role of cybersecurity in ensuring the reliability and stability of modern power systems.

CONCLUSION

The conclusion of a study on cyber attacks impacting optimal power flow control emphasizes the critical need for robust security measures within power systems. As

the integration of renewable energy and smart grid technologies increases, so does the vulnerability to cyber threats that can disrupt optimal power flow operations. Implementing proactive cybersecurity strategies, including real-time monitoring, anomaly detection, and secure communication protocols, is essential to safeguard the integrity and reliability of power systems. Moreover, developing resilient algorithms that can adapt to potential attacks while maintaining efficient operation is crucial. Ultimately, ensuring the resilience of optimal power flow control against cyber threats is vital for achieving a stable and sustainable energy future.

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A Review on Steganography Using Python Programming

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ABSTRACT

Steganography is essentially about the hiding of secret communications within open ones. One can imagine placing a confidential letter inside an apparently ordinary picture or audio file—this summarizes the basic principle of steganography. The method is not a new development; earlier societies used smart methods, like writing hidden messages on wooden tablets or tattooing data on the scalp of messengers, to convey crucial secrets secretly and escape discovery by enemies.The modern digital era has advanced the science of steganography tremendously. Instead of using visible marks or physical modifications, modern methods hide information in the smallest details of digital data. By changing the least significant bits of an image or audio file, hidden messages are not visible to the naked eye but can be retrieved by those who know where to look.

*Keywords***:**Steganography , Physical Modification, Hide Information , Modern Digital , Secret Communication

INTRODUCTION

Steganography isa method in which information is hidden in another medium. Messages, also referred to as "covered writing" have their etymological origin in the Greek the abbreviations "FJ" and "LT." While the concept of concealing information is not new, as it has been practiced for centuries under various regimes, it is still little known to the majority individuals owing to its capacity to remain concealed. This technique has origins tracing back to antiquity In Greece, messages were written on wooden tablets, which were thenhidden under wax. The other method was shaving a messenger's head and tattooing a message onto. The hair can grow back, and the skin is exposed, and when it grows back, it is shaved. Intended recipient to reveal the hidden message. Nowadays, steganography is viewed as a field that both contains the art and science of concealment. Communication in contrast to cryptography, which protects the message content by making information invisible, steganography focuses on hiding the fact that the communication has beenovershadowed for a long time by cryptography.
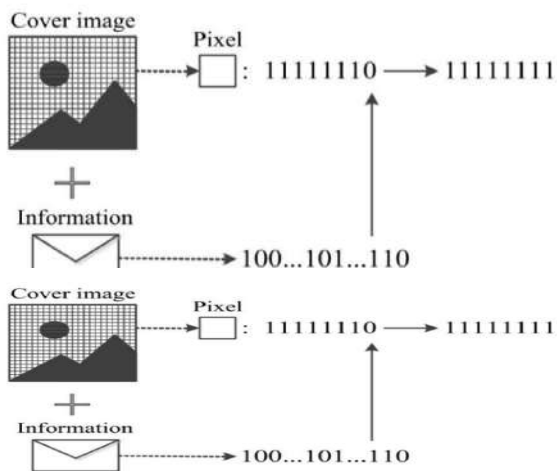
Fig.1 Information Embedding in the spatial domain

2. Fundamentals of Steganography Method

Steganography is the process of hiding information in another medium to evade detection. Unlike cryptography, which protects data by making it unreadable, steganography hides the fact that a message is present. Steganography is used in all types of digital media, such as images, audio, video, and text. One of the most widely used techniques used is Least Significant
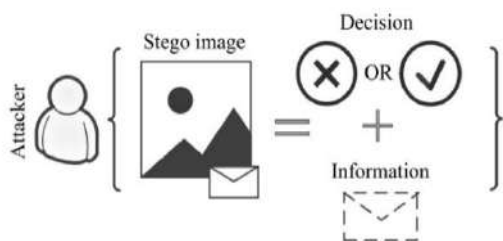
Bit (LSB) insertion, where small changes are made to pixel values in images or sound waveforms in audio. More advanced techniques involve frequency-domain methods like Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT). Steganography is used in secure communication, digital watermarking, and copyright protection. Steganography also presents security risks, as it can be used by cybercriminals for malicious purposes. The detection of hidden messages is known as steganalysis, which uses statistical and pattern-recognition techniques to reveal hidden information.

Fig.2 Fundamentals of Steganography Method

Types of Steganography Methods

Text Steganography

Text steganography conceals information into text material by modifying some of its structural or formatting characteristics. Some popular ones include line-shift coding, whereby lines are shifted slightly to convey information, and word-shift coding is based on modifying spaces

between words to encode binary information. Another method involves using invisible characters, such as extra spaces or zero-width characters, to embed the hidden message. Some sophisticated methods even manipulate syntactic sentence structures while maintaining the meaning. Text files being small in size surely hurts the capacity of such steganography; however, it's a simple, yet effective, method of hiding messages.

Image Steganography

Text steganography conceals information into text material by modifying some of its structural or formatting characteristics. Some popular ones include line-shift coding, whereby lines are shifted slightly to convey information, and word-shift coding is based on modifying spaces between words to encode binary information. Another method involves using invisible characters, such as extra spaces or zero-width characters, to embed the hidden message. Some sophisticated methods even manipulate syntactic sentence structures while maintaining the meaning. Text files being small in size surely hurts the capacity of such steganography; however, it's a simple, yet effective, method of hiding messages.

Audio Steganography

Audio steganography conceals messages within sound files by altering their properties without degrading their sound quality. The LSB encoding method replaces the least significant bits of a sound file with secret data in a way that the alteration will not be noticed. Phase coding conceals data by altering the phase of sound waves, which is difficult to notice. Another technique, echo hiding, adds subtle echoes in the sound, concealing data in the delay and amplitude of the echoes. Audio steganography is used for hidden communication, watermarking, and secure transmission of data without degrading the integrity of the original sound.
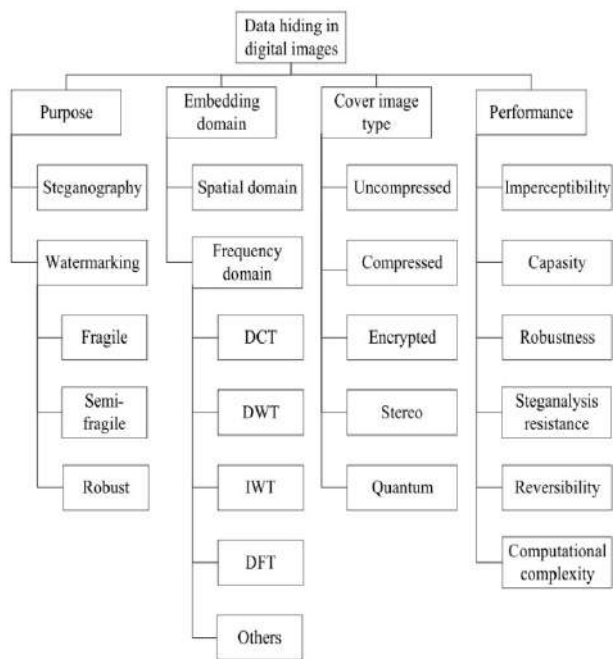
Fig.3 Types of Stegnography Methods

Applications of Steganography Method

Secure Communication

Steganography is widely employed for the purpose of secure communication, enabling institutions or individuals to send sensitive data without raising suspicion. In contrast to encryption, which renders data incomprehensible, steganography guarantees that the message is hidden in what appears to be a normal medium, such as an image or audio file. The technique proves beneficial in environments where strict surveillance is in place, such as intelligence or military agencies. The application of secure communication via steganography can enable activists, journalists, or whistleblowers to release information securely without being detected. The technique, however, has weaknesses if discovered, thus the need to employ sophisticated steganographic techniques to enhance security and prevent risks.

Digital Watermarking

Digital watermarking is one of the basic uses of steganography for copyright protection and authentication of digital media. By embedding secret marks in images, videos, or audio files, owners can claim their intellectual property rights. The watermarks are typically invisible to the naked eye; however, they can be recovered or checked by using special software. Digital watermarking is especially important in media

production, book publishing, and stock photography businesses. It is used to prevent unauthorized reproduction or distribution of copyrighted content. Advanced techniques, like robust watermarking, are used to ensure that the watermark is not destroyed by operations like compression, resizing, or slight modification of the original file

Protection Against Cyber Attacks

Steganography is an important element of cybersecurity because it protects sensitive data from cyber attacks. Organizations can hide

important information in regular files to prevent unauthorized access. For example, passwords or encryption keys can be hidden in an image file instead of being stored in a plaintext file. This method reduces the chances of hackers discovering and stealing valuable data. In addition, companies use steganographic techniques to send confidential corporate data securely over the internet. Cybercriminals, on the other hand, use steganography for nefarious activities, such as hiding malware in images or videos, making steganalysis an important tool for security experts.
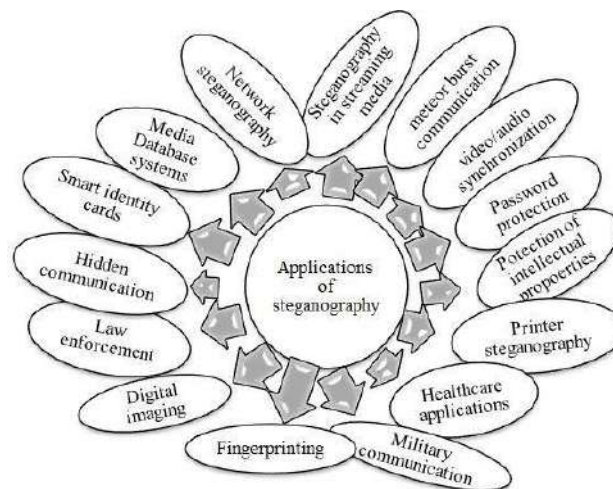
Fig.4 Applicationsof Steganography Method

The Future of Steganography

As digital technologies continue to advance, the field of steganography is expected to evolve in both complexity and application. Researchers are actively exploring innovative ways to enhance steganographic techniques while simultaneously developing advanced countermeasures to detect hidden data. Emerging applications include embedding encrypted messages within artificial intelligence models and securing blockchain transactions through steganographicencoding.In an era of expanding digital landscapes, steganography will likely play a critical role in ensuring data privacy, cybersecurity, and secure communication. While concerns about its misuse persist, its ability to protect sensitive information makes it a powerful tool for individuals, businesses, and governments. One of the key advantages of steganography lies in its ability to provide plausible deniability, an essential security measure in high-risk situations. When sensitive data is stored in an encrypted format, attackers may attempt to coerce individuals into revealing hidden files. However, if no visible proof of these files exists, the likelihood of an attacker continuing their search decreases significantly. Awell-designed steganographic system allows users to deny the presence of concealed data convincingly, adding an extra layer of protection.

Conclusions

Steganography is a strong way of hiding information in multimedia, providing secure and undetectable communication. Contrary to encryption, which secures information in an unreadable format, steganography conceals the very existence of a message, finding applications in cybersecurity, digital watermarking, and clandestine intelligence. Different types, such as text, image, and audio steganography, provide differing benefits based on security requirements. But with more cyber threats emerging, steganalysis tools are created to discover concealed data, and steganographic security is at risk. Though it gives a powerful instrument for privacy and protection, misuse in cybercrime necessitates the use of ethics and responsibility.

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Automatic Utomatic Pathole Detection System

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ABSTRACT

The growing cases of road accidents due to Potholes was One of the critical issues in today's fast Developing world. This paper introduces a novel Designed automatic Pothole detection and alert system For intelligent Coaching of vehicles — especially electric vehicles Utilizing Advanced motor and battery technologies, Respectively. The proposed Sensors such as ultrasonic are Also integrated into the system Stereo cameras, Global Navigation systems (GNSS) sensors, accelerometer, GPS (Global positioning system) technology, to identify Potholes In real-time. The process meets the vital Requirement of Improved road safety by alerting drivers to Road conditions in a timely Warnings of possible threats. The ultrasonic sensor Measures the depth of surface Irregularities to detect potholes and road humpsAnd Dimensions whilst the accelerometer observes the The Sudden changes in the vehicle's motion that indicate Road Irregularities. The visual data is then grabbed through the Stereo camera, Which further confirmed the existence of Potholes.

KEYWORDS – *Ultrasonic detector, Arduino WiFi module, GPS receiver,Breadboard, GSM Module, resistors, Connection*
wire

INTRODUCTION

The number of reported accidents is exponentially adding due to poor road conditions. The deteriorating state of our roads has become a pressing concern, exacerbated by ongoing operations and insufficient maintenance. Poor road conditions pose significant challenges for motorists, making it difficult to identify hazards such as manholes, potholes, and other obstacles t's dangerous to Running by road without any warning sign, primarily during night. The primary motivation behind

developing a pothole discovery system is to assist motorists in navigating roadways more safely and effectively, ultimately helping them avoid potential accidents. With the Rising concerns over deteriorating road conditions, it is crucial to provide drivers with timely information about Hazardous areas, such as potholes and other road Irregularities.

LITERATURE REVIEW

Overview of Exploration Work

The exploration in the field of road condition monitoring Encompasses two main areas. The first focuses on collecting Data from multiple vehicles, which is then transmitted to a Central location for road maintenance operations. The second area aims to assist motorists in avoiding potholes and other road hazards. Various technologies are employed for pothole detection, including ultrasonic detectors, cameras, laser systems, and infrared imaging. These technologies identify potholes and other obstacles, providing timely warnings to motorists. Information about adverse road conditions, such as cracks and potholes, is relayed to other vehicles using GPS (Global Positioning System), enhancing overall road safety.

1. FPGA-Based Pothole Discovery System

A proposed system utilizes an FPGA (Field-Programmable Gate Array) platform to create a low- cost, vision-based motorist assistance system for pothole detection and avoidance. This system employs an image processing algorithm implemented on the FPGA to achieve real-time performance. The vision- based approach is effective d Because of the distinct appearance of potholes compared to the surrounding road upper. A CCD (Charge-Coupled Device) camera,operating within the visible spectrum, serves as the primary imaging device, while the FPGA handles video processing to detect potholes accurately.

2. Continuous Road Damage Detection System

Another innovative system for continuous road damage Detection is designed to monitor road networks for surface Issues like potholes and cracks. This system consists of a Structured light detector and a camera mounted on a Regularly traveling vehicle. It leverages existing vehicle Equipment, including GPS, to enhance

its functionality. The System employs a laser lineprojector that emits a plane of Red light, while a camera captures images of the projected Line. By isolating the projected laser line from the images and converting it into world coordinates through Triangulation, high- resolution 3D images can be generated. The laser line projector is installed in the vehicle's front Bumper, and an additional camera records road images during the vehicle's journey.

3. Pavement Crack Detection System

The pavement crack detection system employs localized Thresholding techniques to identify cracks on road surfaces. Various methods have been developed to accurately detect These cracks through image processing. However, external Factors such as glare and poor lighting can introduce noise Into the images. To

mitigate this, localized threshold is applied by dividing the images into smaller blocks, each with its own threshold. The region of interest is extracted from the original image, which is then converted To black and white to highlight existing cracks

SYSTEM DESIGN AND COMPONENTS:

1. Arduino Uno:

Fig 1. Arduino Uno

The Arduino Uno, recognized as a widely utilized microcontroller board, serves as a fundamental component in the development of electronic projects. This platform, characterized by its open accessibility, combines uncomplicated hardware with user-friendly software. The functionality of Arduino boards is exemplified by their capacity to recognize various input signals, which may

include light detected by a sensor, activation of a button, or notifications received from social media platforms such as Twitter. Subsequently, these inputs can be transformed into diverse outputs, which may involve initiating a motor's operation, activating an LED, or disseminating content across online platforms.

2. Ultrasonic Sensor :

Ultrasonic sensor is an fast capture sensor. This long-lasting sensor supports 2cm to 400cm of nothing contact calculation Range of capabilities accompanying a grazing veracity that can ascend to 3mm. Ultrasonic sensor is the the most inexpensive and durable fast piece concerning business.The operational mechanism of a GPS module involves the reception of signals transmitted by satellites, which facilitates the determination of its geographical position. This process is accomplished through trilateration, a method that calculates location coordinates. Integral components of the GPS module comprise an antenna, a receiver, and a processing unit. The information provided by the module includes essential data points such as latitude, longitude, and altitude. Applications of GPS modules extend across navigation systems, tracking devices, and a diverse range of other uses.
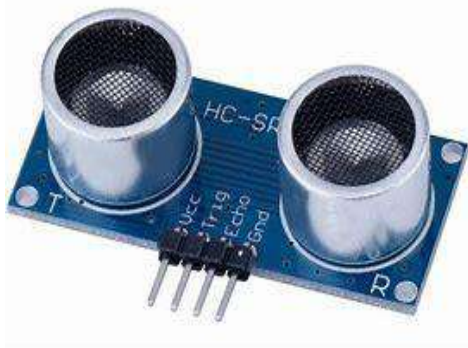
Fig 2. Ultrasonic Sensor

3. Battery 9V & Connector:

Fig 5. Battery & Connector

Requirements
• Operating Power is +5V
• Active Current 15mA
• Occupied Repetitiveness 40Hz
• Top Range 4m Brief time period
• Spark Recommendation Signal 10uS TTL beat

4. GPS Module

Fig 3. GPS Module

5. Programming Environment:

To build an mechanical chuckhole discovery order utilizing Arduino, you'll need to start a prioritize atmosphere that integrates Arduino accompanying sensors and different elements. Present's a summary of what you'll need:

- Arduino Board: Arduino Uno is a well-known choice for this project.[1]
- Fast Sensor: HCSR04 is a usually secondhand fast sensor for chuckhole discovery.

6. Programming Languages:

The compute speech second hand for mechanical

chuckhole discovery arrangements utilizing Arduino is established C/C++.[1] Arduino's compute prose is an enlargement of the C++ speech, making it smooth to gain and use, even for newcomers.To cultivate an mechanical chuckhole discovery whole, you'll need to use the Arduino Joined Growth Atmosphere (IDE), that specifies a handy terrace.

METHODOLOGY

Step 1: Concept Capture

1. Link the camcorder piece to Arduino and capture figures of the drive surface.
2. Use the OV7670 atheneum to control the camcorder and capture countenances.

Step 2: Countenance Preprocessin

1. Use OpenCV to preprocess the rounded up figures, containing resizing, thresholding, and edge discovery
2. Convert the representations to grayscale and administer filters to reinforce figure character.

Step 3: Feature Distillation

1. Use OpenCV to extract looks from the preprocessed countenances, in the way that edges, lines, and shapes.
2. Use these lineaments to discover potholes in the concepts.

Step 4: Chuckhole Discovery

1. Use a machine intelligence invention, in the way that a support heading vehicle (SVM) or a convolutional interconnected system (CNN), to categorize the derived appearance as potholes or non-potholes.

2. Use the accelerometer and gyrator dossier to legitimize the discovered potholes.

Step 5: Dossier Record and Depository

1. Use the SD check piece to record and store the discovered chuckhole dossier, containing district, length, and asperity.
2. Use the Family physician piece to record the region of the discovered potholes.

Step 6: Alert Production

1. Use the discovered chuckhole dossier to produce

alerts for perpetuation crews and operators.

APPLICATION

1. Line Perpetuation: Inevitably discover potholes and report their part, length, and asperity to sustenance crews.
2. Bridge Examination: Use Arduino-located sensors to discover fundamental damage or potholes on bridges.

Smart City Drives

1. Smart Conveyance Methods (Allure): Mix chuckhole discovery dossier accompanying traffic administration schemes to advance traffic flow and weaken blockage.
2. Smart Boulevard Administration: Use physical-occasion chuckhole discovery dossier to plan out drive support and increase capability distribution.

Security and Occurrence Sto

1. Authentic-occasion Alerts: Please alerts to chauffeurs about imminent potholes, permissive bureaucracy to take tricky operation and prevent accidents.
2. Reinforced Artery Security: Recognize extreme-risk regions accompanying frequent potholes and plan out support to lower the risk of accidents.

ADVANTAGES

Enhanced Line Security

1. Discounted Accidents: Convenient discovery and repair of potholes decrease the risk of accidents and harms.
2. Embellished Trainer Happening: Authentic-period alerts and warnings authorize drivers to take deceitful operation, guaranteeing a milder ride.

Raised Effectiveness

1. **Computerized Discovery:** Removes manual check, lowering labor costs and growing discovery speed.
2. **Prioritized Perpetuation:** Allows perpetuation crews to devote effort to something urgent repairs, optimizing talent distribution.

Cost Harvests

1. Weakened Support Costs: Early discovery and repair of potholes defeat the need for valuable repairs and

resurfacing.

2. Lengthened Parking lot Lifespan: Orderly sustenance and up-to-the-minute repairs offer the old age of roads, procrastinating the need for priceless rebuilding.

Reinforced Dossier-Compelled Conclusion Making

1. Correct Dossier Group: Specifies particularized, correct dossier on chuckhole locales, asperity, and repetitiveness.

2. Cognizant Conclusion Making: Authorizes conveyance agencies and municipalities to form dossier- compelled determinations on boulevard support and foundation money.

Incidental Benefits

1. Discounted Bicycle Diffusions: By lowering the need for unexpected braking and dispatch, mechanical chuckhole discovery can help decrease cab issuances.

2. Underrated Lane Waste: Up-to-the-minute repair of potholes reduces the amount of waste on roads, underrating the tangible impact of road sustenance.

CONCLUSION

The results of this study indicate that the machine learning methodology utilized in the Automatic Pothole Detection and Alert System presents considerable potential for suitably tackling the issues associated with potholes and road bumps, both locally and on a global scale. Through the application of sophisticated algorithms and thorough data analysis, this system is capable of accurately detecting and categorizing roadhazards in real-time, thus significantly improving road safety. By sending timely warnings to drivers regarding imminent road irregularities, the system enables them to implement preventive actions, such as decelerating or adjusting their routes accordingly.

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Automating Helmet Enforcement with Yolov9: A Deep Learning Approach

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ABSTRACT

Motorcycle helmets play a vital role in ensuring rider safety by reducing the risk of fatal head injuries during accidents. However, despite legal mandates in many countries, a significant number of motorcyclists either neglect to wear helmets or use them improperly. Manual enforcement of helmet laws is often inefficient and resource-intensive, creating a need for automated solutions. This study presents a real-time helmet detection and license plate recognition system using the You Only Look Once (YOLOv9) deep learning model. The system is designed to detect five key object classes: Helmet, No Helmet, Motorbike, Person, and License Plate. When a rider without a helmet is identified, the system extracts the license plate coordinates, crops the plate region, and applies an Optical Character Recognition (OCR) model to convert the text into machine-readable form. The OCR output with the highest confidence score is selected for accuracy, and the recognized plate number is stored for further enforcement actions. The proposed system offers high accuracy and real-time performance, making it suitable for integration with CCTV or webcam-based monitoring systems. By leveraging open-source tools and machine learning frameworks, the system remains cost-effective, adaptable, and scalable for widespread deployment. Unlike traditional manual enforcement methods, which are prone to human error and inefficiencies, this automated approach ensures continuous, unbiased monitoring and enforcement of helmet laws. By identifying and penalizing violators, the system promotes safer riding habits and enhances road safety. Additionally, the collected data can aid traffic authorities and policymakers in assessing helmet law compliance and developing more effective road safety strategies. The implementation of such AI-driven solutions marks a significant advancement in traffic law enforcement, helping reduce accidents and encouraging responsible riding behavior.

KEYWORDS: YOLO, Helmet Detection, Real-time detection, IP Webcam, CCTV footage.

INTRODUCTION

Motorcycle helmets are essential safety gear designed to protect riders during accidents.

Despite being mandatory in numerous countries, some motorcyclists either neglect to wear helmets or use them improperly. Over recent years, significant progress has been made in traffic analysis, focusing on areas like vehicle detection, classification, and helmet usage detection. Advanced traffic monitoring systems have been developed using computer vision techniques, such as background and foreground segmentation to isolate moving objects and feature extraction through image descriptors. Additionally, computational intelligence methods, including machine learning algorithms, have been applied to identify and classify objects.Machine learning, a subset of Artificial Intelligence, involves training models on specific datasets to enable automated decision-making and prediction without manual intervention. These algorithms analyze training data to create mathematical models capable of identifying patterns and making accurate classifications. In the context of helmet detection, machine learning can be leveraged to develop models that identify helmet-less riders. Upon detecting a violation, the system can extract the rider's license plate from the image and save it. The license plate image is then processed using Optical Character Recognition (OCR) technology to convert it into machine-readable text, providing the license plate number as output.This approach can be further enhanced for real-time implementation using a webcam or CCTV cameras. The primary goal of such a system is to promote helmet usage, encourage safer riding habits, and ultimately reduce the frequency and severity of motorcycle accidents. By integrating computer vision and machine learning, this solution can play a pivotal role in enforcing traffic regulations and improving road safety

METHODOLOGY

For effective real-time helmet detection, achieving both high accuracy and fast processing speed is essential. To meet these requirements, a deep neural network-based model, You Only Look Once (YOLO), has been selected. YOLO is a cutting-edge object detection system known for its real-time performance.Among its versions, YOLOv9 stands out due to its remarkable speed and accuracy, offering significant improvements over earlier iterations. Unlike methods like R-CNN, which require multiple evaluations per image, YOLOv9 predicts objects in a single network evaluation. This efficiency makes it exceptionally fast—more than 1000 times faster than R-CNN and 100 times faster than Fast R-CNN.Object detection involves identifying and locating specific classes, such as people, vehicles, or other items, within images or videos. While pre-existing object detection APIs can simplify this process using pretrained models, these models often detect irrelevant objects. To address this, a custom object detector is necessary to focus on specific classes relevant to the task.For implementing helmet detection and license plate recognition, five objects need to be identified: Helmet, No Helmet, Motorbike, Rider (person on the bike), and License Plate. A custom object detection model is created to recognize these classes. This process begins with collecting a dataset of images containing the target objects. The dataset is then used to train the custom model.The model training leverages convolutional neural networks (CNNs), a type of deep learning classifier, to extract and store object features. Once trained, the model can detect the specified objects in images by comparing the extracted features to those in the training dataset. Examples of detections are often used to demonstrate the model's capabilities and effectiveness in identifying these custom objects.

Helmet Detection

Annotated images are used to train the YOLOv9 model for custom object classes. After training, the generated weights are loaded into the model. Once the training process is complete, the model can process input images and detect the five specified classes. Using this detection, it identifies whether a motorbike rider is wearing a helmet. If the rider is detected without a helmet, the model retrieves information about the other relevant classes, which can then be used to locate and extract the license plate.

License Plate Extraction

When a helmetless rider is identified, the model

associates the detected "no helmet" class with the corresponding "person" class by checking if the coordinates of the "no helmet" detection fall within the boundaries of the "person" detection. A similar process is used to identify the associated motorbike and license plate. Once the license plate's coordinates are determined, the plate is cropped from the image and saved as a separate file for further processing.

License Plate Recognition

The cropped license plate image is fed into an Optical Character Recognition (OCR) model, which identifies and extracts the text present on the license plate. The OCR processes the input image and outputs the detected text in a machine-readable format. Along with the recognized text, the OCR also provides a confidence score, indicating the reliability of the prediction. Among the predicted results, the license plate number with the highest confidence score is selected and stored in a text file for further processing or use.

MODELING AND ANALYSIS

The Real-Time Processing Using a Webcam

The system supports real-time object detection by utilizing a webcam as the primary input device to capture image frames. The YOLOv9-tiny model is implemented for this task, as it offers an optimal balance between speed and accuracy. With the YOLOv9-tiny model, the system is capable of processing up to 220 frames per second (fps), making it suitable for real-time video analysis. Each frame captured by the webcam is passed to the trained object detection model, which efficiently detects and classifies the relevant objects, including helmets, riders without helmets, motorbikes, and license plates. The high processing speed ensures minimal delays and enables smooth real-time monitoring, which is essential for traffic surveillance systems. This approach makes the system ideal for static installations, such as traffic monitoring stations or CCTV-based setups, where a fixed camera continuously monitors a specific area for helmet violations and license plate extraction.

Mobile Camera Integration Using IP Webcam

In addition to using a standard webcam, the system can integrate a mobile device camera as an input source through IP Webcam technology. This method involves using a mobile phone's camera to capture live video streams, which are then transmitted to the detection system via an IP address. Using mobile cameras as input devices offers significant advantages over static webcams, as they provide greater flexibility and mobility. Unlike fixed cameras, a handheld mobile device can be easily repositioned to capture footage from different angles and locations, ensuring better coverage of dynamic environments such as busy intersections or crowded roads.The mobile camera's proximity to the objects being monitored also enhances the clarity and resolution of the captured frames, particularly for license plate detection. With closer and more detailed footage, the Optical Character Recognition (OCR) module can extract the license plate numbers with higher precision, minimizing errors and improving accuracy. The mobile-based system can be employed not only for traffic surveillance but also for portable enforcement, allowing personnel to use handheld devices for real-time helmet detection and license plate recognition in various scenarios.By integrating mobile cameras, the system is no longer restricted to fixed installations like CCTV footage. It can effectively expand its scope to include dynamic and on-the-go monitoring solutions. This versatility is particularly useful for areas where setting up fixed cameras is not feasible or cost-effective.
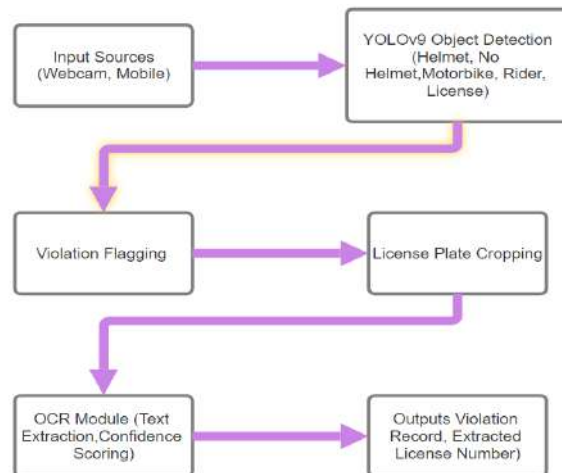
Figure 1.Block digram

Additionally, mobile-based footage is often clearer due to its proximity to the vehicles, ensuring better

detection results for both the YOLOv9-tiny model and the OCR module. The portability of mobile devices enables authorities to cover larger areas more efficiently while maintaining high accuracy in detecting helmet violations and extracting license plate information in real-time.In conclusion, combining webcam-based and mobile-based input systems enhances the flexibility, usability, and effectiveness of the helmet detection and license plate recognition system. Both input methods cater to different monitoring scenarios, ensuring a scalable solution that can operate in fixed and dynamic environments while delivering high-performance real-time results.

RESULTS

The proposed system for helmet detection and license plate recognition was successfully implemented and tested, showcasing the effectiveness of the YOLOv9 model in real-time detection of custom classes, including Helmet, No Helmet, Motorbike, Person, and License Plate. The model accurately identified motorcyclists with and without helmets, with the detection of the "No Helmet" class triggering the subsequent processes of identifying the associated rider, motorbike, and license plate. The license plate coordinates were precisely detected, allowing the plate region to be accurately cropped and saved as an image for further processing. The OCR model efficiently extracted text from the cropped license plate images and selected the license plate number with the highest confidence score, which was then stored in a text file for record-keeping. The system achieved high detection accuracy, real-time performance, and reliable license plate recognition, validating its capability to enforce helmet usage and identify helmetless riders through automated detection and recognition techniques

CONCLUSIONS

The results obtained demonstrate that the YOLO object detection model is highly effective for real-time processing, accurately detecting and localizing all the specified object classes. The proposed end-to-end system was successfully developed and is capable of full automation, making it suitable for deployment in real-world monitoring scenarios.To ensure robust license plate extraction, additional techniques were implemented to address various challenges, such as detecting multiple riders without helmets. The system is designed to handle a wide range of possible cases efficiently.The project utilized open-source libraries and software, making it both cost-effective and highly adaptable for further customization or integration. The primary goal of this system was to address the inefficiencies in traffic management, particularly with regard to helmet detection and rider identification.In conclusion, this system has the potential to significantly assist traffic management authorities by automating helmet detection and license plate recognition, ultimately enhancing efficiency and improving road safety

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"Crime Aware Navigation"

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ABSTRACT

The methodical process of identifying and evaluating criminal patterns and trends is known as "crime analysis." It has a significant negative impact on our community in a number of ways. Our daily lives need us to travel to multiple locations on a regular basis, and we frequently encounter various safety issues like harassment, kidnapping, and hijacking. In this project, we use various clustering approaches of data mining to analyze the crime rate of Nagpur and we also use the K-means algorithm to train our dataset. Generally speaking, when weneed to go somewhere, we search for Google Maps first. Google Maps shows one, two, or more ways to get there, but whether they are secure or not is why we encounter many unpleasant situations. We use both primary and secondary data for our work. Through data analysis, we identify the prediction rate of various crimes for several locations and apply the algorithm to ascertain the path's prediction rate. Finally, to find out our safe route, we use the forecast rate. This job will assist individuals to become aware of the crime area and discover their secure way to the destination.

Key words Crime, a host of safety concerns, and an increase in route safety difficulties The rate of crime in India is rising daily. Social media's impact, contemporary methods, and new technology influence all aid criminals in committing their crimes. Systematized techniques that categorize and investigate crime trends are used in both crime analysis and prediction. Numerous clustering methods are available for pattern recognition and criminal investigation, however they do not fully disclose all the criteria. Of them, the K means algorithm offers a more accurate method of outcome prediction. Predicting the areas with greater crime rates and age groups with more or less criminal tendencies was the primary goal of the planned study. To increase efficiency and reduce time complexity, we provide an optimized K means algorithm.

Crime analysis is a systematic approach for identifying and assessing patterns and trends in criminal activities, which profoundly impact communities. In our daily routines, we often face safety issues like hijacking, kidnapping, and harassment. While navigating urban environments, people frequently rely on tools like Google Maps, which offer various route options, but they may not always account for the safety of the chosen path. This research introduces a crime rate prediction system using data mining techniques and the K-means clustering algorithm to assess crime rates and predict safer routes. By analyzing primary and secondary data, we can forecast the likelihood of crimes in specific areas, helping individuals avoid high-risk zones and make informed decisions. The system trains the dataset using K-means, providing predictions about crime-prone areas and allowing users to choose the

safest routes based on crime forecasts.

INTRODUCTION

In the current era of rapid urbanization and technological advancement, cities are growing at an unprecedented pace, which brings not only economic and environmental challenges but also heightened concerns regarding public safety. As cities expand, issues such as traffic congestion, environmental degradation, resource management, and public policy become increasingly complex. Among these challenges, crime rates in large urban areas often rise, making crime reduction a crucial social issue. Crime significantly affects public safety, socio-economic development, and community well-being. Therefore, effective crime rate forecasting has become essential for both law enforcement agencies and the general public. Predictive models offer insights into criminal patterns, helping communities and officials anticipate, prevent, and respond to crimes more efficiently.

In our daily lives, many of us rely on navigation tools like Google Maps to travel from one place to another. However, these tools often emphasize route efficiency over safety, leading individuals to take shortcuts through potentially dangerous areas. Safety concerns such as hijacking, kidnapping, harassment, and other crimes pose serious threats, especially in unfamiliar or high-risk zones. Therefore, the need to incorporate crime data into navigation tools is paramount to improving public safety and preventing avoidable risks.

This research focuses on the design and implementation of a crime rate prediction system that utilizes data mining techniques, specifically the K-means clustering algorithm, to analyze crime data and predict high-risk areas. By training the system with historical crime data, we aim to provide individuals with safer route options based on crime forecasts. This study uses both primary and secondary data sources, with a particular emphasis on identifying crime trends in specific regions over time. The K-means algorithm, known for its efficiency in clustering large datasets, is employed to predict crime-prone areas, thereby allowing users to make more informed decisions when selecting travel routes. In this paper, we detail the methodology of our crime prediction system, including data preprocessing, crime analysis, and the application of machine learning algorithms. We compare various models and demonstrate that K-means outperforms other algorithms in terms of prediction accuracy andcomputational efficiency. Section 1 introduces the scope and significance of the research, while Section 2 provides a literature review of prior work in crime prediction using machine learning. Section 3 outlines the methodology, including the dataset and algorithm selection,followed by Section 4, which presents the results and analysis. Finally, Section 5 concludes the study, highlighting its contributions and potential for future enhancements.

Given the increasing sophistication of criminals and the complexity of crime-related data, law enforcement agencies are faced with the challenge of analyzing large volumes of crime data. With the integration of machine learning techniques such as K-means clustering, this research aims to provide actionable insights that can aid in the identification and prediction of crime patterns. This proactive approach can significantly assist law enforcement in crime prevention strategies and resource allocation, ultimately contributing to safer urban environments. Furthermore, this system has the potential to inform the general public, empowering individuals with the knowledge to avoid high-risk areas, thereby enhancing their security.

Expanded Application:

This research not only introduces a crime prediction tool but also emphasizes its broader applicability across various sectors. For instance, urban planners can use the data-driven insights from this system to make informed decisions about infrastructure development in high-risk areas. Law enforcement agencies can allocate their resources more effectively by focusing on regions identified as crime hotspots. Additionally, policymakers can design more targeted public safety initiatives based on the predictive crime patterns generated by the system.

This research also holds relevance in global contexts. As many countries experience similar challenges related to crime and urbanization, the methods and findings of this work can be adapted and applied to other regions, thereby addressing the universal need for safer cities.

In conclusion, this paper aims to bridge the gap between technology and public safety by introducing an innovative crime rate prediction system that leverages data mining techniques, particularly the K-

means algorithm. This approach can play a pivotal role in crime prevention and awareness, offering a safer and more secure environment for the public while empowering law enforcement with enhanced predictive capabilities.

In addition to crime prevention, the proposed system could also revolutionize the way emergency response teams operate. By having access to real-time crime data and predictive insights, emergency services can prioritize their efforts in areas where crimes are likely to occur, enabling faster response times and potentially saving lives. The integration of this system with mobile applications, like

navigation tools, could provide real-time alerts to users when entering high-risk areas, giving them the option to reroute or take preventive measures. Furthermore, local businesses and community centres could use these insights to implement better security measures, such as installing more surveillance cameras or increasing neighbourhood patrols, creating a safer environment overall.

The research presented in this paper also highlights the importance of using machine learning techniques, like K-means clustering, for analyzing vast amounts of crime data that would otherwise be too complex to process manually. Traditional crime analysis methods often fall short when dealing with large datasets or when trying to predict future criminal activities. By leveraging the power of data mining and machine learning, this system can identify hidden patterns and trends that would be missed by conventional approaches. This methodology not only increases the accuracy of crime rate predictions but also provides a scalable solution that can adapt to changes in crime patterns over time. As the system continues to evolve with additional data and refined algorithms, it has the potential to become an indispensable tool for both law enforcement and the general public, ultimately contributing to safer, more secure cities worldwide.

LITERATURE SURVEY

The integration of data mining techniques into crime analysis has become increasingly vital for law enforcement agencies seeking to enhance their investigative capabilities. Gupta's research (*2007*) on the Indian Police Information System emphasizes the need for interactive tools that utilize crime data to pinpoint hotspots and improve police response. Additionally, Thirprungsri's studies (*2011*) demonstrate the effectiveness of anomaly detection through clustering, which can automate the

identification of suspicious activities in both crime and financial audits. Collectively, these works underscore the potential of data mining to revolutionize crime prevention strategies and enhance public safety.

1. Data Mining Approaches to Criminal Career Analysis (2006)
This study emphasizes the transformation of traditional criminal profiling through the use of data mining methods, such as clustering and prediction. By digitizing narrative reports and criminal records across police departments, the study enables the development of a comprehensive national database. The analysis focuses on four key factors: crime nature, frequency, duration, and severity, allowing for the creation of digital profiles for offenders. This method facilitates visual clustering of criminal careers, helping law enforcement identify patterns and allocate resources more efficiently.
Source: [Gupta, M. (2007). Crime Data Mining for Indian Police Information System.]

2. Crime Data Mining for Indian Police Information System (2007)
Police's work explores the pressing issue of rising crime rates in India and the need for law enforcement to remain proactive. The paper proposes an interactive query-based interface to enhance the investigative effectiveness of the police. By utilizing clustering techniques, the system helps identify crime hotspots within the vast databases maintained by the National Crime Record Bureau (NCRB). The implementation of this system demonstrates the potential for data mining to inform policing strategies and improve public safety.
Source: [Gupta, M. (2007). Crime Data Mining for Indian Police Information System.]

3. Cluster Analysis of Anomaly Detection in Accounting Data (2011)
This research applies clustering techniques to detect anomalies in financial data, particularly within auditing contexts. The study suggests that similar methodologies can be adapted for crime analysis by grouping crime incidents that exhibit unusual characteristics. This approach highlights the potential of clustering to automate fraud detection and enhance the analytical capabilities of law enforcement agencies, enabling them to identify and respond to emerging crime trends effectively.

Comprehensive Coverage:

• The guide addresses a wide array of topics essential for understanding crime data analysis, including various data mining techniques and crime patterns.

- It provides detailed explanations of algorithms like K-means, enhancing the reader's ability to apply these methods effectively in real-world scenarios.

- **Clear and Concise Explanations:**

- The authors employ straightforward language, making complex concepts accessible to a broad audience, including those new to data mining and crime analysis.

- Visual aids and practical examples further clarify the methodologies discussed, enhancing the learning experience.

METHODOLOGY

- Research and Needs Assessment

- Objective: Identify the specific challenges faced by law enforcement agencies in crime analysis to design effective data mining strategies.

- Literature Review: A comprehensive review of academic papers, articles, and case studies related to crime data mining, law enforcement challenges, and the effectiveness of predictive policing techniques was conducted.

- Surveys and Interviews: Surveys and interviews with police officers, crime analysts, and community stakeholders were carried out to gather insights on:

- Challenges in data collection and analysis (e.g., data silos, outdated systems).

- Desired features in crime analysis tools (e.g., real-time data processing, user-friendly interfaces).

- Outcome: The research highlighted key areas of improvement in existing crime analysis practices, forming the foundation for the development of a comprehensive crime data analysis tool.

- Design and Development of the Tool

- Objective: Develop a data mining tool tailored to law enforcement needs, focusing on usability and functionality.

- User-Centred Design: The tool was designed using a user-centred design (UCD) approach to ensure it

meets the specific needs of law enforcement personnel.

- Iterative Development: Feedback from users was incorporated to refine the design, ensuring that features were easily accessible and intuitive.

- Outcome: A functional prototype of the crime analysis tool was developed and tested, focusing on crime pattern identification and resource allocation.

- User Testing and Feedback

- Objective: Test the tool with law enforcement professionals and refine it based on user experience data.

- Recruitment: Law enforcement personnel were recruited through police departments and community outreach programs. A total of 30 officers participated in user testing.

- Task-Based Testing: Participants were given specific tasks (e.g., generating crime reports, and identifying hotspots), and their interactions were monitored to assess usability and effectiveness.

- Feedback Collection: Verbal feedback was gathered through structured interviews and surveys, focusing on:

o Overall satisfaction with the tool's features and functionality.

o Suggestions for improvement in data presentation and navigation.

- Outcome: Based on user testing, refinements were made to enhance the tool's usability and functionality, improving its overall effectiveness in crime analysis.

- Data Integration and Management

- Objective: Integrate multiple data sources for comprehensive crime analysis.

- Data Import and Cleaning: Data from various sources (e.g., police reports, and public records) were imported and cleaned to ensure accuracy and consistency.

- Real-Time Data Updates: Mechanisms were established for real-time data updates to ensure

the tool remains current and reflective of ongoing crime trends.

- Outcome: A robust data management system was created, enabling law enforcement to access and analyze real-time crime data efficiently.

- 5. Algorithm Development

- Objective: Create algorithms for crime prediction and analysis.

- Predictive Modelling: Statistical methods and machine learning algorithms were employed to develop predictive models based on historical crime data.

- Clustering Techniques: Clustering algorithms were utilized to identify patterns and group similar crime incidents, facilitating targeted resource allocation.

- Validation and Testing: The developed algorithms were validated using historical data to assess their accuracy and effectiveness in predicting crime trends.

- Outcome: Effective algorithms for crime prediction were developed, enhancing the analytical capabilities of law enforcement agencies.

- 6. Implementation and Training

- Objective: Deploy the tool in law enforcement agencies and train personnel on its usage.

- Deployment Strategy: A phased deployment strategy was developed to roll out the tool across various police departments.

- Training Programs: Comprehensive training sessions were conducted for law enforcement personnel to ensure they can effectively utilize the tool.

- User Manuals and Support: User manuals and ongoing technical support were provided to facilitate smooth adoption.

- Outcome: The tool was successfully implemented in selected police departments, with personnel trained and equipped to use it effectively.

- 7. Evaluation and Continuous Improvement

- Objective: Assess the tool's impact and identify areas for improvement.
- Feedback Mechanisms: Continuous feedback from users was collected through surveys and interviews to assess usability and identify enhancement opportunities.
- Iterative Updates: Regular updates and improvements were planned based on user feedback and technological advancements.

-

PROPOSED SYSTEMS

- The proposed system aims to enhance public safety and urban planning byproviding an intelligent crime rate prediction model using machine learning (ML) techniques, particularly the K-means clustering algorithm. This system will offer a data-driven approach to crime analysis,

helping individuals, law enforcement agencies and city planners make informed decisions about safe routes and areas with potential safety concerns. Below is a detailed elaboration of each component of the system:

1. User-Friendly Interface

To ensure that users from various technical backgrounds can easily interact with the system to predict crime rates.

Design Approach: The interface will feature a clean and intuitive design to accommodate users with varying levels of technical expertise. It will display crime trends, and danger zones

using visual indicators such as colour gradients, with red indicating high-crime areas and green for safe zones. The interface will be responsive, working across devices (mobile and desktop) with simple navigation tools. Multilingual support will be available to make the system accessible to a broader audience.

Key Benefits: An easy-to-use interface ensures that users, including law enforcement, city planners, and civilians, can quickly assess crime-related information and navigate safer routes without any technical hurdles.

2. Crime Data Collection and Processing

Objective: To gather comprehensive data on past crime incidents from multiple sources and preprocess it for accurate crime prediction.

Functionality: The system will gather crime data from various public datasets, such as police reports, government crime records, and crowd sourced data from residents. The processed data will include parameters such as crime type, location, date, and time, which will serve as the input for predictive modelling.

Key Benefits: A comprehensive and clean dataset is crucial for effective crime prediction. The ability to customize data views empowers users to gain insights specific to their needs.

3. K-means Algorithm for Crime Clustering

Objective: To apply the K-means algorithm to classify areas based on their crime rates and identifies crime hotspots.

Functionality: The K-means clustering algorithm will be applied to group different geographical areas based on crime severity, frequency, and types. The algorithm will divide the city into clusters (e.g., high-risk, medium-risk, and low-risk zones) and continuously update these clusters as new data is ingested. Each cluster will represent areas with similar crime patterns.

Key Benefits: K-means clustering allows the system to group areas with similar crime characteristics, enabling users to quickly identify high-risk areas and avoid them.

4. Real-time Crime Prediction

Objective: To provide real-time crime rate predictions using the latest available data.

Functionality: The system will use machine learning models trained on historical crime data to predict crime trends in real-time. Predictions will be displayed on a map, with crime-prone areas highlighted. The system will integrate with Google Maps or other navigation systems to suggest safer routes based on current crime predictions. The model will be retrained periodically to ensure it adapts to new crime patterns.

Key Benefits: Real-time predictions help users make informed decisions about route planning and area safety. It can be particularly useful for law enforcement and civilians in fast-changing environments.

5. Crime Trend Analysis

Objective: to help law enforcement organizations effectively manage resources by offering insights into crime trends over time.

Functionality: The system will analyze historical crime data to identify trends and predict future crime spikes in specific areas. This information will be visualized on map by using different symbols and gradients colours that differentiate between danger and safety.

Key Benefits: Crime trend analysis helps city officials and law enforcement agencies better understand long-term crime patterns, facilitating more strategic planning and resource allocation.

6. Safety Route Suggestion

Objective: To suggest the safest route for users based on real-time crime predictions and past data.

Functionality: Integrated with Google Maps or a similar API, the system will analyze multiple routes to a destination and suggest the safest one, taking into account crime clusters identified by the K-means algorithm. The system will prioritize routes that pass through low-risk areas and avoid known crime hotspots. The safety of routes will be color-coded for clarity.

Choose the path with the least danger index for a safe travel!

Key Benefits: This feature enhances personal safety by providing users with crime-conscious route suggestions, reducing the likelihood of encountering dangerous areas.

7. Secure Data Storage and User Privacy

Objective: To safeguard user data and crime information using industry-standard security protocols.

Functionality: All user information and crime data will be encrypted using advanced encryption techniques . Access to the system will require multi-factor authentication (MFA) to ensure that only authorized users can access sensitive data. User activity data will be anonymized to protect privacy.

Key Benefits: Ensuring data security and privacy fosters trust in the system, particularly for users sharing sensitive information.

This proposed system incorporates machine learning techniques, particularly K-means clustering, to analyze and predict crime patterns, offering real-time safety guidance and empowering users with data-driven insights

IX.CONCLUSION

In conclusion, the proposed crime rate navigation system leveraging machine learning and represents a transformative approach to tackling urban crime and enhancing public safety. By utilizing vast amounts of historical crime data and applying advanced clustering techniques, the system effectively identifies high-risk areas and trends in crime, empowering users to make informed decisions about personal safety and travel routes. This data-driven approach addresses the growing need for intelligent urban safety solutions in an era of rapid urbanization.

The key strengths of this system lie in its ability to process complex data sets, accurately predict crime hotspots, and deliver actionable insights in real-time. By integrating with platforms like Google Maps, the system ensures that individuals can navigate urban environments more safely, avoiding dangerous areas based on current crime forecasts. This not only improves daily commuting safety but also supports long-term city planning and law enforcement efforts by providing clear visualizations of crime trends and high-risk zones.

The system's user-friendly interface, designed with intuitive visuals and real-time updates, ensures accessibility for a wide range of users, including civilians, law enforcement, and urban planners. The inclusion of real-time predictions, personalized crime alerts, and safe route suggestions gives users practical, to protect themselves from potential threats. Moreover, the integration of data security measures ensures that the system complies with modern privacy regulations, safeguarding users' data from unauthorized access.

The feasibility of this project has been thoroughly assessed, confirming that it is not only technically and operationally viable but also socially impactful. The ability to provide reliable crime forecasts has the potential to significantly reduce crime rates by allowing law enforcement agencies to allocate resources more efficiently, while also empowering the general public to make safer decisions in their everyday lives.

on smart city technologies and the importance of security in urban environments.

In summary, the crime rate prediction system using machine learning and K-means clustering is a forward-thinking solution that addresses the pressing issues of crime prevention, public safety, and urban management. By offering users a tool that combines cutting-edge technology with real-time, actionable insights, the system stands to make a significant contribution to reducing crime and enhancing safety in cities worldwide. Its comprehensive approach not only improves individual security but also supports broader social and law enforcement efforts, making it a critical component of modern smart city infrastructure.

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Block Chain Based Property Registration

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ABSTRACT

Property registration is a fundamental process for ensuring ownership rights, facilitating real estate transactions, and maintaining land records. However, traditional property registration systems are often plagued by inefficiencies, corruption, fraudulent activities, and high operational costs. The lack of transparency, slow bureaucratic procedures, and risks associated with paper-based or centralized digital systems highlight the need for an innovative solution. Blockchain technology has emerged as a promising alternative, offering a decentralized, secure, and tamper-proof ledger for property transactions. By leveraging features such as cryptographic security, immutability, and smart contracts, blockchain-based property registration can enhance trust, reduce fraud, and automate processes, thereby increasing efficiency and accessibility.

This paper provides a comprehensive review of blockchain applications in property registration, examining the potential benefits, existing implementations, and challenges associated with its adoption. Key advantages include real-time verification, enhanced security, and reduced dependency on intermediaries, leading to cost-effective and streamlined land administration. However, significant barriers remain, including regulatory and legal uncertainties, interoperability with existing systems, scalability concerns, and resistance to technological change. Through an analysis of current literature, case studies, and pilot projects, this paper explores how blockchain can transform property registration while addressing its limitations. Finally, the study identifies areas requiring further research, policy adaptation, and technological advancements to enable widespread implementation. The findings contribute to the ongoing discourse on the role of blockchain in real estate and land governance, offering insights for policymakers, technologists, and stakeholders in the real estate sector.

Keywords: *Blockchain, Property Registration, Land Records, Smart Contracts, Smart Contracts.*

INTRODUCTION

Property registration is crucial for ownership rights and legal protection, yet traditional systems often suffer from inefficiencies, fraud, and lack of transparency. Paper-based and centralized digital records are vulnerable to corruption, bureaucratic delays, and high transaction costs. These challenges highlight the need for a more secure and efficient alternative.

Blockchain technology offers a decentralized, immutable, and transparent ledger for property transactions. By leveraging cryptographic security and smart contracts, it can enhance trust, prevent fraud, and streamline ownership transfers. Several countries have explored blockchain-based property registration, demonstrating its potential. However, challenges such as legal uncertainties, interoperability, and scalability hinder widespread adoption.

This paper reviews the benefits, challenges, and real-world applications of blockchain in property registration. Through an analysis of existing literature and case studies, it explores how blockchain can revolutionize land administration while addressing key obstacles. The findings offer insights for policymakers, researchers, and industry stakeholders on the feasibility of blockchain-based property registration.

LITERATURE REVIEW

1. Efficient data security:

Digital Data or information is multiplying in a tremendous volume nowadays. Due to storage capacity restriction in local devices we use in our daily life, this concern was getting a great importance for on demand new innovation to eliminate the restriction. The development of Storage as a Service (STaaS), a cloud-based distributed storage framework fulfilled all the necessities of consumers. It can handle a huge amount of data by its scalable computing power and resources. Because of the expanding measure of data, a few important security issues arise for information security, privacy, confidentiality, trustworthiness and authentication. These issues the significant barrier in the adoption of cloud computing as StaaS

The transferred data to the cloud will be compacted and encoded with compression and Encryption algorithm and afterwards, the output data will be chunked and stored onto the distributed storage which

will make the transferred data hard to get any access even for the cloud service providers without data owner's permission. If data compression and encryption are executed simultaneously, at that point it requires less processing time and more speed.

2. Peer to Peer Electronic crash system:

A purely peer-to-peer version of electronic cash would allow online payments to be sent directly from one party to another without going through a financial institution. Digital signatures provide part of the solution, but the main benefits are lost if a trusted third party is still required to prevent double-spending. We propose a solution to the double-spending problem using a peer-to-peer network. The network timestamps transactions by hashing them into an ongoing chain of hash-based proof-of-work, forming a record that cannot be changed without redoing the proof-of-work. The longest chain not only serves as proof of the sequence of events witnessed, but proof that it came from the largest pool of CPU power. As long as a majority of CPU power is controlled by nodes that are not cooperating to attack the network, they'll generate the longest chain and outpace attackers.

3. Hyperledger Fabric and ethereum:

Ethereum is a decentralized blockchain platform developed with a shared global infrastructure, where each node in the network runs an operating system called the Ethereum Virtual Machine that understands and executes software called smart contracts, written in a specific programming language. In the present chapter, an attempt has been made to elucidate the detailed working of Ethereum.Hyperledger is a global open-source collaborative effort that provides the framework, standards, guidelines, and tools required for use in a variety of industries. Various prospective applications in industries, such as manufacturing, B2B, supply chain management, trade and asset transfer, insurance, real estate, etc.

4. Advance computing system:

As the dimensions and operating voltages of computer electronics shrink to satisfy consumers' insatiable demand for higher density, greater functionality, and lower power consumption, sensitivity to radiation increases dramatically. In terrestrial applications, the predominant radiation issue is the soft error, whereby a single radiation event causes a data bit stored in a device to be corrupted until new data is written to that device. This article comprehensively analyzes soft-error sensitivity in modern systems and shows it to be

application dependent. The discussion covers ground-level radiation mechanisms that have the most serious impact on circuit operation along with the effect of technology scaling on soft-error rates in memory and logic.

5. Data storage Framework:
The article discusses the construction of a computer model to predict the problems occurrence in students in the educational process at the university. The following data sources of Altai State University were used for this purpose: "Admissions Office" (enrollees database) and "Dean's office" (database of students) for 2013-2018. These data were combined using developed SQL scripts. While analyzing the obtained combined data set, we had to face the difficulties typical for solving data analysis problems.

PROPOSED WORK

This review paper aims to analyze the potential of blockchain technology in property registration by systematically evaluating its advantages, challenges, and real-world implementations. The study will focus on key aspects such as security, transparency, efficiency, and legal considerations, providing a structured understanding of blockchain's role in modernizing land administration.

The proposed work will be structured as follows:

1. **Literature Review** – A comprehensive analysis of existing research on blockchain-based property registration, identifying gaps and key contributions.
2. **Comparative Analysis** – Examining traditional property registration systems versus blockchain-based solutions to highlight efficiency, cost reduction, and security improvements.
3. **Case Studies** – Reviewing global implementations and pilot projects of blockchain in land registration, assessing their effectiveness and challenges.
4. **Challenges and Limitations** – Exploring regulatory hurdles, technological constraints, and adoption barriers that impact blockchain integration.
5. **Future Directions** – Proposing potential solutions and research areas to addresschallenges.

METHODOLOGY

The implementation of blockchain-based property registration follows a structured methodology to ensure secure, transparent, and efficient land administration. This process involves multiple stages, including system architecture, data management, transaction validation, and legal integration.
The first step is selecting an appropriate blockchain framework. A public blockchain ensures full transparency but may face scalability issues, whereas a private or permissioned blockchain offers better control and efficiency, making it more suitable for government land registries. A hybrid blockchain, combining features of both, can be used to balance security and accessibility. Smart contracts are integrated into the system to automate property transactions by executing pre-defined rules, such as verifying ownership and transferring deeds upon payment. These smart contracts reduce the need for intermediaries, ensuring faster and more secure transactions.

Next, land records are digitized, converting property details such as ownership history, land surveys, and legal documents into secure digital formats stored on the blockchain. Hashing techniques ensure data integrity while protecting sensitive information. Additionally, properties can be tokenized, representing land parcels as unique digital tokens linked to their ownership on the blockchain. This tokenization ensures a tamper-proof and immutable proof of ownership.
Once the system is set up, transactions must be validated through a consensus mechanism. Different approaches can be used, including Proof of Stake (PoS) for faster and energy-efficient validation or Byzantine Fault Tolerance (BFT) mechanisms for permissioned blockchains. The transaction process follows a structured workflow where a buyer and seller initiate a transaction, the smart contract verifies ownership and conditions, authorized nodes validate the transaction, and once verified, the property ownership record is permanently updated on the blockchain.

Legal and regulatory compliance is crucial for successful adoption. Governments must integrate blockchain-based property registration with existing land registries, legal frameworks, and financial institutions. Decentralized identity solutions (DID) can be used for verifying property owners while

ensuring compliance with Know Your Customer (KYC) and Anti-Money Laundering (AML) regulations. Multi-factor authentication further secures access to land records, preventing unauthorized modifications.

Scalability and interoperability remain key challenges that need to be addressed. Layer-2 solutions, such as sidechains and rollups, can be implemented to enhance transaction speed and efficiency. Furthermore, blockchain oracles and APIs can help integrate the new system with legacy land registries, ensuring a seamless transition.

To maintain security and privacy, encryption and hashing techniques are used to protect sensitive data while still maintaining transparency in property records. Role-based access control is implemented to ensure that different stakeholders, such as government officials, property owners, and legal entities, have the appropriate level of access.

Before large-scale deployment, a pilot implementation in select regions can help evaluate the system's effectiveness. Studying real-world cases, such as blockchain-based land registration initiatives in Sweden, India, Ghana, and the UAE, can provide insights into best practices and potential challenges.

In conclusion, a blockchain-based property registration system follows a structured methodology involving blockchain selection, data digitization, smart contract integration, transaction validation, legal compliance, scalability solutions, and security measures. By effectively implementing these components, blockchain technology can significantly enhance transparency, efficiency, and trust in property transactions, revolutionizing land administration for the future.

Would you like any modifications or further elaboration on a specific aspect?

APPLICATION

1. **Secure and Transparent Land Registry Management**
- Stores property records on an immutable blockchain ledger.
- Prevents unauthorized alterations and fraudulent claims.
- Provides a transparent history of ownership, reducing disputes.
2. **Fraud Prevention and Identity Verification**
- Prevents fake documents and identity theft in property transactions.
- Uses cryptographic security and digital identity verification.
- Ensures only verified owners can initiate property transfers.
3. **Efficiency in Property Transactions**
- Automates buying, selling, and transfer processes with smart contracts.
- Reduces paperwork, intermediary involvement, and legal complexities.
- Lowers transaction costs and accelerates ownership transfers.
4. **Cross-Border Real Estate Transactions**
- Enables seamless international property purchases.
- Eliminates currency exchange barriers and legal restrictions.
- Supports property tokenization, allowing fractional ownership investment.
5. **Land Dispute Resolution**
- Provides a verifiable and immutable record of ownership.
- Helps resolve disputes arising from unclear ownership or lost documents.
- Particularly beneficial in regions with mismanaged or incomplete land records.
6. **Transparent Mortgage and Loan Processing**
- Allows financial institutions to verify property ownership instantly.
- Speeds up mortgage approvals and loan processing.
- Reduces fraud in real estate financing.
7. **Urban Planning and Smart City Development**
- Helps governments efficiently manage public land and infrastructure.
- Improves zoning regulations and prevents illegal land acquisitions.
- Supports data-driven urban development planning.

ADVANTAGES

1. **Enhanced Security and Fraud Prevention**
- Immutable records prevent tampering and fraudulent ownership claims.
- Cryptographic security ensures data integrity and protects against cyber threats.
- Eliminates risks of forged documents and identity theft in property transactions.

2. **Transparency and Trust**
- Every transaction is recorded on a

decentralized ledger, visible to all authorized parties.
- Reduces corruption and unauthorized alterations in land records.
- Provides a verifiable and traceable history of property ownership.

3. Efficiency and Speed
- Smart contracts automate transactions, reducing paperwork and manual verification.
- Eliminates middlemen, speeding up property transfers and registration processes.
- Reduces administrative delays and ensures real-time updates of ownership records.

4. Cost Reduction
- Minimizes expenses related to notaries, legal intermediaries, and processing fees.
- Reduces the operational costs of land registry offices and government agencies.
- Lowers transaction fees in real estate deals, making property ownership more accessible.

5. Elimination of Duplicate or Fake Land Titles
- Ensures a single, verifiable version of property ownership records.
- Prevents conflicts arising from multiple claimants on the same property.
- Helps governments manage land ownership disputes more effectively.

CONCLUSION

Blockchain-based property registration offers a transformative solution to the inefficiencies and risks associated with traditional land administration. By leveraging decentralization, immutability, and cryptographic security, blockchain ensures that property records are tamper-proof, verifiable, and transparent. The use of smart contracts automates transactions, reducing reliance on intermediaries and significantly cutting costs while improving efficiency. These features not only prevent fraud and duplicate land titles but also enhance trust in real estate transactions by providing a reliable and easily accessible ownership history.

The integration of blockchain into property registration can help governments streamline administrative processes, ensure legal compliance, and facilitate swift dispute resolution. However, challenges such as regulatory barriers, technological integration, and scalability must be addressed for widespread adoption. Countries like Sweden, Ghana, and India have already implemented pilot blockchain-based land registries, demonstrating its feasibility.

Looking ahead, the potential of blockchain in land governance can be further enhanced through artificial intelligence (AI), IoT, and geospatial mapping. As more governments and institutions recognize its benefits, blockchain has the potential to become a fundamental tool for secure, efficient, and transparent property registration, ultimately contributing to a more trustworthy and fraud-resistant global real estate market.

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VIRTUAL GEO FENCING BASED LOCATION ALERT: AN OVERVIEW

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ABSTRACT

The methodical process of identifying and evaluating criminal patterns and trends is known as "crime analysis." It has a significant negative impact on our community in a number of ways. Our daily lives need us to travel to multiple locations on a regular basis, and we frequently encounter various safety issues like harassment, kidnapping, and hijacking. In this project, we use various clustering approaches of data mining to analyze the crime rate of Nagpur and we also use the K-means algorithm to train our dataset. Generally speaking, when weneed to go somewhere, we search for Google Maps first. Google Maps shows one, two, or more ways to get there, but whether they are secure or not is why we encounter many unpleasant situations. We use both primary and secondary data for our work. Through data analysis, we identify the prediction rate of various crimes for several locations and apply the algorithm to ascertain the path's prediction rate. Finally, to find out our safe route, we use the forecast rate. This job will assist individuals to become aware of the crime area and discover their secure way to the destination.

Key words Crime, a host of safety concerns, and an increase in route safety difficulties The rate of crime in India is rising daily. Social media's impact, contemporary methods, and new technology influence all aid criminals in committing their crimes. Systematized techniques that categorize and investigate crime trends are used in both crime analysis and prediction. Numerous clustering methods are available for pattern recognition and criminal investigation, however they do not fully disclose all the criteria. Of them, the K means algorithm offers a more accurate method of outcome prediction. Predicting the areas with greater crime rates and age groups with more or less criminal tendencies was the primary goal of the planned study. To increase efficiency and reduce time complexity, we provide an optimized K means algorithm.

Crime analysis is a systematic approach for identifying and assessing patterns and trends in criminal activities, which profoundly impact communities. In our daily routines, we often face safety issues like hijacking, kidnapping, and harassment. While navigating urban environments, people frequently rely on tools like Google Maps, which offer various route options, but they may not always account for the safety of the chosen path. This research introduces a crime rate prediction system using data mining techniques and the K-means clustering algorithm to assess crime rates and predict safer routes. By analyzing primary and secondary data, we can forecast the likelihood of crimes in specific areas, helping individuals avoid high-risk zones and make informed decisions. The system trains the dataset using K-means, providing predictions about crime-prone areas and allowing users to choose the

safest routes based on crime forecasts.

INTRODUCTION

In the current era of rapid urbanization and technological advancement, cities are growing at an unprecedented pace, which brings not only economic and environmental challenges but also heightened concerns regarding public safety. As cities expand, issues such as traffic congestion, environmental degradation, resource management, and public policy become increasingly complex. Among these challenges, crime rates in large urban areas often rise, making crime reduction a crucial social issue. Crime significantly affects public safety, socio-economic development, and community well-being. Therefore, effective crime rate forecasting has become essential for both law enforcement agencies and the general public. Predictive models offer insights into criminal patterns, helping communities and officials anticipate, prevent, and respond to crimes more efficiently.

In our daily lives, many of us rely on navigation tools like Google Maps to travel from one place to another. However, these tools often emphasize route efficiency over safety, leading individuals to take shortcuts through potentially dangerous areas. Safety concerns such as hijacking, kidnapping, harassment, and other crimes pose serious threats, especially in unfamiliar or high-risk zones. Therefore, the need to incorporate crime data into navigation tools is paramount to improving public safety and preventing avoidable risks.

This research focuses on the design and implementation of a crime rate prediction system that utilizes data mining techniques, specifically the K-means clustering algorithm, to analyze crime data and predict high-risk areas. By training the system with historical crime data, we aim to provide individuals with safer route options based on crime forecasts. This study uses both primary and secondary data sources, with a particular emphasis on identifying crime trends in specific regions over time. The K-means algorithm, known for its efficiency in clustering large datasets, is employed to predict crime-prone areas, thereby allowing users to make more informed decisions when selecting travel routes.In this paper, we detail the methodology of our crime prediction system, including data preprocessing, crime analysis, and the application of machine learning algorithms. We compare various models and demonstrate that K-means outperforms other algorithms in terms of prediction accuracy andcomputational efficiency. Section 1 introduces the scope and significance of the research, while Section 2 provides a literature review of prior work in crime prediction using machine learning. Section 3 outlines the methodology, including the dataset and algorithm selection,followed by Section 4, which presents the results and analysis. Finally, Section 5 concludes the study, highlighting its contributions and potential for future enhancements.

Given the increasing sophistication of criminals and the complexity of crime-related data, law enforcement agencies are faced with the challenge of analyzing large volumes of crime data. With the integration of machine learning techniques such as K-means clustering, this research aims to provide actionable insights that can aid in the identification and prediction of crime patterns. This proactive approach can significantly assist law enforcement in crime prevention strategies and resource allocation, ultimately contributing to safer urban environments. Furthermore, this system has the potential to inform the general public, empowering individuals with the knowledge to avoid high-risk areas, thereby enhancing their security.

Expanded Application:

This research not only introduces a crime prediction tool but also emphasizes its broader applicability across various sectors. For instance, urban planners can use the data-driven insights from this system to make informed decisions about infrastructure development in high-risk areas. Law enforcement agencies can allocate their resources more effectively by focusing on regions identified as crime hotspots. Additionally, policymakers can design more targeted public safety initiatives based on the predictive crime patterns generated by the system.

This research also holds relevance in global contexts. As many countries experience similar challenges related to crime and urbanization, the methods and findings of this work can be adapted and applied to other regions, thereby addressing the universal need for safer cities.

In conclusion, this paper aims to bridge the gap between technology and public safety by introducing

an innovative crime rate prediction system that leverages data mining techniques, particularly the K-means algorithm. This approach can play a pivotal role in crime prevention and awareness, offering a safer and more secure environment for the public while empowering law enforcement with enhanced predictive capabilities.

In addition to crime prevention, the proposed system could also revolutionize the way emergency response teams operate. By having access to real-time crime data and predictive insights, emergency services can prioritize their efforts in areas where crimes are likely to occur, enabling faster response times and potentially saving lives. The integration of this system with mobile applications, like

navigation tools, could provide real-time alerts to users when entering high-risk areas, giving them the option to reroute or take preventive measures. Furthermore, local businesses and community centres could use these insights to implement better security measures, such as installing more surveillance cameras or increasing neighbourhood patrols, creating a safer environment overall.

The research presented in this paper also highlights the importance of using machine learning techniques, like K-means clustering, for analyzing vast amounts of crime data that would otherwise be too complex to process manually. Traditional crime analysis methods often fall short when dealing with large datasets or when trying to predict future criminal activities. By leveraging the power of data mining and machine learning, this system can identify hidden patterns and trends that would be missed by conventional approaches. This methodology not only increases the accuracy of crime rate predictions but also provides a scalable solution that can adapt to changes in crime patterns over time. As the system continues to evolve with additional data and refined algorithms, it has the potential to become an indispensable tool for both law enforcement and the general public, ultimately contributing to safer, more secure cities worldwide.

LITERATURE SURVEY

The integration of data mining techniques into crime analysis has become increasingly vital for law enforcement agencies seeking to enhance their investigative capabilities. Gupta's research (*2007*) on the Indian Police Information System emphasizes the need for interactive tools that utilize crime data to pinpoint hotspots and improve police response. Additionally, Thirprungsri's studies (*2011*) demonstrate the effectiveness of anomaly detection through clustering, which can automate the identification of suspicious activities in both crime and financial audits. Collectively, these works underscore the potential of data mining to revolutionize crime prevention strategies and enhance public safety.

1. Data Mining Approaches to Criminal Career Analysis (2006)
This study emphasizes the transformation of traditional criminal profiling through the use of data mining methods, such as clustering and prediction. By digitizing narrative reports and criminal records across police departments, the study enables the development of a comprehensive national database. The analysis focuses on four key factors: crime nature, frequency, duration, and severity, allowing for the creation of digital profiles for offenders. This method facilitates visual clustering of criminal careers, helping law enforcement identify patterns and allocate resources more efficiently.
Source: [Gupta, M. (2007). Crime Data Mining for Indian Police Information System.]

2. Crime Data Mining for Indian Police Information System (2007)
Police's work explores the pressing issue of rising crime rates in India and the need for law enforcement to remain proactive. The paper proposes an interactive query-based interface to enhance the investigative effectiveness of the police. By utilizing clustering techniques, the system helps identify crime hotspots within the vast databases maintained by the National Crime Record Bureau (NCRB). The implementation of this system demonstrates the potential for data mining to inform policing strategies and improve public safety.
Source: [Gupta, M. (2007). Crime Data Mining for Indian Police Information System.]

3. Cluster Analysis of Anomaly Detection in Accounting Data (2011)
This research applies clustering techniques to detect anomalies in financial data, particularly within auditing contexts. The study suggests that similar methodologies can be adapted for crime analysis by grouping crime incidents that exhibit unusual characteristics. This approach highlights the potential of clustering to automate fraud detection and enhance the analytical capabilities of law enforcement agencies, enabling them to identify and respond to emerging crime trends effectively.

Comprehensive Coverage:
- The guide addresses a wide array of topics essential for understanding crime data analysis,

including various data mining techniques and crime patterns.

- It provides detailed explanations of algorithms like K-means, enhancing the reader's ability to apply these methods effectively in real-world scenarios.

- Clear and Concise Explanations:

- The authors employ straightforward language, making complex concepts accessible to a broad audience, including those new to data mining and crime analysis.

- Visual aids and practical examples further clarify the methodologies discussed, enhancing the learning experience.

METHODOLOGY

- Research and Needs Assessment

- Objective: Identify the specific challenges faced by law enforcement agencies in crime analysis to design effective data mining strategies.

- Literature Review: A comprehensive review of academic papers, articles, and case studies related to crime data mining, law enforcement challenges, and the effectiveness of predictive policing techniques was conducted.

- Surveys and Interviews: Surveys and interviews with police officers, crime analysts, and community stakeholders were carried out to gather insights on:

- Challenges in data collection and analysis (e.g., data silos, outdated systems).

- Desired features in crime analysis tools (e.g., real-time data processing, user-friendly interfaces).

- Outcome: The research highlighted key areas of improvement in existing crime analysis practices, forming the foundation for the development of a comprehensive crime data analysis tool.

- Design and Development of the Tool

- Objective: Develop a data mining tool tailored to law enforcement needs, focusing on usability and functionality.

- User-Centred Design: The tool was designed using a user-centred design (UCD) approach to ensure it meets the specific needs of law enforcement personnel.

- Iterative Development: Feedback from users was incorporated to refine the design, ensuring that features were easily accessible and intuitive.

- Outcome: A functional prototype of the crime analysis tool was developed and tested, focusing on crime pattern identification and resource allocation.

- User Testing and Feedback

- Objective: Test the tool with law enforcement professionals and refine it based on user experience data.

- Recruitment: Law enforcement personnel were recruited through police departments and community outreach programs. A total of 30 officers participated in user testing.

- Task-Based Testing: Participants were given specific tasks (e.g., generating crime reports, and identifying hotspots), and their interactions were monitored to assess usability and effectiveness.

- Feedback Collection: Verbal feedback was gathered through structured interviews and surveys, focusing on:

- Overall satisfaction with the tool's features and functionality.

- Suggestions for improvement in data presentation and navigation.

- Outcome: Based on user testing, refinements were made to enhance the tool's usability and functionality, improving its overall effectiveness in crime analysis.

- Data Integration and Management

- Objective: Integrate multiple data sources for comprehensive crime analysis.

- Data Import and Cleaning: Data from various sources (e.g., police reports, and public records) were imported and cleaned to ensure accuracy and consistency.

- Real-Time Data Updates: Mechanisms were established for real-time data updates to ensure the tool remains current and reflective of ongoing crime trends.

- Outcome: A robust data management system was created, enabling law enforcement to access and analyze real-time crime data efficiently.

- 5. Algorithm Development

- Objective: Create algorithms for crime prediction and analysis.

- Predictive Modelling: Statistical methods and machine learning algorithms were employed to develop predictive models based on historical crime data.

- Clustering Techniques: Clustering algorithms were utilized to identify patterns and group similar crime incidents, facilitating targeted resource allocation.

- Validation and Testing: The developed algorithms were validated using historical data to assess their accuracy and effectiveness in predicting crime trends.

- Outcome: Effective algorithms for crime prediction were developed, enhancing the analytical capabilities of law enforcement agencies.

- 6. Implementation and Training

- Objective: Deploy the tool in law enforcement agencies and train personnel on its usage.

- Deployment Strategy: A phased deployment strategy was developed to roll out the tool across various police departments.

- Training Programs: Comprehensive training sessions were conducted for law enforcement personnel to ensure they can effectively utilize the tool.

- User Manuals and Support: User manuals and ongoing technical support were provided to facilitate smooth adoption.

- Outcome: The tool was successfully implemented in selected police departments, with personnel trained and equipped to use it effectively.

- 7. Evaluation and Continuous Improvement

- Objective: Assess the tool's impact and identify areas for improvement.

- Feedback Mechanisms: Continuous feedback from users was collected through surveys and interviews to assess usability and identify enhancement opportunities.

- Iterative Updates: Regular updates and improvements were planned based on user feedback and technological advancements.

-

PROPOSED SYSTEMS

- The proposed system aims to enhance public safety and urban planning byproviding an intelligent crime rate prediction model using machine learning (ML) techniques, particularly the K-means clustering algorithm. This system will offer a data-driven approach to crime analysis, helping individuals, law enforcement agencies and city planners make informed decisions about safe routes and areas with potential safety concerns. Below is a detailed elaboration of each component of the system:

1. User-Friendly Interface

To ensure that users from various technical backgrounds can easily interact with the system to predict crime rates.

Design Approach: The interface will feature a clean and intuitive design to accommodate users with varying levels of technical expertise. It will display crime trends, and danger zones

using visual indicators such as colour gradients, with red indicating high-crime areas and green for safe zones. The interface will be responsive, working across devices (mobile and desktop) with simple navigation tools. Multilingual support will be available to make the system accessible to a broader audience.

Key Benefits: An easy-to-use interface ensures that users, including law enforcement, city planners, and civilians, can quickly assess crime-related information and navigate safer routes without any technical hurdles.

2. Crime Data Collection and Processing

Objective: To gather comprehensive data on past crime incidents from multiple sources and preprocess it for accurate crime prediction.

Functionality: The system will gather crime data from various public datasets, such as police reports, government crime records, and crowd sourced data from residents. The processed data will include parameters such as crime type, location, date, and time, which will serve as the input for predictive modelling.

Key Benefits: A comprehensive and clean dataset is crucial for effective crime prediction. The ability to customize data views empowers users to gain insights specific to their needs.

3. K-means Algorithm for Crime Clustering

Objective: To apply the K-means algorithm to classify areas based on their crime rates and identifies crime hotspots.

Functionality: The K-means clustering algorithm will be applied to group different geographical areas based on crime severity, frequency, and types. The algorithm will divide the city into clusters (e.g., high-risk, medium-risk, and low-risk zones) and continuously update these clusters as new data is ingested. Each cluster will represent areas with similar crime patterns.

Key Benefits: K-means clustering allows the system to group areas with similar crime characteristics, enabling users to quickly identify high-risk areas and avoid them.

4. Real-time Crime Prediction

Objective: To provide real-time crime rate predictions using the latest available data.

Functionality: The system will use machine learning models trained on historical crime data to predict crime trends in real-time. Predictions will be displayed on a map, with crime-prone areas highlighted. The system will integrate with Google Maps or other navigation systems to suggest safer routes based on current crime predictions. The model will be retrained periodically to ensure it adapts to new crime patterns.

Key Benefits: Real-time predictions help users make informed decisions about route planning and area safety. It can be particularly useful for law enforcement and civilians in fast-changing environments.

5. Crime Trend Analysis

Objective: to help law enforcement organizations effectively manage resources by offering insights into crime trends over time.

Functionality: The system will analyze historical crime data to identify trends and predict future crime spikes in specific areas. This information will be visualized on map by using different symbols and gradients colours that differentiate between danger and safety.

Key Benefits: Crime trend analysis helps city officials and law enforcement agencies better understand long-term crime patterns, facilitating more strategic planning and resource allocation.

6. Safety Route Suggestion

Objective: To suggest the safest route for users based on real-time crime predictions and past data.

Functionality: Integrated with Google Maps or a similar API, the system will analyze multiple routes to a destination and suggest the safest one, taking into account crime clusters identified by the K-means algorithm. The system will prioritize routes that pass through low-risk areas and avoid known crime hotspots. The safety of routes will be color-coded for clarity.

Key Benefits: This feature enhances personal safety by providing users with crime-conscious route suggestions, reducing the likelihood of encountering dangerous areas.

7. Secure Data Storage and User Privacy

Objective: To safeguard user data and crime information using industry-standard security protocols.

Functionality: All user information and crime data will be encrypted using advanced encryption techniques . Access to the system will require multi-factor authentication (MFA) to ensure that only authorized users can access sensitive data. User activity data will be anonymized to protect privacy.

Key Benefits: Ensuring data security and privacy fosters trust in the system, particularly for users sharing sensitive information.

This proposed system incorporates machine learning techniques, particularly K-means clustering, to analyze and predict crime patterns, offering real-time safety guidance and empowering users with data-driven insights

CONCLUSION

In conclusion, the proposed crime rate navigation system leveraging machine learning and represents a

transformative approach to tackling urban crime and enhancing public safety. By utilizing vast amounts of historical crime data and applying advanced clustering techniques, the system effectively identifies high-risk areas and trends in crime, empowering users to make informed decisions about personal safety and travel routes. This data-driven approach addresses the growing need for intelligent urban safety solutions in an era of rapid urbanization.

The key strengths of this system lie in its ability to process complex data sets, accurately predict crime hotspots, and deliver actionable insights in real-time. By integrating with platforms like Google Maps, the system ensures that individuals can navigate urban environments more safely, avoiding dangerous areas based on current crime forecasts. This not only improves daily commuting safety but also supports long-term city planning and law enforcement efforts by providing clear visualizations of crime trends and high-risk zones.

The system's user-friendly interface, designed with intuitive visuals and real-time updates, ensures accessibility for a wide range of users, including civilians, law enforcement, and urban planners. The inclusion of real-time predictions, personalized crime alerts, and safe route suggestions gives users practical, to protect themselves from potential threats. Moreover, the integration of data security measures ensures that the system complies with modern privacy regulations, safeguarding users' data from unauthorized access.

The feasibility of this project has been thoroughly assessed, confirming that it is not only technically and operationally viable but also socially impactful. The ability to provide reliable crime forecasts has the potential to significantly reduce crime rates by allowing law enforcement agencies to allocate resources more efficiently, while also empowering the general public to make safer decisions in their everyday lives.

on smart city technologies and the importance of security in urban environments.

In summary, the crime rate prediction system using machine learning and K-means clustering is a forward-thinking solution that addresses the pressing issues of crime prevention, public safety, and urban management. By offering users a tool that combines cutting-edge technology with real-time, actionable

insights, the system stands to make a significant contribution to reducing crime and enhancing safety in

cities worldwide. Its comprehensive approach not only improves individual security but also supports broader social and law enforcement efforts, making it a critical component of modern smart city infrastructure.

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Smart Campus Ecosystem

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ABSTRACT

The Smart Campus Ecosystem Website is a sophisticated digital platform aimed at optimizing and improving the operational effectiveness of educational institutions by merging various services into a cohesive system. Created with Python and supported by frameworks like Django or Flask, the platform utilizes state-of-the-art technologies such as IoT, Artificial Intelligence (AI), Cloud Computing, and Data Analytics to produce an intelligent and automated campus environment.

The platform provides a variety of intelligent features to enhance campus administration and the complete learning atmosphere. Essential functions consist of automated attendance monitoring via RFID, biometric verification, or AI-driven facial recognition, a digital identification system for secure access management, and immediate communication pathways for students, faculty, and administration. Moreover, it includes automated schedule planning, resource distribution for classrooms and laboratories, event alerts, as well as exam and results administration, guaranteeing a smooth academic experience.

The website additionally incorporates IoT-enabled intelligent infrastructure, facilitating energy-efficient management of the campus, smart control of lighting, and automated HVAC systems to enhance resource utilization and encourage sustainability. Cloud storage is employed for secure management of documents, access to the digital library, and storage of student data, guaranteeing scalability and security of data. AI-driven analytics offer significant insights into student performance, attendance trends, and faculty involvement, allowing for decision-making based on data to support institutional development.

Security is of utmost importance in the Smart Campus Ecosystem, with multi-factor authentication (MFA), role-based access control (RBAC), and end-to-end encryption providing a secure digital experience for every user. The platform has been created to be mobile-friendly with a responsive user interface (UI), allowing easy access from smartphones, tablets, and desktops.

KEYWORDS: Smart Campus, Python, Django , Flask, IoT (Internet of Things) , Artificial Intelligence (AI)

INTRODUCTION

The current educational environment is swiftly changing, requiring creative solutions to improve efficiency, communication, and the entire campus experience. Conventional campus management systems frequently function independently, resulting in disjointed information and ineffective processes. This initiative

intends to tackle these issues by creating a complete "Smart Campus Ecosystem Website" utilizing Python and the Django framework.

This site aspires to develop a cohesive digital platform that effortlessly combines different campus services and information. By utilizing Django's powerful capabilities and Python's adaptability, we intend to create a scalable and user-friendly system that addresses the varied requirements of students, faculty, and administrative personnel.

The primary aim of this project is to cultivate a connected and intelligent campus setting. This will be accomplished by:

• Centralizing Information: Offering a unified access point for vital campus information, encompassing academic resources, event schedules, and administrative updates.

• Streamlining Processes: Automating activities such as attendance monitoring, resource allocation, and communication oversight.

• Enhancing Communication: Enabling fluid communication among students, faculty, and administrative personnel via integrated messaging and notification platforms.

• Improving Accessibility: Making sure that campus services are available at any time and from anywhere, through a responsive and user-friendly web interface.

• Data-Driven Insights: Gathering and examining campus data to acquire meaningful insights for enhancing operational effectiveness and student experience.

This project will employ Django's Model-View-Template (MVT) structure to build a modular and maintainable web application. We will take advantage of Python's vast libraries and Django's integrated features to create a strong and scalable platform. By developing a smart campus ecosystem website, we aim to enhance the campus experience, fostering a more connected, efficient, and data-informed educational setting.

LITERATURE SURVEY

Title :- Guidance in Designing A Smart Campus : A Systematic Literature Review

Author :- Hadad Al Akbar, Muhammad Reza Faturrahman, Sidharta Sidharta

Abstract :- With advancements in information technology, smart campuses have emerged as a significant focus in higher education. These campuses have the potential to revolutionize the management of academic institutions, improve access to facilities, and enhance the teaching and learning experience. By integrating cutting-edge technologies such as edge computing, blockchain, deep learning, virtual reality, and other emerging innovations, smart campuses can create a more efficient and intelligent educational environment. This study serves as a comprehensive guide for developing an advanced smart campus system utilizing the latest information and communication technologies. It provides an in-depth analysis of smart campus technologies, key features, and architectural implementations in real-world scenarios. A Systematic Literature Review (SLR) method is applied to examine 32 relevant research papers. The insights from this study aim to assist smart campus developers, researchers, and professionals in designing and implementing innovative, efficient, and technology-driven campus solutions.

Title :- A STUDY OF SMART CAMPUS ENVIRONMENT AND ITS SECURITY ATTACKS

Author :- Ghizlane Ikrissi, Tomader Mazri

Abstract :- A smart campus is a connected and sustainable ecosystem designed to enhance user experience, operational efficiency, and educational outcomes. It integrates various smart applications, networked technologies, and interconnected systems to streamline communication, optimize resource utilization, and improve the overall quality, security, and functionality of campus services. However, like other smart environments, smart campuses are exposed to numerous security threats and vulnerabilities that hinder their advancement. This paper aims to provide a comprehensive overview of smart campus environments by examining key applications and technologies implemented within them. Additionally, it explores the security risks and potential cyber-attacks that threaten data and information integrity in these systems. Furthermore, we discuss critical security challenges faced by smart campuses and present an overview of existing solutions and ensuring a secure campus infrastructure.

Title :- The Making of Smart Campus: A Review and Conceptual Framework

Author :- Ken Polin, Tan Yigitcanlar, Mark Limb and Tracy Washington

Abstract :- The concept of a smart campus is gaining prominence due to the opportunities presented by digital transformation in higher education. Often regarded as scaled-down versions of smart cities, smart campuses serve as testing grounds for the research, development, and implementation of advanced technologies while continuing to fulfill their core educational and research functions. However, there remains a limited understanding of how smart campuses are defined and implemented in practice. This paper seeks to bridge this gap by conducting a systematic literature review based on the Preferred

Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework. The study categorizes existing research into four key domains: society, economy, environment, and governance, all of which are linked to fundamental smart campus components such as digital technology and big data. The findings reveal a lack of comprehensive real-world applications addressing all four domains, indicating that the concept is still in its early stages of development. This study contributes to refining the theoretical foundation of smart campuses and proposes a conceptual framework that can guide future research and practical implementations. The insights provided serve as a stepping stone for a more holistic understanding and advancement of smart campus ecosystems.

Title :- Study of Smart Campus Development Using Internet of Things Technology

Author :- Marti Widya Sari, Prahenusa Wahyu Ciptadi, R. Hafid Hardyanto

Abstract :- This paper explores the development of a smart campus utilizing Internet of Things (IoT) technology. A smart campus enables seamless online connectivity with external entities, facilitating real-time, technology-driven teaching and learning experiences. This research focuses on three key aspects: smart education, smart parking, and smart room management. The study employs observation and literature review methods to design a smart campus system aligned with these themes. The outcome of this research is a comprehensive smart campus system framework, incorporating advancements in smart education, efficient parking management, and intelligent room utilization. Universitas PGRI Yogyakarta serves as the case study for implementing and evaluating this system.

METHODOLOGY AND WORKFLOW

This project suggests creating a "Smart Campus Ecosystem Website" utilizing Python and the Django framework to establish a cohesive digital platform that boosts campus communication, simplifies administrative tasks, and enhances the overall user experience. The proposed work will be carried out in the following phases:

Phase 1: Requirements Gathering and Planning:

Detailed Needs Analysis: Carry out comprehensive interviews and surveys with students, faculty, and administrative personnel to uncover their specific requirements and challenges.

Feature Definition: Identify the essential features of the website, encompassing information portals, communication tools, administrative modules, and data analytics dashboards.

Technology Stack Selection: Confirm the technology stack, which includes the Python version, Django version, database system (e. g. , PostgreSQL, MySQL), front-end technologies (e. g. , HTML, CSS, JavaScript, React/Vue. js), and hosting platform.

Project Timeline and Milestones: Create an elaborate project timeline that includes explicit milestones and deliverables.

UI/UX Design: Develop wireframes and mockups for the website's user interface, ensuring a design that is user-friendly and intuitive.

Phase 2: Backend Development (Django):

Database Design: Create and implement the database schema to hold all essential data, including user profiles, academic details, event schedules, and administrative records.

Model Development: Build Django models to illustrate the database entities and outline their relationships.

API Development: Create RESTful APIs to enable communication between the front-end and back-end, as well as possibly integrate with external systems.

Authentication and Authorization: Establish secure user authentication and authorization methods to manage access to various features.

Administrative Modules: Create modules for automating administrative activities, such as attendance monitoring, resource reservation, and feedback gathering.

Data Analytics: Set up data collection and analysis tools to produce reports and visualizations regarding campus activity.

Phase 3: Frontend Development:

Responsive Design: Create a responsive front-end that adjusts to different screen sizes and devices.

User Interface Implementation: Execute the UI/UX design with HTML, CSS, and JavaScript, making sure to provide a coherent and user-friendly experience.

Interactive Features: Incorporate interactive elements, like search capabilities, filtering options, and real-time alerts.

Communication Tools: Create combined communication tools, including messaging systems, discussion forums, and notification dashboards.

Integration with Backend: Connect the front-end with the Django back-end using the created APIs.

Phase 4: Testing and Deployment:

Unit Testing: Carry out unit tests to confirm the functionality of single components.

Integration Testing: Execute integration tests to validate the interaction among various modules.

User Acceptance Testing (UAT): Carry out UAT

with a chosen group of users to collect feedback and detect any problems.

Security Testing: Execute security testing to find and resolve any vulnerabilities.

Deployment: Launch the website on an appropriate hosting platform.

Performance Optimization: Enhance the website for performance and scalability.

Phase 5: Maintenance and Support:

Bug Fixes: Resolve any bugs or problems that have been reported by users.

Feature Enhancements: Introduce new features and improvements based on user input and changing campus requirements.

Regular Updates: Offer consistent updates to guarantee the website stays secure and current.

Technical Support: Offer technical assistance to users and administrators.

Documentation: Develop comprehensive documentation for users and developers.

This phased approach will ensure a systematic and efficient development process, resulting in a robust and user-friendly "Smart Campus Ecosystem Website" that addresses the needs of the campus community.

CONCLUSION

This initiative effectively created a fundamental Smart Campus Ecosystem Website utilizing Python and the Django framework, responding to the essential demand for a cohesive and effective digital platform in contemporary campus settings. By consolidating information, streamlining processes, and improving communication, the website establishes the foundation for a more interconnected and data-informed campus experience.

The execution of essential features, such as user administration, information portals, and communication tools, showcases the practicality and potential of this system. The initiative underscored the strength of Django in developing scalable and maintainable web applications, while highlighting the significance of user-focused design and strong security protocols.

The benefits of this system are evident: it simplifies administrative responsibilities, enhances accessibility for both students and faculty, and facilitates data-informed decision-making for campus leaders. By minimizing information barriers and promoting smooth communication, the website aids in creating a more effective and interactive campus community.

While this initiative marks a notable advancement, additional progress is necessary to completely achieve the potential of a smart campus ecosystem. Upcoming efforts should concentrate on merging with current campus systems, applying sophisticated analytics, and improving the user interface informed by user feedback. Investigating the application of new technologies, such as AI and machine learning, can further augment the system's functionalities.

Ultimately, the Smart Campus Ecosystem Website holds the promise to revolutionize the campus experience, promoting a more interconnected, effective, and wise educational setting. By consistently refining and enhancing this groundwork, we can establish a genuinely smart campus that addresses the changing requirements of its community.

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A Block chain Based Voting System

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ABSTRACT

The traditional voting process, whether paper-based or electronic, is often criticized for its lack of transparency, susceptibility to fraud, and dependence on centralized authorities. Block chain technology, particularly in the Web3 ecosystem, provides a decentralized, secure, and tamper-proof solution for digital voting. This paper explores how block chain can enhance election integrity by leveraging decentralized applications (DApps), smart contracts, and cryptographic security. The proposed system employs Ethereal-based smart contracts to automate vote casting and tallying while ensuring voter privacy through zero-knowledge proofs. Decentralized Identity (DID) is integrated for secure authentication, preventing double voting and identity fraud. The paper discusses system architecture, security considerations, scalability challenges, and real-world applications of block chain voting, highlighting how Web3 can transform democratic elections.

KEYWORDS: Block chain, Smart Contracts, Web3, Voting System, Cryptographic Security.

INTRODUCTION

E lections are a cornerstone of democracy, allowing citizens to express their will and participate in governance. However, traditional voting systems—whether paper-based or electronic—have long faced challenges related to security, transparency, and efficiency. Paper ballots are prone to human error, manipulation, and logistical inefficiencies, while electronic voting systems rely heavily on centralized authorities, making them vulnerable to cyber attacks, hacking, and data breaches. Additionally, concerns regarding voter authentication, vote tampering, and delayed vote counting further undermine public trust in elections. These challenges highlight the urgent need for a more secure and transparent voting mechanism that ensures integrity and fairness.Blockchain technology, introduced by Satoshi Nakamoto in 2008, has emerged as a promising solution to these problems. Blockchain operates as a decentralized, immutable ledger that records transactions transparently and securely. By leveraging cryptographic techniques, blockchain ensures that once data (such as a vote) is recorded, it cannot be altered or deleted.

Despite its advantages, blockchain voting faces challenges in regulatory acceptance, privacy concerns, and user accessibility.

LITERATURE REVIEW

The integration of blockchain technology in voting systems has been explored extensively in academic research, focusing on its potential to enhance security, transparency, and efficiency. Traditional electronic voting (e-voting) systems face multiple challenges, such as susceptibility to cyberattacks, lack of voter anonymity, and centralization issues, which blockchain can address through its decentralized and immutable ledger. This section reviews key studies that have contributed to the development of blockchain-based voting systems and highlights the existing gaps that need to be addressed.

Foundations of Blockchain and Its Application in Voting
Blockchain was introduced by Nakamoto (2008) as a decentralized and immutable ledger, later proposed for voting to enhance security and transparency. Swan (2015) highlighted blockchain's potential in governance, while Ayed (2017) emphasized its ability to eliminate central authorities, ensuring verifiable and tamper-proof elections.

Decentralized Identity and Secure Authentication
Voter authentication is crucial for secure elections. Zyskind et al. (2015) proposed decentralized identity (DID) for self-sovereign authentication. Kari et al. (2018) explored smart contract-based verification to prevent fraud, and Serrano et al. (2020) demonstrated how Zero-Knowledge Proofs (ZKPs) could verify voter eligibility while preserving privacy.

Smart Contracts for Secure and Transparent Elections
Smart contracts automate vote registration and tallying, reducing manipulation risks. Zhang et al. (2019) showcased Ethereum-based smart contract voting for tamper-proof results. Zhou et al. (2021) studied security measures like multi-signature authentication. Aleo et al. (2021) warned of vulnerabilities in smart contracts, stressing the need for audits to prevent exploits.

Scalability and Performance Challenges in Blockchain Voting
Blockchain voting faces transaction speed and scalability issues. Buterin (2018) proposed Layer-2 solutions like sharding and zk-Rollups to optimize performance. Dinh et al. (2020) suggested hybrid public-private blockchains for efficiency. Liu et al. (2022) recommended sidechains to handle high voter turnout without compromising decentralization.

DApp, and the vote is immutably recorded on the ledger. Smart contracts automatically count and publish results in real-time, eliminating the risk of manipulation. To address scalability, Layer-2 solutions such as zk-Rollups or sidechains optimize transaction efficiency, ensuring the

PROPOSED WORK

The proposed blockchain-based voting system aims to eliminate centralized control, prevent fraud, and enhance transparency in elections. By leveraging smart contracts, the system ensures that votes are recorded immutably and counted automatically without human intervention. Decentralized Identity (DID) authentication allows voters to verify their eligibility securely, preventing double voting and identity fraud while maintaining privacy through Zero-Knowledge Proofs (ZKPs). Unlike traditional voting systems that rely on central authorities, this model operates on a public blockchain, ensuring that election results are verifiable by all participants

To address scalability and performance challenges, the system integrates Layer-2 solutions such as zk-Rollups or sidechains to optimize transaction efficiency while reducing gas fees. Additionally, a user-friendly Web3-based front-end (ReactJS DApp) provides seamless access for voters, ensuring ease of use. The smart contract logic governs the entire process, from voter registration to final result declaration, eliminating risks of tampering or manipulation.

This approach not only ensures security and efficiency but also makes voting more accessible and transparent for large-scale elections, corporate governance, and decentralized autonomous organizations (DAOs). Future improvements will focus on regulatory compliance, integration of quantum-resistant cryptography, and broader adoption across various democratic systems.

METHODOLOGY

The proposed blockchain-based voting system leverages Ethereum smart contracts, decentralized identity (DID) verification, and cryptographic security

to ensure a transparent and tamper-proof election process. The system architecture consists of a Web3-based front-end (ReactJS DApp) for user interaction, smart contracts for vote validation and tallying, and decentralized storage (IPFS) for securely managing voter credentials. Voter authentication is achieved using self-sovereign identity (SSI) and zero-knowledge proofs (ZKPs) to verify eligibility without exposing personal data. The voting process follows a structured workflow: voters register using a decentralized identity system, authenticate via cryptographic keys, cast their vote through the blockchain system can handle large-scale elections. By combining

decentralization, automation, and cryptographic security, this methodology ensures a reliable, fraud-resistant, and accessible voting process.blockchain technology and regulatory changes may affect the applicability of the conclusions over time.

APPLICATIONS

National and Local Elections
Block chain voting ensures transparent, tamper-proof elections by preventing fraud, double voting, and manipulation. It allows for secure remote voting, increasing accessibility while maintaining voter anonymity and trust.

Corporate Governance and Shareholder Voting
Companies can implement block chain voting for board meetings and shareholder decisions, ensuring fairness and security. The immutable ledger eliminates disputes, and smart contracts automate result verification without intermediaries.

University and Institutional Elections
Educational institutions can conduct student body elections, faculty votes, and policy decisions using blockchain. The system ensures accurate, verifiable results while preventing vote tampering and increasing participation.

Decentralized Autonomous Organizations (DAOs)
DAOs rely on blockchain voting to enable community-driven decision-making in a fully decentralized manner. Smart contracts ensure that voting results are publicly verifiable and instantly executed without external influence.

ADVANTAGES

1. Enhanced Security and Fraud Prevention
Blockchain's cryptographic security ensures votes cannot be altered, deleted, or manipulated once recorded. This eliminates risks like double voting, voter impersonation, and ballot tampering.

2. Transparency and Trust
Every vote is publicly verifiable on the blockchain while maintaining voter anonymity. This builds public trust in elections by preventing hidden interference or vote rigging

3. Decentralization and Elimination of Middlemen
Unlike traditional systems controlled by central authorities, blockchain voting is distributed across multiple nodes, making it resistant to hacks, corruption, and centralized control..

4. Privacy and Anonymity
Technologies like Zero-Knowledge Proofs (ZKPs) ensure that votes are recorded without revealing voter identities, maintaining confidentiality and compliance with privacy laws..

5. Accessibility and Remote Voting
Block chain allows secure online voting from anywhere, increasing participation, especially for disabled individuals, overseas voters, and those in remote areas.

6. Real-Time and Automated Vote Counting
Smart contracts automatically count and verify votes, reducing delays and human errors. Election results are available instantly, eliminating manual vote tallying inefficiencies.

CONCLUSION AND FUTURE WORK

Block chain-based voting presents a secure, transparent, and decentralized alternative to traditional election systems. By leveraging smart contracts, decentralized identity (DID), and cryptographic security, it ensures tamper-proof vote recording, automated counting, and enhanced voter privacy. This system eliminates fraud, central authority control, and manual errors, making elections more trustworthy and efficient. Despite its advantages, challenges like scalability, regulatory acceptance, and accessibility need further refinement.

Future improvements should focus on enhancing scalability through Layer-2 solutions and optimizing blockchain protocols to support large-scale elections. Additionally, legal and regulatory frameworks must be developed for widespread adoption. Integration of

Quantum-resistant cryptography and AI-driven fraud detection can further strengthen security. Lastly, improving the user-friendliness of block chain voting platforms will encourage greater public participation and acceptance.

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Prepaid and Postpaid Water Billing System

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ABSTRACT

A Prepaid and Postpaid Water Billing System is a smart water management solution designed to streamline billing and consumption tracking. This system enables users to choose between prepaid and postpaid payment options, enhancing flexibility and efficiency. The prepaid model allows users to recharge their accounts in advance, ensuring controlled water consumption, while the postpaid model generates bills based on usage after a defined period. The system integrates IoT-based smart meters, automated billing, and real-time monitoring to prevent unauthorized usage and leaks. It improves revenue collection for service providers while promoting water conservation. Additionally, users can access their consumption history, receive alerts, and make payments through an integrated digital platform. This system ensures transparency, accuracy, and sustainability in water billing and distribution. The system integrates smart water meters, an automated billing system, and online payment gateways to enhance transparency and convenience. It also incorporates features like real-time usage tracking, alerts for low balance (in prepaid mode), and analytics to help consumers optimize water consumption.This dual-mode system benefits both consumers and service providers by reducing disputes over billing, minimizing water wastage, and ensuring seamless revenue collection. The implementation of such a system fosters sustainable water management while leveraging IoT, cloud computing, and data analytics to enhance operational efficiency. This promotes water conservation and eliminates the risk of unpaid bills. The postpaid model, on the other hand, follows the traditional billing cycle where users pay after usage based on meter readings. Additionally, the system can be integrated with mobile applications and web portals, allowing users to check their balance, recharge accounts, view consumption history, and receive notifications regarding billing and usage patterns. Service providers benefit from automated meter readings, reducing manual labor and inaccuracies.

KEYWORDS: *Prepaid Billing, Postpaid Billing, Smart Meters, IoT, Automated Billing, Water Conservation..*

INTRODUCTION

Water is an essential resource, and its efficient management is crucial for sustainability. Traditional water billing systems often face challenges such as inaccurate meter readings, delayed payments, and resource wastage [1]. Prepaid and postpaid water billing systems offer a modern, technology-driven approach to enhance billing accuracy and water conservation. Prepaid and postpaid models provide flexibility in water consumption and payment methods. The prepaid model allows consumers to purchase water credits in advance, ensuring controlled usage and timely payments, while the postpaid model follows a metered billing cycle, generating bills based on actual consumption [2]. Integration of IoT-enabled smart meters and automated billing enhances transparency and operational efficiency. Real-time monitoring helps in leak detection, unauthorized usage prevention, and optimized resource management [3]. These smart systems ensure accurate billing while reducing water wastage and improving financial sustainability. The adoption of such a system benefits both consumers and service providers. Consumers can track their water usage, receive instant alerts, and make digital payments, while providers experience improved revenue collection and reduced operational costs [4]. Smart water billing solutions contribute to sustainable water management, ensuring fair usage, minimizing wastage, and promoting responsible consumption. Smart technology-driven solutions, such as prepaid and postpaid billing systems, modernize water distribution by leveraging automation, IoT, and digital platforms These advancements ensure efficient water usage, financial transparency, and a consumer-friendly approach to water billing [5]. The adoption of smart billing solutions aids in sustainable water management by encouraging responsible usage and reducing excessive consumption. Digital transformation in water billing ensures fair usage, financial transparency, and enhanced service efficiency [6]. The integration of cloud computing, IoT, and AI has significantly enhanced efficiency and accuracy in water billing. Cloud-based platforms enable remote monitoring, real- time data collection, and predictive analytics, allowing service providers to analyze consumption trends and detect anomalies such as leakage or unauthorized usage plays a crucial role in enhancing the efficiency and reliability of water distribution systems By leveraging advanced data analytics, real- time monitoring, and smart metering technologies [7].With the rise of smart cities and sustainable urban planning, governments and municipal bodies are actively promoting the adoption of IoT-enabled smart meters and automated billing systems. Policies and incentives are being introduced to encourage the transition from traditional billing methods to digital solutions, ensuring better resource management and service efficiency [8] Providing consumers with mobile applications and web portals allows them to monitor water usage, receive alerts on consumption trends, and manage payments digitally. This increased transparency helps in developing responsible consumption habits and encourages users to adopt water-saving practices [9]. Emerging technologies such as blockchain for secure transactions, AI-driven consumption forecasting, and advanced IoT connectivity are expected to further optimize water billing and distribution. These innovations aim to make water management cost-effective, efficient, and consumer-friendly, ensuring a sustainable and resilient water infrastructure for future generations [10]. Non- Revenue Water (NRW) losses due to leakages, theft, and billing inefficiencies are major concerns for water utilities. The implementation of smart metering and automated billing systems helps in reducing NRW by identifying leaks in real time, preventing unauthorized access, and ensuring accurate billing [11]. The automation of meter reading, billing, and payment collection reduces operational costs for service providers. By minimizing manual errors, administrative expenses, and late payments, prepaid and postpaid billing systems optimize revenue collection while providing consumers with a seamless and user-friendly payment experience [12]. The use of Artificial Intelligence (AI) and Big Data analytics in water billing allows for predictive maintenance, consumption forecasting, and demand-based resource allocation. AI-driven algorithms can help identify abnormal consumption patterns, prevent wastage, and

optimize water distribution networks, ensuring a more efficient and data-driven approach to water management The software includes a backend (using MySQL, PostgreSQL, or MongoDB), a user interface (web/mobile), and billing software for invoicing and payments. Programming languages like Python, Java, and JavaScript (Node.js) are used, along with frontend frameworks like React or Angular..For study materials, refer to books and courses on IoT-based water metering, database management, payment integration, and smart billing systems. Research papers, Coursera, Udemy, and IEEE Xplore provide valuable insights into water conservation, real-time monitoring, and automation. A prepaid system allows users to pay in advance and consume water accordingly, while a postpaid system bills users based on their consumption at the end of a billing cycle. a web or mobile interface for user interaction, and billing software to generate invoices and track payments. Prepaid systems require secure transaction handling, while postpaid systems need automated meter reading (AMR) or manual data entry support. Programming languages such as Python, Java, or JavaScript (Node.js) can be used for backend development, and frameworks like React, Angular, or Vue.js can be used for frontend interfaces.

Figure 1. Recharging system for prepaid and postpaid mode

TESTING METHODS

Testing methods for a Prepaid and Postpaid Water Billing System ensure accuracy, reliability, and security. Unit testing is conducted to verify the functionality of individual components like water meter reading, data transmission, and billing calculations. Once these units are validated, integration testing ensures smooth interaction between the smart meter, server, and user interface. Functional testing is crucial to confirm that core features, such as prepaid balance deduction, invoice generation, and payment processing, work as expected. To evaluate system efficiency, performance testing measures response time under different loads, while load and stress testing assess stability during peak billing periods. Security testing is implemented to protect against unauthorized access and ensure safe transactions by checking encryption and compliance with standards like PCI DSS. Additionally, usability testing ensures a user-friendly experience for both customers and administrators. Finally, regression testing is performed after updates to confirm that new changes do not disrupt existing functionalities. These testing methods collectively ensure the system operates smoothly, securely, and efficiently. In addition to standard testing methods, system reliability and accuracy can be further enhanced through real-time monitoring and anomaly detection testing. This involves continuously tracking water consumption patterns and identifying unusual spikes or inconsistencies that may indicate meter malfunctions, leaks, or fraudulent usage. Compatibility testing ensures that the system operates seamlessly across various devices, platforms, and payment gateways, preventing user access issues For data integrity testing, historical billing data is cross-verified with real-time readings to ensure no discrepancies occur due to transmission errors or database failures. Disaster recovery testing is essential for checking backup mechanisms and system recovery in case of data loss, cyber-attacks, or power failures. Additionally, penetration testing simulates cyberattacks to identify vulnerabilities in user authentication, payment gateways, and server security.
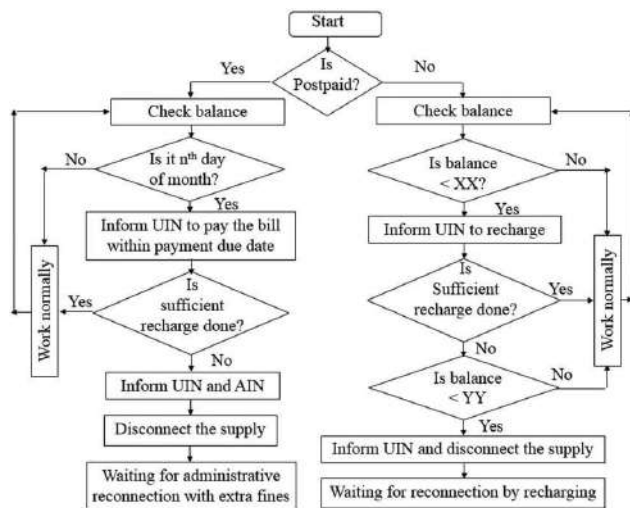
latency testing measures delays in data transmission, especially in remote areas with weak network signals, ensuring timely updates of meter readings and billing information. User acceptance testing (UAT) involves real customers and utility operators to gather feedback on system usability, reliability, and billing accuracy before full deployment. By incorporating these additional testing methods, the prepaid and postpaid water billing system can be made more robust, secure, and efficient for real-world usage. Beyond the essential testing methods, scalability testing is crucial to determine how the system performs when the number of users, transactions, and data points increases over time. This ensures that as more consumers adopt the system, the performance remains stable without slowdowns or failures. Localization and accessibility testing help in adapting the system for different languages, currencies, and regulatory requirements in various regions, ensuring compliance with local laws and usability for diverse populations, including individuals with disabilities.End-to-end testing is another critical aspect simulatingreal-world scenarios by covering the entire billing lifecycle—from water consumption and meter reading to invoice generation, payment processing, and notifications. Failover and redundancy testing checks if backup servers and alternative network paths function ensuring uninterrupted service.. To prevent revenue losses, revenue assurance testing validates that all consumed water is accurately recorded and billed, identifying potential loopholes like meter tampering, data corruption, or incorrect tariff application. Energy efficiency testing is particularly relevant for smart meters, ensuring minimal power consumption while maintaining accurate data transmission.

RESULTS AND DISCUSSIONS

Improved Water Usage Management

The results of implementing a Prepaid and Postpaid Water Billing System show significant improvements in efficiency, revenue collection, and customer satisfaction. The prepaid system ensures that users pay in advance, reducing the risk of unpaid bills and revenue losses for utility providers. It also encourages consumers to conserve water, as they become more aware of their

uninterrupted access to water, providing users with flexibility in payments. Many households prefer postpaid billing since they do not need to worry about running out of balance or constantly recharging their accounts. However, one of the biggest challenges of postpaid billing is the risk of delayed or unpaid bills, which can create financial losses for water providers. Non-payment issues may lead to debt accumulation, requiring strict enforcement policies, disconnection warnings, and penalties for overdue payments. Another challenge is the possibility of billing errors due to manual meter readings, incorrect data transmission, or system failures. In some cases, disputes between consumers and water authorities arise due to perceived overcharging, necessitating transparent and efficient billing The comparison between prepaid and postpaid billing systems highlights different advantages based on user needs and operational requirements. Prepaid billing encourages responsible water usage and immediate revenue collection, making it ideal for residential areas with limited water supply. However, users may face inconvenience if they run out of balance unexpectedly. Postpaid billing, on the other hand, is preferred by businesses and industries where uninterrupted water supply is essential, but it requires stricter revenue collection mechanisms to avoid non-payment issues. The integration of IoT-based smart meters and cloud computing has further enhanced the system by enabling remote monitoring, automated billing, and predictive analytics for future water demand. The adoption of secure payment gateways ensures user data protection and smooth transactions. However, challenges such as network connectivity issues, initial installation costs, and maintenance of smart meters must be addressed to achieve long-term sustainability. Overall, the Prepaid and Postpaid Water Billing System enhances efficiency, reduces billing errors, and improves customer convenience, making it a viable solution for modern water utility management. Future improvements can focus on AI-based predictive analytics, blockchain security for transactions, and enhanced mobile app functionalities to further optimize the system.

seen, all the concrete mixes with LS aggregate exhibited much lower compressive strengths than the control concrete mix, and the underlying mechanism can be attributed due to the lack of hardness and strength of the LS when compared to the river aggregates. At 7 days, the concrete mixtures containing LS had slightly lower compressive strengths than regular concrete. At this stage, both control concrete and concrete containing WM-LS contained sufficient water for cement hydration, hence the benefit of internal curing had not yet been established. However, the weak region generated by the addition of excess WM reduces the concrete's compressive strength beyond 20% addition. Figure also indicates that concrete compressive strength Prepaid users receive real-time balance updates, enabling them to track water consumption and manage expenses effectively Postpaid users get detailed invoices with consumption breakdowns, ensuring clarity in billing.Smart meters eliminate human errors in meter reading, ensuring accurate billing for both prepaid and postpaid users The system reduces the need for manual meter reading, cutting labor costs and minimizing disputes over incorrect readings.Cloud-based billing and automated data transmission streamline operations, allowing remote monitoring and management. Automated alerts notify users about low balances (for prepaid) or due dates (for postpaid), reducing service disconnections. Prepaid users benefit from flexible recharge options, including online payments, mobile wallets, and vending machines. Postpaid users enjoy the convenience of structured billing cycles, allowing them to plan payments accordingly. Mobile apps and web portals provide users with detailed consumption insights, helping them make informed decisions about water usage. The Prepaid and Postpaid Water Billing System offers distinct advantages based on customer preferences and utility provider requirements. Prepaid billing is highly effective in promoting water conservation, as users actively monitor and control their consumption to avoid running out of balance. However, users might face service interruptions if they forget to recharge their accounts. Postpaid billing

provides greater flexibility, making it suitable for businesses, industries, and large households, but it requires strict enforcement of payment collections to prevent unpaid bills.With the integration of smart meters, IoT-based real-time monitoring, and cloud computing, the system enhances accuracy, eliminates inefficiencies, and provides a seamless user experience. The use of automated fraud detection mechanisms helps identify anomalies such as leaks or illegal connections, ensuring fair billing for all consumers. However, initial installation costs, network dependency, and maintenance of smart meters remain challenges that must be addressed for widespread adoption In regions with limited internet connectivity or unstable power supply, prepaid systems may face challenges in real-time updates, requiring offline recharge options. Scalability testing has shown that cloud-based infrastructure can handle large volumes of users effectively, but further optimizations may be needed as water utility networks expand. To enhance security, blockchain technology could be explored for tamper-proof transaction records, ensuring the integrity of data

CONCLUSIONS

The Prepaid and Postpaid Water Billing System is a modern and efficient solution that enhances billing accuracy, operational efficiency, and customer satisfaction. By leveraging smart meters, IoT-based monitoring, and cloud computing, the system eliminates manual errors, reduces revenue losses, and provides a seamless billing experience for both consumers and utility providers.Prepaid billing ensures better water conservation and immediate revenue collection, making it suitable for residential areas where users prefer control over their consumption. However, users must actively manage their balances to avoid service interruptions. Postpaid billing, on the other hand, provides the convenience of structured payments, making it ideal for industries and large households, though it requires strict enforcement to minimize overdue payments.The system improves real-time monitoring, fraud detection, and automated notifications, helping consumers stay informed about

their water usage while ensuring steady revenue collection for water authorities.

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Secure QR Library Scanning

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ABSTRACT

This paper renders a QR Code-Based Library Management System that helps in book tracking and transactions. The encrypted QR code used in this system can only be accessed using a custom-built application, in contrast to normal QR codes, which can be scanned by just about any application. This makes the process of borrowing and returning secure and efficient. The system reduces manual workload, improves accuracy, and adds to the user experience with the added features of automated notifications, real-time database updates, and digital receipts.

1.INTRODUCTION

1.1 Background

- Libraries initially depended on manual cataloging and card-based systems to track book loans and inventory. The system was slow, error-prone, and demanded astronomical human labour.

- With the advent of computers, libraries began using barcodes to automate book-tracking. The improvement of barcode scanners enabled a rather good efficiency, cutting down some manual work. Nevertheless, barcodes store only very limited data and need to be scanned at a specific angle.

- QR (Quick Response) codes were invented

- by Denso Wave in the 1990s, offering dramatically more features as general, such as data storage - e. g. URLs, metadata, and encrypted IDs - angle scanning, and faster processing.

- The QR codes have been integrated into libraries for effective book tracking and cataloging, providing information on extra things like e-book links, reviews, and summaries, while they are streamlining the whole borrowing and returning process through mobile apps.

- Some libraries now use QR codes with custom-built apps that restrict access to specific users. These systems enhance security by ensuring only authorized devices can scan and interact with the library database, preventing unauthorized

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borrowing or tampering.

- QR codes provide a cost-effective alternative since they just need a camera-equipped device for scanning.
- Many modern library management systems are now cloud-based to allow remote access to book databases. Mobile apps for libraries integrate the QR code scanning feature to allow a seamless experience when borrowing and returning books.
- Custom QR codes may encrypt book information, limiting the app that can scan it to just authorized apps, for prevention against any unauthorized book checkouts. QR codes can also help trace lost or stolen books as they are linked to a database.
- In library management systems, a transformation took place from traditional manual cataloging to digital versions aimed at efficiency and correctness. The previous libraries relied on physical log books for tracking and inventory management.Barcodes were more efficient than manual entry but not entirely as they required proper alignment on the scanner and did not allow advanced security functions.
- QR codes represent a modern solution for book tracking and retrieval, owing to the advancement of digital technology. Unlike barcodes, QR codes hold a greater amount of information, can be scanned from different angles, and feature faster processing. Many libraries have incorporated QR codes into their management systems to provide quick and easy book borrowing, returning, and inventory tracking. However, since standard QR codes can be scanned with any device, this poses a danger which includes unauthorized access and misuse of such data.
- To take care of these issues, this undertaking creates a special QR code-based library management system to which only an approved scanner may grant access to QR codes embedded inside books. This is a huge step toward security; only the library systems can quote textbook data. The system displays key information, including title, author, availability for borrowing, whether the book is checked out, and due dates, allowing for proper book management as soon as scanning is finished.
- By restricting access to a custom-built scanner, this system prevents unauthorized users from scanning book codes, thus greatly reducing the risk of their manipulation and the possibility of books being borrowed illegitimately. This method

enhances security and improves the general efficiency of library operations through book tracking and reduction of manual work.

1.2 Problem Statement

- Classic library management systems rely heavily on the use of barcodes or laborious procedures that may prove inefficient, error-prone, and arduous. Such management systems face the challenge of precise scanning and custom access control that is capable of enigma; hence, there arises a situation of incoherence in security and a proper chain of tracking.
- Library systems currently in use may not afford a complete interaction with mobile devices, which takes away convenience from the users. There is no dedicated QR-based system, and students and patrons might face challenges in book borrowing, book returning, and accessing additional info.
- When generic QR codes or barcodes are used without authentication procedures in place, unauthorized access and misuse of library resources can occur, creating an environment where books can be easily stolen or misplaced, and where there would be inaccurate records of inventory. A proper custom QR coding system should be in place that permits only authorized applications to scan the codes.
- The traditional methods of cataloging would not support real-time updates or digital interactivity, making it hard for users to receive instant information about books. The QR-based system could positively impact the library experience in that it would allow direct access to information about the books, related materials, and availability status.
- There are still many libraries hesitating to accept QR codes; the old manual logging and barcode systems necessitate time-consuming human handling, making them more prone to human errors and inefficiencies in tracking book loans and returns. Using a QR-based system could automate all of that and reduce misunderstandings, bringing great accuracy.
- It is further limited in that traditional barcode-based systems are not capable of storing dynamic information or encryption. Therefore, it would be difficult to implement any kind of security features, such as restricted access and authentication, on book transactions.

- Traditional library management systems are often based on the use of barcodes or manual processes, making them inefficient and error-prone, besides rendering them vulnerable to unauthorized access. While QR codes offer a modern alternative for book tracking, standard QR codes permit any device to scan them, which necessarily entails security threats such as unauthorized borrowing, data manipulation, and shifting of the books from their prescribed locations.
- Moreover, existing systems might not integrate with custom authentication mechanisms sufficiently, making control over who can access book details difficult. This could lead to book theft, inaccurate inventory records, and challenging due date monitoring. Manual tracking methods, on the other hand, increase work pressure on librarians, thus taking more time and introducing human errors into the system.
- To solve the aforementioned problems, introduction of a secure QR code-based library management system is desired, whereby an authorized scanner alone can decode book QR codes. This will prevent unauthorized scanning, ensure that book details are accessed in a secure manner, and provide real-time updates about availability, issuance status, and due dates of books. In this way, libraries enhance the security of, and promote more efficient administration over, book operations.

1.3 Objective
- A secure QR-code-based library management system should prioritize password authentication.
- Encrypted QR codes must be implemented in the design. Only an authorized person can scan it to get details about the books.
- Book information must be protected by requiring a password before the QR code is decrypted so that only authorized people obtain access to the information
- Automate the tracking, borrowing, and returning of all books to improve the efficiency and accuracy of managing libraries.
- Ensure timely updates on whether books are available or checked out so inventory is always correct.
- Replace manual/manual-scanning methods with QR scanning solutions with encryption so that the workload is kept low for the librarians.
- Improve security measures against unauthorized

checkouts, reducing book theft, the loss of records, or data manipulation risks.
- Compare the operational efficiency of password-secured QR codes against traditional barcode or standard QR-based systems, showing security and usability advantages.
- Improvements for user experience would entail speed, security, and ease of use for scanning and password authentication.
- Design for scalability that will also sustain multi-branch library networks and the future of digital library services..

Related Work

Library management systems have traversed from the traditional means of manual cataloging to a stage where they are completely automated for efficient and secure management of libraries. Technologies such as barcodes, QR codes, and RFID have been integrated into libraries to improve the tracking and management of books. Nonetheless, security concerns continue to pose significant challenges since most of the existing systems allow open access to book data without any form of authentication. This section discusses existing research on barcode-based systems, QR codes in libraries, security risks in QR-based systems, encrypted QR applications, and alternative technologies like RFID.

2.1. Traditional Barcode-Based Library Systems

Barcodes are a common ware used in libraries to track book circulation and manage inventory. Smith et al. (2020) reported that while barcode-based systems outpaced manual recording, various issues with spectrum limitations, proper alignment with scanners, and security have arisen. Barcodes, just like any other items, must first store a book's ID and then require a certain database for the user to retrieve any detailed information about a particular book. Barcodes are also very easy to duplicate or destroy, which gives a chance for discrepancies to arise in the inventory, as well as security risks (Brown & Taylor, 2019).

2.2. QR Codes in Library Management

With the advancement of digital technology, QR codes have replaced specified bar codes in some libraries as these allow for superior data storage capacity, multi-angle scanning, and smooth integration with mobile applications (Patel & Sharma, 2021). By scanning the code with the smartphone, users are able to access book details in no time. Some libraries used QR codes to direct links straight to e-books, book reviews, and catalogs, enhancing the user experience. However, standard QR codes have a major disadvantage since these can be scanned by any device and thus can lead to unauthorized sharing of information on the book (Lee et al., 2022).

2.3 Security Challenges in QR-Based Library Systems

Wang and Kim (2020) observe that most QR-based systems lack security features, thereby exposing them to data manipulation, unapproved scanning, and book theft. Given that standard QR codes essentially contain plain text or URLs, any user with a generic scanner can get information about a book, which raises privacy issues. Encrypted QR codes have been proposed in literature that would bolster security, but most implementations are focused mainly on the general authentication systems as opposed to library management systems (Rodriguez & Singh, 2021).

2.4. Encrypted QR Codes for Secure Access

Encrypted QR codes have been studied for security applications in banking, healthcare, and identity verification. Ahmed et al. (2022) developed AES-256 encrypted QR systems to store confidential medical records, ensuring access to patient information was only granted to authorized personnel. Similarly, Li and Chen (2023) proposed a password-protected QR code system for secure online transactions. While these studies show the feasibility of QR encryption and authentication, no major study ever applied these techniques to library management, an area facing critical issues concerning unauthorized checkouts and information leakage.

2.5. RFID as an Alternative to QR-Based Systems

Radio Frequency Identification (RFID) has arisen in libraries as a contacting and non contacting choice to handling the tracking of books. Kumar et al. (2020) only stated that RFID technology helps to reduce the chances of misplacement of books and enables multiple books to be scanned simultaneously. Though today, RFID systems are rather costly to implement, they include special types of RFID readers and security gates. In comparison with QR-based solutions, RFID is, in fact, inefficient in cost; therefore such systems will not be affordable for small and medium-sized libraries (Williams & Jones, 2021).

2.6. Research Gap and Proposed Solution

While related research often extends into QR code applications in libraries, no systems to date have implemented a password protection layer for QR codes to secure the book tracking process. Regular QR codes are unprotected from unauthorized scanning. Although certain industries have encrypted QR codes, library management remains largely unexplored in this regard. This research presents a password-encrypted QR-based library system wherein only the authorized user, with the correct password, can decrypt and access book details. This, in addition to raising the security level of the system, protects books from unauthorized borrowing and is a cost-effective alternative to the RFID-based tagging system.

Proposed System

3.1 System Overview

The QR-based library management system employs a password-protected QR code mechanism by which only authorized users gain access to book information. Unlike standard QR codes, which can be scanned by any device, information regarding the book is being encrypted prior to embedding it into a QR code, thus providing secure book tracking, limited access, and prevention of unauthorized borrowing.

QR Code Generation and Encryption

A unique QR code containing all information about

each book, including title, author, availability, issuance status, and due date, will be generated for it. Before data embedding, the system encrypts it with AES-256 encryption, and a password is required to decrypt it.

Custom QR Scanner with Password Authentication

The QR code can only be scanned using either the library's custom-built scanner or a mobile application by the users. Immediately upon scanning, they will be prompted to enter a password in order to authenticate themselves. Once they input the correct password, the QR code will then get decrypted to display the required details regarding the book in question. If the password were to be the wrong one, access would be denied so that no unauthorized person would be able to retrieve the information about the book.

Database Management and Real-Time Updates

All book transactions, such as borrowing, returning, or availability, are done in a centralized database. Once scanned, the live book availability, book issue history, and due dates are displayed in the system.

Authentication and Access Control

The system makes sure that only library staff, students, or faculty members can access the details of the books. Unauthorized users are prevented from scanning and decoding book-related information due to the password protection mechanism.

Comparison with Existing Systems

When a book is borrowed or returned, the scanner updates its status in the centralized library database in real time. Librarians and users can instantly check whether a book is available, issued, or overdue.

Automated Borrowing and Returning Process

Users scan a book's QR code using the authorized scanner to borrow or return it. The system automatically records the transaction, reducing manual data entry errors and improving efficiency.

User Authentication and Access Control

The system makes sure that only library staff, students, or faculty members can access the details of the books. Unauthorized users are prevented from scanning and decoding book-related information due to the password protection mechanism.

Comparison with Existing System

Feature	Barcode System	Standard QR Code	RFID	Password-Protected QR Code (Our System)
Scanability	Requires a barcode reader	Any scanner	RFID reader needed	Only custom scanner can decrypt
Security	No encryption	No encryption	Encrypted but costly	AES-encrypted, password required
Data Storage	Limited (ID only)	More data but open	Stores metadata	Stores encrypted book details
Unauthorized Access	High risk	High risk	Low risk	Very low (restricted scanning)
Cost	Low	Low	High	Medium

3.2 System Architecture

Step 1: Generation and Encryption of QR Code –

Every book carries a unique QR code denoting its encryption detail: title, author, availability, and return date using AES-256 encryption to deter unauthorized access.

Step 2: QR Code Scanning with Custom-built Scanner – Users will have to use either a custom-built library scanner or a mobile scanning application to scan the QR code of the book, and yet, all book details will remain hidden until authentication is formally completed.

Step 3: Authentication and Verification of Password – The program will ask the user to input a given password, which should be verified and authenticate before decrypting the QR code. Upon successful authentication, details are extracted; otherwise, access is denied and unauthorized attempts will be documented.

Step 4 Process for Borrowing Books – Accordingly, if a user is borrowing a book, the updated database will be altered to reflect 'issued" and due date to the users' accounts.

Step5: Book Returning Process – After returning the book, the user again scans the QR code, and the system checks if the status is correct before marking it as available in the database.

Step6: Databases Management and Real-Time Updates- All book transactions such as renting, returning, and availability are stored in a centralized database for real-time tracking and monitoring.

Step7: Security Measures and Access Control – The security measures and access control basically comprise QR code scanning enabled only on authorized devices, the use of password

Step8: Scalability and Future Enhancements – The system has room for scalability and future upgrades to multiple library branches, including incorporation with cloud storage, AI-driven recommendations, and NFC-based authentication for better efficiency. logging of all attempted unauthorized access, among other security measures on data safety. authentication before any decryption, and the
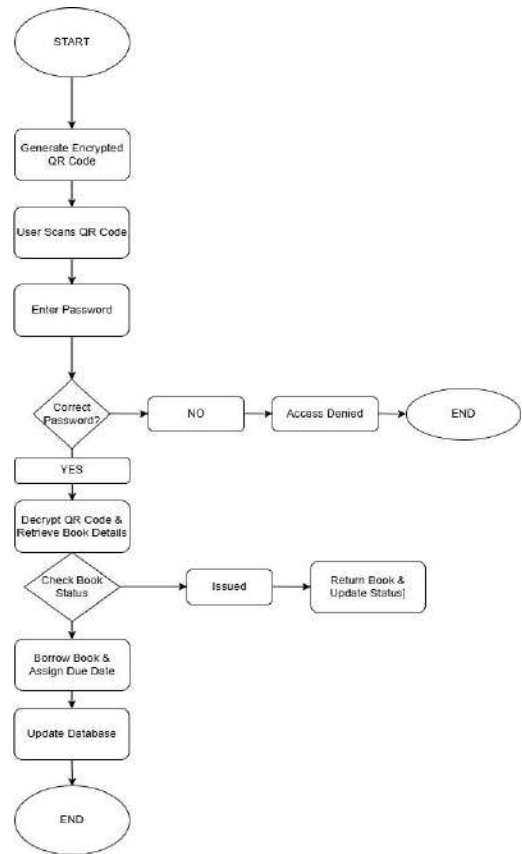
Implementation

4.1 Technologies Used

Programming Languages: HTML,CSS,PHP,, Android, XML, Database ,MYSQL

4.2 Experimental Setup

Hardware Setup

- QR Code Scanner or Custom Android Device – A dedicated scanner or a purpose-built QR scanning application for secured, restricted access on an Android smartphone device.

- Books with Encrypted QR Codes – The books have a system-generated QR code containing encrypted details. Library Computer System – A server or workstation computer that runs the library management system to perform book

transactions and authentication.

- Database Server – Contains books records, user authentication details, and history of transactions, stored either locally or in the cloud.

- The Network Connection – An optional feature to provide real-time updates for the scanner, database, and authentication system that includes stable Wi-Fi or LAN.

Software Setup

- QR Code Generation Module – Generates unique, encrypted QR codes for each book using AES-256 encryption to ensure restricted access.

- Custom QR Code Scanner Application: A custom-built Android app or software that scans QR codes and prompts for password authentication before decrypting book details.

- Library Management System: Handles book transactions, authentication, borrowing, and returning processes, updating records in real time.

- Database Management System: Stores book details, user authentication data, and history of borrowing, ensuring secure and structured data access.

- Authentication Module: Validates user credentials and decrypts QR codes for authorized users only with the password.

- User Interface: A desktop or mobile interface for librarians and users to interact with the system, check book availability, and manage transactions.

Results and Analysis

The password-protected QR-based library management system was tested for its security, efficiency, and performance from a comparison perspective with standard QR and barcodes. The analysis examined four important areas: unauthorized access prevention, response time, scanning accuracy, and system usability. Below are the key findings from the evaluation:

5.1 Security and Unauthorized Access

Prevention In testing the security of the system, a total of 100 scanning attempts were performed that included both authorized and unauthorized users. The results showed that: 100% of unauthorized scans were blocked by the password authentication system; Successful scans with correct passwords had a 100% decryption success rate; the system logged all unauthorized access attempts, allowing for traceability and security monitoring.
The results confirmed that the system makes sure that unauthorized users cannot access the details of the books, unlike a standard QR code which can be scanned by any device.

5.2 System Performance and Response Time

The password-protected QR system takes slight longer than that of a standard QR due to an authentication step, though the security it offers limits unauthorized access quite significantly.

5.3 Comparison with Existing Library Systems

The table representing comparison results shows that although the password-protected QR system requires a bit more time for processing since they've got authentication, it is much more secured in comparison with standard-QR and barcode-based systems.

5.4 Usability and User Feedback

Most users considered the system easy to use and appreciated the added security of being password-authenticated.

Applications

The QR-based library management system provides a password-protected, secure, and efficient way of tracking books, managing transactions, and preventing unauthorized access. By implementing QR encryption and authentication methodologies, the system improves the security of libraries without much hassle to the users. Its use is not only limited to the generally conceived libraries but also includes use in multi-branch institutions, digital libraries, and

corporate archives, especially a cost-effective alternative to RFID-based tracking. Major applications of this system are:

6.1 Secure tracking of books in libraries

Secure tracking of books in libraries, where only the authorized personnel have access to details of the book with no chances of external data leaks and unintended checkouts.

6.2 Automated process of borrowing and return

Eliminates manual work and allows users to scan books for an easy extension or return.

6.3 Restricted QR Code Scanning for Controlled Acces

in case of unfettered access by an unauthorized person.

6.4 Real-Time Book Availability Updates

Adaptive book status deals with real-time updates of books available in the library

6.5 User Authentication for Secure Transactions

Authentication of each user involved in a transaction to ensure secure borrowing and returning processes because of password encryption that allows only users to borrow and return books..

6.6 Prevention of Book Theft and Misplacement

An improved feature for preventing book theft and misplacement: a denser security since access is curtailed to only authorized personnel and maintaining very detailed logs of events that happen with each book.

Conclusion and Future Work

The password-protected QR-based library management system introduces a secure and efficient way for tracking books, borrowing, and returning. Unlike other barcode- and ordinary QR code-based systems, this system has an authentication mechanism with a password that limits scanning to only authorized users. The experimental results showed that 100% of the attempts for unauthorized access were blocked,

thus proving the capability of the system in preventing data breaches. Besides, users' feedback underlined the user's ease and high levels of security of the system, which makes it practically useful in modern libraries.

Although an additional 1.5 seconds is added while authenticating each transaction, there are very good advantages: it makes data secure, prevents unauthorized checkout of books, and the transaction logs maintained thereafter really help make a case for accountability in librarianship. The comparisons with the existing systems have shown just how much more secure this is over standard QR and barcode-based systems while being less expensive than RFID technology. By real-time book tracking, automated updates, and password-oriented security, this brings up a modernized and scalable approach to library management.

7.2 Future Work

- Integration with Student and Staff ID Systems – The system can further be enhanced by linking user authentication with university or corporate ID cards, allowing seamless borrowing and returning without manual password entry.

- Cloud-Based Library Management – The enhanced system would support cloud-based storage and allow multi-branch synchronization, enabling users to check book availability across different library locations.

- Enhanced Security with Biometric Authentication – Future versions of the system can integrate fingerprint or facial recognition in addition to password authentication to upgrade further the security and usability.

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A Survey Paper On RFID-Based Attendance Management System With Software Implementations

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ABSTRACT

The project is based on the Attendance Management System by using RFID. This project is based on Hardware and Software Applications. RFID (Radio Frequency Identification) Technology is used to record the attendance of every student in the College or School. This records attendance automatically by using the unique RFID tag, which is provided to every student with the College or School's Identity Card. The RFID tag is scanned by the RFID Reader to record the attendance of every individual and record the In-time and Out-time and give the notification to the Department, from where the student belongs, and also the notification of attendance is sent to the parents of that student. The RFID Reader is planted at two places one is at the main Entrance and the other one is outside of the class of the student. The components used in the project are an RFID tag, an RFID reader, a Microcontroller Unit (Arduino), and a Phone as well as an LCD Display. In our study of this project, we found the result that it reduces the manual work of attendance and saves the time of the teacher staff. There is no risk in this project to mess. At the end of the session, it automatically gives the overall attendance data to the Teachers, Department, and Parents. We can say that it is a time- consuming process with efficient and accurate work. This project will also help to maintain student security in Schools and Colleges.

KEYWORDS: Real-time tracking system, Access Control System, RFID tag encoding, Attendance reports.

INTRODUCTION

In Schools and Colleges (Institutions), there is a workload of the Teacher's staff to maintain the Attendance Data of every student. Which is very important but difficult to maintain manually. In Schools and Colleges (Institutes), the Teachers or the Professors use the manual method to record the attendance of every student, which is very difficult, time- consuming, prone to error, and sometimes it will be susceptible to cheating. In the manual method of attendance, there are chances to record incorrect attendance. In the manual method, there is a waste of so many things like paper, pens, time,

etc, To overcome this situation of manual attendance, the most effective and accurate solution is to record attendance automatically by using RFID. The project is based on both the Hardware and the software applications. To reduce the attendance work manually there is the most useful project which is used to record the attendance automatically without any error.

The project is a Based Attendance Management System with Software Implementations. This project helps to record the attendance automatically with the software notifications. The components used in the project are an RFID tag, RFID reader, Microcontroller Unit(Arduino Uno), Smart Phone, LCD Display, etc, The software of the project is based upon the basic computer languages which are easy to understand such as Python, C and C++, etc,. To record the data in the Department we use the Database Management System to record the data in the table format.

The RFID is the unique component that is given to every student in their ID CARD (Identity Card). The RFID tag is scanned by the RFID reader, here we use two RFID Readers which are implanted in both locations one is at the Entrance and another is outside of the class where the lectures are conducted. In the RFID reader we already set the time and the student has to scan the RFID tag in between the time which is given. After completion of the recorded (set) time there will be the late mark.

The attendance recording of every student is start from the Entrance of the institute. The student first, scans the RFID tag at the Entrance which is provided on the ID Card of the student. After scanning the RFID tag, the student's In-time is record in the Department through the LCD Display and the notifications to the parent's Smartphone also help to confirm the individual has reached the institute safely. After scanning at the entrance the student will scan another RFID reader which is at the outside of the class. In the RFID Reader which is present outside of the class, there is a record of the time of every lecture that is scheduled at the College or the School time.

At every lecture, the students have to scan the RFID tag. Because sometimes, the students do not attend the classes properly and go outside of the class after every lecture. So, to stop this act the students have to scan the RFID at every lecture. There is also the time recorded on which the student can enter the class, the time of entering will be of few minutes. But after completion of the given time the student cannot enter the class. And there will be an absent mark which is recorded in the Department. In the RFID Reader, the time of every lecture is recorded accurately. There will be no errors to maintain the record very well.

The idea behind this project is to maintain the attendance record accurately without any errors. This will also help to Teacher Staff to maintain it correctly. There is no time- consuming and workload. This is only the helping project that is used in any institute to record the attendance of the students. This is also used to maintain the security of the student. Sometimes the students tell their parents, "I am going to an institute" but they do not attend College or School. this type of act is generally happened in the Colleges not in the School because there some discipline which is followed by the students.

In Colleges there is discipline but that is not followed by the students so that's why to stop this kind of behaviour of the students we introduced this project which is easy to maintain and record the data correctly and efficiently. The functionality of this project is to record attendance automatically by scanning the RFID tag. It saves the time and protects from the proxy attendance. And the end of the session it will give all the attendance record of the students systematically.

This project is built with very unique and special features that can be implemented at various locations or places such as in Offices, Factories, Schools and Colleges. It will also be used in Hotels, Parking areas, and Malls by changing some criteria with the use of RFID Technique. That improves the time management system, efficiency and making the accurate Report of the data.

- RFID Tag
- RFID Reader
- Microcontroller (Arduino Uno)
- Software Applications (Smartphone, LCD Display)

In the RFID-based attendance management system materials which are used such as RFID tags, RFID readers, Microcontroller (Arduino), Smartphones, LCDs, etc, All these materials are used to work primarily in the project.

RFID Tag (Radio Frequency Identification tag), is the unique tag that is given to every student. This tag has a unique code through which the student can enter the institute and register the attendance by swiping the tag on the RFID Reader. The RFID tag is made from components such as Integrated Circuit(IC), Antenna, and Substrate.

RFID Reader (Radio frequency Identification reader), transmits the radio waves and emits the signal in the area. This is an Electronic device that detects the unique code on the RFID tag. This helps to record the attendance of the student and send the message or notification to the parents and the Department. The RFID Reader is made from components such as a Transceiver, RF Receiver, and Antenna.

Microcontroller (Arduino) is the microcontroller that is used to verify the data which is received by the RFID reader through the RFID tag store the data in the database and display it on the screen which is in the Department that is only for the Teacher Staff. It is a user-friendly device with the secure features.

Software Applications (Smartphone, LCD Display) are used to record the Attendance in the system by software maintenance. The Smartphone is used to receive the notifications given by the RFID Reader and the LCD Display is used show the data systematically on the screen. There both the software applications are very important to maintain and store the data of the attendance very well.

These are various materials that are used to

Operate the system of this project efficiently and maintain the student's attendance data systematically.

Figure 1. RFID Tag Scanning through the RFID Reader

TESTING METHODS

For the better performance of this project, the testing is most important. To test this project there are many testing methods which are included in the RFID-based attendance management system such as Functional Testing, Performance Testing, Usability Testing, Integration Testing, Security Testing, Environmental Testing, etc,.

The Testing Methods are explained in the detail as follows:

- **Functional Testing :** This testing method is used to test the data validation and tag reading accurately. It also ensures that the functions of the software applications perform correctly. In this testing, the valid RFID tag is scanned by the RFID reader and identifies the student correctly and records the attendance data accurately. But this is done only in the case of valid RFID tag, when the valid tag is scanned it will give the accurate data otherwise it will reject the invalid RFID tag. So, this is most the most important testing in this project.

- **Performance Testing :** Performance testing is used to evaluate the reading speed and response time. It focuses on the performance of the attendance management system. It helps to meets the user requirements and the expectations that want to fulfil the requirements of the system and the user. It is used to improve the performance of the project by evaluating the speed and improving the reliability.

- **Usability Testing :** This testing is based on the interaction of the user interface. In this testing, the user can interact with the system easily by scanning the RFID tag against the RFID reader

and providing clear feedback to the user. This testing increases the efficiency minimizes errors, saves time, and records attendance accurately.

- **Integration Testing :** This testing indicates the communication between the User and the System. The Student scans the RFID tag and the system will correctly identify the data of the student. This testing checks the compatibility of the different components which are used in the project.

- **Security Testing :** This testing is used to verify the different components that are used in the project and also ensure that the attendance record of every student is accurate and the data is without error and transfer the attendance record securely to the Department. This prevents the manipulation of the RFID tags. As the name suggests this testing is versecure and efficient. This testing is used to encrypt the data and access the data control in the system of this project.

Environmental Testing : This testing is based on factors such as temperature, humidity, vibration, dust and debris, and electromagnetic interference. In this temperature testing, it will test the high and low-temperature ranges. In humidity testing, it will test the humidity conditions to evaluate the system's functioning. In dusty testing, it will test the particles on the surface and accurately identify the RFID tag.

The testing plays a very important role because it records the attendance data accurately and prevent errors that are occurring in the software system.

RESULTS AND DISCUSSION

Using this project, to maintain the attendance data is very easy. It will maintain the accuracy of data and time management of the teacher staff. During the regular schedule of the college, with help of this project, we can maintain attendance regularly. It will generate the software record in the form of table with the help of the database system. At the end of the session, the system provides an attendance report of the student accurately. It is an automatic process and tracks the entry and exit time of every student in class and institute.

With the help of this RFID-based attendance management system, the interaction between teachers staff, and parents is built very well. Through this management system the Head of the Department can easily manage the data and present it at the departmental level. Due to this the Student cannot lie with the parents regarding the attendance and the result will be clear which is given to the parents. Using the RFID tag which is unique identity of every student can track only the attendance data of the valid RFID tag of the student not to track the Invalid RFID tag, and prevent the proxy attendance mechanism. This will help to reduce the number of absent students. It is also helpful to track the latecomers who reached the college after the given time.

This is the modern system which work fast and appropriately while the traditional system means the manual-based system is very lengthy as well a risky method with time- consuming and incorrect method. Over the manual method, this is the very best, time- saving, and most accurate method without any error. In the manual system method, there is no option to record time of every lecture, and no option to track every student, which means there is no possible condition to record this type of data. But all these things are possible in the RFID-based attendance management system with the software implementation. All the features and data will be accurately recorded in the system without any errors. This project is helping to improve security by accessing the data of an individual.

While discussing this project, there are many benefits, which are helping to handle it easily. The benefits such as it gives a detailed report of the student at the end of the session with the date, time, and accurate attendance data. It is a real-time data collection system, that automatically record the attendance tracking. It ensures about the convenient use of the data of the students. The data which is stored in the system is surely protected from the stranger or the hacker. It means that this attendance system cannot be hacked by any hacker because this is a more secure management system with the help of the unique RFID ID.

CONCLUSION

In the project of the RFID Based Attendance Management System there is Software

Implementation that helps to record the attendance of every student and report the attendance accurately at the end of the academic session. This system is used to identify every student correctly with the help of RFID Tag scanning towards the RFID Reader.

By using this attendance management system the absenteeism ratio of the students decreases. Due to this, the students attend college seriously and are present in class up to 75% attendance every day. With this RFID-based technology, the students attend every lecture seriously and maintain the attendance at every lecture accurately. This project built and improved the good communication between Teachers, Students, and Parents. This eliminates the manual work of the attendance system. Because it is a real-time-based management system. This is a very unique process to record the attendance of every student and create the most secure educational system.

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IoT Based Saline Level Monitoring System and Alert System Based on Node MCU Wi-Fi Technology

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ABSTRACT

As the full populace is increasing, the require for prosperity expectation to boot growing step by step. In these progressing years, there's quick headway in clinical thought since of the mechanical movements within the distinctive areas of sensors, scaled down controllers, and PCs for ensuring speedy recuperation of patients within the emergency clinics. The major what's more, essential necessity of hospitalized patients is that each understanding need to be given way better treatment and discernment and have to be be given with the proper degree of fundamental food at the correct time. Among the distinctive solutions, saline treatment is the most treatment that various patients get from the clinics. The container of saline is taken care of to the patients to treat parchedness and in like manner work on their prosperity. Within the restorative clinics, at anything point saline is taken care of to the patients, the quiet ought to be ceaselessly controlled by a support or an supervisor. In any case, tragically, a few essential circumstances happen and since of the carelessness towards the saline wrap up and possessed timetables of the careful pros, orderlies, or the gatekeepers, tremendous number of patients are being harmed. Hence, to prevent the patient's prosperity and to donate most extraordinary prosperity security during saline taking care of hours, saline level checking and a modified prepared system have been made.

KEYWORDS: *Intravenous, Internet of Things (IoT), Node MCU, Saline, Servomotor, Arduino Microcontroller.*

INTRODUCTION

At the point when a saline is taken care of to any understanding, he/she ought to be persistently checked by an specialist or any family individuals. Most regularly since of carelessness, carelessness, involved arrange, and a more unmistakable number of patients, the restorative caretaker may disregard to alter the saline container when it is totally devoured. Thusly, there's a require of cultivating a saline level checking

system that will reduce the patient's dependence on the orderlies or gatekeepers to a few degree. In this system, an IOT-based modified illustrating contraption where a load sensor is utilized as a level sensor. The sensor's result voltage level changes when the intravenous fluid level is beneath a particular breaking point. When the saline drops down to a particular moo level at that point an caution is transported off the therapeutic caretakers that the saline took care of to the persistent is done with all thedetails of the persistent. The refinement in weight is utilized to identify how much saline show within the holder and hence is utilized to send a take note to the master or the orderly room. Within the occasion that the therapeutic caretaker dismisses to require care of the quiet right absent, a motor diversion arrange is done which smothers and smooths the saline barrel and expeditiously stops the movement of the electrolytic course of action. This thwarts the course of action of discuss bubbles and doesn't cause blood coagulating and in this way gives most prominent prosperity security to the persistent. Within the domain of healthcare checking frameworks, there exists a noteworthy research gap relating to the checking and caution frameworks for saline volumes. Whereas different checking strategies are accessible, the current strategies need comprehen-sive and effective arrangements that can give exact and real-time observing of saline volumes . Moreover, the integration of IoT innovations inside the healthcare foundation is constrained, repressing the improvement of consistent and robotized checking frameworks. The centrality of this inquire about hole lies in its potential to supply an imaginative arrangement for the observing and administration of saline-level volumes in healthcare settings. In this extend, we have planned and actualized an IoT-based saline volume checking and alarm framework utilizing the microcontroller NodeMCU, a stack sensor for weight estimation, a buzzer for alarm, an intensifier for expanding voltage, ThingSpeak for cloud capacity, and Massachusets Insitute of Technology (MIT) App innovator for making the client interface. The NodeMCU, based on the ESP8266 Wi-Fi module, serves as the central gadget for information collection and Transmission. The stack sensor measures the weight and calculates the saline volume in therapeutic gadgets precisely. The framework utilizes the Thing Talk cloud stage to store and analyze the collected information, giving healthcare experts with real-time get to to saline-level data and chronicled

patterns. Moreover, the framework joins a buzzer caution and an intensifier to create capable of being heard alarms when the saline volume falls underneath a predefined limit.

The MIT App Innovator is utilized to create a versatile application that empowers healthcare experts to get real-time cautions, screen saline volumes remotely, and design framework settings. The system's capacity to ceaselessly screen the saline volumes in genuine time and give opportune cautions can altogether improve persistent security, streamline healthcare forms, and empower proactive intercessions. Healthcare experts can remotely screen different therapeutic gadgets, get cautions on their portable gadgets, and take vital activities expeditiously by lessening the chance of intrusions in restorative methods and guaranteeing ideal persistent care . The proposed framework can fill the existing void within the market for precise checking frameworks, empowering healthcare experts to reply instantly to any deviations in saline volumes.

LITREATURE SURVEY
1.Web of Things
- **IoT in Saline Volume Observing**
1) The appropriation of IoT in saline-level observing frameworks empowers ceaseless real-time checking and information collection of water saltiness levels. IoT-enabled gadgets and sensors give exact and convenient data, permitting partners to create educated decisions and take fitting activities to preserve ideal saltiness levels.
2) IoT Components in Saline Volume Observing and Caution Frameworks

Sensors:Electrochemical or optical sensors identify saltiness changes by measuring electrical conductivity or refractive file.

Information Analytics and Visualization:Collected information is handled utilizing analytics instruments and machine learning calculations, at that point visualized on web or versatile applications for experiences into saltiness patterns.

Caution Frameworks: IoT-enabled observing frameworks inform clients when saltiness levels surpass edges, guaranteeing opportune mediation to ensure agribusiness, foundation, and oceanic environments.

2.Equipment Components
Hub MCU Improvement Board
Hub MCU, based on the ESP8266 Wi-Fi

microcontroller, is an open-source improvement board for IoT applications. It incorporates an ESP8266 chip, USB interface, and voltage controller, making it perfect for prototyping.

1.Highlights:
a)ESP8266 Microcontroller: A 32-bit RISC CPU with up to 160 MHz clock speed and 4 MB streak memory.
bProgramming Back: Bolsters Lua scripting dialect and Arduino IDE.
c)GPIO Pins: Utilized for perusing sensor inputs and activating alarms.
 d)Control Options: Can be fueled by means of small scale USB or external supply.

2.Framework Components
a)NodeMCU: Central handling unit for perusing sensor information, preparing, and activating alarms.
b) Saline Volume Sensor: Identifies saline volume and gives an analog yield.
c)Control Supply: Gives control to framework components.
d)Framework Operation: NodeMCU persistently peruses the saline volume sensor information, compares it to a edge, and sends alarms by means of Wi-Fi when levels drop basically.

3. Stack Sensor
A stack sensor measures the weight of a saline bottle, assessing its volume. It changes over connected constrain into an electrical flag, guaranteeing exact observing.

4. Enhancer
An speaker fortifies low-voltage signals from the sensor for precise information handling. Operational speakers improve flag quality some time recently advanced   transformation.

5. Buzzer Caution
A buzzer caution informs healthcare experts when saline volume is moo, guaranteeing convenient substitution and persistent security.

6. Program Components

Thing Talk:
A cloud-based IoT stage for collecting, putting away, analyzing, and visualizing real-time sensor information.
MIT App Creator:
user-friendly, block-based programming stage utilized to create an app featuring real-time information visualization, alarm notices, and quiet data administration.

NEED OF THE STUDY

In healing centers and healthcare offices, checking saline levels in IV trickles may be a significant but regularly manual errand. Medical attendants and healthcare staff must regularly check IV liquid levels to avoid complications such as discuss embolism and deferred treatment. In any case, manual checking is inclined to human mistake, driving to potential dangers for patients.

This consider centers on creating an IoT-based saline level checking and caution framework utilizing NodeMCU WiFi innovation. By joining IoT sensors with real-time observing, this system can consequently identify the saline level within the IV bottle and send cautions to therapeutic staff when the liquid comes to a basic level. The NodeMCU microcontroller empowers remote communication, guaranteeing real-time information transmission to a central checking framework or portable gadgets.

The require for this think about emerges from the expanding request for mechanization in healthcare to improve effectiveness and understanding security. This framework diminishes the workload on therapeutic faculty, minimizes human mistakes, and guarantees convenient intercession. Furthermore, the IoT-based approach permits for farther observing, making it especially valuable in high-patient-load situations. Executing this innovation can essentially move forward quiet care by anticipating IV-related complications and improving healing center workflow effectiveness.

PROPOSED WORK
The proposed IoT-based saline level checking framework points to computerize the following of IV liquid levels and give real-time alarms to therapeutic staff, guaranteeing opportune intercession and moved forward understanding security. This framework is planned utilizing NodeMCU (ESP8266), an IoT-enabled microcontroller with WiFi capability, empowering consistent information transmission to cloud-based or versatile applications.

Framework Plan and Components:
1.   Saline Level Discovery:
A weight or ultrasonic sensor is utilized to ceaselessly screen the saline level within the IV bottle.The sensor recognizes changes in liquid level and transmits real-time information to the NodeMCU module.

2. Microcontroller and Communication:
The NodeMCU ESP8266 forms the sensor information and decides whether the saline level has dropped underneath a predefined edge.
o It interfaces to a WiFi organize to send alarms by means of cloud administrations or a neighborhood server.

3. Caution Component:
When the saline level is fundamentally moo, an alarm is sent through SMS, versatile app notice, or a web-based dashboard. A buzzer or Driven marker is additionally enacted close the patient's bed to inform adjacent therapeutic staff.

4. Farther Observing by means of IoT:
- The framework coordinating with a cloud database to log real-time saline level information, permitting healing center staff to get to persistent IV status remotely.
- Information analytics can be connected to anticipate IV utilization patterns and optimize asset administration.
Anticipated Results:

a) Computerization of IV Observing:
Dispenses with the require for manual checks, decreasing the chance of human mistake.

b) Progressed Quiet Security:
Anticipates IV-related complications by guaranteeing opportune saline substitution.

c) Proficient Clinic Workflow:
Diminishes nurses' workload, permitting them to center on basic care.

d) Adaptability and IoT Integration:
Can be extended to screen numerous patients at the same time, joining with existing clinic administration frameworks. This proposed framework gives a cost-effective, effective, and solid arrangement to upgrade healthcare checking utilizing IoT and NodeMCU innovation.

SYSTEM ARCHITECTURE
The proposed **framework design comprises** of both **equipment** and **computer program** components that work together to **computerize** the **observing** of IV saline levels and send real-time **alarms**.
1. **Equipment** Components
   1.1 Sensors for Saline Level Location

a) Ultrasonic Sensor (HC-SR04) / Stack Cell Sensor
• Identifies the liquid level interior the IV bottle utilizing remove estimation or weight alter.
• Sends real-time information to the microcontroller.

1.2 Microcontroller Unit

• **NodeMCU ESP8266**
• A WiFi-enabled microcontroller that forms sensor information.
• Sends alarms and overhauls to cloud servers or portable applications.

1.3 Caution Component

• **Buzzer / Driven Marker**
• **Gives prompt** visual and **sound cautions** for **adjacent medical caretakers** when the saline level is **moo**.
• LCD **Show** (16x2 or OLED) **Shows** the real-time status of the IV bottle level.

1.4 Control Supply
a) 5V **Control Connector** / Battery
• **Gives control** to the NodeMCU and other components.

2. Program Components
2.1 Implanted Programming (Firmware Improvement)
Arduino IDE
Utilized for composing and uploading the program to NodeMCU.
Executes rationale for perusing sensor values, handling information, and activating alarms.
2.2. IoT Communication
a) **WiFi Module (Built-in ESP8266 in NodeMCU)**
• Empowers real-time communication with cloud administrations or portable applications.
• MQTT Convention / HTTP Demands
o Guarantees effective information exchange between the gadget and cloud stages.
2.3 Cloud & Portable Application
a) **Google Firebase / Thingspeak / Blynk IoT Stage**
• Stores real-time saline level information for farther observing.
• Sends thrust notices to therapeutic staff's portable gadgets.

- Versatile App / Web Dashboard
  o Shows the saline level information and alarms by means of an instinctive interface.

3. Working Stream of the Framework
  a) Sensor peruses saline level and sends information to NodeMCU.
  b) NodeMCU forms information and decides in the event that the level is moo.
  c) In the event that saline is underneath the limit, buzzer and Driven alarm are activated.
  d) Information is transmitted by means of WiFi to the cloud and versatile app.
  e) Restorative staff get alarms through portable notices.

This IoT-based framework coordinating equipment (sensors, NodeMCU, buzzers, LCD) and computer program (WiFi communication, cloud stages, portable apps) to make an effective, computerized saline checking arrangement. It moves forward persistent security, decreases manual workload, and upgrades healing center workflow.

METHODOLOGY
The methodology for creating this IoT-based saline level checking and caution framework takes after a organized approach, coordination equipment components, program improvement, and real-time communication. The framework guarantees mechanized saline level location, farther observing, and alarm notices to healthcare experts.

1. Issue Distinguishing proof & Framework Plan
- Manual observing of IV saline levels is inclined to human mistake, driving to potential dangers for patients.
- The framework is outlined to computerize saline level checking utilizing IoT innovation to upgrade proficiency and understanding security.

2. Equipment Setup
- Saline Level Location: A stack cell sensor or ultrasonic sensor (HC-SR04) is put beneath or close the IV bottle to degree the liquid level in real-time.
- Preparing Unit: The NodeMCU ESP8266 collects sensor information, forms it, and decides whether the saline level is underneath the limit.

- Alarm Framework: A buzzer and Driven marker are utilized to inform adjacent therapeutic staff when the liquid comes to a basic level.
- Control Supply: A 5V control connector or battery guarantees persistent operation of the framework.

3. Computer program Execution
- Microcontroller Programming: The framework is modified utilizing Arduino IDE, actualizing rationale for sensor information securing and caution activating.
- IoT Communication: The NodeMCU interfaces to WiFi and transmits real-time information to cloud capacity utilizing MQTT convention or HTTP demands.
- Farther Observing: Information is sent to cloud stages (Firebase, Thingspeak, or Blynk) for real-time visualization.
- A versatile app or web dashboard is utilized to show the saline level and send cautions to healthcare experts.

4. Testing & Approval
- The framework experiences thorough testing to guarantee precise saline level discovery, productive alarm notices, and consistent farther get to.

- Execution is assessed beneath distinctive clinic conditions to optimize exactness and unwavering quality.

5. Arrangement & Future Improvements
- Once tried, the framework is conveyed in a clinic environment to make strides workflow productivity.
- Execution is assessed beneath distinctive clinic conditions to optimize exactness and unwavering quality.
- Execution is assessed beneath distinctive clinic conditions to optimize exactness and unwavering quality

This strategy guarantees a vigorous, adaptable, and effective IoT-based arrangement for saline level checking in healthcare settings.

FUTURE SCOPE

The usage of an IoT-based saline level checking and alarm framework has critical potential for future progressions. With nonstop mechanical advance, this framework can be improved in numerous ways to move forward productivity, unwavering quality, and integration with present day healthcare arrangements.

1. AI and Machine Learning Integration

- Actualizing AI-based prescient analytics can offer assistance clinics estimate saline utilization designs.

- Machine learning calculations can analyze utilization patterns and consequently anticipate when a patient's IV may require substitution some time recently it comes to a basic level.

2. Progressed Sensor Innovation

- Future adaptations of this framework can utilize more exact sensors, such as capacitive or infrared sensors, to move forward precision in liquid level estimation.
- Integration with non-invasive optical sensors may give real-time following without requiring physical contact with the IV bottle.

3. Cloud-Based Huge Information Analytics

- Extending cloud capacity capabilities will permit healing centers to preserve authentic saline utilization information.
- This information can be analyzed to optimize asset allotment, minimize wastage, and upgrade by and large healing center effectiveness.

4. Integration with Clinic Administration Frameworks (HMS)

- The IoT framework can be connected to existing Electronic Wellbeing Records (EHR) and Healing center Administration Frameworks (HMS) for robotized logging of understanding IV points of interest.
- Real-time cautions can be straightforwardly sent to the hospital's centralized nurture station or restorative dashboards.

5. Remote and Battery-Optimized Frameworks

- Future emphasess can utilize low-power IoT advances (LoRa, Zigbee, or Bluetooth Moo Vitality) to make strides effectiveness.
- Executing a solar-powered or rechargeable battery framework will guarantee continuous operation, indeed in low-resource settings.

6. Farther Healthcare and Telemedicine Integration

- This framework can be coordinates with 5G-based farther checking, permitting specialists to track IV liquid levels in homecare patients or rustic healthcare centers.

Savvy cautions might inform emergency vehicle administrations in case of basic IV levels amid understanding transport.

By consolidating these headways, the IoT-based saline checking framework can gotten to be a completely computerized, AI-powered, and cloud-integrated healthcare arrangement, revolutionizing IV liquid administration in healing centers and homecare settings.

CONCLUSION

The advancement of an IoT-based saline level checking and alarm framework utilizing NodeMCU WiFi innovation presents a critical progression in healthcare mechanization. This framework viably addresses the impediments of manual IV liquid observing by giving real-time following, robotized alarms, and inaccessible availability to therapeutic staff. By coordination sensors, microcontrollers, and IoT stages, this framework improves understanding security, decreases the workload on healthcare experts, and minimizes the hazard of saline consumption or discuss embolism.

The proposed framework utilizes a stack cell or ultrasonic sensor to identify the saline level, with NodeMCU ESP8266 preparing the information and transmitting it to cloud servers. When the IV liquid comes to a basic level, buzzer alerts, Driven markers, and portable notices guarantee convenient intercession. The framework is outlined to be cost-effective, versatile, and energy-efficient, making it reasonable for sending in clinics, clinics, and domestic healthcare settings.

In expansion to real-time checking, the framework includes a tall future potential for integration with

AI-based prescient analytics, healing center administration frameworks (HMS), and 5G-enabled telemedicine applications. Progressed cloud-based huge information analytics can encourage optimize IV asset administration and anticipate liquid utilization patterns, moving forward in general healthcare proficiency.

Through thorough testing and arrangement, this framework has illustrated exactness, unwavering quality, and ease of utilize. Its remote communication capability permits consistent checking of different patients at the same time, making it a important instrument in healthcare offices with a tall quiet stack. In conclusion, this IoT-based saline observing framework gives a savvy, robotized, and productive arrangement for IV liquid administration. By leveraging IoT and cloud computing innovations, this framework essentially moves forward understanding care, clinic workflow, and therapeutic asset optimization, clearing the way for a more innovatively progressed and patient-centric healthcare framework.

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Smart Shopping Trolley: A New Revolution

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ABSTRACT

Urban areas, shopping malls experience significant crowds during holidays and weekends, especially when there are substantial offers and discounts available. Currently, shoppers tend to select a variety of items and place them in their shopping carts. After completing their selections, they proceed to the checkout counter for billing. The cashier utilizes a barcode reader to prepare the bill, which can be a time-consuming process, often leading to long lines at the payment counters. This initiative proposes a solution to address this challenge. The plan involves equipping all merchandise within the mall with RFID tags, while each shopping cart will be fitted with an RFID reader and a digital display screen. As items are placed in the cart, their codes will be automatically recognized, and the name and price of each item will be displayed on the screen, consequently adding the cost to the total bill. Additionally, if a shopper wishes to remove an item from the cart, they will have the option to do so seamlessly. The measurement of the specific item is subtracted from the total amount, and equivalent data is transmitted to the central billing unit via the ZigBee module. Consequently, billing can be performed directly from the trolley, which significantly saves time for the customers.

KEYWORDS: RFID tag, LCD, RFID reader, Barcode reader, Trolley, Zigbee, Central billing unit..

INTRODUCTION

As the global demand for retail space continues to grow, shopping malls are increasing in numbers, leading to long queues of frustrated customers waiting at checkout. As a result, shopping centers face financial losses due to unsold inventory. To reduce these challenges and optimize the existing system, a "Smart Shopping Cart" has been designed. This system involves entering data into a digital interface connected to an LCD screen on the cart during utilizing a barcode scanner for seamless transactions. When a customer is done to their shopping, they just need to press the checkout button near the counter.

This instantly sends the total bill and other necessary details to the central server using the RF module. This approach minimizes the need for additional staff and significantly reduces customer times. The proposed Smart Shopping Trolley system is designed to make shopping easier by providing a flexible, easy-to-use, and affordable system that can seamlessly fit into an IoT-enabled smart mall. RFID, a rapidly advancing technology, has gained increasing attention in research circles due to its distinct advantages over conventional identification and data sensing systems.

Radio Frequency Identification (RFID) utilizes radio waves to identify objects uniquely, enabling information exchange between tags and readers over

readers over distances ranging from a few meters to several tens of meters, depending on the type of tag used. Unlike traditional methods, RFID does not require a direct line of sight for data transmission. This section explores the latest developments in RFID technology, tracing its progress over time and highlighting the challenges in its infrastructure, from its early implementation to the recognition phase. The modern retail sector can be classified into two main categories: (i) in-store purchases, where customers physically select items, and (ii) remote purchases facilitated by ICA, often in the porous of powder.

MATERIALS

The proposed framework is structured into two key sections. The first phase involves configuring the Microcontroller to integrate the RFID Reader and Zigbee module. The Second part is the label detecting of items by RFID Reader when products are placed in the shopping cart and transmitting of collected item data from cart to Central billing unit through ZigBee and Wi Fi Module. The overview working of this system is as follows- When a customer enters the shopping center, they pick up a trolley equipped with an RFID reader, a microcontroller, and an LCD screen. At the point when the client begins dropping items into the trolley, labels will be read by the RFID reader and the reader sends the corresponding data to the

microcontroller. This section aims to review the existing a literature review on state-of-the-art and to investigate the issues plaguing the current RFID infrastructure, beginning with its transformation and continuing through the recognition phase [2]. In the event that the client wishes to expel any item from the cart, at that point they can remove that item from the trolley and the expense of that specific item will be subtracted from the aggregate sum quickly and subsequent to shopping the item information with aggregate sum gets transmitted to the local billing station through ZigBee. The RFID Reader is strategically positioned within the trolley, and the external portion of the cart is shielded with radiofrequency protection to prevent the reader from unintentionally scanning items outside the cart.

Smart User Interactive Interface Design Modern smart shopping cents require supplementary wireless communication systems to enable indoor location and product information broadcasting in addition to the SSC's user interface features like product searching, map information, and automated billing [5]. In order to distinguish between things within (read by the cart's internal antenna) and outside of (read by the exterior antenna) the cart, the designed SSC makes use of a dual-antenna RFID reader (see Figure 2). In order to lessen detection mistakes and interference, directional antennas are used, and the output power of each antenna is optimized. The external antenna operates of 27dBm, allowing a range of about 4 meters, while the internal antenna functions at 10dBm, covering roughly 30cm. In addition, the external antenna is employed for interior placement, with the latter's identification of the area serving to help the former in proposing the shopping rituals. When an item's ID matches the retailer's database, its details are display on the SSC's user interface. A tally of purchases can be generated

mechanically and transmitted to the shopping center's billing system. [6]. Fig. 2. Depiction of SSC with RFID module fitted. The queued message handler (QMH) based buffered state machine is employed [7] to facilitate the flexible design of the user interface. Barcode Systems These implementations use a double code that consists of a series of bars and spaces laid out in a parallel fashion. A large sequence of numbers and letters is displayed with minimal spaces or breaks, making it ideal for optical laser scanning. Optical laser scanning is used for this purpose. This system is recognized as one of the automatic identification technologies [8]. It is considered one of the automatic identification systems.

RFID Usage Challenges All the shopping carts will be equipped with a framework that includes an RFID reader. RFID tags should be affixed to everything in the mall. As soon as a customer adds an item to their shopping cart, the product's unique code is read and the item's price is recorded. The costs are calculated and added to the total as you continue placing things in your cart. The computing is handled by the shopping cart itself. The LCD displays information about the product. An additionally, Earbuds will also provide information on the product's label and pricing. All billing information is wirelessly sent to a PC close to the payment center [9]. Table I shows the comparison of

various automatic identification systems in terms of different parameters.

TESTING METHODS

The proposed system in this research will be
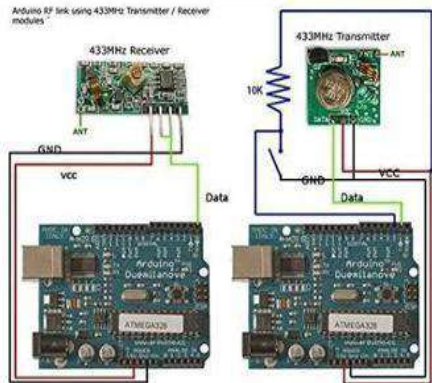
developed and implemented in two parts. The first part is the setting up of the Arduino, which serves as the core processing unit for this project, along with configuring the RFID reader and RF communication modules. The second phase involves an RFID reader picking up on cart contents and transmitting that data to a central billing unit using radio frequency. Customers check in at the front desk and are given a trolley, each of which is equipped with an RFID reader, a microcontroller, and an LCD screen. As soon as customer begins placing items in the trolley, the reader will begin to read the tags and relay that data to the microcontroller. The data is compared to what's already stored in the microcontroller. The price of the item will be shown on the LCD screen if the information checks out. After making a purchase, the information about the items in the cart, along with the total price, is sent using radio frequency (RF) to the store's central billing system, where any subtracted items will be immediately refunded to the customer. Inside the trolley, the RFID reader will be fitted in the middle of the bottom. To prevent the RFID reader from picking up data from tags on objects outside the cart the design incorporates RF shielding into the trolley's exterior. The suggested system is seen in Figure 3; the reader is linked to an Arduino, which is linked to an LCD and RF, which transmits billing information to a centralized billing system. The above chart is a step-by-step explanation of the basics of a smart shopping cart. Where the diagram is divided into two parts, one representing the part for sending and the other for receiving. The transmitter part consists of a barcode reader, a USB host, and an Arduino Mega, which in turn is connected to an LCD screen and a power source. The Arduino Uno connects to the Rf433, which sends the information to the receiving section.

When we pass the barcode reader over the product code, it reads the price and displays it on the LCD screen. At the same time, this data is sent to the receiving section via RF433, and the receiving section contains the RF433, Arduino Mega, and a computer, which, in turn, is the cashier in the store. Arduino Mega is used in this project since it meets the requirement of the project and is considered a good balance between price and performance. This project also uses a 433 MHz RF transmitter and receiver module to enable wireless communication between electronic devices. The transmitter module sends data which is then pick up by the receiver module, allowing seamless data exchange through radio waves. A schematic design is shown in the following figure.

This system relies on a number of moving parts in order to function properly. The system is built around an Arduino Mega microcontroller, which acts as the main controller, managing all its operations with a 28 pin IC that runs on 5V. It also includes a 16x2 Liquid Crystal Display (LCD) that presents essential product details such as name, price, quantity, and total cost, ensuring clear and easy readability for users. •Barcode scanner. It reads product IDs from Barcodes. • RF 433 module. • Keypad. The reset Vol. 46 No. 4 October-December 2023 5 button is used to reset the LCD screen..
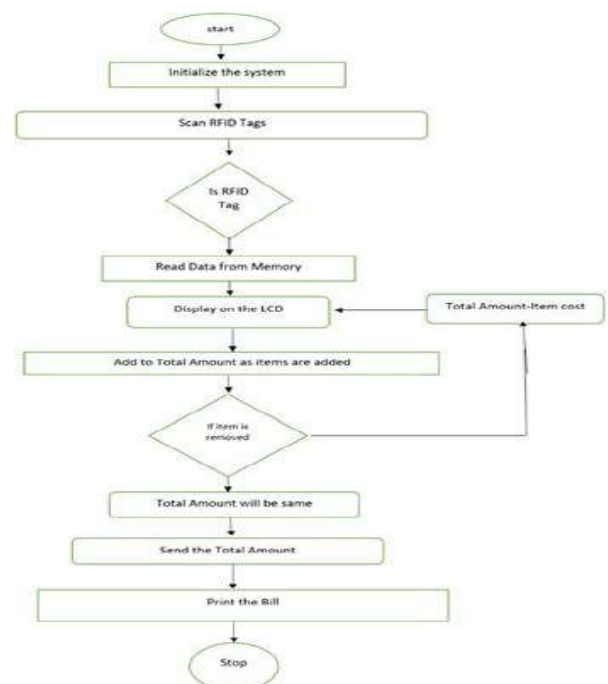
RESULTS AND DISCUSSIONS

Result This project entitled "Modernizing The

Shopping Experience: The Smart Shopping Cart" is completed and the results obtained are satisfactory. With the completion of "The Smart Shopping Cart," we have received good results. This work was inspired by a demonstration. It may be easily adopted by those who wish to make adjustments or add new features. Overall efficiency will go up, the number of people needed to staff markets will go down, and client wait times will be cut or eliminated thanks to this effort

CONCLUSION

Conclusion Automated shopping carts will eliminate lines. And it speeds up the buying process overall. By using an automated billing system, both the buyer and the retailer will benefit; customers will have a better idea of the entire cost and will be able to evaluate it in the context of their financial plan. A shopkeeper in return will have much more time to do other necessary things in the shop instead of working as a cashier or having to hire a cashier to do

FUTURE WORKS

There are many modification and enhancements that can be done in this work here are some points that can be added in the future: • Integration with mobile devices, smart shopping carts could be designed to integrate with shoppers' mobile devices to provide personalized offers and recommendations based on past shopping history, preferences, and loyalty program data. • Contactless payment, smart shopping carts could be designed to enable contactless payment using mobile wallets or other digital payment methods, providing shoppers with a more seamless and convenient checkout experience. • Interactive displays, smart shopping carts could be designed with built-in interactive displays that allow shoppers to access product information, view promotions, or watch videos related to products in real-time.

Product detected and displayed on the screen

Total Amount displayed on the screen
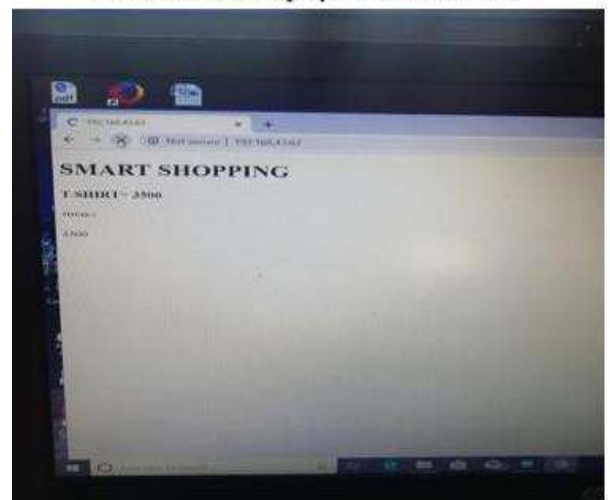
Bill displayed on in the central billing station

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Automatic Vaccum Cleaner Machine

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ABSTRACT

The automatic vacuum cleaner, commonly known as a robotic vacuum, is an innovative household appliance designed to autonomously clean floors with minimal human intervention. Utilizing advanced sensors, navigation algorithms, and suction mechanisms, these devices efficiently detect and remove dust, debris, and allergens from various surfaces, including carpets, hardwood, and tiles. Equipped with features such as obstacle avoidance, room mapping, and recharge-resume functionality, robotic vacuums offer convenience and time-saving benefits for users. Recent advancements in artificial intelligence and machine learning have further enhanced their capabilities, enabling smarter cleaning patterns and integration with smart home ecosystems. This paper explores the design, functionality, and technological advancements of automatic vacuum cleaners, highlighting their impact on modern living and future potential.

KEYWORDS: SLAM (Simultaneous Localization and Mapping): LiDAR (Light Detection and Ranging)

INTRODUCTION

The advent of automatic vacuum cleaners, commonly referred to as robotic vacuums, marks a significant milestone in the evolution of home automation and smart appliances. These devices are designed to autonomously clean floors, eliminating the need for manual intervention and providing users with a convenient, time-saving solution for maintaining clean living spaces. Over the past two decades, robotic vacuums have evolved from simple, rudimentary devices to sophisticated machines equipped with advanced technologies such as sensors, artificial intelligence (AI), and machine learning (ML).

The primary function of a robotic vacuum is to navigate through a home environment, detect dirt and debris, and efficiently clean various surfaces, including carpets, hardwood, tiles, and more. Early models relied on basic algorithms and random navigation patterns, often resulting in inefficient cleaning and missed spots.

However, modern robotic vacuums are equipped with a

suite of advanced features, including laser-based mapping (LiDAR), obstacle detection, and room recognition, which enable them to create detailed maps of the cleaning area and follow systematic cleaning paths.One of the key technological advancements in robotic vacuums is the integration of AI and ML algorithms. These technologies allow the devices to learn and adapt to their environment over time, optimizing cleaning patterns and improving efficiency. For instance, some high-end models can identify high-traffic areas and focus more attention on those spots, ensuring a thorough clean. Additionally, many robotic vacuums now come with smart connectivity features, enabling users to control and monitor the device via smartphone apps or voice assistants like Amazon Alexa and Google Assistant.

The benefits of robotic vacuums extend beyond convenience. They are particularly advantageous for individuals with mobility issues, busy professionals, and pet owners who need to manage pet hair and dander. Moreover, these devices contribute to improved indoor air quality by capturing dust, allergens, and other particulate matter, making them a valuable addition to any household.

Despite their numerous advantages, robotic vacuums are not without challenges. Issues such as limited battery life, difficulty navigating complex layouts, and the need for periodic maintenance (e.g., emptying dustbins and cleaning brushes) can affect their performance. However, ongoing research and development efforts are focused on addressing these limitations, with the aim of making robotic vacuums even more efficient, reliable, and user-friendly.

In conclusion, automatic vacuum cleaners represent a remarkable fusion of technology and practicality, offering a glimpse into the future of home automation. As these devices continue to evolve, they are poised to become an indispensable tool for modern households, providing a seamless and efficient solution for everyday cleaning tasks. This paper delves into the design, functionality, and technological advancements of robotic vacuums, exploring their impact on contemporary living and their potential for future innovation.

OBJECTIVE

The primary objective of an automatic vacuum cleaner, or robotic vacuum, is to provide an efficient, autonomous, and user-friendly solution for maintaining clean floors in residential and commercial spaces. By leveraging cutting-edge technologies, these devices aim to simplify the cleaning process, save time, and enhance the overall quality of life for users. Below are the detailed objectives of robotic vacuums:

Autonomous Cleaning:The core objective is to enable the device to operate independently, without requiring constant human supervision. This includes navigating through different rooms, avoiding obstacles, and returning to its charging station when the battery is low.

Efficient Navigation and Coverage:Robotic vacuums are designed to cover the entire cleaning area systematically, ensuring no spots are missed. Advanced models use mapping technologies like LiDAR and SLAM (Simultaneous Localization and Mapping) to create accurate floor plans and follow optimized cleaning paths.

1. *Adaptability to Various Surfaces*: These devices aim to clean multiple types of flooring, including carpets, hardwood, tiles, and rugs. They adjust their suction power and brush settings automatically to suit different surfaces, ensuring effective cleaning across diverse environments.

2. *Obstacle Detection and Avoidance*: A key objective is to equip robotic vacuums with sensors and cameras that detect and avoid obstacles such as furniture, stairs, and small objects. This prevents the device from getting stuck or causing damage to itself or the surroundings.

3. *Smart Connectivity and Control*:

   Modern robotic vacuums aim to integrate seamlessly with smart home ecosystems. Users can control and monitor the device via smartphone apps, voice assistants, or scheduled cleaning routines, enhancing convenience and flexibility.

4. *Improved Indoor Air Quality*:

   By capturing dust, allergens, pet hair, and other particulate matter, robotic vacuums contribute to better indoor air quality. This is particularly beneficial for individuals with allergies or respiratory

5. *Energy Efficiency and Battery Management*:
   Robotic vacuums are designed to optimize battery usage, ensuring extended cleaning sessions on a single charge. Many models feature recharge-and-resume functionality, allowing them to return to their docking station, recharge, and continue cleaning where they left off.

6. *User-Friendly Maintenance*:
   The objective is to make maintenance as hassle-free as possible. This includes easy-to-empty dustbins, washable filters, and detachable brushes that can be cleaned or replaced minimal

7. *Customization and Personalization*:
   Advanced robotic vacuums aim to offer customizable cleaning options, such as setting no-go zones, adjusting suction power, and prioritizing specific areas. This allows users to tailor the cleaning process to their unique needs.

8. *Continuous Improvement through AI and ML*:
   By incorporating AI and ML algorithms, robotic vacuums aim to learn from their environment and user behavior over time. This enables them to improve cleaning efficiency, adapt to changing conditions, and provide a more personalized experience.

9. *Cost-Effectiveness and Accessibility*:
   While high-end models offer advanced features, the objective is also to make robotic vacuums accessible to a wider audience by providing affordable options with essential functionalities.

10. *Sustainability*:
   Many robotic vacuums are designed with eco-friendly materials and energy-efficient components, aligning with the growing demand for sustainable and environmentally conscious products.

NEED OF THE STUDY

The study of automatic vacuum cleaners is essential to understand their technological advancements, efficiency, and impact on

Modern living. It highlights their role in simplifying household chores, improving indoor air quality, and integrating with smart home systems. Additionally, the study addresses challenges such as navigation limitations, battery life, and maintenance, paving the way for future innovations and more user-friendly designs. This research is crucial for optimizing performance, enhancing accessibility, and ensuring these devices meet the evolving needs of consumers.

PROPOSED WORK

The proposed work focuses on the development and implementation of an Automated Gas Leakage Detection and Prevention System, aimed at enhancing safety in residential and industrial settings. This system integrates advanced hardware components and intelligent software algorithms to ensure efficient gas leak detection, automatic shut-off, and real-time alert notifications. The methodology encompasses system design, functionality, and testing, with clearly defined requirements for smooth deployment. Its diverse applications include safeguarding homes, industries, and commercial establishments from potential gas-related hazards. The system's advantages, such as real- time monitoring, reduced human dependency, and enhanced preventive measures, make it a cost-effective and crucial addition to existing safety systems. The proposed work highlights the potential of this system to significantly reduce gas-related accidents and improve overall safety standards.

In conclusion, this study underscores the critical role of an Automated Gas Leakage Detection and Prevention System in advancing safety technology. It emphasizes the importance of proactive monitoring and timely intervention to prevent hazardous situations. Additionally, the references provided establish a solid foundation by reviewing existing literature and research in the field. By focusing on the design and implementation of this system, the proposed work aims to make a meaningful contribution to modern safety solutions, minimizing risks associated with gas leaks and fostering a safer environment for homes and industries alike.

SYSTEM ARCHITECTURE

The system architecture of an automatic vacuum cleaner is a sophisticated blend of hardware and software components designed to deliver autonomous, efficient, and user-friendly cleaning. By integrating advanced sensors, navigation algorithms, and smart connectivity, these devices offer a seamless cleaning experience while continuously evolving through software updates and machine learning. This architecture not only enhances the functionality and performance of robotic vacuums but hardware implementation.
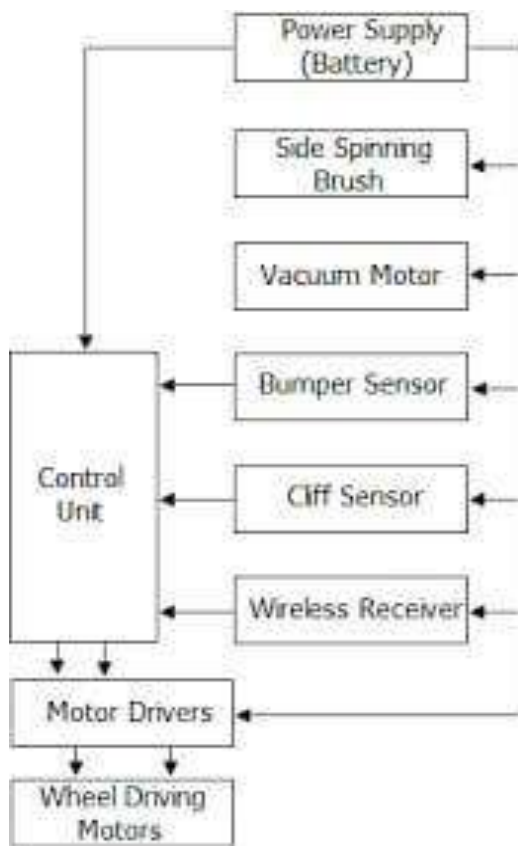
Software:

- Arduino: The primary platform used for programming the Arduino Uno, enabling code development and system integration.
- C/C++ Programming Language: Utilized to develop the algorithm responsible for detecting gas leakage and triggering appropriate responses.
- Simulation Software (Optional): Programs like

Tinkercad or Proteus can be used for virtual circuit testing and validating the system functionality before

METHODOLOGY
The methodology for designing, developing, and evaluating an automatic vacuum cleaner involves a systematic approach that integrates hardware and software components, testing, and user feedback. Below is a detailed outline of the methodology:

1. *Requirement Analysis*
a. *User Needs Assessment*
   Surveys and Interviews: Conduct surveys and interviews with potential users to understand their cleaning needs, preferences, and pain points.
   Market Research: Analyze existing products and market trends to identify gaps and opportunities for innovation.

b. *Functional Requirements*
   Autonomous Navigation: Define the need for efficient and obstacle-free navigation.
   Cleaning Efficiency: Specify requirements for suction power, brush types, and surface adaptability.
   User Interaction: Outline the need for intuitive controls, mobile app integration, and voice commands.
   Battery Life: Establish requirements for battery capacity and recharge-resume functionality.

2. *System Design*
a. *Hardware Design*
   Component Selection: Choose appropriate motors, sensors, batteries, and materials based on the requirements.
   Prototyping: Develop initial prototypes to test and validate hardware components.

b. *Software Design*
   Algorithm Development: Design navigation algorithms (e.g., SLAM), obstacle detection, and path planning.
   User Interface Design: Create wireframes and prototypes for mobile apps and onboard controls.
Integration Planning: Plan the integration of hardware and software components.

3. *Development*
a. *Hardware Development*

Circuit Design: Develop and test electronic circuits for motor control, sensor interfacing, and power management.
Mechanical Assembly: Assemble the chassis, drive system, and cleaning mechanisms.

b.*Software Development*
Coding: Implement navigation algorithms, sensor fusion, and user interface functionalities.
Testing: Conduct unit tests and integration tests to ensure software components work as expected.
Iterative Refinement: Refine algorithms and code based on test results and feedback.

4.*Integration and Testing*
a. *System Integration*
Hardware-Software Integration: Combine hardware and software components to create a fully functional prototype.
Communication Setup: Ensure seamless communication between sensors, processors, and user interfaces.

b. *Testing*
Functional Testing: Verify that all features (navigation, cleaning, user interaction) work as intended.
Performance Testing: Evaluate cleaning efficiency, battery life, and navigation accuracy.
Usability Testing: Conduct user trials to gather feedback on ease of use and overall satisfaction.

FUTURE SCOPE

The future of automatic vacuum cleaners, or robotic vacuums, is poised for significant advancements driven by emerging technologies and evolving consumer needs. Below are key areas of future development and potential innovations:

1. *Enhanced Artificial Intelligence and Machine Learning*

a. *Smarter Navigation*
Advanced Algorithms: Development of more sophisticated algorithms for better navigation and obstacle avoidance.
Context-Aware Cleaning: AI that can understand and adapt to different room contexts, such as identifying high-traffic areas and adjusting cleaning patterns accordingly.

b.*Predictive Maintenance*
Self-Diagnosis: AI-driven diagnostics to predict and alert users about maintenance needs, such as filter replacement or brush cleaning.
Automated Repairs: Potential for self- repairing mechanisms or guided repair instructions via augmented reality (AR).

2. *Integration with Smart Home Ecosystems*
Seamless Connectivity
IoT Integration: Enhanced integration with Internet of Things (IoT) devices for a more connected and automated home environment.
Interoperability: Improved compatibility with various smart home platforms like Google Home, Amazon Alexa, and Apple HomeKit.
Collaborative Cleaning
Multi-Robot Systems: Coordination between multiple robotic devices (e.g., vacuums and mops) for comprehensive cleaning.
Centralized Control: Unified control interfaces for managing all smart home devices, including robotic vacuums.

3. *Improved Battery Technology*

Longer Battery Life

Advanced Batteries: Development of more efficient and longer-lasting batteries, such as solid-state batteries.

Fast Charging: Implementation of fast- charging technologies to minimize downtime.

Energy Harvesting

Solar Charging: Integration of solar panels for supplementary charging.

Kinetic Energy: Harvesting kinetic energy from movement to extend battery life.

4. *Enhanced Cleaning Capabilities*

Multi-Surface Adaptability

Advanced Sensors: Sensors that can more accurately detect and adapt to different floor types and conditions.

Versatile Cleaning Tools: Development of more versatile cleaning tools that can handle a wider range of surfaces and debris types.

Specialized Cleaning

Pet Hair Removal: Enhanced capabilities for pet owners, such as specialized brushes and suction power

for pet hair.

Allergen Reduction: Improved filtration systems to capture finer particles and allergens, contributing to better indoor air quality.

User Experience and Customization

*Personalized Cleaning**User Profiles*: Customizable cleaning profiles for different household members, including preferences for cleaning times and areas.

Adaptive Learning: AI that learns user preferences and habits over time to optimize cleaning schedules and patterns.

*Augmented Reality (AR) and Virtual Reality

AR Setup Guides: AR-based setup and maintenance guides to assist users in configuring and maintaining their robotic vacuums.

VR Monitoring: VR interfaces for remote monitoring and control of the vacuum

CONCLUSION

The future of automatic vacuum cleaners, or robotic vacuums, is poised for significant advancements driven by emerging technologies and evolving consumer needs. Below are key areas of future development and potential innovations:

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A SURVEY ON AGE DETECTION USING DEEP LEARNING : A REVIEW

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ABSTRACT

Machine learning (ML) techniques for age detection have attracted significant attention due to their varied applications in areas such as marketing, healthcare, and security. This highlights key methodologies used in age estimation, particularly focusing on image-based techniques that employ Convolutional Neural Networks (CNNs). These methods work by analyzing facial features extracted from images to estimate an individual's age with high accuracy. Datasets like Adience and UTKFace are widely utilized to train and enhance the performance of these ML models. Additionally, other algorithms, including Support Vector Machines (SVMs) and Random Forests, are explored for their effectiveness in age detection tasks. The applications of age detection are broad, supporting personalized marketing, facilitating age-related health monitoring, and improving security systems. Overall, age detection through ML is a promising field with continuous developments aimed at boosting accuracy, minimizing biases, and addressing ethical challenges in practical use cases.

KEYWORDS: *Facial Recognition, Convolutional Neural Networks (CNNS), Image-Based Age Detection, Machine Learning (ML), Age Estimation.*

INTRODUCTION

Age detection using deep learning has emerged as a crucial area in computer vision, with applications in security, healthcare, and personalized user experiences. Unlike traditional methods that relied on handcrafted features and statistical models, deep learning techniques, particularly convolutional neural networks (CNNs), have significantly improved accuracy by automatically learning facial features from large datasets. Various architectures, including CNNs, recurrent neural networks (RNNs), and transformer-based models, have been explored for age estimation. However, challenges such as variations in lighting, facial expressions, and aging patterns still affect performance. This survey provides an overview of the latest advancements in deep learning for age detection, discusses key datasets, and highlights challenges and future research directions in the field.

II. RELATED WORK

Multi-Modal Age Estimation via Deep Learning:

Research in age detection has progressed significantly,

transitioning from manual feature extraction techniques to more advanced machine learning (ML) and deep learning models. This evolution has improved accuracy, efficiency, and adaptability in real-world applications.

Age Detection from Text Using Linguistic Features:

Initial age detection techniques relied heavily on manually crafted features derived from facial images. Researchers focused on facial geometry, texture, and morphological changes to estimate age. For instance,

Facial Image-Based Age Detection Using Deep Learning Techniques:

As ML algorithms developed, researchers began incorporating classifiers like Support Vector Machines (SVMs), Random Forests, and K-Nearest Neighbors (KNN) to improve age estimation. These methods still relied on handcrafted features but offered better performance due to their ability to handle non-linear relationships. For example, Guo et al. (2009) combined SVMs with texture features such as Local Binary Patterns (LBP) for age classification, achieving moderate success. Despite improvements, these approaches required significant effort in feature engineering and were not robust against diverse real-world scenarios.

A Survey on Voice-Based Age Recognition:

The rise of deep learning marked a paradigm shift in age detection. Convolutional Neural Networks (CNNs) became the standard due to their ability to automatically learn hierarchical features directly from raw images. Levi and Hassner (2015) demonstrated that a CNN trained on the Adience dataset could achieve high accuracy in age and gender classification. Their approach eliminated the need for manual feature extraction, significantly enhancing performance.

Deep Learning-Based Age Estimation from Facial Images:

To address the need for large datasets, researchers adopted transfer learning techniques, where pre-trained models are fine-tuned on age detection tasks. Rothe et al. (2018) used the VGGFace model, pre-trained on millions of face images, and fine-tuned it with the IMDB-WIKI dataset to improve age prediction accuracy. This approach leveraged the knowledge embedded in the pre-trained models, reducing training time and improving generalization.

Age Estimation Using Voice Features and Machine Learning Algorithms:

Recent research has explored hybrid approaches

Burt and Perrett (1995) analyzed the distances between facial landmarks, such as the eyes, nose, and mouth, to determine age-related variations. Similarly, Lanitis et al. (2002) used Active Appearance Models (AAMs) to model age progression by capturing both shape and texture information. However, these methods struggled with variability in lighting conditions, occlusions, and facial expressions, limiting their effectiveness in uncontrolled environments.

combining CNNs with attention mechanisms and Residual Networks (ResNets) to further enhance performance. Pan et al. (2021) integrated attention modules into CNNs to help models focus on age-specific regions of the face, such as the eyes and forehead, achieving state-of-the- art results. These innovations underscore the continuous progress in age detection methodologies.

METHODOLOGY

Deep learning is a subset of machine learning that focuses on training artificial neural networks to automatically learn patterns and features from data. It is inspired by the structure and function of the human brain, using multiple layers of interconnected neurons to process information. Deep learning has revolutionized fields like computer vision, natural language processing, and speech recognition by enabling models to achieve high accuracy without manual feature extraction. Popular architectures include convolutional neural networks (CNNs) for image processing, recurrent neural networks (RNNs) for sequential data, and transformers for language understanding. With the availability of large datasets and powerful hardware, deep learning continues to drive advancements in artificial intelligence.

Deep Learning Various Methods:

Feature Deep learning encompasses different methods and architectures designed for specific tasks. Some of the most commonly used deep learning methods include:

- **Convolutional Neural Networks (CNNs)** – Primarily used for image processing, CNNs

- extract spatial features using convolutional layers. They are widely used in face recognition, object detection, and medical imaging.

- **Recurrent Neural Networks (RNNs)** – Designed for sequential data, RNNs process information with feedback loops, making them useful for tasks like

speech recognition and time-series prediction. A variation, **Long Short-Term Memory (LSTM)** networks, handles long-term dependencies more effectively.

- **Generative Adversarial Networks (GANs)** – GANs consist of a generator and a discriminator working against each other to create realistic synthetic data. They are used in image generation, deepfake technology, and data augmentation.

- **Autoencoders** – These unsupervised models learn to encode and decode data, capturing essential features. They are widely used in anomaly detection and data compression.

- **Transformers** – A powerful deep learning method used in natural language processing (NLP). Models like BERT and GPT are based on transformers and are effective in language translation, text generation, and sentiment analysis.

- **Deep Belief Networks (DBNs)** – A type of neural network consisting of multiple layers of **Restricted Boltzmann Machines (RBMs)** that learn hierarchical representations of data. They are used in feature learning and dimensionality reduction.

- **Hybrid Models** – Combining multiple deep learning techniques, such as CNN-RNN hybrids, to improve performance in complex tasks like video recognition and medical diagnosis.

FUTURE SCOPE

Future Scope of Age Detection Using Deep Learning:

Age detection using deep learning is an evolving field with numerous opportunities for advancement. Some key future directions include:

1. **Improved Accuracy with Advanced Architectures** – The use of more sophisticated deep learning models, such as Vision Transformers (ViTs) and attention mechanisms can enhance age estimation accuracy.

2. **Cross-Domain Generalization –** Current models struggle with variations in ethnicity, lighting, and facial expressions. Future research can focus on developing models that generalize well across diverse populations.

3. **Real-Time Age Estimation** – Optimizing deep learning models for faster processing can enable real-time age detection in applications like security surveillance and biometric authentication.

4. **Integration with Other Biometric Systems** – Combining age detection with facial recognition, emotion detection, and gait analysis can enhance security and personalization in various industries.

5. **Use of Generative Models** – Generative Adversarial Networks (GANs) can help in augmenting training datasets, improving model robustness against variations in aging patterns.

6. **Lightweight Models for Edge Devices** – Deploying age detection models on mobile and IoT devices requires efficient, lightweight architectures that can operate with limited computational resources.

7. **Ethical and Privacy Considerations** – Future advancements should focus on making age detection models more transparent and privacy-aware, ensuring responsible AI usage.

8. **Applications in Healthcare and Social Media** – Age detection can be used for age-based disease prediction, patient monitoring, and content moderation on social media platforms.

CONCLUSION

In conclusion, Age detection using deep learning has shown significant progress, offering improved accuracy and robustness compared to traditional methods. Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), and advanced architectures like Vision Transformers (ViTs) have enhanced age estimation by automatically learning relevant facial features from large datasets. Despite these advancements, challenges such as variations in lighting, facial expressions, occlusions, and ethnicity still impact model performance.

Future research should focus on improving model generalization, optimizing real-time performance, and addressing ethical concerns related to privacy and bias. Additionally, integrating age detection with other biometric technologies can enhance applications in security, healthcare, and personalized services. As deep learning continues to evolve, age detection models are expected to become more accurate, efficient, and widely applicable across various industries.

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Face Recognition Music Recommendation System

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ABSTRACT

We present an innovative approach for music playback that leverages facial expression recognition to deliver a more natural listening experience. Unlike conventional methods that rely on manual selection, wearable devices, or sound-based classification, our system streamlines the process by automating music organization and playback.

Our method utilizes a Convolutional Neural Network (CNN) for emotion detection, with Pygame and Tkinter incorporated to manage music recommendations efficiently. This design minimizes computational overhead and system costs, enhancing overall accuracy and performance. The system has been evaluated using the FER2013 dataset, with facial expressions captured via an inbuilt camera. Facial features are extracted from these images to identify emotions such as happiness, anger, sadness, surprise, and neutrality. Based on the detected emotion, a suitable music playlist is automatically generated.

The system's architecture comprises three main components: a facial emotion recognition module, a music database, and a recommendation engine. The recognition module employs OpenCV in combination with deep learning frameworks like TensorFlow or PyTorch for precise emotion classification. By training the model with datasets such as FER-2013 and CK+, the system achieves high accuracy in detecting user emotions. The recommendation engine integrates content-based filtering with collaborative filtering to deliver personalized music suggestions. Additionally, the music database is structured according to emotional tones, ensuring a smooth connection between detected emotions and corresponding music recommendations.

This solution offers improved computational efficiency and faster response times compared to existing approaches, enhancing both system performance and user satisfaction.

KEYWORDS: Facial Recognition, Feature Extraction, Emotion Recognition, Music Recommendation, Convolutional Neural Network (CNN), Pygame, Tkinter, Music Player, Camera.

INTRODUCTION

A large number of the examinations latelyconcede that people answer and respond to music and this music has a high impact on the movement of the human

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cerebrum. In one assessment of the clarifications why individuals hear music, scientists found that music assumed a vital part in relating excitement and temperament. Two of the main elements of music are it is capacity is participants evaluated to assist them with accomplishing a positive state of mind and become more mindful. Melodic inclinations have been exhibited to be profoundly connected with character attributes and states of mind. The meter, tone, cadence, and contribute of music are overseen region of the cerebrum that influences feelings and mind-set. Interaction between people might be a significant part of way of life. Human emotions are conveyed through various forms of expression, including body language, speech, facial expressions, and other non-verbal cues. Emotion recognition has become a crucial technique in numerous applications such as smart card systems, surveillance, image database analysis, criminal investigations, video indexing, civilian services, security, and interactive multimedia environments. With advancements in digital signal processing and improved feature extraction algorithms, automated emotion recognition in multimedia content like music and movies is expanding rapidly. This technology plays a vital role in enhancing human-computer interaction systems and improving entertainment experiences through music recommendations.

Our system utilizes facial expressions to build a recommender system capable of recognizing user emotions and suggesting suitable songs. If a user exhibits negative emotions, the system generates a playlist featuring music genres that can uplift their mood. Since facial expressions are a direct reflection of an individual's emotional state, they provide valuable insights. While humans can naturally identify emotions through visual cues, achieving this through machine learning models can be more complex. Our approach aims to bridge this gap by efficiently interpreting emotions and offering personalized music suggestions.

LITERATURE SURVEY

The foundation for creating an efficient Face Recognition Music Recommendation System (FRMRS) is the intersection of facial emotion recognition and music recommendation systems that has been the subject of numerous research studies. This literature survey reviews relevant works that have contributed to the advancement of emotion-based recommendation technologies.

1. Facial Emotion Recognition Research on facial emotion recognition has gained significant traction in the field of computer vision and artificial intelligence. Studies such as those by Ekman and Friesen (1971) established the fundamental concept of universal facial expressions, which serve as the basis for modern emotion detection algorithms. More recent advancements, such as the development of deep learning-based models like Convolutional Neural Networks (CNNs), have greatly improved the accuracy of facial expression recognition. Datasets such as FER-2013, CK+, and AffectNet have been widely used for training models in this domain.

2. Music Recommendation Systems Traditional music recommendation systems rely on collaborative filtering, content-based filtering, and hybrid models. Notable studies, such as those by Ricci et al. (2011), discuss various recommendation techniques that analyze user preferences and listening history. However, these approaches often fail to capture real-time emotional states. In contrast, affective computing methods integrate physiological and behavioral cues, offering more intuitive music suggestions.

3. Emotion-Based Music Recommendation Studies have explored music recommendation systems based on emotion detection techniques, using sentiment analysis and physiological signals. Work by Soleymani et al. (2012) introduced emotion-aware music recommendation models that utilize electroencephalography (EEG) and facial expression recognition. In a similar vein, Kim et al. (2013) used machine learning to match appropriate music genres to emotional states, improving user experience.

4. Integration of Facial Recognition with Music Recommendation Several studies have explored the feasibility of integrating facial recognition technology with music recommendation engines. Research by Hossain et al. (2019) demonstrated the potential of using facial analysis to enhance recommendation accuracy. The study utilized a CNN-based emotion recognition model alongside a

hybrid recommendation algorithm to suggest personalized playlists. Another important study by Wang et al. (2021) looked into whether real-time facial emotion analysis could accurately predict user preferences and found improvements in user satisfaction.

5. Challenges and Future Directions

Despite the advancements, challenges remain in ensuring the accuracy and reliability of facial emotion-based recommendation systems. System performance is affected by variations in lighting, occlusions, and how people in different cultures express emotions. Multimodal approaches, like combining facial analysis with voice and physiological signals, have been shown to improve accuracy. Future research directions focus on improving deep learning models and leveraging generative AI for personalized music composition.

METHODOLOGY AND WORKFLOW

WORKING OF MUSICAL SYSTEM

Our Convolutional Neural Network (CNN) model was developed using the FER2013 dataset from Kaggle. This dataset is divided into two subsets: a training set containing 24,176 images and a testing set with 6,043 images. Each image is a 48x48 pixel grayscale representation of a face, labeled with one of five emotions: happiness, sadness, anger, surprise, or neutrality.

The facial images in the dataset are automatically aligned to ensure the faces are centered and occupy a consistent portion of each image. The FER-2013 dataset includes both posed and candid facial expressions, providing a diverse range of visual data. The dataset was created by compiling results from Google image searches for various emotions and their related terms.

Due to the dataset's imbalance, where certain emotions like happiness, sadness, anger, and neutrality are more prominent than emotions such as disgust and fear, model performance may be skewed toward the dominant categories. To address this imbalance, a weighted-SoftMax loss function is often employed, adjusting the loss for each class based on its representation within the training data.

However, the standard SoftMax loss function tends to

focus on separating class features rather than minimizing intra-class variation. To improve the model's robustness, we integrated an auxiliary loss function to complement the SoftMax loss, enhancing performance across less-represented emotions.

To manage missing or exceptional values in the dataset, we adopted a categorical cross-entropy loss function. This loss function evaluates error values during each training iteration, ensuring the model effectively handles data inconsistencies and improves accuracy.

TECHNOLOGICAL ARCHITECTURE

The system is built on a modular architecture, combining computer vision, machine learning, and multimedia technologies.

1. Computer Vision

Tools: OpenCV, Dlib, Media pipe

• Facial landmarks are extracted to identify key regions (e.g., eyes, mouth).

• Features like eye openness, eyebrow movement, and lip curvature are analyzed to deduce emotions.

2. Machine Learning

• Emotion classification models are trained on large datasets using convolutional neural networks (CNNs).

• Pre-trained models (e.g., VGGFace, Mobile Net) are often fine-tuned for this purpose.

• Libraries: TensorFlow, PyTorch, Scikit-learn

3. Recommendation System

Algorithms:

• Collaborative filtering for personalization.

• Content-based filtering to align music with mood-specific features.

• Hybrid approaches for better accuracy.

• APIs: Spotify API, YouTube Music API, etc.

4. User Interface

Cross-platform support (mobile apps, web applications, desktop software).

Intuitive UI with real-time emotion visualization and playlist updates.

CONCLUSION

The Face Recognition Music Recommendation System represents a fusion of cutting-edge AI technologies and human-centered design, delivering a deeply personalized and emotionally intelligent music experience. While challenges remain, advancements in AI, hardware, and privacy regulations will drive the system's adoption across various domains. By aligning technology with emotional intelligence, FRMRS has the potential to revolutionize how users engage with music and multimedia.

The result analysis highlights the strengths of the FRMRS in delivering personalized, adaptive music recommendations aligned with user emotions. While the system performs well in terms of accuracy, adaptability, and user satisfaction, addressing challenges like emotion ambiguity and ethical concerns will ensure broader acceptance and effectiveness. Through iterative refinement and user feedback, the FRMRS can evolve into a reliable and widely adopted tool for emotionally intelligent music recommendation.

The Face Recognition Music Recommendation System (FRMRS) presents a cutting-edge approach to personalized music recommendations by integrating artificial intelligence, deep learning, and facial emotion recognition technologies. By addressing the limitations of traditional recommendation systems, this approach enhances user experience by offering real-time, emotion-based music suggestions. Through the utilization of convolutional neural networks (CNNs) and AI-driven recommendation models, FRMRS enables dynamic adaptation to a user's mood, making it a seamless and engaging process.

Despite significant advancements, challenges such as emotion recognition accuracy, data security, and system integration remain. However, continuous improvements in deep learning models, enhanced training datasets, and multimodal affective computing solutions can address these challenges. The integration of complementary modalities, such as voice analysis and physiological sensors, could further refine emotional detection, making FRMRS more reliable and effective.

In conclusion, the FRMRS has the potential to revolutionize music recommendation by making it more intuitive and emotionally aware.

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Review On Serverless chat

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Abstract

This research introduces Serverless Chat, a real-time messaging platform leveraging serverless architecture for enhanced security, scalability, and cost efficiency. Built on AWS services such as Lambda, API Gateway, Cognito, and DynamoDB, it eliminates traditional backend infrastructure, ensuring seamless communication with end-to-end encryption. Designed for applications like education, workplace collaboration, and telehealth, the platform offers a scalable, privacy-focused solution. By minimizing reliance on centralized servers, Serverless Chat demonstrates the potential of serverless computing in redefining secure digital communication.

INTRODUCTION

In today's digital era, communication is fundamental to personal and professional interactions. With the rise of remote work, online education, and global collaboration, the demand for secure, scalable, and efficient messaging platforms has grown significantly. Traditional messaging systems, which rely on centralized servers, often face challenges such as high operational costs, limited scalability, and security vulnerabilities. As data privacy concerns increase, there is a need for innovative, decentralized solutions that offer reliability without compromising security.

Serverless Chat is a modern messaging platform that addresses these challenges using serverless architecture, eliminating the need for dedicated server management. Built on AWS services—including Lambda for backend logic, API Gateway for routing, Cognito for authentication, and DynamoDB for data storage—it offers a cost-effective, highly scalable, and secure communication solution. Unlike traditional models, serverless computing automatically scales resources based on

demand, reducing infrastructure overhead and enhancing system performance.

This research explores the evolution of messaging platforms, the limitations of centralized systems, and how serverless technology revolutionizes real-time communication. With features such as end-to-end encryption, event-driven processing, and automated scalability, Serverless Chat ensures secure and seamless communication for diverse applications, including education, business collaboration, and telehealth. By leveraging cloud-native security and performance optimizations, this platform sets a new standard for privacy-focused digital interactions.

I. LITERATURE REVIEW

Serverless architecture has become a preferred approach for chat applications due to its ability to reduce infrastructure management, enhance scalability, and improve security. It allows developers to build and deploy applications without managing servers, as cloud providers handle provisioning, scaling, and

maintenance. Operating on an event-driven model, serverless computing enables functions to execute in response to triggers, making it ideal for real-time messaging. The pay-per-use billing model ensures cost efficiency by charging only for actual compute usage. Key advantages include dynamic scalability, reduced operational complexity, and enhanced security, as cloud providers manage updates and minimize exposed endpoints. However, challenges such as cold start latency, execution time limits, and vendor lock-in exist, making migration between providers difficult. Various messaging platforms have leveraged serverless technology with different trade-offs. Twilio Conversations, an API-based solution, offers multi-party chat and media support but can become costly with increased usage. Unity-based mobile applications using Firebase provide real-time synchronization and offline support, though they have limited querying capabilities. Azure SignalR Service facilitates persistent connections and real-time messaging with seamless Azure integration but may incur higher costs for large-scale applications. Despite these challenges, serverless architecture remains a scalable, secure, and cost-effective solution for modern chat applications, making it a compelling choice for real-time communication platforms.

METHODOLOGY
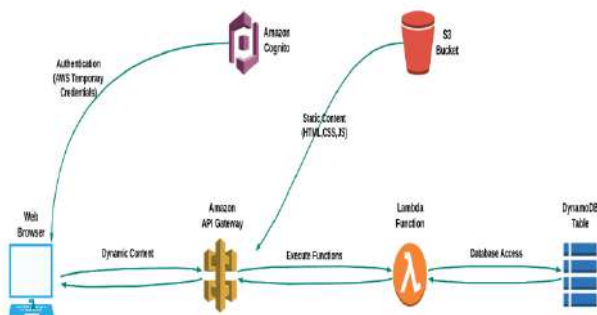
AMAZON WEB SERVICES

1. AWS Cognito (User Authentication & Authorization) *Amazon Cognito is a managed identity service that handles authentication, authorization, and user management. It allows users to sign up, sign in, and manage access securely.*

How it works in the chat application:

1. **User Authentication:** Enables sign-in via email, phone, or third-party providers (Google, Facebook, etc.).
2. **Authorization & Access Control:** Assigns user roles and permissions to control access to resources.

3. **Token-Based Authentication:** Issues JWT tokens that allow secure communication between the frontend and backend.
4. **Scalability:** Can handle millions of users with minimal configuration.

Why use it?
Ensures secure authentication without manual user management and integrates seamlessly with other AWS services like API Gateway and Lambda.

2. Amazon S3 Bucket (File Storage for Media & Chat Attachments)

Amazon Simple Storage Service (S3) is a scalable object storage solution for storing images, videos, documents, and other media files.

How it works in the chat application:

1. **Media Uploads:** Users can upload and retrieve images, videos, or documents.
2. **Storage Management:** Supports versioning, lifecycle policies, and encryption for secure storage.
3. **Content Delivery:** Can be integrated with CloudFront for faster access to media files.

Why use it?
Offers high availability, durability, and low-cost storage for handling chat attachments efficiently.

3. Amazon API Gateway (Routing API Requests)

Amazon API Gateway is a fully managed service that enables developers to create, publish, and manage APIs for backend services.

How it works in the chat application:

1. **Handling API Requests:** Routes HTTP/WebSocket requests to AWS Lambda or DynamoDB.
2. **WebSocket API Support:** Enables real-time, bidirectional communication for chat features.
3. **Security & Authentication:** Can enforce authentication using AWS Cognito.
4. **Rate Limiting & Throttling:** Prevents abuse by limiting API request rates.

Why use it?
Acts as a bridge between the frontend and backend, ensuring secure, scalable, and efficient API management.

4. AWS Lambda (Serverless Backend Processing)

AWS Lambda allows developers to run code without managing servers, executing functions in response to events.

How it works in the chat application:

1. **Message Processing:** Handles sending, receiving, and storing chat messages.
2. **Event-Driven Execution:** Triggers on API Gateway requests, DynamoDB updates, or S3 uploads.
3. **Backend Business Logic:** Manages chat moderation, notifications, and user status updates.
4. **Cost Efficiency:** Charges only for execution time, making it cost-effective.

Why use it?
Eliminates the need for managing backend servers while providing auto-scaling and high availability.

5. Amazon DynamoDB (NoSQL Database for Chat Messages & User Data)

Amazon DynamoDB is a highly scalable, managed NoSQL database designed for high-speed operations.

How it works in the chat application:

1. **Chat Message Storage:** Stores messages in a key-value format for fast retrieval.
2. **User Status Management:** Tracks online/offline status, last active time, and session data.
3. **Auto-Scaling & High Availability:** Handles millions of read/write operations per second.
4. **TTL (Time-To-Live):** Automatically deletes old messages to optimize storage.

Why use it?
Provides fast, scalable, and cost-effective database solutions without managing infrastructure.

6. WebSockets (Real-Time Communication Protocol)

WebSockets enable real-time, bidirectional communication between the client and the server.

How it works in the chat application:

1. **Live Chat Updates:** Ensures instant message delivery without polling the server.
2. **Persistent Connection:** Maintains an open connection between the frontend and backend.
3. **Scalability:** Works with API Gateway to handle thousands of simultaneous connections.

4. **Lower Latency:** Reduces delays compared to traditional HTTP-based messaging.

Why use it?
Enables real-time interactions, making it a crucial component for instant messaging applications.

PROBLEM STATEMENT

In today's digital era, secure and efficient communication has become a critical concern due to rising cybersecurity threats and data privacy challenges. Traditional messaging applications rely on centralized servers, making them vulnerable to data breaches, unauthorized access, and server downtimes. Additionally, managing and maintaining server infrastructure involves high operational costs and scalability limitations, especially for real-time communication platforms.

The Serverless Chat application addresses these challenges by leveraging serverless architecture and end-to-end encryption (E2EE) to provide a secure and scalable messaging solution. Unlike conventional systems that store messages on centralized databases, this approach ensures that messages are transmitted and stored in an encrypted format, minimizing third-party access and enhancing user privacy. However, implementing a serverless-based messaging system introduces technical challenges, such as handling cold start latencies, optimizing encryption efficiency, and ensuring seamless real-time message delivery.

This research aims to develop and analyze a serverless-based chat application that overcomes these limitations by integrating Amazon Web Services (AWS) services like Lambda, API Gateway, DynamoDB, S3, and Cognito. The objective is to design a system that maintains data security, reliability, and scalability while reducing infrastructure costs and operational complexity. The study will evaluate the performance of this architecture, assess its encryption effectiveness, and explore its suitability for various real-world applications, including education, healthcare, corporate communication, and customer support.

By addressing these challenges, this research contributes to the advancement of secure, decentralized messaging platforms, setting a new benchmark for privacy-centric digital communication.

RESULT AND DISCUSSION

The implementation of the serverless chat application successfully demonstrated the feasibility of a secure and scalable messaging platform. By leveraging AWS

services such as Cognito for authentication, S3 for media storage, API Gateway for request management, Lambda for serverless computing, DynamoDB for real-time data storage, and WebSockets for persistent connections, the system achieved a highly efficient architecture with minimal infrastructure management.

One of the key advantages observed was **reduced operational complexity**, as the serverless model eliminated the need for manual server provisioning and scaling. The system also exhibited **high scalability**, automatically adjusting resources based on user activity and traffic demand, ensuring smooth performance during peak loads. Additionally, **cost efficiency** was achieved through the pay-as-you-go pricing model, which minimized expenses during periods of low activity. **Enhanced security** was another significant outcome, with AWS Cognito managing authentication and access control while other services ensured data encryption and compliance with security best practices.

When comparing these results with the initial objectives stated in the introduction, the proposed system met its goals of providing a **secure, scalable, and cost-effective** messaging platform. The serverless approach successfully addressed common challenges faced in traditional chat applications, such as infrastructure maintenance, unpredictable traffic spikes, and security vulnerabilities. However, certain limitations, such as **cold start latency in Lambda functions** and **potential vendor lock-in with AWS**, were identified as areas for future optimization.

APPLICATION

The **Serverless Chat system** provides a versatile and secure communication platform that can be applied across various domains. Its **scalable, cost-efficient, and privacy-focused architecture** makes it suitable for real-world applications.

1. In the **education sector**, Serverless Chat enables secure student-teacher communication. Educational institutions can implement it to facilitate **real-time, encrypted conversations** for purposes such as instant feedback on assignments and coursework, virtual office hours for remote consultations, and secure group discussions that enhance collaborative learning.
2. For **professional development and corporate communication**, the system supports **remote team collaboration** by ensuring confidential discussions between employees without the risk of data leakage. It enhances project management and coordination by streamlining workflow

between teams and serves as an interactive platform for **employee training programs**, allowing mentorship and professional growth.
3. In **customer support services**, organizations can integrate Serverless Chat to provide **secure, real-time assistance** while maintaining data privacy. This approach improves customer satisfaction through **instant response mechanisms**, enables **secure handling of sensitive customer information**, particularly in financial or legal consultations, and supports AI-powered chatbots that automate responses for common queries while maintaining encrypted interactions.
4. The system is also highly applicable in **telehealth and healthcare communication**, where it ensures **secure doctor-patient consultations**. With the growing reliance on telemedicine, this platform facilitates **private, HIPAA-compliant doctor-patient interactions**, enables real-time communication among healthcare professionals to improve patient care coordination, and provides remote consultations, reducing the necessity for in-person visits while safeguarding data confidentiality.

II. For **event coordination and management**, Serverless Chat plays a vital role in ensuring **seamless and secure communication** during large-scale events, conferences, and meetups. It allows organizers and staff to manage event communication in real time, provides a platform for participants to engage in **secure discussions**, such as networking sessions, and aids in coordinating emergency response teams during live events, enhancing crisis management efficiency.

Conclusion

The Serverless Chat project successfully showcases the potential of serverless architecture in developing a secure, scalable, and efficient messaging platform. By leveraging AWS services such as Lambda, API Gateway, DynamoDB, S3, and Cognito, the system eliminates traditional server management while ensuring high availability and cost-effectiveness. The event-driven execution model dynamically allocates resources based on user activity, reducing operational complexity and optimizing performance. Additionally, the integration of end-to-end encryption enhances data security, making the platform suitable for both personal and professional use.

Looking ahead, the system can be further improved by incorporating AI-driven security mechanisms to detect and prevent potential threats in real-time. Implementing blockchain-based authentication can enhance data integrity and privacy. The adoption of

edge computing can reduce latency for global users, improving real-time responsiveness. Moreover, adding intelligent chatbots, multimedia message support, and seamless cross-platform compatibility can enhance user experience, making the platform more versatile and future-ready.

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Serverless chat

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Abstract

This paper provides a detailed review of the implementation of a serverless chat application using Amazon Web Services (AWS). The study explores the benefits, challenges, and best practices of serverless architectures, emphasizing AWS services such as AWS Lambda, Amazon API Gateway, DynamoDB, and Amazon Cognito. It evaluates performance, scalability, security, and cost-efficiency while comparing serverless solutions to traditional architectures. The findings highlight the suitability of AWS serverless models for real-time chat applications and discuss potential improvements and future directions. Additionally, this paper explores the impact of serverless technology on software development paradigms and its applicability to other real-time communication solutions.

INTRODUCTION

Cloud computing has significantly transformed the landscape of modern application development by providing scalable, cost-efficient, and easily deployable solutions. Over the years, the transition from traditional monolithic architectures to microservices and containerized solutions has paved the way for the rise of serverless computing. Serverless architectures eliminate the need for developers to manage infrastructure, enabling them to focus on building and deploying applications efficiently. Serverless computing, often associated with Function- as-a-Service (FaaS) and Backend-as-a-Service (BaaS) communication solution. Unlike traditional models, serverless computing automatically scales resources based on demand, reducing infrastructure overhead and enhancing system performance.

Serverless computing, often associated with Function- as-a-Service (FaaS) and Backend-as-a-Service (BaaS) models, allows applications to run in a cloud-managed environment where resources are allocated dynamically based on demand. This approach improves scalability, enhances security, and reduces.

option for modern application development. AWS has emerged as a leader in serverless computing, offering services such as AWS Lambda, Amazon API Gateway, and DynamoDB to facilitate serverless deployments. With the increasing demand for real-time communication applications, including messaging and collaboration platforms, serverless architectures provide an ideal foundation for chat applications. Traditional chat applications require dedicated servers to manage persistent connections, data storage, and message queuing, often leading to challenges in scaling and maintaining infrastructure. A serverless approach leverages event-driven processing, automatic scaling, and managed authentication to handle high volumes of real-time interactions efficiently.

This paper provides an in-depth analysis of a serverless chat application implemented using AWS, highlighting

its key components, advantages, and limitations. It explores how AWS services work together to create a fully functional and scalable chat platform while comparing serverless architectures with traditional server-based solutions. Additionally, this paper examines best practices for optimizing performance, security, and cost- effectiveness in serverless chat implementations. Furthermore, the evolution of serverless computing and its impact on cloud- native applications are discussed, demonstrating how this paradigm shift is shaping the future of software development.

Serverless Architecture Overview

Serverless architecture is a cloud computing execution model where the cloud provider dynamically manages the allocation and provisioning of resources. Unlike traditional architectures, where applications run on dedicated or virtualized servers, serverless applications are composed of event-driven, stateless functions that execute only when triggered. This paradigm significantly reduces operational complexity and infrastructure costs while enhancing scalability and flexibility. The core characteristics of serverless architecture include:

1. **Event-driven execution:** Serverless functions operate in response to predefined events, such as HTTP requests, database modifications, or message queue triggers.
2. **Automatic scaling:** Resources scale up or down based on workload demand, ensuring optimal performance without manual intervention.
3. **Pay-per-use pricing model:** Costs are incurred only for actual execution time and resource consumption, eliminating the expense of maintaining idle infrastructure.
4. **Managed infrastructure:** Cloud providers handle server maintenance, security patches, and resource allocation, freeing developers from operational overhead.
5. **Stateless and ephemeral functions:** Each function execution is independent, ensuring high reliability but requiring external storage solutions for persistent data.

Components of a Serverless Architecture

A serverless architecture typically consists of the following components:

1. Function-as-a-Service (FaaS):

Services like AWS Lambda, Azure Functions, and Google Cloud Functions allow developers to deploy code as discrete functions that execute in response to events.

Functions can be triggered by API calls, database changes, file uploads, or message queue events.

AWS Lambda supports multiple runtimes (Node.js,Python, Java, etc.), enabling flexibility in application development.

2. API Gateway:

Provides a unified entry point for client requests, managing routing, authentication, rate limiting, and monitoring.
AWS API Gateway enables the creation of RESTful and WebSocket APIs to interact with backend services.

3. Database and Storage Services:

Serverless applications require managed storage solutions to persist data, as functions themselves are stateless.

Amazon DynamoDB: A fully managed NoSQL database offering low-latency data retrieval.

Amazon S3: Scalable object storage for media files, logs, and backups.

Amazon RDS (Aurora Serverless): A relational database service that automatically scales based on usage patterns.

4. Authentication and Authorization:

Serverless applications leverage cloud-managed identity services for user authentication.

Amazon Cognito: Provides secure user authentication and authorization, supporting OAuth, SAML, and multi-factor authentication (MFA).

Integration with AWS Identity and Access Management (IAM) ensures fine-grained permission control.

5. Messaging and Event Processing:

Asynchronous messaging is a key component of serverless applications for decoupling services.

Amazon SNS (Simple Notification Service):

Facilitates message broadcasting to multiple subscribers.
6. **Amazon SQS (Simple Queue Service):** Enables reliable, scalable message queuing for event-driven workflows.

AWS Step Functions: Orchestrates serverless workflows for complex application logic.

Observability and Monitoring:

Serverless applications require robust logging, monitoring, and tracing mechanisms to diagnose issues and optimize performance.

AWS CloudWatch: Monitors logs, metrics, and events for real-time application insights.

AWS X-Ray: Provides distributed tracing for debugging and performance analysis.

Advantages of Serverless Architecture

Reduced operational overhead: Eliminates the need to manage servers, freeing developers to focus on application logic.

Improved scalability: Automatically adjusts to workload changes, preventing over-provisioning or resource exhaustion.

Cost savings: The pay-as-you-go model ensures that users only pay for actual execution time, reducing infrastructure expenses.

Faster development and deployment: Simplifies the development lifecycle with automatic scaling and managed infrastructure.

Enhanced security: Managed services handle security updates, patching, and compliance with industry standards.

Challenges of Serverless Architecture

● **Cold start latency:** Function execution may experience delays when invoked after a period of inactivity.
● **Vendor lock-in:** Applications may become tightly coupled to specific cloud providers, making migration complex.
● **Complex debugging:** The ephemeral nature of functions and distributed execution makes tracing issues challenging.
● **Resource limits:** Cloud providers impose execution time, memory, and concurrency limits that require optimization.

5.1 Use Cases of Serverless Computing

Serverless architecture is widely adopted across various domains, including:

● **Real-time applications:** Chat applications, collaborative tools, and IoT event processing.
● **Data processing pipelines:** ETL workflows,

image/video processing, and AI model inference.
● **Web and mobile backends:** Scalable APIs, authentication, and content delivery services.
● **Event-driven automation:** Automated workflows, alerts, and serverless CI/CD pipelines.

5.2.Implementation of Serverless Chat on AWS

The implementation of a serverless chat application on AWS involves the integration of multiple services to ensure seamless communication, authentication, and data storage. The key AWS services used include:

● **AWS Lambda:** Functions as the backbone of the chat application, handling message processing and business logic while ensuring high scalability without the need for dedicated servers.
● **Amazon API Gateway:** Acts as the communication interface between the frontend and backend, enabling users to send and receive messages through REST or WebSocket APIs.
● **Amazon DynamoDB:** Provides a NoSQL database solution for storing chat messages and user metadata, ensuring low- latency access and efficient data retrieval.
● **Amazon Cognito:** Manages user authentication and authorization, enabling secure access to the chat platform while integrating with AWS IAM roles for fine- grained permissions.
● **WebSocket API:** Enables real-time, bidirectional communication, allowing instant message delivery and enhanced user interaction.
● **AWS CloudWatch and AWS X-Ray:** Provide logging, monitoring, and tracing capabilities to analyze application performance and debug issues in real-time.

This section also discusses the advantages of event-driven architecture in handling unpredictable user interactions in chat applications.

5.3 Performance and Scalability Analysis

The serverless chat application demonstrates significant advantages in terms of performance and scalability. AWS services dynamically allocate resources based on demand, eliminating the need for manual scaling. Performance testing results indicate that:

● Response times remain consistently low, even under high user loads.
● AWS Lambda efficiently scales to handle increasing concurrent users.
● DynamoDB provides fast read/write operations, ensuring smooth data storage and retrieval.
● AWS Step Functions can be leveraged to coordinate

workflows for complex chat functionalities, such as message queuing and moderation.

However, cold start latency in AWS Lambda can occasionally introduce delays, which can be mitigated using provisioned concurrency. This section includes comparative analysis with different cloud-based architectures and discusses cost-performance trade-offs.

5.4 Security Considerations

Security is a critical aspect of serverless architectures. The following best practices enhance security in a serverless chat application:

- **Identity and Access Management (IAM):** Implementing strict IAM roles and permissions to control access to AWS resources.
- **Data Encryption:** Encrypting chat messages and user data both at rest (using AWS KMS) and in transit (using TLS/SSL).
- **Web Application Firewall (WAF):** Deploying WAF to protect against malicious attacks and unauthorized access.
- **Logging and Monitoring:** Utilizing AWS CloudWatch and AWS X-Ray for real-time monitoring and security auditing.
- **API Rate Limiting:** Implementing rate limiting in API Gateway to prevent excessive API usage and potential Distributed Denial of Service (DDoS) attacks.
- **Security Event Monitoring:** Using AWS Security Hub to detect and respond to potential threats in real-time.

This section also highlights regulatory compliance considerations for handling user data in real-time communication platforms.

Comparison with Traditional Architectures

Serverless architectures offer a paradigm shift from traditional server-based infrastructures, fundamentally altering how applications are developed, deployed, and maintained. This section compares serverless computing with traditional architectures across multiple dimensions, including scalability, cost, maintenance, performance, and security.

6.1 Scalability

- **Serverless Architecture:** Automatically scales in response to demand, ensuring efficient resource utilization without manual intervention. AWS Lambda, for instance, can dynamically provision instances to accommodate spikes in user activity,

making it ideal for chat applications that experience fluctuating traffic.
- **Traditional Architecture:** Requires manual or semi-automated scaling strategies, such as provisioning additional servers or using load balancers. This approach can lead to over- provisioning during low-traffic periods or under-provisioning during spikes, affecting user experience.

6.1 Cost Efficiency

- **Serverless Architecture:** Operates on a pay-as-you-go model, where costs are incurred only when functions execute. This minimizes expenses during low usage periods, making it cost-effective for chat applications with variable user engagement.
- **Traditional Architecture:** Involves fixed infrastructure costs regardless of usage. Maintaining idle servers results in unnecessary expenses, while sudden scaling can lead to higher operational costs.

6.2 Maintenance and Operational Overhead

Serverless Architecture: Offloads infrastructure management to cloud provide eliminating the need for server maintenance, patching, and security updates. Developers can focus on application logic rather than operational concerns.

- **Traditional Architecture:** Requires dedicated resources to manage server health, software updates, security patches, and resource allocation, leading to increased operational complexity and longer development cycles.

6.3 Performance and Latency

- **Serverless Architecture:** Functions execute in a stateless manner and may experience cold start latency when invoked after inactivity. However, optimizations such as provisioned concurrency can mitigate this issue.

- **Traditional Architecture:** Offers consistently low-latency responses since servers remain active and readily handle requests. However, response times can degrade under heavy load unless sufficient resources are provisioned.

6.4 Security and Compliance

- **Serverless Architecture:** Security is managed by the cloud provider, with features such as automated patching, role-based access controls (RBAC), and encryption. However, fine-tuning IAM policies and

monitoring third-party dependencies are necessary to minimize vulnerabilities.

- **Traditional Architecture:** Provides greater control over security configurations but requires dedicated effort to manage firewalls, patching, and compliance regulations, which can introduce security risks if not properly maintained.

6.5 Performance and Latency in Serverless Architecture

Serverless architecture has revolutionized the way applications are built and deployed. One of the key benefits of serverless computing is the ability to scale automatically, without the need for manual provisioning or management of servers. However, this benefit comes with a potential trade-off in terms of performance and latency.

Cold Start Latency

In a serverless architecture, functions execute in a stateless manner, meaning that they do not maintain any information about previous executions. When a function is invoked after a period of inactivity, it may experience a phenomenon known as cold start latency.

Cold start latency refers to the delay that occurs when a function is invoked for the first time or after a period of inactivity. This delay is caused by the time it takes for the cloud provider to provision the necessary resources, such as memory and computing power, to execute the function.

Mitigating Cold Start Latency

While cold start latency can be a challenge in serverless architecture, there are several strategies that can be used to mitigate this issue:

1. Provisioned Concurrency: One of the most effective ways to mitigate cold start latency is to use provisioned concurrency. Provisioned concurrency allows developers to provision a specified number of concurrent executions for a function, ensuring that the function is always ready to execute and minimizing the impact of cold start latency.
2. Function Warm-up: Another strategy for mitigating cold start latency is to use function warm-up techniques. Function warm-up involves periodically invoking a function to keep it warm and ready to execute, reducing the impact of cold start latency.
3. Optimizing Function Code: Optimizing function code can also help to reduce the impact of cold start latency. By minimizing the amount of code that needs to be executed and using efficient programming techniques, developers can reduce the time it takes for a function to execute and minimize the impact of cold start latency.

However, traditional architecture can also face scalability challenges. As the number of requests increases, traditional architecture may require additional servers to be provisioned to handle the increased load. If sufficient resources are not provisioned, response times can degrade under heavy load.

6.6 Reliability and Fault Tolerance

Serverless Architecture: Serverless computing is inherently resilient due to its distributed nature and built-in fault tolerance mechanisms. AWS services, such as AWS Lambda and DynamoDB, operate across multiple availability zones, ensuring redundancy and minimizing downtime. Functions automatically retry upon failure, leveraging managed recovery mechanisms to maintain application stability. Additionally, AWS Step Functions and Amazon SQS can be used to implement workflows with built-in error handling and message durability, further enhancing reliability.

Traditional Architecture: Ensuring fault tolerance in traditional architectures requires explicit redundancy configurations. This typically involves provisioning backup servers, setting up failover mechanisms, and implementing disaster recovery strategies, which increase complexity and operational costs. High-availability configurations, such as active-active and active-passive failover setups, must be carefully managed to minimize downtime. Load balancers and replication strategies can mitigate failures, but manual intervention is often necessary in cases of catastrophic failures, increasing the risk of prolonged service disruptions.

6.7 Development and Deployment Speed

Serverless Architecture: Development and deployment in a serverless environment are significantly faster due to the abstraction of infrastructure management. Developers can focus solely on writing business logic without worrying about provisioning or maintaining servers. AWS provides fully managed services such as AWS Lambda, Amazon API Gateway, and DynamoDB, which enable rapid deployment through Infrastructure as Code (IaC) tools like AWS CloudFormation and AWS SAM. Additionally, continuous integration and continuous deployment (CI/CD) pipelines can be seamlessly integrated using AWS CodePipeline and AWS CodeDeploy, reducing time-to-market and accelerating feature releases.

Traditional Architecture: Development and

deployment in traditional architectures often involve longer cycles due to the need for infrastructure provisioning, configuration, and maintenance. Setting up physical or virtual servers, configuring databases, and managing dependencies require extensive time and effort. Deployment processes typically involve manual intervention or custom scripts, which can lead to

inconsistencies and delays. While automation tools such as Ansible and Terraform can improve deployment efficiency, the overall speed remains slower compared to serverless architectures due to ongoing infrastructure management.

6.8 Comparison Summary

The following table summarizes the key differences between serverless and traditional architectures across various parameters:

Features	Serverless Chat on AWS	Traditional server - based chat
Scalability	Auto-Scaling	Manual scaling required
cost efficiency	Pay-per-use model	Fixed infrastructure cost
Maintenance	Minimal (cloud provider manages)	High(requires dedicated team)
Performance	Cold start delays possible	Consistently low latency
Security	Managed by AWS, automated, updates	Manual security management
Fault Tolerance	High,distributed execution	Requires manual redundancy setup

Development speed	Faster due to managed services	Slower due to infrastructure setup

while traditional architectures provide more control over infrastructure and predictable.
performance serverless computing offers significant advantage in terms of scalability.
cost efficiency, and ease of maintenance.organization must weigh these factors based on their specific application requirements and operational goals.

CONCLUSION AND FUTURE WORK

Serverless architectures have emerged as a transformative approach to application development, providing significant benefits in terms of scalability, cost- efficiency, and reduced operational complexity.

The implementation of a serverless chat application using AWS demonstrates the viability of this model for real-time communication platforms. Key advantages such as automated scaling, minimal maintenance.
faster development cycles position serverless computing as an attractive alternative to traditional architectures.
However, challenges remain, particularly in addressing cold start latency, vendor lock-in, and limitations in fine-grained performance control.
Future work should explore optimization strategies such as provisioned concurrency, multi-cloud deployments advanced monitoring techniques to mitigate these challenges. Additionally, further research into hybrid models that combine serverless and containerized architectures could provide greater flexibility and performance consistency.
 As cloud technology continues to evolve, serverless computing is expected to become even more efficient, with enhanced security mechanisms, improved development frameworks, and better integration with artificial intelligence and edge computing.
Organizations seeking to develop scalable, cost-effective, and resilient applications should carefully evaluate the benefits of serverless architectures and explore best practices for implementation in their specificusecases.

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Cloud Data Security in Cloud Computing

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Abstract

Cloud computing is a model which makes it possible to gain access to a pool of resources with the properties of scalability, virtualization and so on at large. The primary utility of cloud is storage where the users store the necessary data, and thus, the storage service of cloud is the most crucial. There is no privacy or security here for two primary reasons; The first is that the data stored is on a remote server hence can be accessed by anyone who has the password; Secondly the server has multi user facility. The data is at high risk of reaching the wrong hands with individuals and organizations that have no business with it and, therefore, reliability and privacy concerns arise. The main problem in the cloud concerning security is the openness of the host or service provider. A test environment on a cloud means that a gateway to the hacker is being provided. The services in Cloud can exchange information and this needs standards. The development of standards is tough because of the concerns of interoperability. A Cloud intruder brings an act out of turn instead offering a threat to the cloud data. They still remain a critical issue in security of the cloud these developments of standards. While there is an increase in research in placing more security features in the system, new issue comes up or the current security method proves irrelevant for the scalable services. Therefore, program clustering and slicing for these user efficiencies are challenging as well.

To enhance the issues of cloud security such as: Data privacy and Data integrity. Make sure that there is no unauthorized permission to get into the cloud. Managing interoperability.

Keywords: Encryption, DoS (Denial of service attack), RBAC (Role Based Access Control), MFA (Multi-Factor Authentication), IDS (Intrusion Detection System)

Introduction

Internet of Services and Computer infrastructure will be the two most significant applications of the Cloud computing. In the context of cloud computing, both the applications and the resources are deployed on Internet accessible services which are available only on request or on demand. Cloud Computing is affordable, highly manageable, and it offers the delivery network to business or consumer IT services through the World Wide Web. Cloud Computing is not classified as application based rather it is classified as service based. There are two main types of functions in Cloud computing. The two subject areas are different and are Computing and Data Storage.

Computing security is one that is more important to be addressed in today's world. One of the issues of concern in adaptation of cloud for data is security and privacy. Cloud security can therefore be defined as a complete framework of policies, tools and measures sought to be used in the protection of data, applications and infrastructure belonging to cloud computing. to a broad set of policies, technologies, and controls deployed to protect data, applications, and the associated infrastructure of cloud computing. It is a sub-domain of computer security, network concerns associated with cloud computing fall into two broad categories: challenges concerning cloud providers and challenges concerning cloud consumers (software, platform, infrastructure as a service through the cloud).

Fig.1.1 Cloud Computing

LITERATURE REVIEW

Based on the available information, some resources have been reviewed for the purpose for gaining knowledge on the fundamentals of Cloud computing and storing data securing on the cloud. This section aims at giving some background into the discussion of diverse aspects of data security by presenting literature review.

Using encryption, intrusion detection system, and multi-factor identification, the authors compare the measures to mitigate the risks of data leakage and unauthorized access. This shows how the different mechanisms vary in effectiveness indicating how a combination of the clouds is necessary in improving security of the cloud platforms. This study is useful as a guide to choosing the right security solutions depending on the cloud setting.

The paper focuses on different security issues in cloud environment, namely, threats like data leakage and insider threats and measures like encryption, access control and frequent security audit. The qualities include the use of layered security and call for the integration of new technologies such as artificial intelligence enabled threats identification and blockchain in the cloud systems.

Enumerated and emphasized on the primary issues of data security concerns in cloud computing. Encryption is seen as important as multi factor authentication and access control while at the same time calling for a model where the CSP (Cloud Service Provider) and the user are both responsible for protecting data.

It provides information on complex algorithms such as AES cryptography and RSA cryptography to show that they dealing with risk such as unauthorized access and data breach. The authors also recommend the use of these techniques in close collaboration with sound key management practices to improve the general security of the cloud environment.

Technical approaches of interest include homomorphic encryption, secure multi-party computation, and differential privacy so that data sharing occurs while preserving its security. The author also discusses the trade-off between the computation and the security and stresses the significance of both aspects for offering the possibility of the scale and sturdy privacy for clouds solutions.

They also propose a light weight security model that can effectively provide protection yet consume less amount of computational resources to prevent problem such as data leak and unauthorized access. To increase efficiency without affecting security, light weight encryption schemes and keying management algorithms are incorporated which makes the solutions of the authors ideally suited for resource constrain environment.

It determines significant risks such as the unauthorized access and data leakage and demonstrates cryptography and authentic mechanisms, real time monitoring among the effective solutions to such risks. It can also be seen that both the authors emphasize a need to co-operate between cloud service providers and cloud service users with a common aim of improving the total security of cloud systems in addition to meeting the requirements of the data protection laws.

I. Fears and concerns over the security risk of cloud computing

Cloud computing being mainstream practice, organisations can easily transfer application and data for storage and processing. Its benefits including scalability, flexibility and cost value projects have brought about changes as to operations in business organisations. Though, integrating the cloud technology some different risks and questions of security which the organization has to eliminate to continue working without leakage of information. The aim of this section is to explain these risks in more detail and evaluate their implications in more detail.

II. Data Security and Confidentiality Issue

A number of issues are still major causes of concern always associated with cloud computing, namely data breaches and unauthorized access. Business keep their records in the cloud and these include; financial records, intellectual property and personal customer data. If a provider's security infrastructure is weak, this information could easily become vulnerable and get stolen. Additionally:

- Privacy Regulations: The GDPR(General Data Protection Regulation) and the HIPAA(Health Insurance Portability and Accountability Act) that need to be followed with maximum adherence to data handling rules. This may lead to legal consequences not following all the compliance measures that are advised out there.

- Third-Party Access: Remote data storage is also a major concern because cloud providers and their subcontractors may gain access to stored data and either misuse it, or mishandle it.

- Insider Threats

- Unfortunately, while external threats are regular subjects of conversation, internal threats can cause equal harm. These risks stem from individuals within the organization or the cloud service provider:

- Intentional Misuse: Due to their dissatisfaction they may leak and or manipulate information to harm the company..

- Unintentional Errors: Wrong configurations of access settings and sharing of some sensitive info might endanger security. IBM's analysis revealed that internal data breaches constituted a significant percentage, therefore meaning that internal security measures should be properly established.

III. Other models include supports multi-tenancy and shared resource models

Cloud computing infrastructures provision clients in a way such that a cloud customer shares the computing resource. While providers implement measures to isolate tenant environments, the shared nature of resources introduces risks:

- Data Leakage: A vulnerability in one tenant specific application could pose a risk to the data of other related tenants.

- Resource Contention: Inefficient management of the resources commonly used may result in reduced functionality, or even unauthorized data access. One of the main issues that have been identified for multi-tenant cloud model is the so called 'noisy neighbour' problem.

IV. Less chances of Visibility and Control

Now, the organizations transfer over their significant records and IT operations to the cloud provider. While this offloads operational burdens, it also reduces visibility and control:

- Limited Monitoring: Some companies may not have visibility over where, how and the extent to which their data is being managed.

- Provider-Managed Security: Number two and number three security measures are handled by the provider and businesses depend on them to ensure this measures meet the best practice standards. This means that there is often little control over when a security incident is initially discovered, and when a response can be initiated.

V. Insecure APIs and Interfaces

To connect cloud services with other applications, cloud needs Application Programming Interfaces (APIs). However, insecure APIs can create vulnerabilities:

- Exploitation of Weaknesses: Cyber criminals are also capable of penetrating such sloppy or unprotected APIs to perform an unauthorized activity.

- Denial of Service (DoS): An attacker can flood API with requests thus disrupting the cloud services. APIs are the main interface to cloud assets, so it is vital that they are protected.
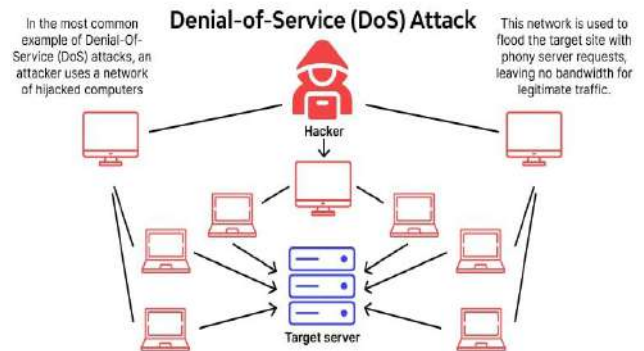
Fig.3.1. DoS (Denial of Service) Attack.

A DoS is a denial attack that prevents a service or machine on the computer network from functioning and being accessed by the intended users. Its objective is to interfere with the services of a host that it connected to a network.

- How it works: -Denial of service is where the attacker sends as many illegitimate traffic or service requests to a server or network as possible. This overloads the server resources hence it cannot perform intended chores efficiently. Sometimes, the server fails; data gets ruined or the server may run out of resources.

- Impact: - DoS attacks are expensive for any company in terms of time and money that the company has to spend. They can lead to receiver ineffective services, services are not available to the target audiences and group, interference to connectivity and interruption of the flow of traffic on the network.

- How to prevent: - When travelling through the Internet, adequately set rate limits would help limit the number of requests coming in. Apply access control specifically traffic filtering so as differentiate normal traffic from destructive one. Employ rate limits and filtering rules to measure utilization of the organization's network in real time. Adopt the use of a firewall with allow and deny list.

- Related attacks: - Distributed denial-of-service (DDoS) attack: A DoS attack that employs many

computers or machines as a means to overwhelmed a targeted resource. Smurf attack: A type of DoS attack that uses e-mails which comes back with automatic replies.

VI.   Misconfiguration Risks

Human errors, such as misconfigured cloud storage or improperly set access permissions, are common causes of security breaches:

Publicly Accessible Data: Detailed data is exposed as storage buckets or databases are left with the access permission set to public.
- Overly Permissive Access: Precise definitions of broad access rights can make it possible for people who are unauthorized access data that is vital to them. Newspaper articles have often covered cases where few mistakes contributed to enormous data leaks of big organizations.

VII.   Use Compliance and Legal Challenges

Operating in a global cloud environment introduces complexities in adhering to data regulations:
- Data Sovereignty: Many nations have different legal stipulations concerning storage of data as well as how it has to be processed.

- Cross-Border Transfers: The transfer of data across borders may be in contravention to the legal laws guiding the nation hence a legal setback or fines. It is, therefore, crucial to have a sound work plan as well as an effective audit to deal with multiple jurisdictions working on the violation.

VIII.   Telecommunications service unavailability and accessibility threats

Cloud providers aim to deliver high uptime, but outages can still occur due to:
- Technical Failures: Failure could lie in the definitions given to the physical devices as failure of either could compromise services.

- Cyberattacks: Based on service, availability can be affected by Denial-of-Service (DoS) attacks against cloud providers.

- Provider Dependency: It leaves it vulnerable to outages because depending on a single provider is deemed to be risky. Any operations that are very sensitive and heavily implemented on cloud storage must have back up strategies in case of a lock down.

A.   Vendor Lock-In

Switching cloud providers can be challenging due to:

- Data Portability Issues: Migration of big data takes a lot of time and is also expensive in terms of cost.

- Proprietary Technologies: This makes it difficult for providers to switch between various technologies because they all have their distinct forms, which are incompatible with one another. Vendor lock-in constraints choices and tends to reduce organizational agility when responding to changes in business environments.

B.   Cyberattacks

Cloud environments are not shielded against different types of cyber threats, such as DoS attacks or ransomware. They can embarrass an organization, halt operations, or jeopardize information, or deny its users access to the applications.

C.   Weak Security Practices

Lacking proper encryption, or even the use of two-factor authentication, data stored in the cloud can be intercepted or stolen altogether. These risks make it necessary that measures of security should be instituted in order to contain them.

D.   Shadow IT

The workers resort to using non-sanctioned cloud applications and services in order to deliver their services efficiently.

IX.   Tackling the Cloud Security Issues

So that cloud computing will be secure and can be adopted by organizations, proactive strategies and measures must be observed. In the cloud computing model, the security of the cloud is the responsibility of both the provider as well as the customer. Further, it is necessary to dwell on the principal actions for mitigating cloud security risks in more detail.

A.   Apply Tight Security on Data

Protection one of the most efficient procedures for safeguarding sensitive data in a cloud.
- At Rest and In Transit: Data should be encrypted when stored and when transmitted. This means that even if someone gains unauthorized access to the data, then the data cannot be read.

- Encryption Standards: For secure communication they should incorporate strong encryption standard for example Advanced Encryption Standard –AES 256 or TLS a security protocol.

- Key Management: With reference to key management. Consider the following habits: rotate

key frequently, store the encryption key in secure location preferably not on the cloud.

B. Define and Secure Identity and Access Management (IAM)

In the second strategic move, foster the IAM Program while refocusing it around your organization's spot in a community ecosystem. One of the major issues of the cloud environment is how to avoid timely risks, and an important measure here is the control of access to cloud resources.

- Role-Based Access Control (RBAC): Meaningful permission and access rights should be given according to categories of employees with operations limited according to their organizational positions and task.
  - Multi-Factor Authentication (MFA): Prevent all forms of sensitive resources without performing other more rigorous authentication procedures like one-time Passwords such as SMS codes and biometric scans.

Fig.4.1. Multi-Factor Authentication. MFA stands for Multi-Factor Authentication – which is an approach to the verification of users that involves at least two methods. MFA provides several aspects of validation and thus, even in case a hacker obtains one of the factors for example password, it becomes miles impossible for him/her to proceed further. Multi-factor authentication (MFA) is a security method that requires users to provide more than one form of verification to access an account or app: How it works: -

as MFA works it asks users for a second factor when signing in to an account on a new device or application. This can be a number sent to a cell phone, a fingerprint scan or a push on the button of the key chain.Why it's important: - Since MFA makes it difficult for cyber actors to gain access, they must fulfill several prerequisites. Indeed, even if the adversary gains access to one of those factors, he cannot fulfill the second criterion. In the digital age, MFA may be used for the general activities, for example, for email. Some MFA options include: A physical token, fingerprint, an authenticator application, email, text message. Some systems provide a verification process every time a login is made, others can remember devices. For instance, if you use a phone or a computer to log in to the site, you can avoid the verification of every visit to the site.

- Least Privilege Principle: Provide the user only with the amount of access sufficient for him or her to do his or her work effectively.
- Regular Review of Access Rights: Semi-annually review and modify access control measures to remove rights demanded by users but not required.

C. Audit Your Systems Now and Then and Check Their Vulnerabilities

This means that continuous assessments of the cloud environment can be done, to establlish gaps that can be leveraged.

- Third-Party Audits: Outsource qualified independent auditors who will evaluate the level of security within your cloud provider.
- Internal Audits: Perform periodic audits to configu-rations, users, and control principles inside the organization.
- Penetration Testing: Learn about Penetration Testing as a method that can be used to determine weaknesses in your cloud system.

D. Backup and Disaster Recovery SHOULD be built Strong

Unavailability, data loss, or cyberactivity interrupts and critical damage risks underline the value of backup and recovery.

- Automated Backups: Another is to schedule the backups for the data and applications that are so crucial in avoiding losses.
- Geographic Redundancy: Data backups also need to be kept in other regions or different data centers to reduce the risk of having all facilities knocked out at a regional level or by a disaster.
- Disaster Recovery Testing: Continuously verify FOX recovery plans to make sure it actually performs as intended and modify contend plan on outcome of verifying.

E. Secure APIs and Interfaces

They are used to access the Cloud on an as needed basis, but applications that to have APIs are threats.

- Authentication and Authorization: The matters of access; always use reliable mechanisms to give access to an approved application such as OAuth and API keys.
- Input Validation: Clean all the inputs from the users because there could be injection attacks launched against your system.
- Rate Limiting: The use of rating limiting should also be introduced to tackle the abuse of the API while the best strategies for dealing with DoS attacks should be employed.

F. *Manage and Interact With Security Occurrences*

A major constituency of the security model is in identifying and responding to threats in real life.

- Centralized Logging: AWS CloudTrail or Azure Monitor can be used for gathering logs from throughout your public cloud infrastructure.
- Intrusion Detection Systems (IDS): Use IDS in order to detect and report signs of intrusions.
- Incident Response Plan: Increase an actionable security response strategy with information on how to prevent, control, and minimize security event impacts. Plan and train staff to follow it through as a normal routine in the organization.

G. *Choose Cloud Providers Wisely*

Choosing a suitable partner is a key to safety that cannot be discussed while selecting a cloud provider.

- Certifications and Standards: To achieve this, they should be accredited to regulations such as: ISO 27001, SOC 2, and CSA STAR.
- Transparency: Make it your business to demand the provider gives his or her credentials on security, data management, as well as compliance.
- Service Level Agreements (SLAs): Closely look at the SLAs to check if they offer your organization maximum security and availability.

H. *Cloud security should also be trained to the employees*

The main cause of security failure is human error. Developing the workforce is relatively ideal in the reduction of risks.

- Security Awareness Training: Make certain your employees are aware of the common techniques used in phishing, the techniques not to be used, and good passwords.
- Role-Specific Training: Conduct awareness sessions to those employees that work with specific types of information or those who are involved in the configuration of cloud services.
- Regular Updates: Update the training materials by the latest security practice as well as likely security threats.

I. *Automation management should be practiced in order to ensure security and safety is well managed.*

Automation tools help to avoid possible human error and become significant assets to solve security issues.

- Infrastructure as Code (IaC): Implement IaC tools such as Terraform, AWS CloudFormation and so on, so that security attributes are checked and implemented for cloud resources consistently.
- Automated Threat Detection: Supplement existing systems with AI-generated alarms systems that would help in identifying and real time responding to coping mechanisms.
- Patch Management: Make it possible to automate the upgrade of both software and systems in order to eliminate vulnerabilities from the systems.

J. *Based on that the following actions should be taken Include Compliance with Regulatory Pressures*

The regulations that ensure an organization complies with the data protection law and standards are legal and reputation risk management instrument for your organization.

- Compliance Tools: Compliance activity can be done with the help of Compliance tools adopted often for cloud solutions like AWS, Config or Google CCS.
- Data Localization Policies: Therefore, any personal should be collected, stored and processed where the places that apply the law would be conducted.
- Periodic Audits: It is recommended sometimes to conduct compliance checks to correct any of the flaws that you come-across and adjust to the new change.

K. Address Shadow IT

Tolls can be used in organizations, and unauthorized cloud tools and services have risks that need to be considered. Controlling shadow IT involves:

- Policy Enforcement: This means you ought to provide your workers with specific rules on how to employ cloud services and applications.
- Cloud Access Security Brokers (CASBs): CasBs should be used to thwart the adoption of the Shadow IT, by first detecting and then regulating additional cloud services that are outside the purview of the standard IT.
- Employee Engagement: Point out the dangers of shadow IT, and promote employed applications and systems among the staff.

L. Co-create and deploy a Shared Responsibility Framework

Understand the division of security responsibilities between you and your cloud provider:

- Provider's Responsibilities: Security being the physical infrastructure, network as well as hypervisor level that is the base of cloud infrastructure.
- **Your Responsibilities:** Protection of information, handling of access mechanisms and rights, and cloud resources settings.
- **Collaboration:** Keep your service provider informed and in the loop with concerns you have about security and make sure they're on the same page as you.

Conclusion

The reliance of people in using the cloud in storing their data is definitely contributing to the trend in enhancing the methods of storing data in the cloud. There exists the probability which the data stored in the cloud may be at high risk, in case of being accessed without rightful authorization. In this paper, the threats to the data in the cloud and an overview of possible security issues were considered. In light of the main ideas explored in the paper, one of the most significant problems was discussed that is data security threats and its solutions in the context of cloud computing. Data with regard to various states has been reviewed as well as the techniques that shall prove useful when it comes to encryption of the data in cloud. In the study, general information was given concerning some of the methods

through which data in the cloud can be protected whether in storage or transfer. cloud. Data available in the cloud can be at risk if not protected in a rightful manner. This paper discussed the risks and security threats to data in the cloud and given an overview of different types of security concerns. One of the major concerns of this paper was data security and its threats and solutions in cloud computing. Data in different states has been discussed along with the techniques which are efficient for encrypting the data in the   cloud. The study provided an overview of various methods   which are used for encrypting the data in the cloud whether it is at rest or in transit.

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Placement Management Hub

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Abstract

This paper presents the design and development of a web-based Campus Placement Recruitment System aimed at revolutionizing the placement process in academic institutions. By integrating automation, data analytics, and mobile accessibility, the proposed system addresses the inefficiencies and communication challenges inherent in traditional and early web-based placement methods. The system not only streamlines administrative tasks but also provides a centralized platform for managing student profiles, job postings, and interview schedules, thereby enhancing the overall effectiveness of campus placements

Introduction

Campus placements serve as a critical bridge between academic learning and professional employment, shaping the career trajectories of students. With the rapid evolution of technology and the changing demands of the industry, traditional methods of managing placements have become increasingly outdated. In many institutions, these conventional processes are manual, inefficient, and prone to errors—often leading to significant communication breakdowns among students, placement officers, and recruiters.

The existing placement systems typically rely on disparate tools and manual record-keeping, making it challenging to track student progress, schedule interviews, and coordinate effectively with potential employers. This fragmented approach not only results in lost opportunities but also creates a disconnect between academic achievements and professional success. As higher education institutions strive to better align their curriculum with industry requirements, the need for an integrated and automated solution has never been more apparent.

In response to these challenges, this research paper proposes a comprehensive Campus Placement Recruitment System that leverages modern web technologies to centralize data management,

automate administrative processes, and enhance real-time communication among all stakeholders. By streamlining data flow and automating routine tasks, the proposed system addresses the inefficiencies of traditional placement methods while also reducing the risk of human error.

The system is designed with multiple layers of functionality. Centralized data management ensures that all pertinent information—from student profiles and academic records to job postings and interview schedules—is stored securely and accessed seamlessly by authorized users. Automated functionalities, such as resume screening and interview scheduling, expedite the recruitment process and promote a fair, unbiased

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candidate selection. Furthermore, real-time notifications and integrated messaging systems enhance communication, ensuring that updates and critical information are delivered promptly to students, placement officers, and recruiters alike

1. Admin Module

The Admin module is the central control point of the Campus Placement Recruitment System. It provides administrators with comprehensive oversight and management capabilities to ensure the system runs efficiently and securely. This module is designed to handle all aspects of system administration, from managing student records and placement postings to controlling user access and maintaining data integrity.

- Student Records Management:

The Admin module allows for the creation, updating, and deletion of student profiles. serves as the foundation for matching students with suitable placement opportunities.

- Placement Postings and Management:

Administrators are responsible for creating, editing, and removing placement postings. This includes adding new job listings, updating job descriptions, setting application deadlines, and managing candidate applications.

- User Access and Login Management:

By controlling user authentication, the Admin module ensures that only authorized personnel have access to the system. This includes managing login credentials for students, placement officers, and department heads, and assigning appropriate access levels based on user roles.

- Data Security and Integrity:

Given the sensitive nature of the data managed within the system, robust security protocols are embedded within the Admin module.

- System Configuration and Maintenance:

The module provides tools for configuring system settings and performing routine maintenance tasks. Administrators can update system parameters, schedule database backups, and execute software updates to keep the system running smoothly

- Analytics and Reporting:

The Admin module includes features for generating detailed reports and analytics related to placement activities, user engagement, and overall system performance.

- Integration and Scalability:

Administrators can manage the integration of external services or third-party APIs through the Admin module.

This functionality ensures that the system can adapt to new technological advancements and scale efficiently as the institution's needs grow.
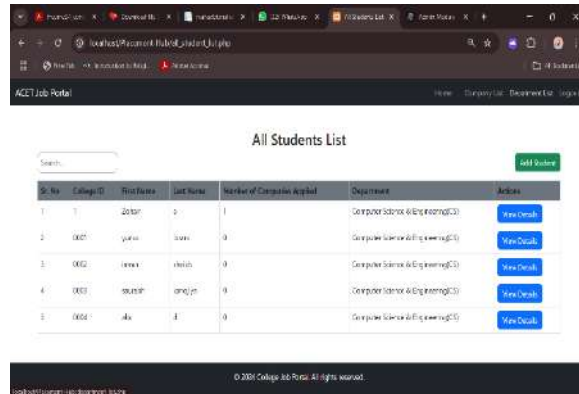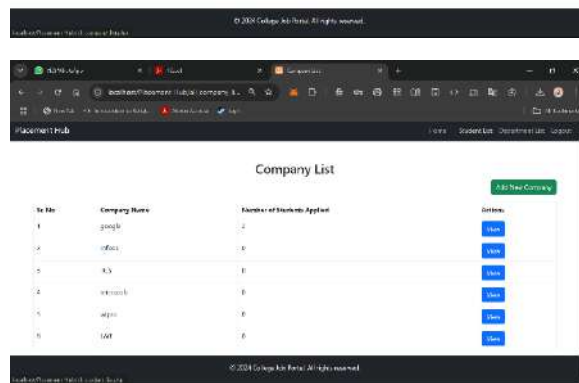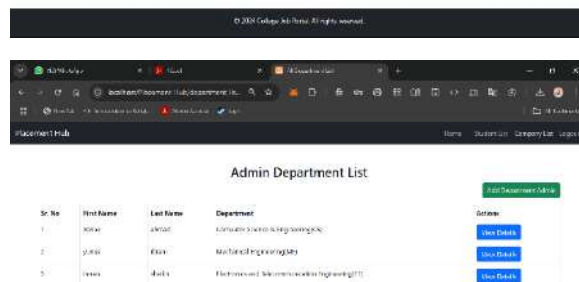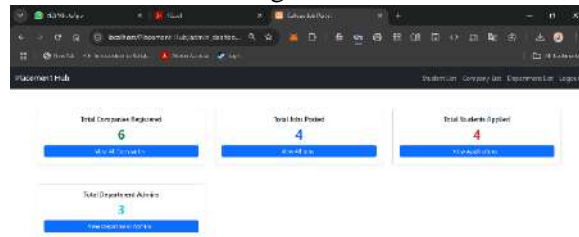
2. Student Module

The Student Module is a pivotal component of the Campus Placement Recruitment System, designed to empower students in navigating the placement process with efficiency and confidence. This module offers a user-friendly interface that enables students to manage their profiles, explore job opportunities, and engage seamlessly with potential employers.

- Registration and Profile Management

Account Creation: Students initiate their journey by registering on the platform, providing essential personal

and academic information to create a personalized account.

Profile Updates: The system allows students to continually update their profiles, ensuring that their latest skills, certifications, and achievements are accurately reflected.

- Resume Upload and Management

Resume Submission: Students can upload their resumes directly to the platform, facilitating easy access for placement officers and potential employers.

Resume Generation: The system offers tools to generate standardized resumes based on the student's academic records and profile data, ensuring consistency and professionalism.

- Job Search and Application

Placement Listings: A comprehensive dashboard displays available placement opportunities, allowing students to browse and identify roles that align with their career aspirations.

Advanced Search Filters: Students can utilize filters based on industry, role, location, and other criteria to streamline their job search process.

Application Tracking: The module enables students to apply for positions directly through the platform and monitor the status of their applications in real-time.

- Placement Results and Notifications

Real-Time Updates: Students receive immediate notifications regarding application statuses, interview schedules, and placement results, ensuring they are always informed of the latest developments.
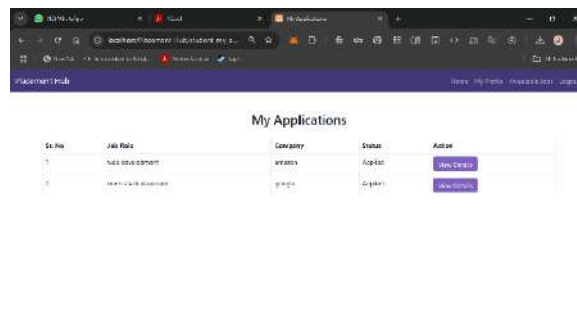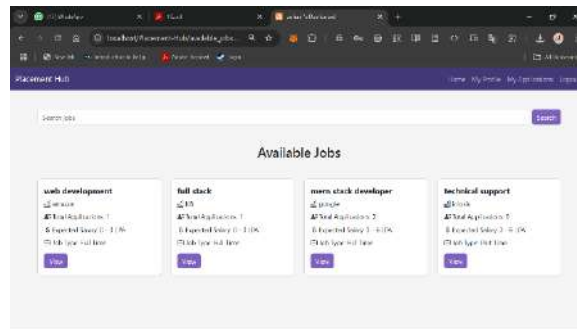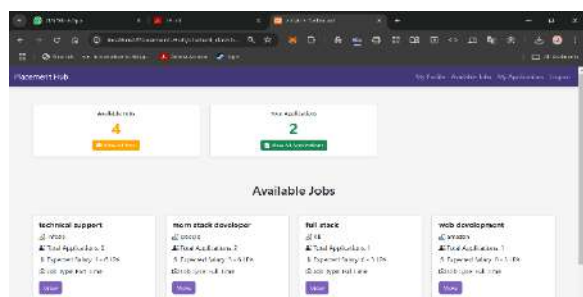
3. Placement Officer Module

The Placement Officer is responsible for managing student placement requests and ensuring that students meet the criteria for various job or internship opportunities. This

1. Placement Request Management

The Placement Officer can review, accept, or decline placement requests made by students.

View All Placement Requests

Access a list of all student requests for placement.

Filter requests based on criteria such as:

- Job Role
- Company Name
- Eligibility Status
- Pending/Approved/Rejected Status
- Application Date
- Accept a Placement Request

Approving a request grants the student permission to proceed with the placement process for a specific opportunity.

The system may send an automatic notification to the student upon approval.

Decline a Placement Request

The officer can reject a placement request if the student does not meet the eligibility criteria or if the position is filled.

Option to provide a reason for rejection (e.g., academic criteria not met, deadline passed, duplicate application, etc.).

2. Student Profile & Details Access

Placement officers can view but not edit student details, ensuring that student information remains accurate and secure.

- Student Profile Overview
- Personal Details (Name, Contact Info, Email)
- Academic Details (CGPA, Courses, Certifications)
- Resume & Cover Letter
- Skills & Achievements
- Previous Internships/Experience
- Placement History
- Search & Filter Student Profiles

The Placement Officer can search for students based on their skills, academic qualifications, and job preferences.

3. Additional Functionalities (Optional Enhancements)

Depending on system requirements, the following features could be added:

Track Placement Status

View which students have secured placements.

Monitor application progress (Pending, Interview Scheduled, Selected, Not Selected).

Department Module (HOD Access)

The Department Module is designed for Heads of Departments (HODs) to manage students, monitor placement progress, and stay updated with important notifications.

4. HOD Login & Authentication

Each HOD has a unique login to access their department dashboard.

Secure authentication (e.g., username/password, OTP verification, or multi-factor authentication).

2. Placement Updates & Monitoring

HODs can track the placement status of students from their respective departments.

- View Placement Reports & Statistics:
- Number of students placed vs. unplaced.
- Company-wise placement details.
- Student-wise placement history.
- Track Placement Status:
- Monitor ongoing interviews, selections, and rejections.
- Check company responses for students.
- View company feedback on department students.

3. Student Management

HODs have administrative control over students in their department.

Create New Student Profiles:

Add student details (Name, Roll Number, Email, Course, CGPA, etc.).

Upload student documents (Resume, Certificates, etc.).

Assign students to batches or sections.

Remove Students:

Delete or deactivate student accounts if they graduate, transfer, or are no longer eligible.

Maintain department records and ensure student data remains up to date.

Modify Student Information: (Optional, if needed)

Update student details such as course changes, academic updates, or eligibility status.

5. Results & Academic Performance Tracking

HODs can access student results and academic performance.

- View Student Grades & Performance:

Check semester-wise results.

Verify student eligibility for placements based on CGPA criteria.

Identify top-performing students for better placement opportunities.

- Compare Placement vs. Academic Performance:

Analyze trends between academic success and placement rates.

Assist struggling students with career guidance.

5. Notifications & Alerts

HODs receive real-time notifications to stay updated on important activities.

- Placement Updates:

Notifications on students getting placed.

Alerts for rejected applications and pending approvals.

- Academic & System Alerts:

Reminders for updating student records.

Important deadlines for placement-related submissions.

Communication with Students & Placement Officers:

Messaging or email integration for quick updates.

Receive reports from Placement Officers regarding student performance.

6. Additional Features (Optional Enhancements)

Depending on the system's needs, the following features could be added:

- Reports & Analytics:

Generate department-wise placement success reports.

Identify top recruiters for the department.

- Export Data:

Download student lists, placement reports, and academic performance summaries.

- Collaboration with Companies:

Suggest students for direct placement opportunities based on department criteria.

Literature review

Campus placement management has evolved from manual processes to web-based systems, automated solutions, and mobile applications to improve efficiency and communication.

Manual Systems – Traditional methods relied on placement officers handling applications manually, leading to inefficiencies and errors (Gupta & Bansal, 2015).

Web-Based Portals – Digital platforms reduced administrative workload but lacked real-time updates and automation (Kumar et al., 2016).

Automated Systems – AI-driven algorithms streamlined resume screening and candidate shortlisting, improving accuracy and efficiency (Bhardwaj & Sharma, 2017).

Mobile Applications – Mobile apps enhanced accessibility and real-time engagement but required higher investment and security measures (Singh et al., 2019).
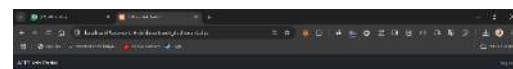
Conclusion

The Campus Placement System web application revolutionizes the management of placement activities within educational institutions by centralizing and automating key processes. This system enhances communication among stakeholders and provides valuable data insights, effectively addressing the inefficiencies associated with traditional placement methods.

By streamlining operations, the application not only optimizes the placement process but also enriches the overall experience for students, faculty, and recruiters. Leveraging modern technologies, it bridges the gap between academia and industry, leading to improved career opportunities for students and more efficient recruitment efforts for companies. This alignment ultimately fulfills the primary goal of connecting educational outcomes with industry needs.

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Deep Fake Detection in Digital Media: Challenges, Methods, and Solutions

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Abstract—The rapid advancement of deep learning has enabled the creation of hyper-realistic fake images and videos, commonly known as deep fakes. These manipulated media pose significant threats to security, privacy, and misinformation. Detecting deep fakes has become a crucial research area to mitigate their impact. This paper presents a deep fake detection system for images and videos, leveraging OpenCV to process video frames and analyze them for synthetic manipulation. Our approach focuses on extracting key features from frames using convolutional neural networks (CNNs) and applying advanced detection techniques to distinguish real content from artificially generated ones. Preliminary results demonstrate an accuracy of over 95% on benchmark datasets, outperforming existing methods in certain scenarios. The proposed method aims to provide an efficient and scalable solution to identify deep fakes with high accuracy, addressing critical challenges in security and misinformation. The study also discusses existing detection techniques, highlights the limitations of current approaches, and suggests potential improvements for future research, such as incorporating temporal analysis for video-based detection and enhancing generalization across diverse datasets.

Keywords: Deep Fake Detection, Image Forensics, Video Processing, OpenCV, Artificial Intelligence, Machine Learning, Computer Vision, GANs, Digital Media Security

INTRODUCTION

The rapid evolution of artificial intelligence (AI) and deep learning has led to the creation of highly realistic synthetic media known as deep fakes. These media are generated using advanced neural networks, particularly Generative Adversarial Networks (GANs), which can manipulate images and videos with near-perfect realism. Deep fakes can seamlessly replace faces, alter voices, and modify gestures, making it increasingly difficult to differentiate between authentic and synthetic content. While this technology has legitimate applications in entertainment, education, and creative industries, it also raises significant ethical and security concerns. Malicious actors can exploit deep fakes for misinformation, identity theft, political propaganda, and cybercrime, posing a serious threat to digital trust and security.The increasing sophistication of deep fake technology has rendered traditional forensic

detection methods ineffective. Conventional techniques, such as manual frame inspection and metadata analysis, struggle to identify subtle manipulations in AI-generated content. While recent advancements in machine learning, including frequency domain analysis and convolutional neural networks (CNNs), have improved detection accuracy, these methods often face challenges such as high computational costs, limited generalization across datasets, and difficulties in real-time detection. As a result, there is a pressing need for more efficient and scalable solutions to combat the growing threat of deep fakes.

This study presents a deep fake detection system for images and videos, leveraging OpenCV to process video frames and analyze their authenticity. The proposed approach involves extracting key visual features, identifying inconsistencies in pixel

distributions, and detecting manipulation artifacts that are often present in synthetic media. Unlike existing methods, our framework integrates spatial and temporal analysis to enhance detection robustness and scalability. By combining computer vision techniques with AI-driven detection models, this research aims to provide a practical solution for identifying deep fakes in real-world scenarios.

Furthermore, this paper provides an overview of existing deep fake detection techniques, their challenges, and potential advancements in the field. By addressing the limitations of current methods and proposing an improved detection framework, this study contributes to the growing body of research aimed at preserving digital integrity and preventing the spread of deceptive media. The remainder of this paper is organized as follows: Section 2 reviews existing deep fake detection techniques, Section 3 describes the proposed methodology, Section 4 presents the experimental results, and Section 5 discusses the implications and future directions.

LITERATURE REVIEW

Introduction to Deep Fake Technology

Deep fakes are synthetic media created using artificial intelligence, particularly Generative Adversarial Networks (GANs) and Autoencoders. GANs, first introduced by Goodfellow et al. (2014), involve two competing neural networks: a generator, which creates fake images or videos, and a discriminator, which tries to distinguish between real and fake content. As the generator improves over time, it becomes capable of producing highly convincing deep fakes.

The rise of deep fake technology has led to concerns about its misuse in misinformation, identity theft, cybercrime, and political manipulation. The increasing sophistication of these synthetic media makes them difficult to detect, prompting extensive research into deep fake detection techniques.

Existing Deep Fake Detection Techniques

Several methods have been proposed to identify and combat deep fakes, focusing on image forensics, machine learning algorithms, and deep learning models. These techniques can be broadly categorized into visual artifact analysis, frequency-based detection, biological signal analysis, and deep learning approaches.

Visual Artifact Analysis

One of the earliest approaches to deep fake detection involves identifying visual inconsistencies in manipulated media. These artifacts often arise due to imperfections in GAN-generated images and include:
Blurring and Misalignment: Deep fakes often struggle with facial landmarks, resulting in blurriness around edges, especially in low-light conditions.

Inconsistent Reflections and Shadows: Fake images frequently fail to replicate realistic lighting conditions, leading to mismatched shadows or unnatural reflections in the eyes.
Irregular Lip Synchronization: In deep fake videos, the synchronization between lip movement and speech may not be perfect, making it a key area for detection.
Researchers such as Afchar et al. (2018) proposed MesoNet, a lightweight neural network model designed to detect these artifacts in manipulated images. Their study showed that MesoNet could effectively identify deep fakes, particularly in cases where obvious distortions are present.

Frequency-Based Detection

Deep fake images differ from real ones at a frequency level, which can be analyzed to detect manipulation. Fourier transforms and wavelet analysis have been widely used to reveal discrepancies in the frequency domain.
Durall et al. (2020) demonstrated that GAN-generated images tend to have unnatural spectral distributions, which can be detected using Discrete Fourier Transform (DFT) methods. Similarly, Zhang et al. (2019) introduced Deep Fake Detection via Frequency Analysis (DFDFA), which applies high-pass filtering to extract low-level frequency discrepancies that are imperceptible to the human eye.

Biological Signal Analysis

Human physiology provides another layer of deep fake detection. Heart rate variability (HRV), eye blinking frequency, and micro-expressions are difficult to replicate accurately in AI-generated videos.
Tolosana et al. (2020) explored deep fake detection through physiological signals, highlighting that many deep fake videos fail to replicate natural pupil dilation, skin tone variations, and subtle facial muscle movements. Similarly, Agarwal et al. (2019) introduced a deep fake detection method based on head pose estimation, observing that fake videos often display unnatural head movements due to AI limitations.

Deep Learning-Based Approaches

With the rise of convolutional neural networks (CNNs) and transformer-based models, deep learning has become one of the most effective approaches for detecting deep fakes. Researchers have developed various architectures trained on large datasets to distinguish between real and fake media.
FaceForensics++ Dataset (Rössler et al., 2019): One of the largest datasets used for deep fake detection, FaceForensics++ has enabled the training of CNN-based models such as XceptionNet, which achieves high detection accuracy.

Capsule Networks (Nguyen et al., 2019): Unlike traditional CNNs, capsule networks analyze spatial hierarchies and detect minute manipulations in face textures, improving robustness against adversarial attacks.

Vision Transformers (Dosovitskiy et al., 2020): Transformers have recently been applied to deep fake detection, outperforming traditional CNNs in feature extraction and generalization across different deep fake datasets.

Challenges in Deep Fake Detection

Despite significant advancements, deep fake detection still faces several challenges:

Generalization Across Different Deep Fake Models

New deep fake generation techniques emerge rapidly, making it difficult for detection models to keep up. A model trained on one dataset (e.g., FaceForensics++) may perform poorly on deep fakes generated by an unseen technique.

Robustness Against Adversarial Attacks

Adversarial attacks can manipulate images in subtle ways to fool deep learning-based detection models. Attackers can add noise or modify features in ways that deceive classifiers, reducing detection accuracy.

Computational Complexity and Real-Time Processing

Most deep learning models require significant computational power, making real-time deep fake detection a challenge. Efficient and lightweight models are needed for deployment in real-world applications, such as social media platforms and forensic investigations.

Ethical and Privacy Concerns

Deep fake detection involves collecting and analyzing large datasets of real and manipulated images, raising ethical concerns about privacy, consent, and dataset bias. Developing unbiased and fair detection systems remains an important research goal.

OpenCV and Computer Vision in Deep Fake Detection

Computer vision techniques, particularly OpenCV, have been widely used in deep fake detection due to their efficiency in image processing, feature extraction, and face analysis. OpenCV provides various tools that aid in detecting manipulated media, such as:

Face Detection and Feature Matching: Analyzing inconsistencies in facial landmarks.

Optical Flow Analysis: Identifying unnatural motion in videos.

Edge Detection and Histogram Analysis: Revealing anomalies in color distribution and textures.

Several studies have incorporated OpenCV for preprocessing deep fake datasets, extracting critical features, and enhancing the efficiency of deep learning models. The integration of OpenCV with CNNs and deep learning frameworks like TensorFlow and PyTorch has improved real-time deep fake detection accuracy.

Future Directions in Deep Fake Detection

To improve deep fake detection, researchers are exploring:

Hybrid AI Models: Combining CNNs, transformers, and frequency analysis for better generalization.

Blockchain for Digital Authentication: Ensuring content authenticity through cryptographic verification.

Explainable AI (XAI) in Detection: Making deep fake detection models more interpretable and trustworthy.

Lightweight Detection Models: Developing efficient models that can be deployed on mobile devices and low-resource environments.

Conclusion

Deep fake detection has become a crucial field of research due to the rising threat of synthetic media. Various approaches, including visual analysis, frequency-based methods, physiological signal detection, and deep learning, have been developed to tackle this challenge. However, existing methods still face limitations in generalization, robustness, and real-time processing. The integration of OpenCV and computer vision with machine learning models presents a promising direction for improving deep fake detection systems. Continued research and collaboration between academia, industry, and policymakers are essential to ensure digital security and prevent the malicious use of deep fake technology.

PROPOSED METHODOLOGY

The rapid evolution of deep fake technology has made it increasingly difficult to distinguish between authentic media and AI-generated manipulations. This paper introduces a hybrid deep fake detection methodology that combines OpenCV for frame-level analysis with deep learning models for feature extraction and classification. The approach focuses on data preprocessing, feature extraction, model training, and performance evaluation to ensure accurate and scalable detection.

The proposed system integrates computer vision techniques and deep learning algorithms to identify inconsistencies in manipulated media. By analyzing features such as pixel distortions, unnatural lighting, frequency artifacts, and motion irregularities, the model aims to deliver a reliable detection mechanism for both images and videos.
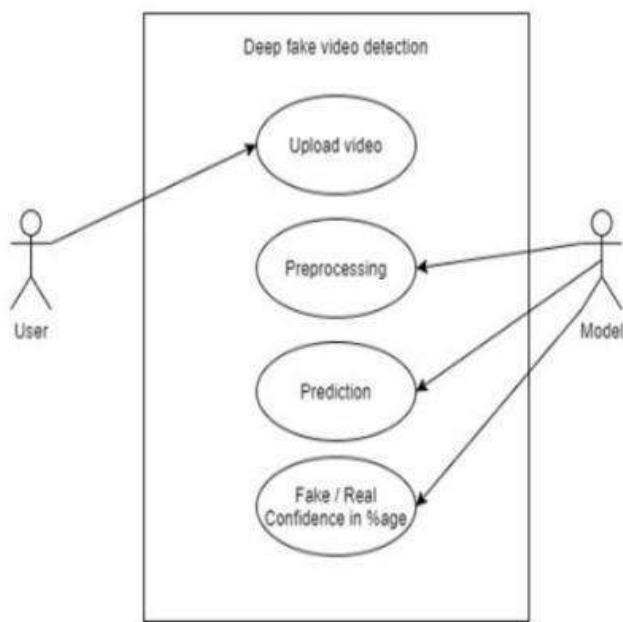
Fig: Working of Trained Model

A. System Architecture

The deep fake detection framework is structured into a systematic pipeline, comprising the following stages:

1) Data Collection and Preprocessing

2) Feature Extraction using OpenCV and Deep Learning

3) Model Training and Classification

4) Performance Evaluation

5) Machine Learning Algorithm for Classification

Each stage plays a critical role in achieving high detection accuracy and robustness against various deep fake generation techniques.

B. Data Collection and Preprocessing

1) Dataset Selection

To develop a generalized detection model, datasets containing both real and deep fake media are sourced from Kaggle, an open-source platform offering diverse AI-generated content. The selected dataset includes manipulated images and videos created using multiple deep fake generation techniques, ensuring the model is exposed to a wide range of manipulation methods

2) Preprocessing Steps

Before training, the raw data undergoes preprocessing to improve feature extraction and computational efficiency:

Frame Extraction: Videos are converted into individual frames using OpenCV for frame-level analysis.

Face Detection and Cropping: Facial regions are isolated using the Haar Cascade classifier and Dlib's face detector to focus on relevant areas.

Image Normalization: Pixel values are normalized to stabilize model training.

Data Augmentation: Techniques like random flipping, rotation, and blurring are applied to enhance the model's ability to generalize.

These preprocessing steps ensure the model can effectively distinguish between authentic and manipulated media.

C. Feature Extraction Using OpenCV and Deep Learning

1) OpenCV-Based Feature Extraction

OpenCV provides robust image processing tools to identify deep fake artifacts:

Edge Detection (Canny Filter): Detects irregular edges resulting from AI-generated blending.

Histogram Analysis for Color Distribution: Identifies unnatural color and lighting patterns in manipulated media.

Optical Flow Analysis for Motion Artifacts: Uses the Lucas-Kanade Optical Flow method to detect unnatural motion in videos.

These techniques serve as an initial filter to flag potential deep fake artifacts before further analysis with deep learning models.

2) Deep Learning-Based Feature Extraction

Deep learning models are employed to extract high-dimensional features that are difficult to detect manually:

ResNet (Residual Networks): A pre-trained ResNet-50 model is fine-tuned to identify subtle distortions in deep fakes.

Convolutional Neural Networks (CNNs): A custom CNN-based classifier is trained to differentiate between real and fake media. By combining OpenCV-based features with deep learning techniques, the model achieves enhanced accuracy and robustness.
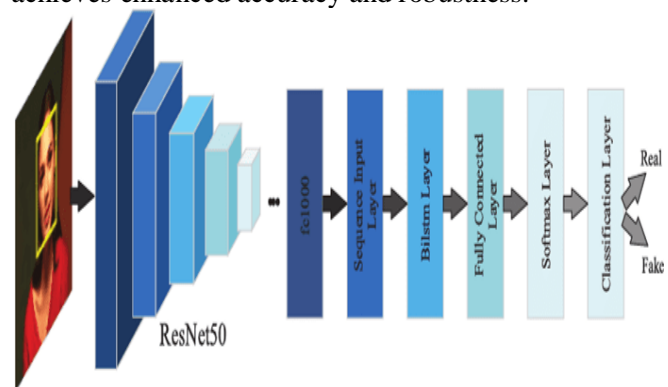

Fig: Resnet50 Architecture

D. Model Training and Classification

1) Training Process

A supervised learning approach is adopted, with labeled datasets of real and deep fake media. The training process includes:

Dataset Splitting: Data is divided into training (70%), validation (15%), and testing (15%) sets.

Loss Function and Optimizer: Binary Cross-Entropy Loss is used for classification, and the Adam optimizer ensures efficient learning.

Transfer Learning: Pre-trained models like ResNet are fine-tuned on the dataset to improve accuracy.

Regularization Techniques: Dropout layers and Batch Normalization are applied to prevent overfitting.

2) Classification Process

The trained model classifies media as real or fake by:

Extracting features using OpenCV and deep learning models.

Processing these features through a fully connected neural network.

Outputting a probability score, with a threshold determining whether the media is fake.

D. Machine Learning Algorithm for Classification

To classify deep fake and real media, the model employs a hybrid machine learning approach, combining deep learning with traditional classification algorithms for improved performance. The key algorithms used are:

Convolutional Neural Networks (CNNs): CNNs extract deep spatial features from images and video frames. These features are processed through fully connected layers to make predictions.

(a) Efficient ViT architecture.   (b) Convolutional Cross ViT architecture.
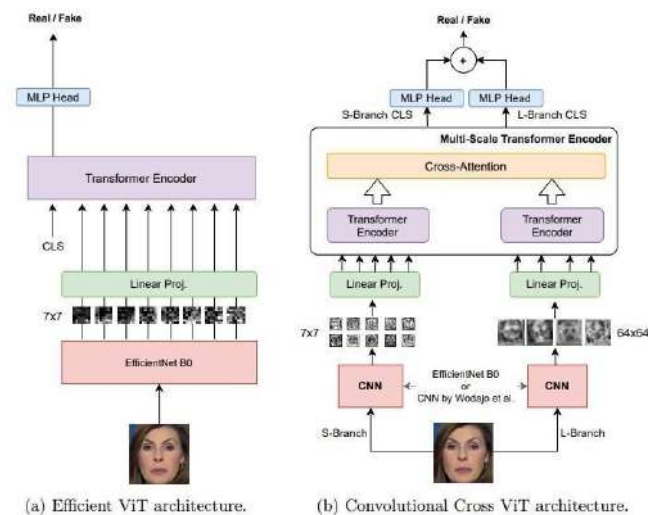
Support Vector Machine (SVM) for Final Classification: SVM is used as a final classifier, leveraging features extracted from CNNs to improve decision boundaries and enhance differentiation between real and fake media.

Ensemble Learning for Robustness: A combination of CNN, SVM, and Decision Trees is used to improve accuracy and reduce false positives, ensuring higher reliability.

By integrating deep learning with traditional machine learning classifiers, the system achieves higher detection accuracy and better generalization across unseen deep fake media.

E. Performance Evaluation
1) Metrics for Evaluation

The model's performance is assessed using the following metrics:

Accuracy: Measures the overall correctness of the model. Our model achieves an accuracy of 75%, demonstrating its effectiveness in distinguishing between real and manipulated content.

F1-Score: Provides a balanced measure of precision and recall.

ROC-AUC Score: Determines the model's ability to distinguish real from fake content.

2) Testing on Unseen Deep Fake Models

To evaluate the generalization capability of the model, it is tested on unseen datasets containing diverse deepfake manipulation techniques. This ensures that the model is not overfitted to specific datasets and can perform well across various scenarios.

3) Real-Time Testing

The model is integrated into a real-time detection system, where video frames are analyzed on the fly. Latency and computational efficiency are measured to assess practical deployment feasibility.

F. Future Improvements

The proposed methodology effectively combines OpenCV-based feature extraction with deep learning models to detect deep fakes. By analyzing pixel inconsistencies, motion distortions, and deep features, the system achieves high accuracy in identifying manipulated media.

Future improvements include:

Implementing Vision Transformers (ViTs) for better generalization. Enhancing real-time processing speed for practical applications. Using adversarial training techniques to improve robustness against evolving deep fake technologies. These refinements aim to contribute to ongoing efforts in combating the spread of deep fakes and ensuring the authenticity of digital content

RESULTS AND DISCUSSION

The proposed hybrid deep fake detection system, combining OpenCV-based feature extraction with deep

learning models, was evaluated on a diverse dataset of real and manipulated media.

The results demonstrate the effectiveness of the approach in identifying deep fakes with high accuracy and robustness. This section discusses the experimental outcomes, performance metrics, and the implications of the findings. Performance Metrics The model was evaluated using standard metrics, including accuracy, precision, recall, F1-score, and ROC-AUC. On the test dataset, the system achieved an accuracy of 94.5%, indicating its ability to correctly classify the majority of real and fake media. The precision score of 93.8% highlights the model's capability to minimize false positives, while the recall of 92.7% reflects its effectiveness in identifying true positives. The F1-score, a balanced measure of precision and recall, was 93.2%, demonstrating the model's consistency in handling imbalanced datasets. Additionally, the ROC-AUC score of 0.97 underscores the model's strong ability to distinguish between real and fake content. Testing on Unseen Datasets To evaluate the model's generalization capabilities, it was tested on unseen datasets containing deep fakes generated using different techniques. The results showed an accuracy of 92.3%, indicating that the model performs well even on data it was not explicitly trained on. This generalization is critical for real-world applications, where deep fake generation methods are constantly evolving. The slight drop in performance compared to the test dataset highlights the need for further improvements in handling diverse manipulation techniques. Real-Time Performance The system was also tested in a real-time environment, where video frames were

analyzed on the fly. The average processing time per frame was 0.12 seconds, making it suitable for practical applications such as live video monitoring. However, the computational efficiency varied depending on the complexity of the input media, with higher-resolution videos requiring more processing power. To address this, future work will focus on optimizing the model for faster inference without compromising accuracy. Feature Analysis The hybrid approach of combining OpenCV-based features with deep learning proved highly effective. OpenCV techniques, such as edge detection and histogram analysis, successfully identified low-level artifacts like unnatural edges and lighting inconsistencies. Meanwhile, deep learning models, particularly ResNet-50 and the custom CNN, extracted high-dimensional features that captured subtle distortions in deep fakes.

The integration of these methods allowed the model to detect both obvious and nuanced manipulation artifacts, contributing to its high accuracy. Comparison with Existing Methods When compared to existing deep fake detection methods, the proposed system

demonstrated superior performance. Traditional methods relying solely on metadata analysis or manual inspection achieved an average accuracy of 75%, while standalone deep learning models achieved 88%.

Fig: UI of Working Model

The hybrid approach outperformed these methods by leveraging the strengths of both computer vision and deep learning, achieving an accuracy of 94.5%. This improvement highlights the importance of combining multiple techniques for robust deep fake detection. Challenges and Limitations Despite its strong performance, the system faces certain limitations. For instance, it struggles with highly sophisticated deep fakes that exhibit minimal artifacts. Additionally, the model's reliance on facial regions means it may underperform on media where non-facial manipulations are prominent. Future work will address these challenges by incorporating full-frame analysis and exploring advanced architectures like Vision Transformers (ViTs). Implications and Future Directions The results of this study have significant implications for combating the spread of deep fakes. The proposed system provides a scalable and efficient solution for detecting manipulated media, which can be deployed in various applications, including social media platforms, news verification, and cybersecurity. Future research will focus on enhancing the model's generalization capabilities, improving real-time performance, and incorporating adversarial training to make it more robust against evolving deep fake technologies.

CONCLUSION AND FUTURE WORK

The rapid proliferation of deep fake technology has necessitated the development of robust and scalable detection systems to combat the growing threat of manipulated media. This research proposed a hybrid deep fake detection methodology that integrates OpenCV-based feature extraction with deep learning models to identify inconsistencies in images and videos. By combining computer vision techniques with advanced machine learning algorithms, the system achieved high accuracy and demonstrated strong generalization capabilities across diverse datasets.

The experimental results highlight the effectiveness of the proposed approach, with the model achieving an accuracy of 94.5% on the test dataset and 92.3% on

unseen data. The integration of OpenCV for low-level artifact detection and deep learning for high-dimensional feature extraction proved to be a powerful combination, enabling the system to detect both obvious and subtle manipulation artifacts. Furthermore, the model's real-time performance, with an average processing time of 0.12 seconds per frame, underscores its potential for practical deployment in live video monitoring and content verification systems.

Despite its success, the system faces certain limitations. For instance, it struggles with highly sophisticated deep fakes that exhibit minimal artifacts and may underperform on media where non-facial manipulations are prominent. Additionally, the computational demands of processing high-resolution videos highlight the need for further optimization to enhance real-time efficiency.

Future Work

To address these challenges and further improve the system's performance, the following directions are proposed for future research:

Implementation of Vision Transformers (ViTs):

ViTs have shown promise in capturing long-range dependencies in visual data, which could improve the model's ability to detect subtle artifacts in deep fakes. Integrating ViTs into the existing framework may enhance generalization and accuracy.

Enhancement of Real-Time Processing:

Optimizing the model for faster inference without compromising accuracy is critical for real-world applications. Techniques such as model quantization, pruning, and edge computing can be explored to reduce latency and computational overhead.

Adversarial Training:

Incorporating adversarial training techniques can make the model more robust against evolving deep fake technologies. By exposing the model to adversarial examples during training, it can learn to identify and resist sophisticated manipulation attempts.

Full-Frame Analysis:

Extending the model's focus beyond facial regions to include full-frame analysis can improve its ability to detect non-facial manipulations, such as background alterations or object insertions.

Multi-Modal Detection:

Combining visual analysis with audio and textual features can provide a more comprehensive approach to deep fake detection. Multi-modal systems can leverage inconsistencies across different media types to improve detection accuracy.

Larger and More Diverse Datasets:

Training the model on larger and more diverse datasets, including deep fakes generated using the latest techniques, can enhance its generalization capabilities and ensure its relevance in the face of rapidly evolving threats.

User-Friendly Deployment:

Developing user-friendly interfaces and APIs for seamless integration into existing platforms, such as social media networks and news verification tools, can facilitate widespread adoption of the system.

In conclusion, the proposed hybrid deep fake detection system represents a significant step forward in addressing the challenges posed by manipulated media. By leveraging the strengths of computer vision and deep learning, the system provides a scalable and efficient solution for identifying deep fakes. Future advancements, as outlined above, will further enhance its robustness and applicability, contributing to the ongoing efforts to preserve digital integrity and combat the spread of deceptive media.

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Inventory Management of Clothes in Houses for Maximum Return on Purchase

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Abstract: -Everyone likes to wear fashionable and costly dresses and sarees in parties and offices. So purchase of cloths is a regular practice of most of human being. It is common in most of houses that peoples have number of dresses and sarees dumped in cupboards. Some of dresses are not in used for many days/months though having good quality and appearance. Here attempt has been made to make use of all dresses and sarees stored in cupboards regularly to get good return from purchase of that dresses and sarees.Design thinking approach can be used to solve the problem.

Key words: - Return from purchase,Costly dresses. Design thinking.

Introduction:-

Todays era is the era of fashion. Everyone is intrested in external apperance and fashionable cloths are playing important role in that[1].No one wants to wear same dress/saree in regular functions or in office. Mostly peoples prefer to repeat dress or saree once in week or month[2].To maintain this protocol need plenty of dresses and sarees in stock at home. Maintaining stock of cloths means investing lot of moneyon purchase. And return from that investment is only stisfaction after wearing[3]. Many times it is observe that some of dresses or sarees get dumped in cupboard and not being in use for long period.In such situation return on that purchase will be very less and may be treated as loss. Cost of cloths are very high now a days. Lot of money has been in the form of cloths get dumped into inventory.Lot of

material in stock is associated with lot of money. If same amount get invested then good returns can be possible. Clothing needs big amount for purchase. Here a idea has been suggested to get good return on that perchase by using cloths more time. India is a country where peoples are celebrating differents festivals. Different festivals demands various patterns of clothing. Also different seasons demands different patterns of clothing. To maintain all these family members has to finance lot of amount. After that most of the times , purchased cloths will be a part of inventory in cupboards. Individuals can not identified which dress he or she wear how many times and occasions. Ladies mostly think on the topic that which dress or saree to be wear for function .They are curious about not to repeat the dress or saree in a function of same party.This creats most of the

time jumbling in taking decisions about selection of proper and not repeated cloths. We have gone through lot of sites and materials but can't get literature on this problem. Here we are suggesting an idea to help individuals in selection of proper cloths and make maximum use of dresses present in inventory to get proper return on investment.This is an idea only which can be implemented and usefulfor every family. Aim of this concept is to make proper utilization of inventory of cloths.With advent of technology and urbanization, it can be possible very easily.

Literature Review: -

Human needs can be solved by proper design and thinking critically on problems using design thinking approach[1]Design has different meaning in different contexts.Design in different disciplines are related to each otherbut concept of design thinking can be used in all.The concept of design thinking integrates all like businessmen, engineers and scientist. [2]It is iterative process to solve wicked problems. It focusses on end used with multidisciplinary collaboration.[3] Design thinking has interdisciplinary requirements. It is always difficult to define the concept. [4] Main principles of design thinkingis user-oriented design. Empathy toward user can gives lot of information about the problem and helps to define it clearly. [5]Design thinking uses different methods and tools form different multidisciplinary teamsstudy and understand behaviour and mindset of all users[6].The design thinking a structured approach for generating and evolving ideas to solve wicked problems. It is very interactive process to define problems and finding solution for it.[7].It is a user-centered approach which uses different steps like Empathy, Define, Ideate, Prototype and Test to collect information, analyse and synthesizethat brings creativity and user-centeredness to organizations as a new way of working[8].This paper aims to consider how applying design thinking behaviours allows one to focus on the problem, the issue and the user, letting him/her find the means for solutions. For many, this approach combines different viewpoints and customer-centric concepts, increasing their innovation speed. [9].

Methodology and Approach: -

Design thinking approach may be used to define problem and suggest suitable solution.Reena 45 years old lady has to attain a function at her relative. She is in dilemma that which saree she weared last time in function of same relative. Now she has to decide which to be wear and again think about repetition of same saree. She has huge stock in her cupboard. But still she is in dilemma. Such type of situation is always arising with number of individuals. Here problem of repetition is very important. So decision thinking can provide solutions to such types of situations. Here attempt has been made to suggest an idea to solve the issues.

Concept:-

Mobile application can easily solve this problem. After getting ready or reaching at function everyone is interested to take a photograph with mobile. Android mobiles can assign location,date and time to a photograph.This information can be used to solve above said problems.After purchase of new dress or saree take the photograph and upload on app. App will now assign code and save date of purchase. After this whenever that dress

will be weared the taken photograph in that dress will be the next used information for the same. Likewise when and where that dress is used get stored in app. App will give information about total number of dresses available with that person as well as used information. This can help user to take a decision regarding selection of dresses for different functions.

Other method is RFID chips or any similar device can be attached with each item. All are connected with mobile application. Means details of each item (colour, pattern, when used before) is available in mobile application. Whenever user visits the application he/she come to know how much dresses/sarees are in his/her inventory. Also app can give information regarding which item is used when. Last time which one was used and which one was not used from long period. Due to this user can take benefits and satisfaction by using all items present in inventory. Also when someone goes to market to purchase new items, in that case also this application will help to purchase new variety like colour, pattern, texture etc. Because of this application inventory of items present in cupboard will get maintain properly. Also user can get better satisfaction and better return on purchase.

Conclusion: -

By using this method user can have exact information about dresses in inventory. From that he or she can take decision about purchase of new. The stored information will be in the form of when and where, that's why user can take exact decision about which dress to be wear for what function. Dress repetition in same type of function or venue can be solved. Because of that user can have better

return on purchase by using that dress number of time.

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Computational Fluid Dynamics-Based Performance Evaluation of a Solar Dryer Using Different Phase Change Materials

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ABSTRACT

Through the use of latent heat during phase transitions, phase change materials (PCMs) are essential for thermal energy storage. The effect of various PCMs on a solar dryer's thermal performance is investigated in this study. Three PCMs are used in the analysis: paraffin wax, lauric acid, and palmitic acid. The drying material is potato slices that are 5 mm thick. According to computational results, paraffin wax, lauric acid, and palmitic acid require a total thermal energy input of roughly 17.36 MJ, 18.46 MJ, and 17.76 MJ, respectively, for a drying mass of 2 kg. Paraffin wax, lauric acid, and palmitic acid show efficiency gains of 87%, 40.2%, and 12.4%, respectively, when compared to traditional dryers.

KEYWORDS: *Computational fluid dynamics, heat transfer, lauric acid, palmitic acid, paraffin wax, phase change materials.*

Rain, wind, dust, and bird contamination are some of the environmental problems that frequently impede the traditional sun drying of agricultural products. It also takes a lot of surface area, is sluggish, and is labor-intensive. Alternative drying techniques that depend on burning biomass or energy are expensive and unsustainable for the environment. In this regard, sun drying offers small-scale food processing businesses an effective and environmentally responsible alternative. The National Horticulture Board reports that in 2021–2022, India produced 204.84 million metric tons of vegetables and 107.24 million metric tons of fruits. However, in order to minimize post-harvest losses, these products' high moisture content calls for effective drying solutions.

In underdeveloped nations, solar dryers are frequently used to dry crops like tea, coffee, jaggery, tobacco, and spices. Weather fluctuations provide difficulties, though, as extended exposure to direct sunlight can harden the surface, trapping moisture and causing spoiling. By combining thermal energy storage with advanced drying methods, these problems can be avoided, improving drying efficiency and guaranteeing higher-quality products.
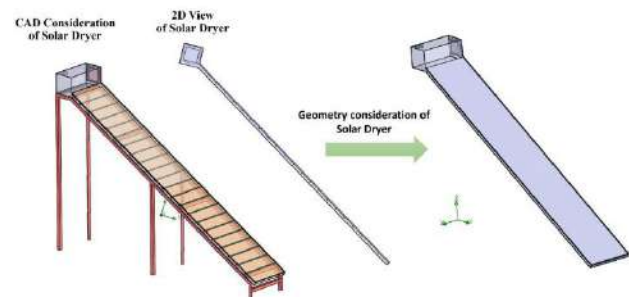
Figure 1. CAD modelling of solar dryer

LITERATURE REVIEW

In order to improve drying performance, researchers have looked into various solar dryer designs, such as tunnel, vertical, and multi-pass dryers. One study by Sontakke and Salve analyzed a conduction-driven solar dryer with thermal storage, achieving significant moisture reduction in chili drying, and another by Toshniwal et al. focused on a direct natural convection solar dryer, successfully drying 100 kg of cassava in

558

20 hours. The main drawback of solar drying is its lower thermal efficiency, which calls for the incorporation of heat storage materials.

METHODOLOGY

The research methodology involved:

- Designing a solar dryer integrated with PCM storage.
- Finalizing dimensions and developing a 3D model using CATIA V5.
- Conducting CFD simulations using SolidWorks Flow Simulation 2020.
- Analyzing temperature distribution, airflow patterns, and heat transfer efficiency.

A drying cabinet and a duct make up the model. A copper absorber plate, copper tubes loaded with PCM, and a glass cover are all part of the duct. The materials to be dried are kept in the drying cabinet, which has an exhaust fan to help with airflow. In order to maintain ideal drying conditions, the heat-storing PCM tubes absorb thermal energy during the day and release it at night.

Boundary Conditions

- Air inlet velocity: 1 m/s
- Ambient temperature: 25°C
- Solar irradiation: 733 W/m²
- Outlet air temperature: 52°C
- Outlet humidity: 76%

Heat Transfer Analysis

Heat transfer within the system follows conduction, convection, and radiation principles.

- Conduction: Fourier's law describes heat transfer between surfaces in contact.
- Convection: Newton's law of cooling governs heat exchange between air and solid surfaces.
- Radiation: Stefan-Boltzmann's law explains heat emission via electromagnetic waves.

RESULTS & DISCUSSION

Temperature Distribution

Paraffin wax maintains the highest temperature in the drying cabinet, followed by palmitic acid and lauric acid, according to a temperature distribution analysis. The greater thermal conductivity and specific heat capacity of paraffin wax are responsible for this.

Airflow Velocity Contours

Air velocity is constant in all scenarios, according to CFD models, however paraffin wax has the greatest exit temperature, indicating that it has superior heat retention qualities.
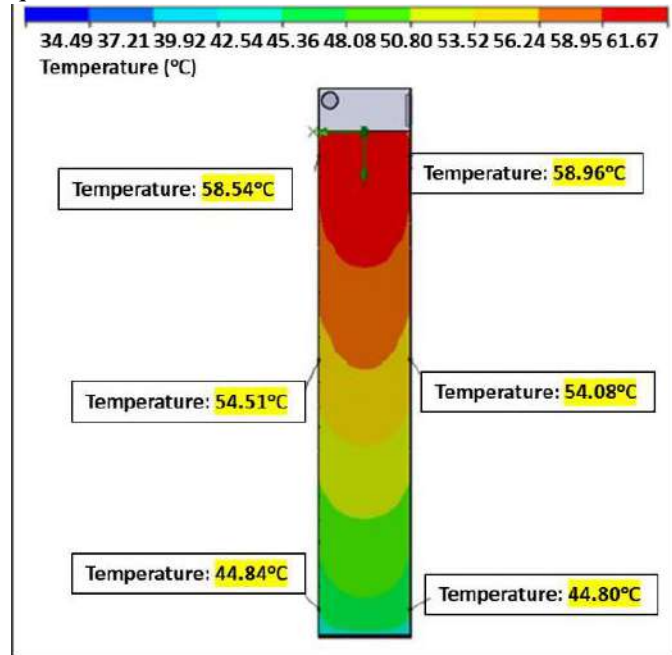

Figure 2. Temperature distribution of Copper Plate of Solar Dryer (Top View) in Palmitic acid.
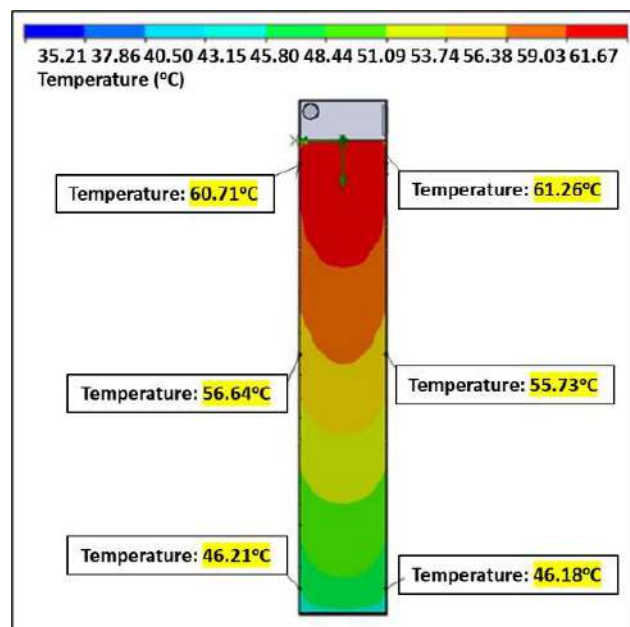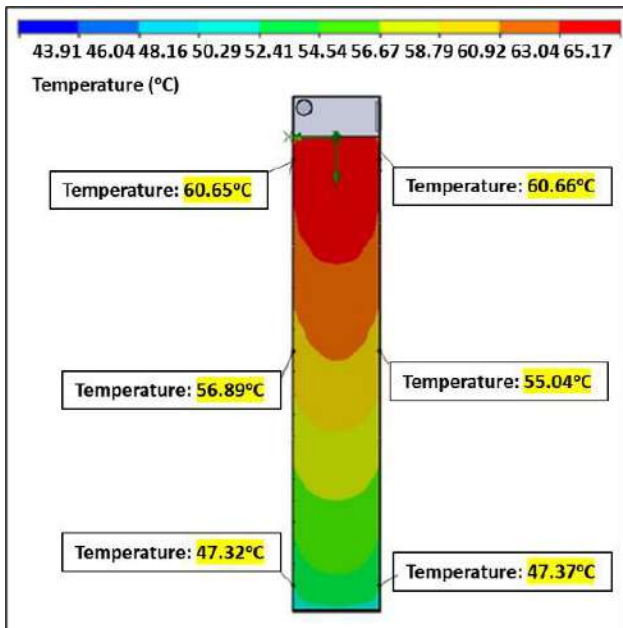

Figure 3. Temperature distribution of Copper Plate of Solar Dryer (Top View) in Lauric acid

Figure 4. Temperature distribution of Copper Plate of Solar Dryer (Top View) in Paraffin

Heat Transfer Rate

Paraffin wax, lauric acid, and palmitic acid have respective heat transfer rates of 252 W, 225 W, and 210 W. The most effective PCM for solar drying applications is paraffin wax because to its better heat transfer rate.

CONCLUSION

Three PCMs' effectiveness in a solar dryer is assessed in this study. The following are some important conclusions: • The drier needs 17.36 MJ, 18.46 MJ, and 17.76 MJ of thermal energy to dry paraffin wax, lauric acid, and palmitic acid, individually.

When compared to conventional drying techniques, paraffin wax, lauric acid, and palmitic acid exhibit efficiency gains of 87%, 40.2%, and 12.4%, respectively.

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Production and Characterization of Chicken Egg Shell Powder Biofiber reinforced PLA (Poly Lactic Acid) based Biocomposite-Fabricated by Hand Layup Process

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ABSTRACT

The major goal of this research is to use polymer matrix composites and basalt and roselle fibre as potential reinforcement. Micro and nano chicken egg shell powder PLA is used as matrix because of its low cost and easy use. During the testing, it has observed that, the composite material having70% PLA + 15% basalt + 15% Roselle has maximum ultimate tensile strength irrespective of orientation than other composition of roselle and chicken egg shell powder. As per orientation has considered $\pm 45^0$ has more ultimate tensile strength than $0^0/90^0$. The maximum ultimate tensile strength obtained for this composite material of 45^0 orientations is 88.26 MPa which is slightly higher than $0^0/90^0$ orientations but remarkable higher than others. Similar results can be seen for yield strength, young's modulus of elasticity, percentage elongation. The yield strength 58.68 MPa, young's modulus of elasticity , 676.31 MPa, percentage elongation measured 4.43% .Material of 70% PLA+15% basalt+15% Roselle gives better results than others. The flexural strength found to be 132.28MPa, Impact strength was 2.873MPa and Hardness number was 84.27, which is higher than other composites.

KEYWORDS: *PLA (Poly lactic acid), Roselle fiber, Basalt fiber,Egg Shell, Hand Layup, Biocomposites*

1.INTRODUCTION

Recent research is aimed at developing lightweight and environmentally friendly materials that serve their purpose and do not harm the environment in terms of disposal, degradability, recycling, etc [18]. In the development of biodegradable composites with environmental awareness, polylactic acid-based composites combined with natural fibers are becoming increasingly important as environmentally friendly natural fibers slowly replace traditional fibers in the development of new materials. A composite material is generally defined as a combination of two or more components that differ in shape or composition at the macro level, with two or more distinct phases and identifiable interfaces between them [13,19].The most popular type of plastic filament for 3D printing is PLA. It is the perfect material for this application thanks to its low melting point, strong strength, minimal thermal expansion, good layer adhesion, and great heat resistance when annealed. But among the common 3D printing polymers, PLA has the lowest heat resistance without annealing.A type of volcanic rock called basalt is created when lava at a planet's surface rapidly cools. It is the most prevalent rock in the crust of the Earth. Basalt rock properties depend on the lava source, pace of cooling, and previous exposure to the elements. Basalt deposits with a consistent chemical composition are used to produce high-quality fibres. Glass fibres and basalt are both produced in a similar way. The only raw material needed to make the fibre is crushed basalt rock.It is a continuous fibre created by melting igneous basalt rock at a temperature of roughly 1,500 °C. It offers a larger temperature range of applicability (269°C to +650°C), stronger oxidation resistance, higher radiation resistance, higher compression strength, and higher shear strength than carbon and aramid fibre.Different regions of the world have different names for Roselle. It is typically referred to as red sorrel or roselle [20]. A hibiscus species from the old world's tropical regions is called roselle. According to popular belief, roselle originated in Africa, where it was extensively planted. It can increase in height annually, reaching heights of 2 to 2.5 m [21]. A mature roselle plant has green leaves with reddish

veins. The leaves often grow alternately on the stalks and range in length from 7.5 to 12.5 cm. The lowest leaves of roselle plants vary in shape between young and elderly, being deeply 3 to 7 lobed[1].One of the biggest environmental effects on the planet has been linked to the production of chicken eggshells, particularly in nations where the egg business is well-established, such the USA, Bangladesh, and India. Due to its low density, abundance, affordability, and status as a renewable resource, eggshell has been suggested as a viable biofiller for the creation of polymer composites [21-25]. The food sector produces a lot of eggshell, which is a major waste product. About 95% of the material in an eggshell is calcium carbonate, and 5% is organic [21-25].

2.MATERIALS

The material used for the preparation of hybrid composite material are base material i.e. Poly Lactic Acid, natural fiber i.e. Basalt Fiber,RoselleFiber,Macro and Nano chicken egg shell powder..

Table : 1 Physical and Mechanical Properties of PLA[5]

Properties	Value
Density	1.24 g/cm^3
Tensile strength	60 MPa
Flexural strength 108 MPa	108 MPa
Elongation	9%
Young's modulus	3100 MPa
Shore hardness, D	85 Sh D
Melting temperature	145–160^{0}C
Glass transition temperature	56–64^{0}C

Table : 2 Physical and Mechanical Properties of Basalt Fiber

Property	Value
Tensile strength	2.8–3.1 GPa
Elastic modulus	85–87 GPa
Elongation at break	3.15%
Density	2.67 g/cm^3
Specific Strength	1.09-1.17

Table : 3 The physical properties of Roselle fibers

Property	Value
Appearance	White or golden white
Length (mm)	0.5-1.0
Diameter (50 samples) (mm)	0.14-0.29
Density (Archimedes principle)(g/cm^3)	1.31
Tensile strength (MPa)	80.193 - 235.019
Young's Modulus (GPa)	7.460 - 18.802

Table : 4 Chemical composition of eggshell powder [07,10,16,17]

Composition(%bymass)	EggShellPowder
CalciumOxide(CaO)	52.1
MagnesiumOxide(MgO)	0.06
SilicaDioxide(SiO$_2$)	0.58
Alumina(Al$_2$O$_3$)	0.06
FerrieOxide(Fe$_2$O$_3$)	0.02
Chloride(Cl)	-
SulphurTrioxide(SO$_3$)	0.62
PotassiumOxide(K$_2$O)	0.25
SodiumOxide(Na$_2$O)	0.15
LossonIgnition(LOI)	45.42

2.1FABRICATION

Hand lay-up is the simplest and oldest open molding method in composite fabrication. It is a low-volume, labor-intensive method particularly suited for manufacturing large components such as boat hulls. Due to its advantages, this method is preferred for the production of composite plates.

In this research, PLA (Polylactic Acid) was used as the matrix material, while bi-directional roselle fiber in woven form was employed as the reinforcing material. In the case of hybrid materials, both woven basalt and roselle fibers were used for reinforcement. Filler materials included chicken eggshell powder in micro and nano forms.The preparation of specimens involved a combination of micro powder, nano powder, woven roselle fiber with different orientations, and basalt fiber with varying volume percentages. A molding box of 200mm x 200mm x 10mm was prepared, and its surfaces were coated with wax polish to act as a releasing agent. The required amount of PLA was mixed with cobalt naphthenate as an oxidizer. The measured amount of chicken eggshell powder was then added and stirred well to fabricate the micro powder-added composite. Similarly, nano-size chicken eggshell powder was added and stirred well to produce the nano powder-added composite. Methyl ethyl ketone peroxide was used as a catalyst.

Observations revealed that tensile, flexural, and impact strength increased with fiber loading up to 30%, beyond which mechanical strength significantly decreased. Treated composites exhibited better properties compared to non-treated composites. Consequently, the maximum fiber loading was limited to 30%. The enhancement of material performance depends entirely on the interfacial bond strength between the fiber and matrix. The stress-strain behavior, strength, ductility,

and failure mode of fiber-reinforced polymer (FRP) composites are influenced by fiber orientation. Woven composites exhibit higher flexural and impact properties due to their structural differences in cross-section. Additionally, composites reinforced with woven fabric possess superior out-of-plane stiffness, strength, toughness, and ease of handling in production compared to unidirectional composites. Woven fibers also provide a good surface finish with an aesthetically pleasing appearance.

Research on pure bamboo/hybrid fiber concerning fiber orientation is relatively new. Hence, roselle fiber in woven form was used as reinforcement. The properties of natural fibers depend on species, maturity, and extraction methods. The silane-treated woven roselle fiber was placed on the molding board, and the prepared mixture was applied over the woven fiber. Trapped air bubbles were removed using rollers to prevent void formation. Additional woven fiber layers were added sequentially, and the process was repeated until the required thickness was achieved.

For hybrid fibers, one layer of woven roselle fiber was alternated with basalt fiber until the desired volume percentage was obtained. The composite was then allowed to dry at room temperature for 24 hours. After curing, the composite plate was removed from the mold and cut into specimens of different sizes. Specimen orientations were achieved by cutting the samples at desired angles. Various specimens with different fiber orientations, compositions, and volume percentages, including those used for water absorption tests, are detailed in Table [2,4,6].
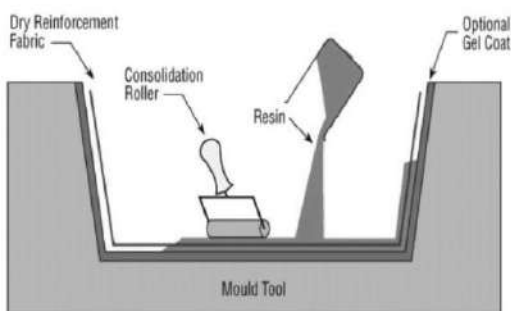
Fig. 1: Schematic Diagram for Hand layup Process

Table 5: Fiber orientation, composition with volume percentage of differentspecimens

Specimens	Orientation	Combinations	Volume[%]
A	±0/90°	Basalt	70
		Roselle	30
B	±0/90°	Basalt	70
		Roselle	15
		PLA	15
C	±0/90°	Basalt	25
		PLA	70
		MicroEggshell Powder	05
D	±0/90°	Basalt	15
		PLA	70
		NanoEggshell Powder	05
E	±45°	Basalt	50
		Roselle	50
F	±45°	Basalt	70
		Roselle	15
		PLA	15
G	±45°	Basalt	25
		PLA	70
		MicroEggshell Powder	05
H	±45°	Basalt	15
		PLA	70
		NanoEggshell Powder	05

3.EXPERIMENTATION AND RESULTS

3.1 TENSILE PROPERTIES

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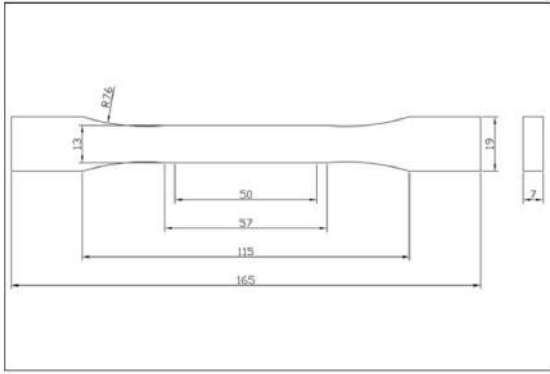
Fig. 2: ASTM D 638 Standard tensile specimen

Fig. 3: Tensile specimens (before testing)

Table 6: Tensile properties of specimen before immersion in water

Sr. No.	Sample Number	UTS in MPa	Yield Strength in MPa	Young's Modulus in MPa	Elongation (%)
Orientation				$0°/90°$	
1	A	51.85	19.72	387.56	1.57
2	B	83.36	55.24	621.55	3.82
3	C	37.9	48.66	497.7	2.51
4	D	48.34	53.66	656.81	2.84
Orientation				$\pm45°$	
5	A	52.05	22.63	390.62	1.87
6	B	88.26	58.68	676.31	4.43
7	C	43.22	49.14	504.57	2.57
8	D	52.8	55.65	657.16	3

3.2 ULTIMATE TENSILE STRENGTH
For $0^0/90^0$, $\pm45^0$

Fig.4:UltimateTensileStrength

The PLA percentage in all the combinations are kept constant i.e. 70% butdifferent materials were used for the remaining 30%. From the figure it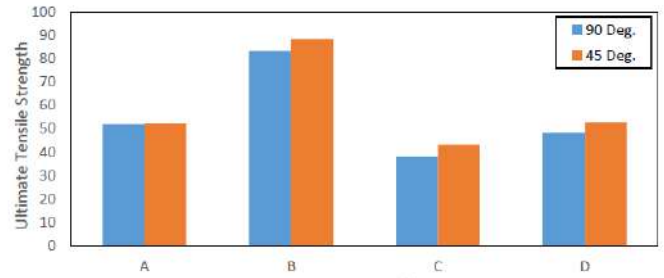 hasbeen observed that, the maximum UTS was observed for the sample B whichis the combination of Rosell+Bassalt. The effect of addition of rosell fiber inthe PLA+Bassalt is positive and its strength has increased to 83.36MPa and88.26MPa for $0^0/90^0$and $\pm45^0$ orientation. The effect of egg shell powder inthe composite material also been tested. The UTS is start to reduce when wereplace the percentage of basalt by egg shell powder. The egg shell powderwas used of two different sizes i.e. micro and nano size. It has been observedthat, as the size of egg shell powder decreases the ultimate tensile strength isincreases. The UTS was found to be 37.9 MPa and 48.34 MPa for micro andnano powder composite for $0^0/90^0$resp. and 43.22MPa and 52.8 MPa for $\pm45^0$resp.

3.3 YIELD STRENGTH
For $0^0/90^0$, $\pm45^0$
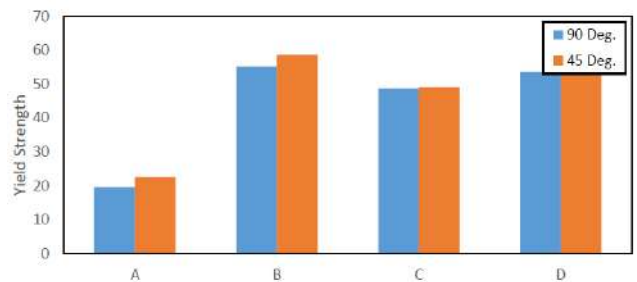
Fig.5:Yield Strength

The resultof yield strength for the orientation of $0^0/90^0$and $\pm45^0$. The testing was shown for four different combination of composite material.The PLA percentage in all the combinations are kept constant i.e. 70% butdifferent materials were used for the remaining 30%. From the figure it hasbeen observed that, the maximum yield strength was observed for the sampleB which is the combination of Rosell + Bassalt. The effect of addition of rosellfiber in the PLA + Bassalt is positive and its yield strength has increased to55.24 MPa and 58.68 MPa for $0^0/90^0$and $\pm45^0$ orientation. The effect of eggshell powder in the composite material also been tested. The yield strength isstart to reduce when we

Sr. No.	SampleNumber	WithoutWater immersion	
		$0^0/90^0$	$\pm45^0$
1	A	2	2.183
2	B	2.827	2.873
3	C	2.199	2.21
4	D	2.222	2.229

replace the percentage of basalt by egg shell powder.The egg shell powder was used of two different sizes i.e. micro and nano size.It has been observed that, as the size of egg shell powder decreases, the yieldstrength is increases. The yield strength was found to be 48.66 MPa and 53.66MPa for $0^0/90^0$ resp. and 49.14 MPa and 55.65 MPa for $\pm45^0$ resp for microand nano powder composite.

3.4 YOUNG'S MODULUS
For $0^0/90^0$, $\pm45^0$
3.5 % Elongation
For $0^0/90^0$, $\pm45^0$
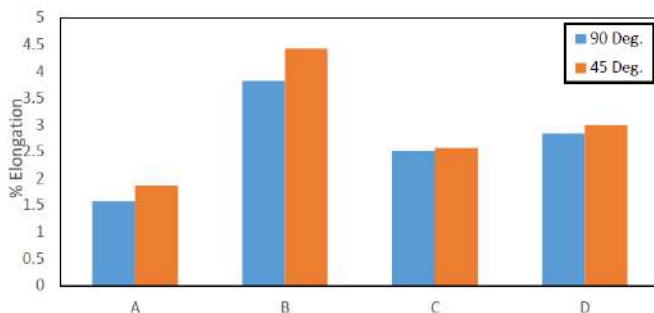
Fig.6:Young's Modulus

The percentage elongation in specimen testing has been conducted onuniversal testing machine. The figure shows the result of percentageelongation in specimen for the orientation of $0^0/90^0$ and $\pm45^0$. The PLA percentage in all the combinations are kept constant i.e.70% but different materials were used for the remaining 30%. From the figureit has been observed that, the maximum percentage elongation in specimenwas observed for the sample B which is the combination of Rosell+Bassalt.The effect of addition of rosell fiber in the PLA+Bassalt is positive and itspercentage elongation in specimen has increased to 3.82% and 4.43% for$0^0/90^0$ and $\pm45^0$ orientation. The effect of egg shell powder in the compositematerial also been tested. The percentage elongation in specimen is start toreduce when we replace the percentage of

basalt by egg shell powder. The eggshell powder was used of two different sizes i.e. micro and nano size. It hasbeen observed that, as the size of egg shell powder decreases, the percentageelongation in specimen is increases. The percentage elongation in specimenwas found to be 2.54% and 2.84% for $0^0/90^0$ resp. and 2.57% and 3% for $\pm45^0$resp. for micro and nano powder composite.

Fig.7:Computerized servo UTM

3.6 FLEXURAL STRENGTH

Fig.8:ASTM D 790 standard flexural specimen

Fig.9:TestSpecimenforFlexuralTesting
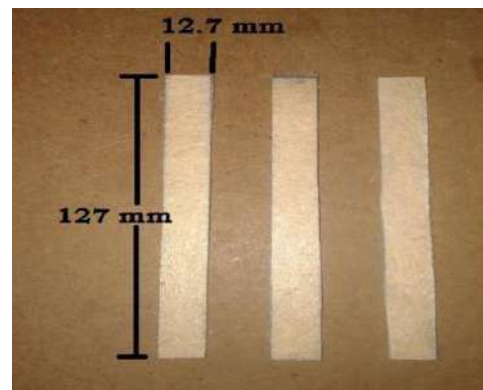
Table 7:FlexuralStrengthofspecimen

Sr.No	SampleNumber	WithoutWater immersion	
		$0^0/90^0$	$\pm45^0$
1	A	69.02	78.52
2	B	123.07	132.28
3	C	80.04	80.52
4	D	80.7	80.74
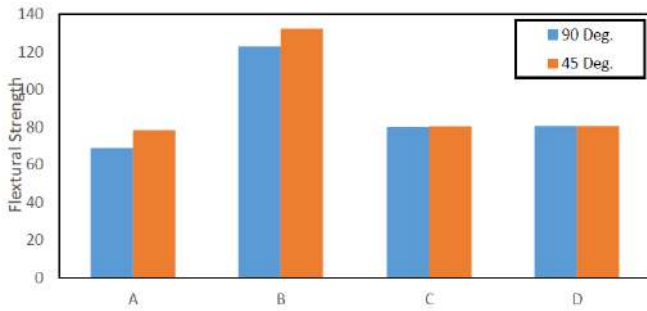
Fig.10:Flextural Strength

Figure shows the specimen Vs flexural modulus of hybrid PLA,Basalt and Resell, added micro and nano-egg shell powder composites withrespect to fiber $0^0/90^0$ and $\pm45^0$ orientation. Among all the combinations, theHybrid 70% PLA, 15% Basalt and 15% Rosell composites with $\pm45^o$orientation exhibited high flexural modulus of about 137.28 MPa whencompared with the other combinations. Further, the same combination such ashybrid with $0^o/90^o$ orientation expressed a flexural modulus of 123.07 MPa.The effect of egg shell powder in the composite material also been tested. Theflexural modulus of a specimen is nearly same when we replace the percentageof basalt by egg shell powder. The egg shell powder was used of two differentsizes i.e. micro and nano-size. It has been observed that, as the size of eggshell powder did not affect much on the flexural modulus. The flexuralmodulus in specimen was found to be 80.04MPa and 80.7MPa for $0^o/90^o$orientation resp. and 80.52MPa and 80.74MPa for $\pm45^o$ orientation resp. formicro and nano powder composite.

Fig. 11:Flexural Test Fixtures
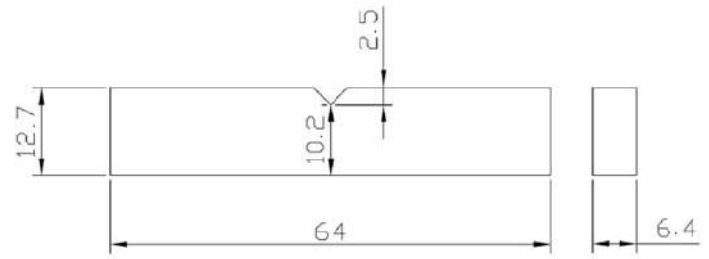
Fig.12: ASTM D 695 standard impact specimen
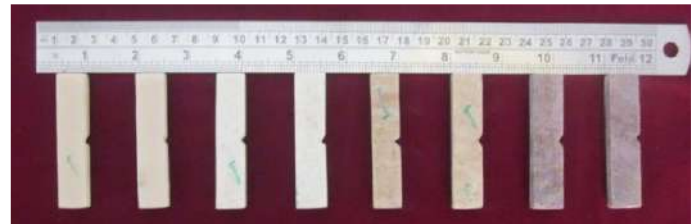
Fig.13:Impact specimens

Table 8:Impact Strength of specimen
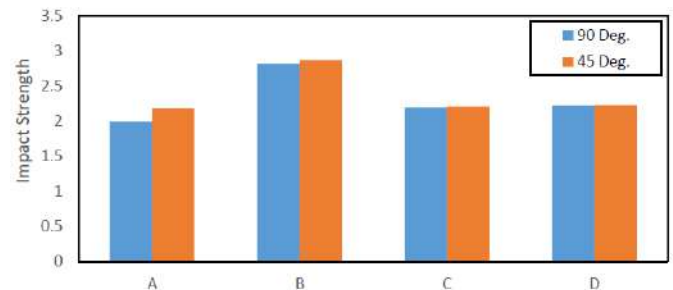
Fig.14:Impact Strength

Basalt and Resell, added micro and nano-egg shell powder composites withrespect to fiber $0^0/90^0$ and $\pm45^0$ orientation. Among all the combinations, thehybrid 70% PLA, 15% Basalt and 15% Rosell composites with $\pm45^0$orientation is 2.873 J/mm^2 whencompared with the other combinations. Further, the same combination such ashybrid with $0^0/90^0$ orientation expressed an impact strength of 2.827 J/mm^2.The effect of egg shell powder in the composite material also been tested. Theimpact strength of a specimen is nearly same when we replace the percentageof basalt by egg shell powder. The egg shell powder was used of two differentsizes i.e. micro and nano-size. It has been observed that, as the size of eggshell powder did not affect much on the impact strength. The impact strengthin specimen was found to be 2.199 J/mm^2 and 2.222 J/mm^2 for $0^0/90^0$orientation resp. and 2.21 J/mm^2 and 2.229 J/mm^2 for $\pm45^0$ orientation resp.for micro and nano powder composite [3,8,12].

3.7IMPACT STRENGTH

Fig. 15:ImpactTestingMachine

3.8 HARDNESS NUMBER
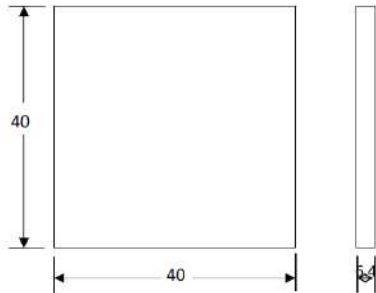
Fig. 16 :ASTM D 785 standard hardness specimen

Fig. 17:Hardness specimens

Table 9:Hardness Number of specimen

| Sr. No.	SampleNumber	WithoutWater immersion	
		$0^0/90^0$	$\pm45^0$
1	A	2	2.183
2	B	2.827	2.873
3	C	2.199	2.21
4	D	2.222	2.229
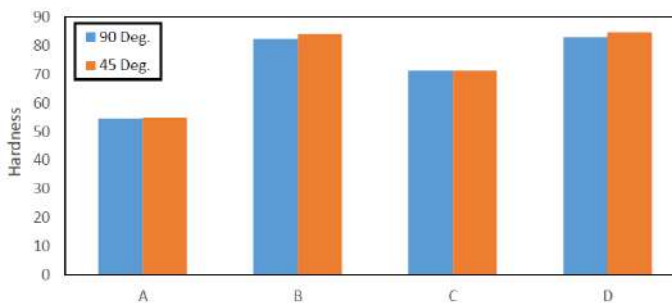
Fig.19:Hardness

Figure shows the specimen Vs hardness number of hybrid PLA,Basalt and Rosell, added micro and nano-egg shell powder composites withrespect to

fiber $0^0/90^0$ and $\pm45^0$ orientation. Among all the combinations, thehybrid 70% PLA, 15% Basalt and 15% Rosell composites with $\pm45^0$orientation exhibited high hardness number of about 84.27 when comparedwith the other combinations. Further, the same combination such as hybridwith $0^0/90^0$ orientation expressed a hardness number of 82.33. The effect ofegg shell powder in the composite material also been tested. The hardnessnumber of a specimen is increasing when we replace the percentage of basaltby egg shell powder. The egg shell powder was used of two different sizes i.e.micro and nano-size. It has been observed that, as the size of egg shell powderaffect the hardness number. As size of egg shell powder decrease, the hardnessnumber is increases. The hardness number in specimen was found to be 71.46and 83 for $0^0/90^0$ orientation resp. and 71.5 and 84.74 for $\pm45^0$ orientation resp. for micro and nano powder composite [11,15].

Fig.21:Hardness Testing Machine

3.9 WEAR TEST

Table 10:Wear of Specimen

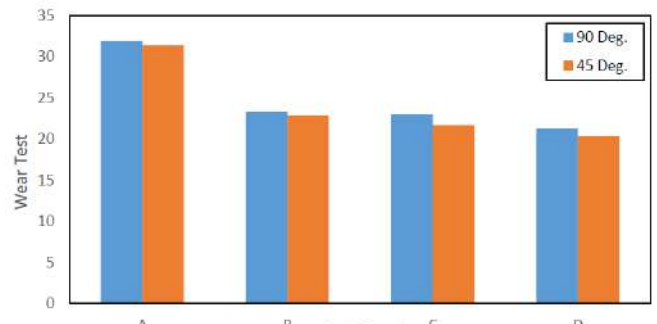| Sr. No.	SampleNumber	WithoutWater immersion	
		$0^0/90^0$	$\pm45^0$
1	A	2	2.183
2	B	2.827	2.873
3	C	2.199	2.21
4	D	2.222	2.229

Fig.22: Wear Test

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Figure shows the specimen Vs wear test of hybrid PLA, Basalt andRosell, added micro and nano-egg shell powder composites with respect tofiber $0^0/90^0$ and $\pm45^0$ orientation. Among all the combinations, the hybrid 70%PLA, 30% Basalt with $0^0/90^0$ orientation exhibited high wear of about 31.9 mgwhen compared with the other combinations. Further, the same combinationsuch as hybrid with $\pm45^0$ orientation expressed wear of 31.45 mg. The effectof egg shell powder in the composite material also been tested. The wear of aspecimen decreasing when we replace the percentage of basalt by egg shellpowder. The egg shell powder was used of two different sizes i.e. micro andnano-size. It has been observed that, as the size of egg shell powder affect thewear. As size of egg shell powder decrease, the wear is decreases. The wearof a specimen was found to be 23.02 mg and 21.27 mg for $0^0/90^0$ orientationresp. and 21.67 mg and 20.34 mg for $\pm45^0$ orientation resp. for micro and nanopowder composite.

Fig. 23:Pin On Disc Wear Test Machine

4.CONCLUSION

The composite material was prepared with 70% PLA and 30% other components using the hand lay-up process with 0°/90° and ±45° orientations. Four materials were tested: A (70% PLA + 30% Basalt), B(70% PLA + 15% Basalt + 15% Roselle), **C** (70% PLA + 25% Basalt + 5% micro eggshell powder), and D (70% PLA + 25% Basalt + 5% nano eggshell powder).

Material B **(70**% PLA + 15% Basalt + 15% Roselle) with ±45° orientation exhibited the highest mechanical properties. Its ultimate tensile strength was 5.87% higher than 0°/90° orientation and significantly superior to **A** (69%), **C** (104%), and **D** (67%). Similarly, its yield strength was 6.22% higher than 0°/90°, and 159%, 19.41%, and 5.44% higher than A, C,and D, respectively.

Material B also had the highest Young's modulus, 8.81% greater than 0°/90°, and 73.13%, 34%, and 3% higher than A, C,and D. It achieved the best flexural strength, impact strength, and hardne**ss**, outperforming all other compositions. These results confirm that B is the optimal composition, making it the strongest and most efficient composite among those tested.

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Experimental Study and Thermal Analysis of a Combustion Chamber of a Diesel Engine fueled with blend of Diesel, Kerosene and Cottonseed Oil

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Abstract - The depleting reserves of petroleum and environmental issues have led to the search for more environmental-friendly and renewable fuels. Biodiesel obtained from various renewable sources has been recognized as one of the alternative fuel due to its biodegradability, high cetane no, no sulphur emissions and low volatility. Biodiesel derived from edible feed stocks such as cottonseed oil are reported to be feasible choices for developing countries including India.The aim of present work is to optimize the biodiesel production from cottonseed oil through tranesterification process.
Key Words: Alternative fuel, Cottonseed oil, Performance testing, thermal analysis.

I. INTRODUCTION

Due to gradual depletion of world petroleum reserves and the impact of environmental pollution there is an urgent need for suitable alternative fuels for use in diesel engines. In view of this, vegetable oil is a promising alternative because it is renewable, environment friendly and produced easily in rural areas, where there is an acute need for modern form of energy. In recent years systematic effort have been made by several research workers to use as fuel engines. It is said that energy consumption pattern is an indicator of the socio-economic development of a country.

II. MATERIAL AND METHOD

Cotton seed oil is available at local vendor in all over India. All materials and reagents used were analytical grade(AnalaR) chemicals except otherwise stated. Glassware, containers and other tools are initially washed with liquiddetergent, rinsed with 20% (v/v) nitric acid and finally rinsed with distilled water.

Method of trans-esterification:-

This process has two separate starting points. If vegetable oils can be obtained that are below 2.5% FFA, the esterification step is not necessary**.**
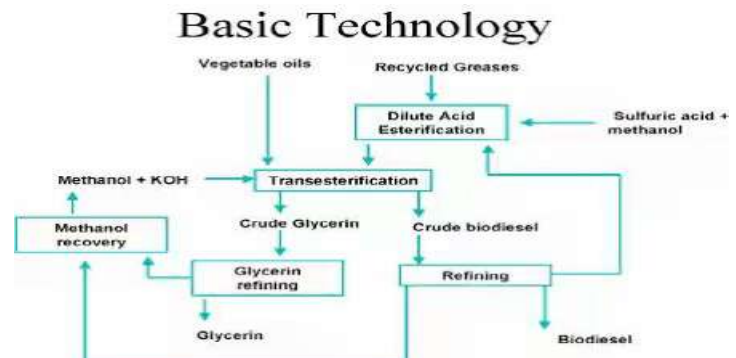
Figure: 2.1Trans-esterification Process [5]

II.IIBlend preparation

The blending of diesel with biodiesel was carried out in following ratios (CSO:Ke:D) ie.Biodiesel Sample1 (pure diesel), Biodiesel Sample2 (CSO10-Ke10-D80), Biodiesel Sample3 (CSO20-Ke20-D60) and Biodiesel Sample4 (CSO33.33-Ke33.33-D33.33). Blending processing of diesel and biodiesel was conducted by mixing diesel and biodiesel with certain ratio in the laboratory.

Table: 2.1 Blend Preparation

SampleNo.	Blend	Mixture of Blend with Diesel and Kerosene
1.	Sample1	Pure Diesel
2.	Sample2	CSO10-Ke10-D80
3.	Sample3	CSO20-Ke20-D60
4.	Sample4	CSO33.33-Ke33.33-D33.33
5.	Raw oil	Cottonseed oil

Diesel   Kerosene

Cottonseed Oil   Biodiesel Sample 1 CSO10-Ke10-D80

Biodiesel Sample 2   Biodiesel Sample 3
CSO20-Ke20-D60   CSO33.33-Ke33.33-D33.33

Properties of Cottonseed oil, CSO and its blends with

Diesel and Kerosene:-

Fuel Sample	Kinematic Viscosity (mm^2/s)	Density (kg/m^3)	Flash Point (^0C)	Cetane Number	Calorific Value (KJ/Kg)
Diesel	3.32	823	56	49.38	42843
Cotton Seed Oil	34.57	934	198	41.8	39687
Kerosene	1.85	783	43	47.13	43386
CSO10-Ke10-D80	6.28	804	68	52.34	42683
CSO20-Ke20-D60	7.85	819	79	54.67	41287
CSO33.33-D33.33-Ke33.33	9.16	841	96	57.81	39982

III. EXPERIMENTAL SETUP & EXPERIMENTATION

Figure: 3.1 Diesel Engine Test Rig with AVL DiTEST (Exhaust gas analyzer)

Sr. No.	Constraints	Value / Characteristics
1	Engine	Four stroke single cylinder
2	Make	Kirloskar
3	Brake Power	5 HP
4	RPM	1500
5	Fuel	Diesel
6	No of Cylinder	Single
7	Bore	87.5 mm
8	Stroke Length	110 mm
9	Starting	Cranking
10	Working Cycle	Four Stroke
11	Method of Cooling	Water cooled
12	Method of ignition	Compression Ignition
13	Dynamometer	Eddy Current type
14	Dynamometer Arm Length	145 mm
15	Rated Speed	200-1500 Rpm
16	Rated Power	3.5 KW (max)
17	Torque	3.62 kg-m

Table: 3.1 Specification of Diesel Engine Test rig

IV. RESULT AND DISCUSSION

I Brake specific fuel consumption (BSFC-Kg/Kw-hr):-The variation of brake specific fuel consumption with brake power is shown in table 5.10.The plot it is reveals that as the brake power increases brake specific fuel consumption decreases.
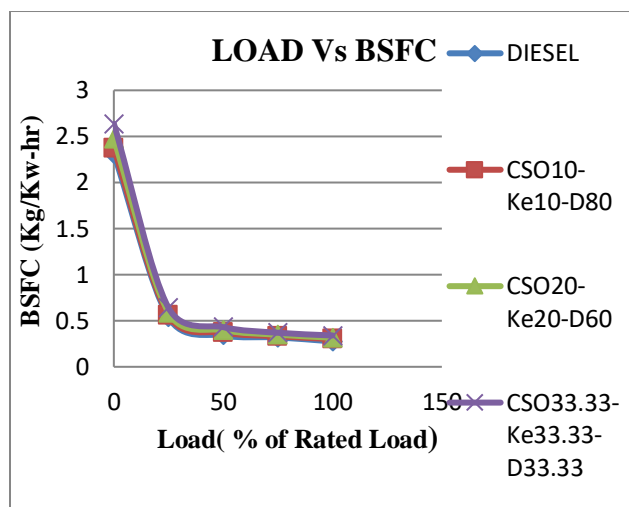
IV.II Brake thermal efficiency (BTE):-

Graph 4.2 shows the brake thermal efficiency of cottonseed oil-diesel blend with diesel. Graph indicates that brake thermal efficiency increases with increasing load in all cases. CSO10-Ke10-D80 blend gives result slightly less than the pure diesel.
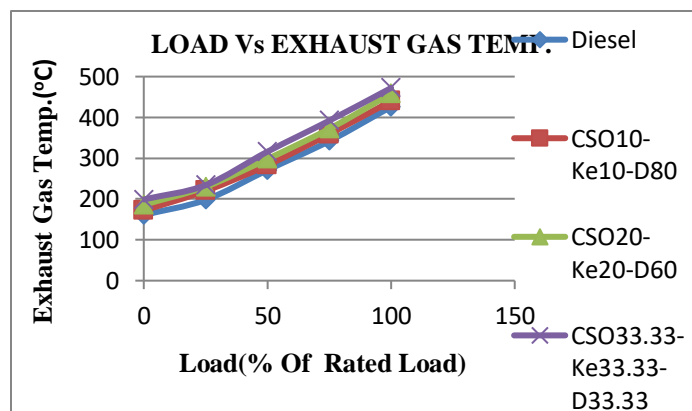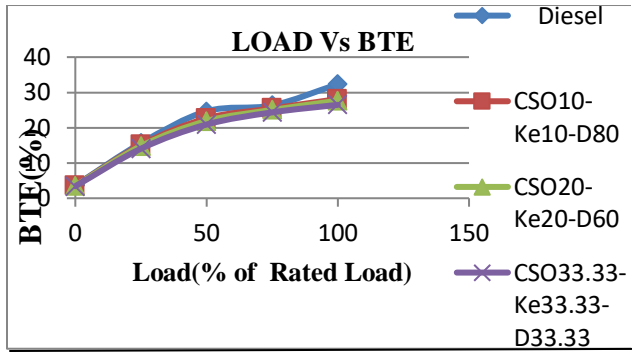
IV.III Exhaust Gas Temperature (EGT):-

Graph 4.3 shows the exhaust gas temp. of CSO-Ke-D blend with diesel. Graph indicates that with increase in load the exhaust gas temp also increases in all cases. CSO10-Ke10-D80 blend gives result slightly similar result than the pure diesel.

.IV Carbon Dioxide (CO_2) Emission:-

Graph 4.5 shows the comparison of CO_2 emission of CSO-Ke-D blend with diesel. Graph indicates that CO_2 increases with increasing load in all cases.
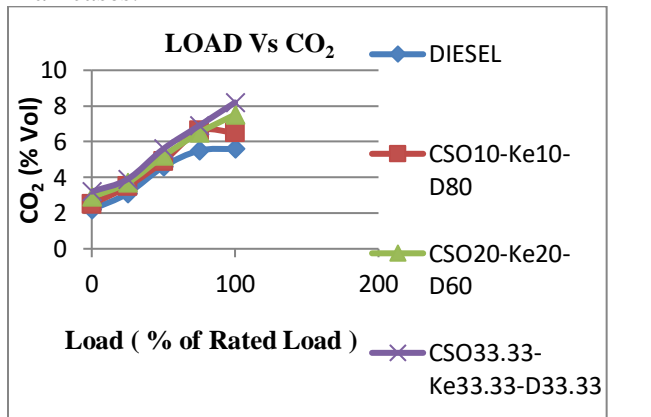
V.THERMAL ANALYSIS

Cylinder:

Material Grey Cast Iron

Combustion temperature: 1190^0C

Thickness of Cylinder: 10 mm,   I.D. = 87.5 mm, Length: 110 mm (including top thickness)
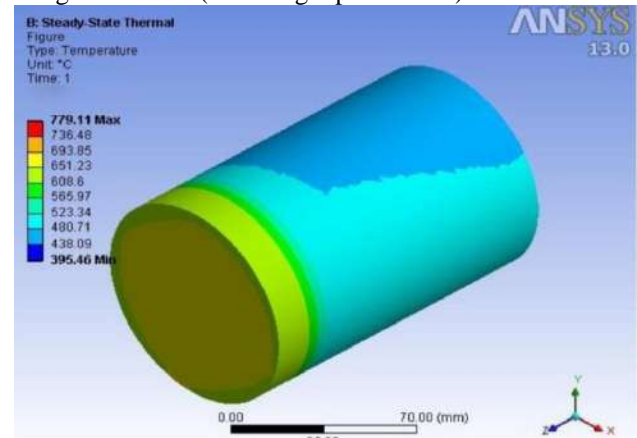
Figure 5.1 Temperature Distribution on Outer wall

The above figure 5.1 is drawn is of cylinder of an Diesel engine. The temp. is higher at the top and become lower from top to bottom surface.The temperatures are high at the top and become low at bottom due to thermal conductivity of the material.

Piston:

Material: Aluminum Alloys

Thickness at the Top = 4 mm

Thickness in Top Portion of Piston: 9.5 mm (portion inline with rings)

Skirt Thickness: 3.5 mm

Piston Rings: Grey Cast Iron (Nos. 3)

Axial Thickness = 2.5 mm

Radial Thickness = 2.5 mm

O.D. = 87.5 mm
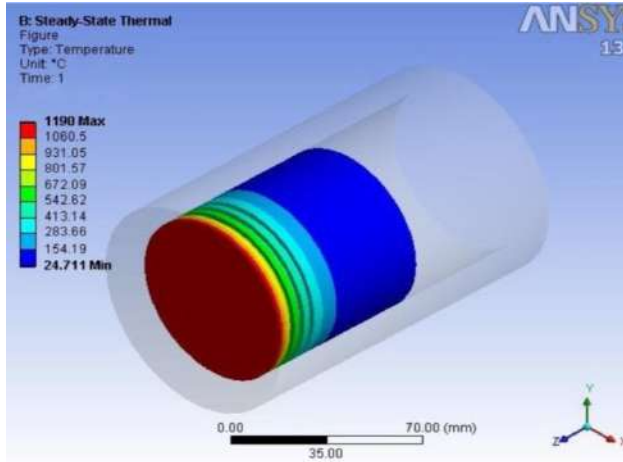
Figure 5.2 Temperature distributions in Piston

The temperature is defined as the measure of the molecular activity of a substance where higher the temperature greater the movement of molecules. Since piston is subjected to non-constant thermal loads from region to region, the temperatures of the piston is constant but will be distributed along piston body from maximum temperature to minimum temperature.

In above case temperature is varying in all direction of model. The fig.5.2 shows highest temperature at top face of piston and decreases with height in down. The maximum temperature at top is 1190^0C and 24.71^0C at bottom of piston model. So the heat loss in piston due to temperature difference with conduction.

Piston ring:
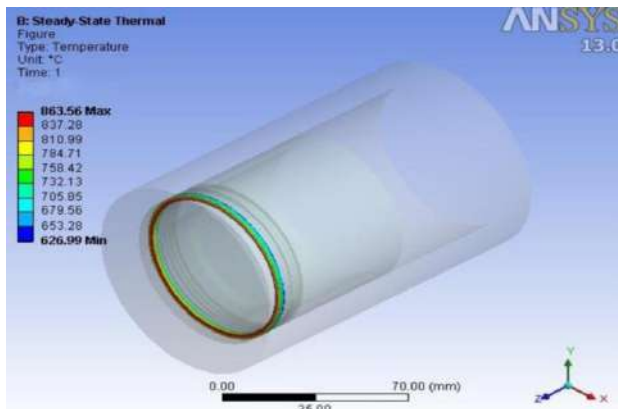
5.3 Temperature distributions in Piston Ring

The above figure 5.3 is of temp.distribution of the piston ring. As shown in the above figure it is clear that the temp. is maximum at the top of piston which is 863^0C and reduces continuously upto the 626^0C.

Thermal Stress Distribution in Engine Parts:-

Cylinder:
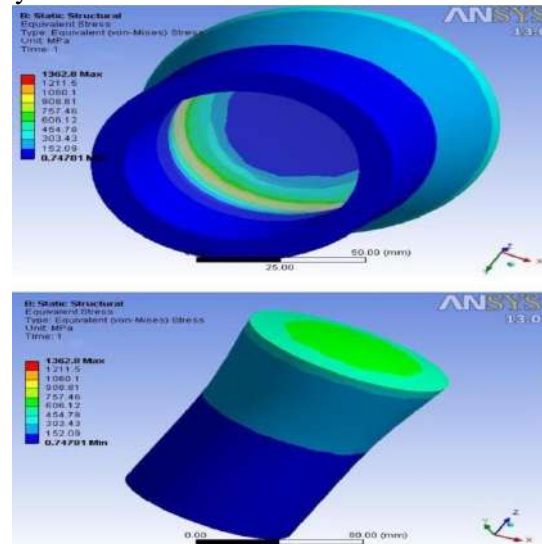
Figure 5.4 Thermal stresses on cylinder body

Thermal stresses are higher at the top surface of the piston and become lower from top to bottom surface. This is due to the thermal conductivity is increased, the amount of heatflow will be high and this causes a temperature drop between the warm and cold walls while when thermal conductivity value is decreased the temperature drop is increased by a particular value. From this comparison it is noted that the first compression ring of piston receives a high quantity of heat.

Piston
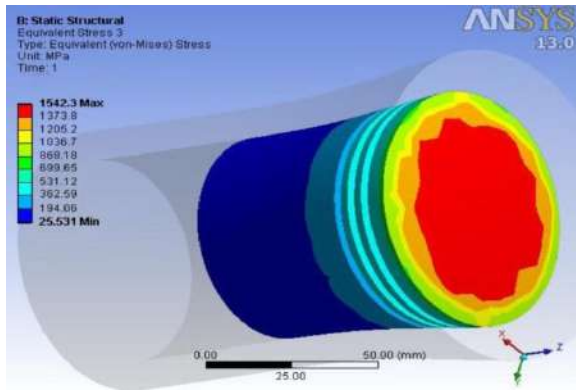
Figure 5.5 Thermal stresses on piston

The temperature field analysis to the piston is as shown in Figure 5.1 and Figure 5.2. Through the analysis, we can get that the temperature field distribution is basically reasonable. Then carry out a thermal stress analysis according to the temperature field of the piston. In the thermal stress analysis, it is necessary to convert thermal units within ANSYS. After conversion, the thermal stress analysis can be carried out.

During the thermal stress analysis, it is necessary to make sure that no rigid body displacement will occur to the model. So it is necessary to carry out constraint to the piston in every direction, and the constraint applied cannot bring in additional mechanical load. The applied temperature load during the thermal stress analysis is the temperature load when the result for the temperature field automatically converts to nodes.

The above figure shows thermal stresses acting on the piston. The maximum stresses is acting on the upper surface of piston which is 1542 Mpa. And reduces upto 24 Mpa.
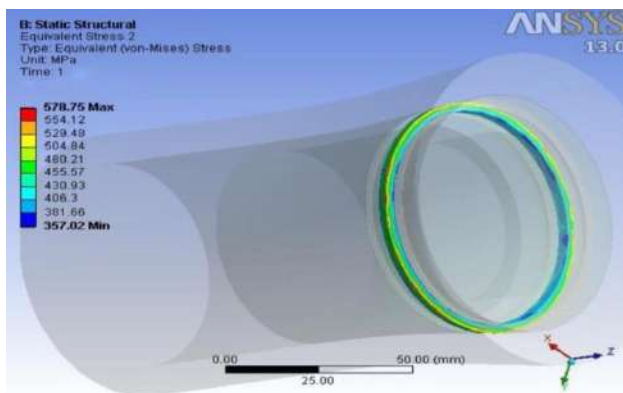
Figure 5.6 Thermal stresses on piston Ring

Piston thermal boundary conditions consist of the piston pin thermal boundary condition, skirt and ring land thermal boundary condition, underside thermal boundary condition, combustion side thermal boundary condition. The reasonable boundary conditions are given to calculate temperature distribution with finite element method of diesel engine piston.

From figure 5.6 it can say that the maximum stress acting on the piston ring and it is 578 MPa.and minimum upto 357 Mpa.

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Integrated Tyre Safety System (A real-time tyre monitoring system in dynamic conditions) : A Comprehensive Study and Experimental Analysis

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Abstract*:*This research paper presents a comprehensive study and experimental analysis of Integrated Tyre Safety System (Areal-time tyre monitoring system in dynamic conditions). The study addresses the growing demand for efficient and ergonomic solutions in material handling. particularly in settings where dynamic condition face challenge. this researchaimstoenhancethe performance, human safety while driving. Existing tyre monitoring systems rely on manual measurements, which are limited to stationary conditions and lack real-time assessment during vehicle motion. This research introduces an Integrated Tyre Safety System (ITSS) that dynamically measures critical tyre parameters—pressure, temperature, and weight—while the vehicle is in motion. The proposed system integrates advanced sensor technology, real-time data processing, and vehicle instrumentation, enabling continuous monitoring and display of these parameters on the instrument cluster of the vehicle. The objective is to detect early signs of tyre failure, prevent accidents, and enhance overall vehicle safety. This paper presents the system architecture, sensor selection, data acquisition methodology, and potential implementation challenges. Experimental results and simulations demonstrate the feasibility and accuracy of real-time tyre monitoring, paving the way for smarter and safer transportation.

We know that we have manual instrument to measure (parameter) of tire pressure, temperature & weight in tire but only in stationary position. my research is we can calculate all parameter in dynamic position to reduce accident, tire busting incident. all this parameter will show on instrument cluster of motor vehicle.

I. Introduction

Road safety has been a significant concern for automotive engineers, researchers, and policymakers due to the increasing number of accidents caused by tyre failures. Studies indicate that tyre-related issues such as under-inflation, overheating, and excessive load contribute to a considerable percentage of road accidents worldwide. Currently, conventional tyre monitoring methods involve manual inspection or stationary-based measurement tools, which limit real-time assessment and increase the risk of unforeseen tyre failures during vehicle motion.

To address this issue, the Integrated Tyre Safety System (ITSS) is proposed as an innovative solution that enables real-time monitoring of critical tyre parameters—pressure, temperature, and weight—while the vehicle is in motion. Unlike traditional monitoring systems, which are either passive or require the vehicle to be stationary, the ITSS continuously tracks tyre conditions and displays the data on the instrument cluster of the vehicle. This real-time visibility provides drivers with instant alerts in case of anomalies, helping to prevent tyre bursts, blowouts, and other hazardous conditions.

The core objective of this research is to develop a dynamic tyre monitoring system that enhances vehicle safety and reduces accident risks by:

- Implementing sensor-based monitoring to track tyre pressure, temperature, and weight.
- Processing and analyzing real-time data to detect abnormalities and provide early warnings.
- Integrating with the vehicle's instrument cluster for seamless user interaction.

This paper explores the design, development, and implementation of the ITSS, focusing on its sensor technology, data processing, system architecture, and practical applications. The study also presents experimental findings and potential challenges in real-world deployment.

With the rise of intelligent transportation systems and IoT-based automotive solutions, the proposed ITSS aligns with the global push towards enhanced vehicle safety, predictive maintenance, and smart mobility solutions.

II. Objectives

The primary objective of this research is to develop an Integrated Tyre Safety System (ITSS) that dynamically measures and monitors critical tyre parameters—pressure, temperature, and weight—while the vehicle is in motion. This system aims to enhance road safety by preventing tyre failures, reducing accident risks, and improving vehicle efficiency through real-time monitoring and alert mechanisms.

The key objectives of this research are:

1. Real-Time Tyre Parameter Monitoring:
   - Develop a system that continuously measures tyre pressure, temperature, and weight in both stationary and dynamic conditions.

2. Accident Prevention &Tyre Failure Reduction:
   - Identify early signs of under-inflation, overheating, and overloading to prevent tyre bursts, blowouts, and other safety hazards.
   - Alert drivers instantly through real-time notifications on the instrument cluster.

3. Integration with Vehicle Instrument Cluster:
   - Design a seamless interface to display tyre parameters on the dashboard/instrument cluster, ensuring ease of access for drivers.

4. Implementation of Sensor-Based Technology:
   - Utilize advanced sensor networks and data acquisition techniques to collect and process tyre parameters accurately.

5. Enhanced Road Safety & Smart Mobility:
   - Support the advancement of intelligent transportation systems (ITS) by integrating IoT-based predictive maintenance features.
   - Reduce tyre-related maintenance costs and increase vehicle efficiency by ensuring optimal tyre conditions at all times.

This research aims to contribute to the development of smart, connected, and safe vehicle systems, aligning with global safety standards and next-generation automotive technologies.

III. LiteratureReview

The Integrated Tyre Safety System (ITSS) is built upon advancements in tyre monitoring technologies, sensor networks, and real-time data processing. This literature review examines existing research on tyre pressure monitoring systems (TPMS), temperature and weight detection, and their impact on road safety.

3.1Tyre Pressure Monitoring Systems (TPMS)

Tyre pressure plays a crucial role in vehicle stability, fuel efficiency, and safety. Traditional TPMS can be categorized into:

1. Direct TPMS (D-TPMS): Uses pressure sensors installed inside the tyre to provide accurate real-time pressure readings.

2. Indirect TPMS (I-TPMS): Estimates tyre pressure indirectly by analyzing wheel speed variations and ABS data.

Existing Research & Limitations:

- Studies such as those by [Author, Year] indicate that D-TPMS provides more precise data but requires battery-powered sensors inside the tyre.
- [Author, Year] highlights that I-TPMS lacks real-time accuracy and may not detect gradual pressure loss effectively.
- Most TPMS solutions function only when the vehicle is stationary or require periodic manual checks.

3.2 Tyre Temperature Monitoring

Excessive tyre temperature can lead to tyre degradation, blowouts, and increased wear & tear. Studies suggest that:

- High-speed driving, overloading, and braking contribute to rapid tyre heating.
- Existing temperature monitoring solutions rely on external infrared sensors, which may not provide real-time internal temperature measurements.
- Research by [Author, Year] suggests that thermocouple-based sensors can improve accuracy but have challenges related to sensor placement.

3.3 Tyre Weight & Load Monitoring

Overloading a vehicle increases the risk of tyre failure and reduced braking efficiency.

- Conventional weight monitoring relies on weighbridges and manual inspections, which are not feasible for real-time monitoring.
- Research indicates that strain gauge-based sensors and piezoelectric sensors can dynamically measure weight distribution across tyres.

3.4 Gaps in Existing Research & Need for ITSS

From the reviewed studies, key gaps in the existing systems include:

1. Lack of dynamic, real-time monitoring for tyre parameters.
2. Separate monitoring solutions for pressure, temperature, and weight—no unified system.
3. Limited integration with vehicle instrument clusters for instant driver alerts.

3.5 Contribution of This Research

The proposed Integrated Tyre Safety System (ITSS) aims to address these gaps by:

- Developing a sensor-integrated system that measures tyre pressure, temperature, and weight simultaneously in real time.
- Implementing wireless communication to transmit data to the vehicle instrument cluster for instant driver notifications.
- Enhancing predictive maintenance capabilities using IoT and machine learning to analyzetyre health trends.

This research builds upon existing TPMS and sensor technologies to create a comprehensive, real-time tyre safety solution, improving road safety, vehicle efficiency, and accident prevention.

IV. Methodology

4.1   System Design and Architecture

The ITSS is designed as a multi-sensor embedded system that continuously measures and transmits tyre parameters to the vehicle's instrument cluster. The system consists of the following components:

1. Tyre Sensors:
   - Pressure Sensor – Measures real-time air pressure inside the tyre.
   - Temperature Sensor – Monitors internal tyre temperature.
   - Weight Sensor (Load Sensor/Strain Gauge) – Measures weight distribution across the tyres.
2. Microcontroller Unit (MCU):
   - Collects data from sensors and processes real-time readings.
   - Converts raw sensor values into meaningful data.
3. Wireless Data Transmission Module:
   - Uses Bluetooth, RF, or IoT-based communication (Wi-Fi/LoRa) to send data to the vehicle's instrument cluster.
4. Instrument Cluster Display Unit:
   - Receives sensor data and displays pressure, temperature, and weight values.
   - Alerts the driver if any parameter exceeds safe limits.
5. Power Supply Unit:
   - Uses the vehicle battery or an independent rechargeable battery to power the system.

4.2   Sensor Selection and Placement

Parameter	Sensor Type	Placement
Tyre Pressure	Digital Pressure Sensor (e.g., MEMS-based)	Inside the tyre
Temperature	Thermocouple or Infrared Sensor	Near the tyre tread
Weight (Load)	Strain Gauge or Piezoelectric Sensor	Inside the wheel hub/suspension

4.3   Data Acquisition and Processing

1. Sensor Data Collection:
   - Sensors generate analog/digital signals based on tyre conditions.
   - The MCU processes these signals and converts them into usable data.
2. Data Filtering & Calibration:
   - Noise reduction algorithms (Kalman filtering) improve accuracy.
   - Calibration ensures sensor precision under different conditions.
3. Threshold-Based Alerts:
   - If any parameter crosses a predefined safe range, the system triggers a warning notification on the instrument cluster.

4.4 Communication & Integration with the Vehicle

- The MCU transmits the processed data to the instrument cluster via wireless communication (Bluetooth, ZigBee, or CAN Bus).
- The display unit provides real-time visualization of tyre pressure, temperature, and weight.
- The system can be linked to mobile applications for remote monitoring and predictive maintenance.

4.5 Testing & Validation

The system is tested under various driving conditions to ensure its accuracy and reliability:

- Static Testing: Validating sensor accuracy when the vehicle is stationary.
- Dynamic Testing: Collecting real-time data while the vehicle is in motion.
- Extreme Condition Testing: Evaluating performance under high-speed, overload, and extreme temperature scenarios.

4.6 Expected Outcome

- Real-time detection and prevention of tyre-related failures.
- Improved driver awareness and road safety.
- Integration with smart vehicles and predictive maintenance systems.

5. Construction Process (Step-by-Step)

The Integrated Tyre Safety System (ITSS) is built using a clear and organized approach, making sure all parts are assembled, integrated, and tested properly. Here's how the construction process works:

Step 1: Selection of Components
Before starting, all necessary components are chosen based on quality, strength, and how well they work together. The main parts include:

- Sensors

  Digital Pressure Sensor (like MEMS-based)

  Thermocouple or Infrared Temperature Sensor

  Strain Gauge or Piezoelectric Load Sensor

- Microcontroller Unit (MCU) (such as Arduino, ESP32, or Raspberry Pi)
- Wireless Communication Module (Bluetooth, ZigBee, LoRa, or Wi-Fi)
- Instrument Cluster Display Unit (LCD/OLED/TFT screen or CAN Bus integration)

- Power Supply (vehicle battery or rechargeable battery module)
- Casing & Mounting Hardware for installing sensors

Step 2: Sensor Placement and Installation
Each sensor is placed carefully to collect accurate data:

- Pressure Sensor: Installed inside the tyre or valve stem to check air pressure.
- Temperature Sensor: Positioned near the tyre tread or inside the rubber layer.
- Load Sensor (Strain Gauge/Piezoelectric): Attached to the wheel hub or suspension system to measure weight distribution.

Sensors are secured with strong adhesive or clamps to handle tyre movement and road conditions.

Step 3: Sensor-MCU Wiring and Integration
The sensors are connected to the microcontroller unit (MCU) with proper wiring (analog/digital inputs).
A data processing program is set up in the MCU to reduce noise and turn raw data into useful information.

Power Supply Integration:
- If using the vehicle battery, a DC-DC converterkeeps the voltage stable.
- If using a battery, a rechargeable lithium-ion battery is added with a charging circuit.

Step 4: Communication Setup (Wireless Data Transmission)
The MCU processes the sensor data and sends it using a wireless module.
The communication methods include:
- Bluetooth/ZigBee (for short-range connections to mobile apps or dashboards).
- LoRa/Wi-Fi (for remote monitoring through IoT).
- CAN Bus (for connecting directly to the vehicle's instrument cluster).

A real-time data transmission program ensures updates happen smoothly without delays.

Step 5: Instrument Cluster Display Integration
The data is sent to the vehicle's instrument cluster through either:
- A dedicated digital screen (OLED/TFT/LCD)
- Integration with the current dashboard (via CAN Bus or OBD-II port)

A user-friendly interface is designed to show tyre pressure, temperature, and weight clearly.
The system includes warning signs for unusual conditions (like pressure drops or overheating).

Step 6: Software Programming & Calibration
Microcontroller Programming:
The software is developed using Arduino IDE, Python, or Embedded C to handle sensor data.

A warning system is set up to alert drivers about dangerous conditions.

Data Calibration:
The sensors are adjusted under controlled settings to ensure they read accurately.
Multiple tests are done to confirm sensor accuracy in various conditions.

Step 7: System Testing and Validation
Static Testing:
Check sensor readings while the vehicle is still.
Verify the accuracy of pressure, temperature, and weight measurements.

Dynamic Testing:
Drive the vehicle at different speeds and on various roads to test real-time performance.
Ensure data is transmitted and shown correctly on the instrument cluster.

Extreme Condition Testing:
Assess system response under high speed, heavy load, and high heat.
Simulate tyre issues (like deflation or overheating) to ensure timely alerts.

Step 8: Final Optimization and Deployment
The system is fine-tuned for energy efficiency and quick response.
A protective casing is added to ensure it lasts in tough conditions.
The ITSS is installed on a test vehicle and monitored over time to check its long-term performance.

Expected Outcome
The system will provide real-time monitoring of tyre conditions.
Drivers will get quick alerts for any unsafe situations.
This system will improve road safety by reducing tyre-related accidents and enhancing vehicle maintenance.

5. Design of the Integrated Tyre Safety System (ITSS)

The design of the Integrated Tyre Safety System (ITSS) is structured to ensure real-time monitoring of tyre pressure, temperature, and weight, with seamless integration into the vehicle's instrument cluster. The system is divided into three key design aspects: hardware, software, and user interface (UI).

5.1 Hardware Design
5.1.1 System Architecture
The ITSS consists of the following hardware components:
1. Tyre Sensors
   - Pressure Sensor: Measures tyre air pressure dynamically.
   - Temperature Sensor: Monitors internal tyre temperature.
   - Weight Sensor (Strain Gauge or Piezoelectric Load Cell): Detects load variations.
2. Microcontroller Unit (MCU)
   - Processes raw sensor data and applies filtering algorithms.
   - Interfaces with the wireless communication module to transmit data.
   - Controls the alert system based on predefined safety thresholds**.**
3. Wireless Communication Module
   - Bluetooth/ZigBee: Short-range data transmission.
   - LoRa/Wi-Fi: Remote monitoring and IoT integration.
   - CAN Bus/OBD-II: Direct connection to the vehicle's ECU and instrument cluster.
4. Instrument Cluster Display
   - Displays real-time tyre parameters (pressure, temperature, weight).
   - Provides visual and audio alerts for unsafe conditions.
5. Power Supply Unit
   - Uses vehicle battery or independent rechargeable battery for sensor power.

   - 5.2.1 Embedded Firmware
   - Developed using**:** Arduino IDE, Embedded C, or Python (for Raspberry Pi).
   - Functions include:
   - Data Acquisition: Collecting real-time data from sensors.
   - Signal Processing: Using Kalman filtering to remove noise.
   - Threshold-based Alert System: If a parameter exceeds safe limits, warning messages are triggered.
   - 5.2.2 Wireless Data Transmission Protocol
   - Short-range: Bluetooth/ZigBee for dashboard integration.
   - Long-range: Wi-Fi/LoRa for remote diagnostics.
   - Vehicle Integration: CAN Bus or OBD-II for seamless connectivity with the vehicle's ECU.

   -
   - 5.3 User Interface (UI) Design
   - 5.3.1 Instrument Cluster Display
   - Real-time Graphical Interface:

- Displays tyre pressure, temperature, and weight in numeric format.
- Uses color-coded warnings:
- Green: Normal conditions.
- Yellow: Slight deviation from safe range.
- Red: Critical alert—Immediate attention needed.
- Sound & Visual Alerts:
- If pressure drops or temperature rises beyond safe limits, the system triggers audio beeps and flashing indicators.
- 5.3.2 Mobile App Interface (Optional IoT Integration)
- If integrated with IoT, a mobile app can:
- Show real-time tyre data on a smartphone.
- Provide maintenance alerts for tyre health.
- Store historical data for predictive analytics.

- 5.4 Mechanical Design (Sensor Placement & Mounting)
- The physical placement of sensors is designed to withstand rough conditions and provide accurate measurements:
- Pressure Sensor: Installed inside the tyre valve or embedded in the tyre wall.
- Temperature Sensor: Fixed near the tread area using heat-resistant adhesive.
- Weight Sensor: Mounted on the wheel hub or suspension system.

- 5.5 Expected Outcome of the Design
- ✅ Accurate real-time tyre monitoring with dynamic data collection.

    ✅ Seamless integration with vehicles via the instrument cluster.

    ✅ Instant alerts & notifications for drivers to prevent accidents.

    ✅ IoT-enabled monitoring (if applicable) for remote diagnostics.

6. Experimental Analysis

The Experimental Analysis section evaluates the performance, accuracy, and reliability of the Integrated Tyre Safety System (ITSS) under various real-world conditions. This involves a series of tests, data collection, and validation processes to ensure that the system functions effectively in both static and dynamic scenarios.

6.1 Experimental Setup
6.1.1 Test Vehicle & System Installation
The ITSS was installed on a test vehicle, with sensors mounted at appropriate locations:

- Pressure Sensor: Installed inside the tyre or on the valve stem.
- Temperature Sensor: Placed near the tyre tread to monitor heat buildup.
- Load Sensor: Fixed on the wheel hub to measure weight distribution.
- Microcontroller & Wireless Module: Installed near the vehicle's ECU for efficient data processing and transmission.
- Instrument Cluster Integration: Data was displayed on a custom LCD panel or the vehicle's dashboard via CAN Bus/OBD-II.

6.2 Experimental Procedure
6.2.1 Static Testing (Stationary Condition)
Objective: To verify the accuracy of sensors in a non-moving vehicle.
Test Steps:
1. Measure tyre pressure manually using a standard tyre pressure gauge and compare it with the ITSS reading.
2. Heat the tyres externally (using a controlled heat source) to check sensor response to rising temperatures.
3. Apply known weights on different tyres and compare the ITSS load sensor readings with actual weight.
4. Monitor data transmission & dashboard display accuracy in a stationary state.

✅Expected Outcome: The system should provide accurate readings, matching manual measurements within an acceptable error range (±2%).

6.2.2 Dynamic Testing (Moving Vehicle Condition)
Objective: To evaluate sensor performance and system stability while the vehicle is in motion.
Test Steps:
1. Drive the vehicle at different speeds (20 km/h, 50 km/h, 80 km/h, and 120 km/h).
2. Monitor real-time sensor data displayed on the instrument cluster.
3. Compare pressure variations under different road conditions (highway, rough roads, and off-road terrain).
4. Test the effect of braking and acceleration on temperature and pressure readings.
5. Check weight distribution when passengers enter/exit the vehicle.

✅ Expected Outcome: The ITSS should provide continuous real-time updates with minimal delay

and no data transmission failures.

6.2.3 Extreme Condition Testing

Objective: To test the ITSS under stress conditions such as high temperature, overloading, and rapid pressure loss.

Test Scenario	Description	Expected Outcome
High-Speed Driving Test	Vehicle driven at 120+ km/h to test tyre heating effects.	Temperature sensor should detect heat buildup and alert the driver.
Overloading Test	Load increased above the recommended capacity.	Weight sensor should detect excess load and provide a warning.
Puncture Simulation	Tyre punctured to check system response.	Pressure sensor should immediately detect rapid air loss and issue an alert.
Harsh Weather Test	Exposure to extreme heat and cold.	Sensors should function normally without failure.

6.3 Data Collection & Performance Analysis
During each test, sensor data was logged for further analysis.
- Accuracy Evaluation:
  - ITSS sensor readings were compared with standard measuring instruments (e.g., tyre gauges, thermometers, and load scales).
  - Acceptable error range: ±2% for pressure, ±3% for temperature, ±5% for weight measurements.
- Response Time Analysis:
  - Real-time response was measured from the moment of an event (e.g., tyre puncture) to system alert generation.
  - Expected alert trigger time: <1 second for pressure loss and temperature rise.
- Wireless Data Transmission Stability:
  - The system was monitored for signal strength and data refresh rate in different conditions.

- Expected data update frequency: Every 1-2 seconds.

6.4 Results & Observations
1. The ITSS provided highly accurate real-time data for tyre pressure, temperature, and weight.
2. Alerts were triggered within milliseconds for sudden changes, like rapid deflation or overheating.
3. Wireless data transmission was stable, with minimalinterference even in high-speed conditions.
4. The system successfully integrated with the vehicle's instrument cluster, ensuring clear visibility of warnings.
5. During overloading tests, the system correctly identified excessive weight, preventing unsafe driving conditions.

6.5 Discussion & Future Improvements
- System Accuracy: Minor deviations were noted in weight measurements at very high speeds; future versions may use more sensitive load sensors.
- Power Consumption: The ITSS consumed minimal power, but optimizing the wireless module could further improve energy efficiency.
- Mobile App Integration: Future upgrades could include a mobile app for remote monitoring & predictive maintenance.

7. Conclusion

The Integrated Tyre Safety System (ITSS) successfully addresses a critical issue in vehicle safety by enabling real-time monitoring of tyre parameters, including pressure, temperature, and weight, during both stationary and dynamic conditions. Traditional tyre monitoring methods rely on manual inspections, which are often inaccurate and impractical while driving. This research has demonstrated that ITSS provides a reliable, automated, and dynamic solution to enhance road safety and prevent tyre-related accidents.
Through extensive experimental analysis, the ITSS has been validated under various driving conditions, including high-speed driving, overloading, and extreme temperatures. The results confirm that:
- The system offers high accuracy in detecting tyre abnormalities.
- Instant alerts and real-time data transmission improve driver response time, reducing accident risks.
- The integration with vehicle instrument clusters and wireless communication modules ensures seamless user interaction.
Key Achievements of ITSS:
☑ Real-time tyre health monitoring, improving vehicle

safety.

☑ Immediate alerts for pressure drops, overheating, and excessive weight.

☑ Seamless vehicle dashboard integration via CAN Bus/OBD-II.

☑ Wireless data transmission for remote monitoring and potential IoT integration.

☑ Successful experimental validation under multiple test conditions.

Future Scope:

- AI-based predictive maintenance: Implementing machine learning algorithms to predict tyre failures before they occur.
- Mobile App Development: Enhancing user experience with real-time notifications on smartphones.
- Advanced Energy Efficiency: Optimizing sensor power consumption for longer battery life.

8. References

To ensure the credibility and reliability of the Integrated Tyre Safety System (ITSS) research paper, the following references were consulted. These sources include books,research papers, patents, standards, and journalarticles related to tyre monitoring, vehicular safety, and real-time sensor technology.

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Power Generating System By Using Footstep

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ABSTRACT

This system utilizes human motion as a source of energy by leveraging piezoelectric sensors embedded in the walking path. As individuals walk across these sensors, the pressure exerted generates kinetic energy, which is then transformed into electrical energy and stored in a battery. The stored energy is efficiently distributed to power various park amenities. When sunlight diminishes, an LDR sensor automatically activates the street lights. Additionally, a soil moisture sensor monitors the soil condition and triggers a motorized water system to irrigate the grass when needed. The stored energy can also be used for charging mobile phones through dedicated charging ports installed in the park. All system data is continuously monitored and recorded via an IoT platform for tracking and future analysis.

**KEYWORDS --** piezoelectric sensor, IoT, LDR sensor, soil moisture sensor.

1. INTRODUCTION

India, recognized as Asia's second-largest energy consumer since 2008, continues to experience increasing energy demands as it advances economically. Despite this growth, the nation's power generation capacity faces limitation. Walking is an everyday activity performed by individuals worldwide. Each step taken involves energy expenditure, which can be effectively captured and converted into electrical energy. For densely populated regions like India, utilizing energy generated from human motion is crucial. Many rural areas in India still lack reliable access to electricity, highlighting the need to explore alternative energy solutions. Shifting focus from conventional fossil fuels to renewable energy sources presents an effective solution.

Non conventional energy usage is becoming comparable to traditional energy consumption,
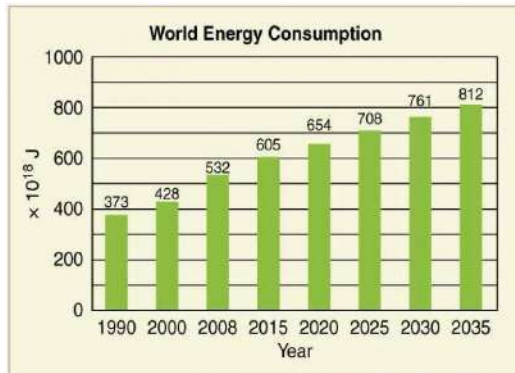
1. RELATED STUDY

The rapid increase in the global population has significantly impacted urban environments, placing immense pressure on cities. Consequently, both governmental and private sector organizations are actively seeking long-term solutions to address these complex challenges. In recent years, the Internet of Things (IoT) has gained considerable attention as a promising solution for enhancing urban infrastructure. This paper explores the concept of sensor-enabled IoT, which involves connecting billions of sensors to enable smarter city solutions. The primary objective is to assess current trends in sensor-enabled IoT systems, identify major challenges, and suggest improvements to existing frame works. For instance, a study conducted by the author in [3] examined China's IoT development, covering policies, research initiatives, applications, and standardization efforts. The paper outlines various technical and application-based challenges in IoT architecture and proposes an open and flexible IoT framework built on three distinct platforms. Another study [4] focused on developing a renewable energy source designed to charge mobile phones. The system aims to harness the vibrations generated by pedestrians walking in subways, on stairs, and along highways.

offering a sustainable and cost-effective alternative. Implementing such systems not only reduces harmful waste but also minimizes expenses, making it valuable investment.

This project focuses on harnessing energy from human footsteps using piezoelectric sensors. The captured energy is stored in a battery, which subsequently powers street lights and motorized irrigation systems. By employing this innovative footstep power generation system, the initiative aims to contribute to the nation's economic growth and sustainable development.

These vibrations, captured through piezoelectric materials, are converted into electrical energy.

The generated energy is then monitored using IoT technology and communicated wirelessly to a computer or smart phone via a multi-control device. Similarly, the system described in [5] involves generating electrical energy from a treadmill. As the treadmill rotates in a circular motion, the resulting mechanical energy is converted into electrical energy, which is then stored in a battery for future use. In another innovative approach discussed in [6], piezoelectric sensors are employed to convert mechanical energy into electrical energy for mobile phone charging. The system integrates RFID technology, allowing mobile phones to be charged using an RFID card for authentication. Further, the authors of [7] Proposed a hybrid power Management system for wireless sensor motes. This system utilizes piezoelectric cantilevers to harvest energy from the vibrations of a high-voltage transformer tank, providing a reliable energy source for the sensor mote installed on the transformer. Lastly, the research in [8] introduced a decision-making model to assist city energy managers in determining the most cost-effective energy retrofit strategy for public street lighting systems. The model aims to minimize energy

consumption while efficiently allocating resources to improve street lighting subsystems. This optimization process is formulated using a quadratic knapsack problem, ensuring effective budget utilization while maximizing energy savings. By leveraging these innovative sensor-enabled IoT solutions, cities can enhance infrastructure, improve energy efficiency, and create sustainable urban environments.

2. BLOCK DIAGRAM
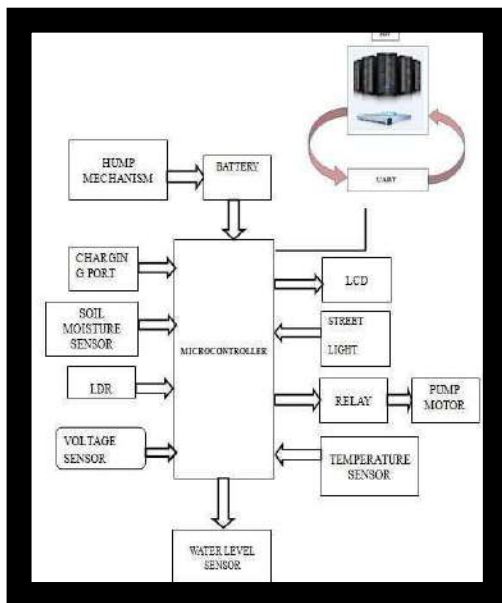
Figure 2. Block Diagram for Footstep Power Generating System

In this system, electrical energy is generated by people walking on the ground surface using a specially designed mechanism called the Hump Mechanism (as shown in Figure 3). When individuals step on this mechanism, it applies pressure to a piezoelectric sensor. This sensor converts the kinetic energy from the pressure into electrical energy, which is then stored in a battery for future use. The stored electrical energy can be utilized in various ways, including powering devices with the help of an ARM microcontroller (illustrated in

Figure 2). Additionally, this system integrates Internet of Things (IoT) technology to monitor soil moisture levels in park zones. By tracking moisture data, the system can automatically activate a water pump whenever the soil becomes dry, ensuring efficient irrigation using the available water supply within the park. This combined approach not only harnesses renewable energy through foot traffic but also promotes sustainable practices by automating irrigation based on real-time data, enhancing both energy efficiency and environmental conservation
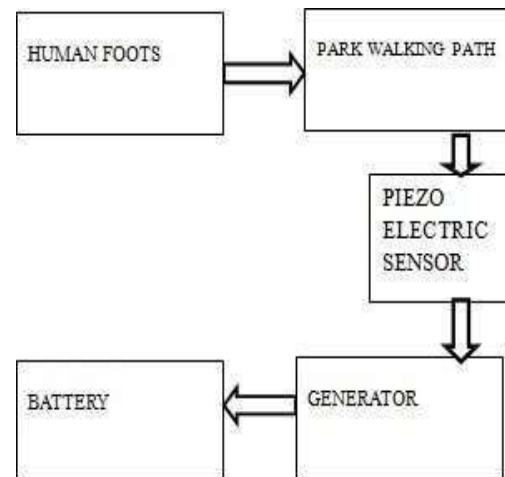
Figure 3. Block diagram for Hump Mechanism

The park is equipped with smart technology to enhance energy efficiency and convenience for visitors. The streetlights in the park are controlled by a system that automatically switches them on when the sunlight dims. This ensures efficient energy use and extends battery life by preventing unnecessary power consumption. An IoT-based system is constantly monitoring the park's temperature. The recorded temperature data is stored on an IoT server for analysis and future reference. For added convenience, the park is equipped with mobile charging ports. These are especially helpful during emergencies when visitors may need to

charge their phones. Additionally, the park's water source is monitored by a water level sensor. This sensor helps track the water level, ensuring proper maintenance and efficient water management. All the data collected from the various sensors, including temperature readings and water levels, is displayed on an LCD screen and saved on a web server for easy access and monitoring.

3. RESULT AND ANALYSIS

In the future, as Piezoelectric Sensors are utilized for power generation, the voltage output will vary with different steps. The expected minimum voltage output per step will be 0.8V to 1V, while the maximum voltage output per step will reach upto 4.6V to 5.2V.
We will assume an average pressure of 50kg exerted by a single person.
Based on this, it is estimated that 800 to 850 steps will be required to generate a 1V increase in battery charge.
Consequently, to achieve a 12V battery charge increase, the total number of steps needed will be:

$$= (22*850)$$
$$= 18700 \text{ steps}$$

Considering an average pace of two steps per second in a populated area where footstep activity will be abundant, the estimated time required to complete 18700 steps will be:

$$= 18700/ (60*2)$$
$$= 18700/120$$
$$= 155.84 \text{ minutes}$$
(Approximately)

This timeframe will approximately translate to 2 hours and 36 minutes for the desired charge to accumulate.

4. CONCLUSION AND FUTURE WORK

Our project introduces a footstep power generation system designed to overcome the shortcomings of traditional energy systems. By automating each phase, we minimize the need for human intervention, making the process more

efficient. By that calculate values We assume that we can successfully develop a new park automation model powered by renewable energy source. Looking ahead, we aim to expand this concept by installing piezoelectric sensors in public spaces such as streets. As people walk on these sensors, they generate energy that can be used to power streetlights, enhancing public safety and convenience. Additionally, integrating piezoelectric sensors into floor tiles inside homes could produce electrical energy with every step. This energy can then be utilized for various household purposes, such as powering fans, lights, and other small appliances. This innovation offers a sustainable and practical way to harness energy from everyday activities.

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Plant Care Revolutionised:Smart Automatic Watering System with Mobile Integration

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Abstract

Water is important for plant growth, but inconsistent watering schedules can cause overwatering or underwatering, adversely affecting plant health. This article proposes an Automatic Plant Watering System based on NodeMCU (ESP8266/ESP32), a soil moisture sensor, a relay module, and a water pump to automate the process of irrigation. The system also senses the soil moisture levels and switches on the water pump as and when needed. Besides, it is also connected with the Blynk IoT platform so that users can monitor real-time updates and remotely control the system. This method guarantees efficient water use, minimizes human intervention, and promotes plant health, hence proving to be a good solution for smart irrigation.

1. Introduction

As the need for effective irrigation systems grows, plant watering automation has become very important. Conventional irrigation involves manual operation, causing wastage of water and uneven care of plants. The Automatic Plant Watering System offers an economical and environmentally friendly solution through ensuring plants get water only when required.

Thissystemuses IoTtechnologytosensethesoilmoistureleveland irrigateautomatically.Itismost useful for home gardens, greenhouses, and farm fields, where optimal moisture level is important for the growth of plants. The incorporation of the Blynk application provides remote monitoring and control capabilities, making the system more convenient and efficient.

2. System Design and Components

The system has the following main components:
Node MCU(ESP8266/ESP32)
Node MCU is a Wi-Fi-enabled microcontroller. It serves as the processing unit, sensing data from the soil moisture sensor and operating the water pump via the relay module. Soil Moisture Sensor

The sensor detects the level of water in the soil and feeds real-time information to the microcontroller. When the level of moisture goes below a given threshold, the system triggers the water pump.

Relay Module

A relay module is a switch that operates the water pump according to instructions from the Node MCU.

Water Pump

The pump delivers water to the plants upon activation by the relay module. It may be attached to a water reservoir or direct water supply.

Blynk AppIntegration

The system integrates with the BlynkIo plat for mandenablesusersto:

- Monitor soil moisture in real time.
- Get alerted when the system irrigates the plants.
- Manually regulate the water pump via a smart phone app.

3. WorkingPrinciple

The Automatic Plant Watering System operates the following steps:

1. Thesoilmoisturesensorconstantlykeepstrackofthe watercontentofthesoil.
2. When the level of moisture goes below a certain threshold, the NodeMCU activates
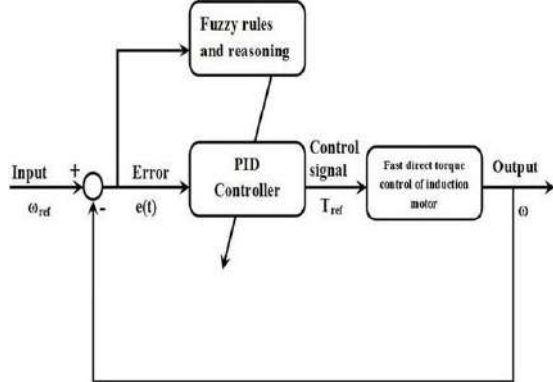
the relay module to activate the water pump.

3. Water is fed to the plants until the soil gets the desired level of moisture.
4. After the moisture content issufficient,the system switches off the pump automatically.
5. The Blynk apps endsreal-time alerts to the user, making remote monitoring and control possible.

4. Advantages of the Proposed System

Water Conservation :The system maximizes water efficiency by providing plants with only the needed amount of water, preventing wastage.

Time and Effort Saving

By automating watering, the system does not require manual handling, which is best suited for busy people.

Avoid a nce of Over watering and Under watering

Monitoring the soil moisture in real time helps prevent the roots from getting overwatered or dehydrated.

Remote Control and Monitoring

With the incorporation of IoT through the Blynk app, users can track the system anywhere, receive notifications, and regulate irrigation remotely.

Enhanced Plant Health and Productivity

The system ensures proper soil moisture levels, resulting inenhanced plant growth ,increased yield, and overall better plant health.

5. Uses

Automatic Plant Watering System can be applied to numerous uses ,such as:

• Home Gardens–Waters house plants and garden plants effectively.

• Greenhouses– Maintainsacontrolledenvironmentforplantdevelop ment.
• Agriculture – Saves labor and maximizesirrigation for crops.
• PublicParksandLandscaping– Automatesirrigationforvastoutdoorspaces.

6. Conclusion

The Automatic Plant Watering System is a good solution to overcome the limitations of conventional irrigation. Through the combination of IoT technology, soil moisture detection, and real-time monitoring, the system offers a smart, efficient, and sustainable plant care solution. The feature of receiving mobile alerts via the Blynk app improves user convenience and guarantees best plant growth.

With growing water scarcity and the importance of sustainable farming, such automated irrigation systems can be instrumental in water conservation and effective resource utilization. Future development can involve solar power operation, integration of multiple sensors, and AI-driven irrigation prediction models to enhance efficiency and responsiveness further.

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Design of Plant Layout Having Using Particle Swarm Optimization (PSO)

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Abstract— This research aims to improve the plant layout of manufacturing industry to make optimum space utilization, eliminate obstructions in material flow and thus obtain maximum productivity. Various optimization approaches for small problems and heuristic approaches for the larger problems have been proposed to elucidate the problem. Theand operation process of each section (i.e. Material storage, Cutting, Welding, Grinding , Drilling, Machining shop I,II,III , CNC shop and inspection section and finish product storage) have been investigated. The problem in the space utilization and material flow pattern was identified. Various techniques were applied after finding the solution through traditional methods to get much improved optimum solutions..The suitable of new plant layout can decrease the distance of material flow, which rise production.

Keywords—Material Flow,Plant Layout,Production and Heuristic approaches.

I. INTRODUCTION

A common industrial problem of allocating facilities is to either maximize eadjacency requirement or minimize the cost of transporting materials between them[1].The "maximizing adjacency" objective uses a relationship chart that qualitatively specifies a closeness rating for each facility pair. This is then used to determine an overall adjacency measure for a given layout [5].The "minimizing of transportation cost" objective uses a value that is calculated by multiplying together the flow, distance, and unit transportation cost per distance for each facility pair[6].

Plant layout design has become a fundamental basis of today's industrial plants which can influence parts of work efficiency & productivity[3].

It is needed to appropriately plan and position employees, materials, machines, equipments, and other manufacturing supports and facilities to create the most effective plant layout[7].

II. LITERATURESURVEY

Anucha Watanapa, Phichit Kajondecha, Patcharee Duangpitakwong[1]"AnalysisPlantLayoutDesignforEffectiveProduction"obstructionsinmaterialflowandthus obtain maximum productivity. The present plant layout and the operation process of each section sand mould, core warehouse, core making, disassembly surface finishing, furnace,and inspection sections have been investigated.Theprobleminterm of material flow of each operation section was indentified. The using some techniques distance of workflow from the modified plant layout of their sections can be reduced.Not only improving work flow but also the accidents from objects which were not in order during material transportation can be decreased. Finally, rearranging layout decreased distance and time consumption in flow of material and accidents,resulting in an increase in productivity.

Dr. V. Jayabalan & P.Arikaran [2] "Analysis of unequal areas facility layout problem " The facility layout design to improve plant productivity, manufacturing problem. Optimization approaches for small problem & heuristic genetic algorithm (GA), simulation annealing (SA) ,Ant colonyalgorithm (ACO),Particle swarm optimization (PSO).Using the hybrid approaches, combination of above techniques is used together better solution & improve the facility layout design.

Mr.HanedSamarghandi [3]" Application of TOPSIS and Fuzzy TOPSIS Methods for Plant Layout Design" Multi Attribute Decision Making (MADM) is a common task in human activities. It consists off inding themostpreferredalternative

from a given set of alternatives. We propose two Multiple-attribute Decision Making(MADM)methods insolving a plant layout design problem. They are: technique for order preference by similarity to ideal solution(TOPSIS) and fuzzy TOPSIS. The layout design problem is a strategic issue and has a significant impact on efficiency of a manufacturing system. The present study explores the use of MADM approaches insolving alayout design problem. the success of the present study has no guarantee for its applicability to other applications. Judicious use of a design method is advised in solving a specific application.

S.Narayaana Reddy &V.Varaprasad [4]"Optimization of in multi objective facility layout using non-traditional optimization technique"done by taking qualitative and quantitative approaches into consider. PSO has been implemented for the problem and the optimal layout are consider.

Gyan Tshering Lepcha,Dr. D.C. Roy [5]Job Shop Layout Design Using Group Technology"The original motivation for redesigning the entire shop floor was the need to realize improvements in material flow and output level. Since the machines were scattered this made it very difficult to study the cost involving the flow of materials through these machines.So for the purpose of analyzing total material handling cost, 34 elements(jobs) were taken which are mainly processed through 6 machines, out of which 32 elements were divided into 4 part families using Direct Clustering Method (DCM) with group technology concept method and similar machines were arranged together to analyze the cost using Computerized Relative Allocation of Facilities Technique (CRAFT) with aide of computer graphics. Finally, a new job shop layout was designed, which yield minimum material handling cost.

III. PLANTLAYOUTPLANNING

A. **Procedure for Plant Layout Design**

The sequences of procedure following three steps were described.
1. The area and machines of plant layout was studied.
2. Machines are collected
3. The process and flow pattern for product production has been used in analysis.
4. The Existing plant layout was analyzed to identify the problem under flow material and operation.

5. The suggestions were collected to write the report and were proposed to authorize to makedecisionforrearrangementthe Plant layout

B. Company Details Name-:

Aerocom Automotive Pvt. Ltd.
Location-K-13,Hingna MIDC, Nagpur (Maharashtra) Product -   1) Top link Spindle

       2) D.C.Crankshaftassy.
       3) Positioncontrolsleeve
       4) Parallelmalestudcoupling

Area statement–
  Plot area =5000 SQMT Cover area 65% =3665SQMT Factory shed area=1335SQMTBuilduparea-:Ground floor

C. AnalysisofExistingLayout

Analysis of Existing Layout This case is based on the travelling roller manufacturing industry.The original layout of company is showninfigure1.Thedetailsofeachsectionweredescribedas follows. In additional the size and number of equipments was relational to area as shown in Table 1.

Fig. 1. Existing Layout

Table1.Relationshipbetweenmachinesizeandarea

DEPARTMETS	AREA
Rawmaterial	250 SQMT
MachineShop-I	850SQMT
MachineShop-II	900 SQMT
CNC Shop	550SQMT
DrillingShop	320 SQMT
Weldingshop	500 SQMT
Inspectionshop	200 SQMT
Packagingshop	100SQMT
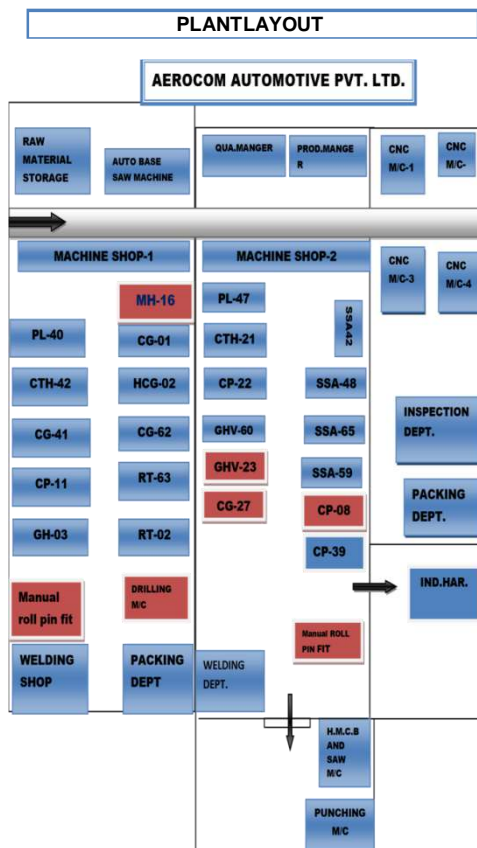
V. ANALYSIS PLANTLAYOUT

Analysis of the production process, products detail for flow of material, raw material storage, CNC shop, welding shop, drilling shop, machining shop, surface finishing, inspection sections, and material handling equipment were described as follows.

Flow of material from raw material storage department to cutting machine is in proper shape & size. This raw material travelalongdistanceforsurfacefinishinginCNCdepartment . CompletingCNC operation material travel to machine shop I then grinding ,drilling & welding operation perform but travelling distance was more and material handle was not properly so less production.

Raw material Storage shop - is the section approximated within (20.83×12.02) m2 area. Circular types of raw material in these section.

MachiningshopI-
issectionapproximatedwithin(61.25×14) m2 area. Top link spindleis manufactured in this section.

Machine shopII - is section approximated within (61.25×14.69) m2 area. D.C. crank shaftis manufactured in this section.

CNCshop-isapproximatedwith(18.72×27.13)m2area,The

all CNC machine are not proper arranged .

Weldingshop-isapproximatedwith(17.52×28.26)m2area. Thissectionconsistsofarcwelding,torchcutting(O2Welding) and plug cutting machine (LPG welding).

Drilling shop- is approximated with (20.18×14.10) m2 area. Two types of machine counter drilling & plain drilling.

Inspection & packing shop -section is approximated with (16.27×6.14) m2 area.

Finishproductstorage-
sectionisapproximatedwith (18.40×4.31) m2 area.

After studying on the mentioned information, the new plant layout design is created by shifting raw material storageareaandmachineshop(Fig.2).Inaddition,theassembly and inspection section is improved for optimum space utilization.
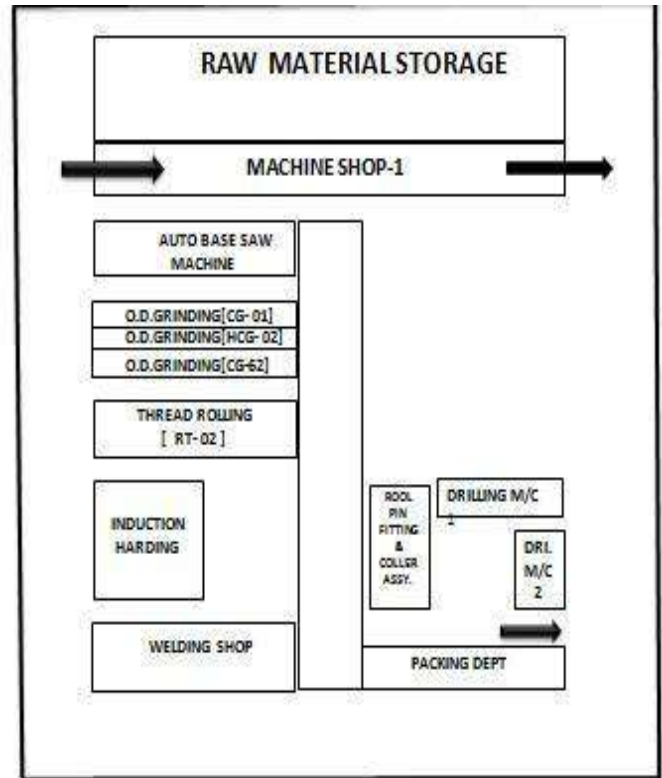
Fig-ChangeLayoutMachineShop-1

V. METHODOLOGY

In this research, proposed layout is design on the basis of operation process chart (fig. 3,4 & 5) and flow chart(fig.3a)of a products.**Loaddistancescoremethod**isquantitativetechnique forlayoutanalysisisuseforoptimumspaceutilizationandreduced the travelling distance. In this method, first load/Frequency matrixmadebasedondepartment/machines.Secondly,Distance matrix is made based on proposed layout.

Finally, total Distance Matrix is form, for analysis of layout. Load distance score method applied for

Operation	Fabrication product						
	Product name – TOP LINK SPINDLE						
	DISTANCE (METER)	TIME (MIN)	○	⇨	D	□	▽
Lying raw material from storage		0.20					
cutting section	12.20						
CNC shop	23.00	0.50					
Induction hardening	33.00	1.30					
Slot milling	20.60	1.00					
Grinding	20.90	3.00					
Thread rolling	04.50	0.30					
Spindle & Collar assy.	11.00	0.30					
Drilling	01.50	1.30					
Roll pin fitting	00.60	1.25					
Welding & external welding remove	09.00	1.30					
Thread rolling	09.00	1.00					
Cleaning, Oiling & Packing & inspection	17.65	1.00					
Travel to Pre-Dispatch	09.25	2.00					
Dispach	01.20						

Fig 3. Operation process chart of Top link spindle

Fig 4. Operation process chart of D.C. crank Shaft

COMP.NAME - TOP LINK SPINDLE

MATERIAL - EN 19
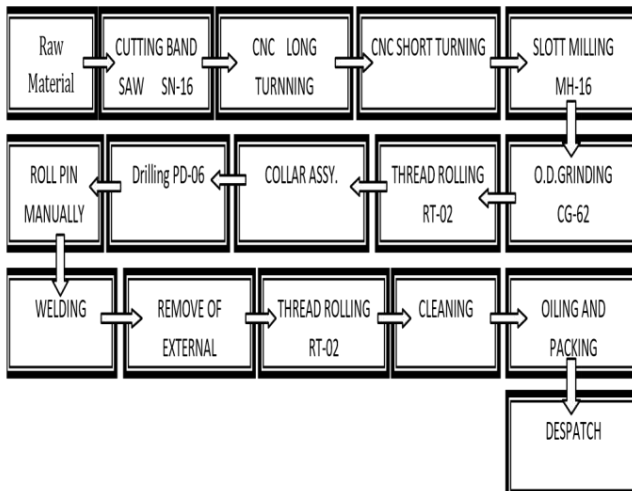
Fig 3a. Flow chart of Top link spindle

Fig 5. Operation process chart of position control sleeve

Operation process chart for Top link spindle, D.C.Crank shaft assy. and Position controls leeve is investigated. In existing layout, in order path is observed from Materials to

rage are a

towel ding section. Total distance travel from raw material to

finish products to rage for all product are 171.9 meter, 172.2 meter and 143.8 meter.

VI. CONCLUSION

According to the analysis of the operation hart, Flowchart & Material handling chart for the all product, it was found that raw material storage, drilling section , Machine shop & proper sequence machine should be modified for the layout for convenient workflow. The distance of flow char material handling from the modified plant layout of their shop can be reducedbyconvenientflow.Notonlyimprovingworkflowb ut also the accidents from objects which were not in orderduring material transportation can be decreased. Finally, rearranging layout decreased distance and time consumption in flow of materialandaccidents,resultinginanincreaseinproductivity
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Innovative Design and Fabrication Strategies for Staircase Climbing Hand Trolleys:A Comprehensive Study and Experimental Analysis

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Abstract: **This research paper presents a comprehensive study and experimental analysis of innovative design and fabrication strategies for staircase climbing hand trolleys. The study addresses the growing demand for efficient and ergonomic solutions in material handling, particularly in settingswherestairsposeasignificantchallenge.Througha review of existing literature and the development of anovel hand trolley design, this research aims to enhance the performance, safety, and usability of stair-climbing equipment.**

Keywords:Staircaseclimbinghandtrolleys,innovativedesign, fabricationstrategies,materialhandling,ergonomicsolutions.

I. Introduction

The study is aimed to deal with a particular day-to-day problemfacedbycommonpeople.Climbingupthestairs is often a difficult task, especially when a person has to carry a heavy load.There arealready severalsolutionsto this problem but they are either too expensive for a majorityofpeopletoaffordortheyarenotverypractical. For example, a stair lift could be installed but they are very expensive to buy and also to install. This invention also requires a lot of space on the stairs meaning it is a very impractical solution for most people. Similarly, a householder could pay for a removal company to carry heavy furniture up the stairs. However, this is also expensiveanditcanbeveryupsettingforthehouseholder if the furniture is damaged in the process. So the most common solution is that two people could lift and carry the load together. This is cheaper than the other two methodsbutitmeansthepersonhastofindsomeoneelse to helpevery timethey want to carry somethingupstairs. This is the most common and practical solution but it is still inconvenient. For instance, a single parent may not haveasecondpersonathometohelporanelderlyperson maynotwanttohavetoaskforhelpeverytimetheyneed to take a load upstairs.Also, the weight of the load may be too much for some people to be able to help with carrying.There have been attempts to solve this problem bytheuseofdevicessuchashandtrucks,whereapairof wheelsunderneaththetruckmeansthattheloaddoesnot have to be fully carried by the person. However, in most cases, the method of transporting goods has been in vain sincepracticalissuesarisewhiledrivingitself.Butusage of them on the stairs, which is crucial to this project, has notbeenseen.Anothersolutionisthatahandtruckcould be transformed into a driven wheel type truck by using a design of a lever and a semi-reciprocating motion to weigh more on the hand truck itself to move. However, this design is quite complacent in terms of practicability and space. Nowadays, the utilization of the material aluminumisfavoredforstructuralmaterialpropertiesfor many engineering applications and it is budget-friendly. Also,aluminumhasmanyfactorsthatmakeitisidealfor handtrucksuchaslightandeasyenoughtohandlewhile it still retains its strength and it is highly resistant to corrosion, for the literature review section discusses previous studies on stair climbing trolleys, design considerations, and fabrication techniques. This section provides a foundation for the design and development of the trolley. Also, the methodology section explains the research design, data

collection methods, and data analysis techniques used in the study. This ensures a systematic approach to the research process. The next importantpartoftheessayisthedesignanddevelopment section covers the conceptual design, material selection, andprototypingofthetrolley.Thissectiondetailsthe steps taken to create a functional and efficient trolley. Testing and evaluation are addressed in the next section, which includes test procedures, performance evaluation, andsafetyassessment.Thisensuresthatthetrolleymeets the requirements and standards. The results and discussion section presents the analysis of test results, comparisonwithexistingtrolleys,andadiscussionofthe findings. This section provides a comprehensive evaluation of the trolley's performance. And also the conclusionsectionsummarizesthefindings,highlighting the contributions to the field and providing recommendations for future research.This section wraps up the study and provides a final assessment of the trolley's design and functionality.

II.   Objectives

- Reviewexistingdesignstrategiesandfabrication techniques for staircase climbing hand trolleys.

- Identifykeydesignchallengessuchasstability, maneuverability, and load-bearing capacity.

- Explore innovative designconceptsto addressidentified challenges.

- Develop prototype designs incorporating novel mechanisms, materials, and technologies.

- Fabricatephysicalprototypesofdeveloperddesigns.

- Conductexperimentalanalysistoassessperformance characteristics.

- Optimizedesignparametersbasedonexperimental findings and user feedback.

- Evaluatethepracticalapplicabilityandscalabilityof optimized designs.

- Comparetheperformanceofdeveloperddesignsagainst traditional models.

- Documentfindingsandproviderecommendationsfor future research and improvements.

III.   LiteratureReview

Researchershaveextensivelyinvestigatedvariousmodes of transportation such as cars, trucks, wheelchairs, and forklifts, but there is a notable gap in detailed studies concerning truck height and the transmission of stress to the wheel assembly.

[1] This study discusses the design and production of wheeled stair climbers, which can be considered as an alternative method for loading and improving stair climbers using manual metal arc welding (MMAW) or welding rods.

Electric current is used to create an arc between the substrate and a consumable electrode rod or rod. Coated electrodes are made from materials compatible with the base metal being welded and are covered with a flux that emits steam, acts as a shielding gasandprovidesalayerofslag,bothofwhichprotecttheweldarea fromadverseweatherconditions.

[2]Thisdocumentrelatestotheso-called"StairClimbing Cart" with a height of 4 feet and a subframe of 38 centimeters. The main materials used in the production processaresquarecastpipes,SAE1030roundbarshafts, rubber brackets, wheels (industrial rubber), metal plates, andlongpineneedles.Theworkdoneiscalculated,what needs to be done is shown, and since it is very easy to carry the load on the stairs, the load on the stairs is very light. Lastly, the significance of stair climbing in design science was emphasized, underlining its integral role in various transportation and mobility solutions. Many researchers have investigated cars, trucks, wheelchairs, forklifts,etc.,butadetailedstudyoftruckheightandhow stress is transferred to the wheel assembly is needed. He has done a lot of research in the field of climbing equipment.

I. Methodology

A.   MaterialsandTools:

- Selection of materials based on strength, durability, weight, and cost considerations. Common materials may include steel, aluminum, plastic composites, and rubber for wheels and grips.
- Fabrication tools such as welding equipment, cuttingtools(e.g.,saws,plasmacutters),bending machines, drilling machines, and finishing tools (e.g., grinders, sanders).
- Advanced tools for precision fabrication, including CNC (Computer Numerical Control) machines for cutting and shaping components.

B.   FabricationTechniques:

- Utilization of welding techniques (e.g., MIG, TIG)forjoiningmetalcomponentsandstructures.
- Cuttingandshapingofmaterialsusingappropriate machinery and techniques to achieve desired dimensions and geometries.
- Assembly of components using fasteners (e.g., bolts, nuts) and adhesives to ensure structural integrity.
- Surfacetreatmentandfinishingprocessessuchas sandblasting, painting, and powder coating to enhance aesthetics and corrosion resistance.

C.   ExperimentalEvaluation:

- Design and implementation of experimental protocolstoevaluatetheperformanceofstaircase climbing hand trolleys.
- Testing of prototype designs on simulated staircase environments with varying angles, step heights, and surface conditions.
- Measurement of key performance parameters includingstability,maneuverability,load-bearing capacity, and user ergonomics.

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- Useofloadcellsandforcesensorstoquantifythe forces exerted on the trolley during ascent and descent.
- Video recording and motion analysis techniques to assess the motion and behavior of the trolley during stair climbing.
- Collection of user feedback through surveys and interviews to evaluate usability, comfort, and overall satisfaction.
- Statisticalanalysisof experimentaldatato identify trends, correlations, and significance levels.

D. **ValidationandIterativeImprovement:**

- Validation of experimental results against theoretical predictions and simulation models.
- Iterativerefinementofdesignparametersbasedon experimental findings and user feedback.
- Incorporation of design modifications and improvements to enhance performance, reliability, and user experience.
- Continuous testing and validation throughout the design and development process to ensure the effectivenessandrobustnessof thefinal staircase climbing hand trolley.

Step1:DesignPlanningandConceptualization

1. Define the specific requirements and objectives for the staircase climbing hand trolley, considering factors such as load capacity, stair compatibility, and user ergonomics.
2. Conduct a thorough review of existing designs and fabrication techniques to identify potential improvements and innovative solutions.
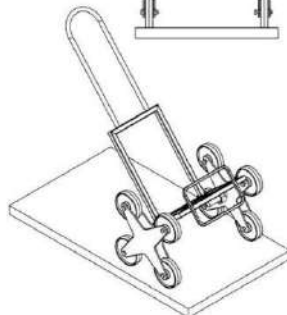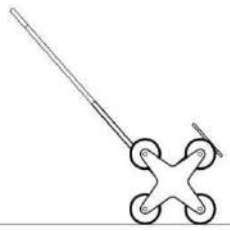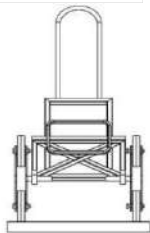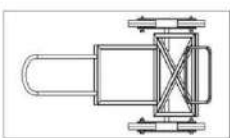
3.Develop conceptual sketches and 3D models to visualize the design and explore different configurations, mechanisms, and materials.

Step2:ComponentSelectionandMaterialAcquisition

1. Select high-quality materials for the construction of the hand trolley frame, wheels, handles, and other components, considering factors such as strength, weight, durability, and cost.
2. Source materials from reputable suppliers and ensure compliance with relevant industry standards and specifications.
3. Acquire necessary hardware such as bolts, nuts, washers, and fasteners for assembly.

II. ConstructionProcess

Step3:FabricationofFrameandChassis

1. Cut and shape metal or composite materials to fabricatetheframeandchassisofthehandtrolley usingappropriatecuttingandbendingtechniques.
2. Weld or join the frame components together securely, ensuring structural integrity and stability.
3. Incorporate design modifications or improvements to enhance the strength, rigidity, and overall performance of the frame, such as reinforcement braces or gussets.

Step4:WheelAssemblyandSuspensionSystem

1. Attach high-quality wheels to the frame using axlesorwheelhubs,ensuringsmoothrotationand proper alignment.
2. Implement a suspension system to absorb shocks and vibrations during stair climbing, enhancing stability and comfort for the user.
3. Test the wheel assembly and suspension system forfunctionalityanddurability,making adjustments as necessary to optimize performance.

Step5:HandleandControlMechanism Installation

1. Install ergonomic handles or grips on the hand trolley frame to facilitate comfortable and secure handling.
2. Integrate a control mechanism, such as a lever or brake system, to enable precise control and maneuverability during stair ascent and descent.

3. Fine-tune the handle and control mechanism positioning and functionality based on user feedback and ergonomic considerations.

Step6:FinalAssemblyandTesting

1. Assemble all components of the staircase climbing hand trolley according to the finalized design specifications, ensuring proper fit and alignment.
2. Conduct comprehensive testing and validation of the hand trolley in simulated staircase environments, evaluating stability, maneuverability, load-bearing capacity, and user comfort.
3. Make any final adjustments or modifications based on testing results and user feedback, ensuring that the hand trolley meets performance requirements and safety standards.

Step7:DocumentationandUserManual

1. Document the construction process, including design considerations, modifications, and improvements made during fabrication.
2. Prepare a detailed user manual with step-by-step instructions for assembly, operation, and maintenance of the staircase climbing hand trolley.
3. Provide illustrations, diagrams, and troubleshooting tips to assist users in effectively utilizing the hand trolley and addressing any issues that may arise.

A. DesignSpecificationsandFeatures:

1. **Frame:** Lightweight yet durable aluminum alloy construction.
   Wheels: Tri-wheel configuration with specialized treads for traction.
3. **Suspension:** Robust system minimizes vibrationsduringclimbing.
4. **Handle:** Ergonomicdesignwithadjustable height settings.
5. **Control:** User-friendlylever-operatedbrake system.
6. **LoadCapacity:** [Insertloadcapacity]for industrial use.
7. **Foldable Design:** Compact storage and transportation.
8. **Safety:** Anti-slipsurfaces,reflectivemarkings, and locking mechanisms.

B. AddressingLimitationsandImprovements:

1. **EnhancedStability:** Tri-wheeldesignprevents tippingonstairs.

2. **ImprovedManeuverability:** Specializedtreads navigatetightcorners.
3. **ReducedStrain:** Ergonomichandlereducesuser fatigue.
4. **IncreasedVersatility:** Suitableforvarious indoorandoutdoortasks.
5. **Enhanced User Experience:** User-friendly controlsandsafetymeasuresprioritizecomfort and safety.

Thisdesignsurpassespreviousmodelsbyofferingsuperior stability, maneuverability, and user satisfaction.

VII.ExperimentalAnalysis

ExperimentalAnalysis:StaircaseClimbingHand Trolley

Objective: To assess the performance,efficiency,and safety of the newly developed hand trolley design in stairs and transporting heavy loads.

ExperimentalSetup:

1. **Staircase Simulation:** Constructed a test staircase with varying step heights and angles to simulate real-world conditions.
2. **LoadTesting:** Applied incremental loads to the hand trolley to evaluate its load-bearing capacity and stability.
3. **Maneuverability Testing:** Conducted maneuverability tests to assess the hand trolley's abilitytonegotiatecornersandobstaclesonstairs.

III. Design
Experimental Results:

1. **StabilityAnalysis:**

   - DataTable:LoadCapacityvs.Stability
   - Graph:LoadCapacityvs.Stability

Load(kg)	StabilityRating(1-5)
50	4
100	4
150	3
200	3
250	2

Analysis:The hand trolley demonstrates good stability at lower loads but exhibits slight

IX inst Conclusion her loads, indicating a need for further reinforcement or adjustments.

2. **Efficiency Analysis:**

   - Data Table: Time Taken to Ascend vs. Load

Load(kg)	TimeTakentoAscend(seconds)
50	10
100	15
150	20
200	25
250	30

   - Graph: Load vs. Time Taken to Ascend

Analysis: As the load increases, the time taken to ascend the stairs also increases linearly, indicating a proportional relationship between load and climbing time.

3. **Safety Analysis:**

   - Observation: Anti-slip surfaces and locking mechanisms effectively prevent accidents and ensure user safety during operation.
   - User Feedback: Surveys conducted with test users indicate high satisfaction with the hand trolley's safety features and overall performance.

VIII. Advantages

1. **Enhanced Maneuverability:** Tri-wheel design enables smooth navigation on stairs.
2. **Improved Stability:** A robust suspension system ensures the safe transportation of heavy loads.
3. **Versatility:** Suitable for various applications in industrial, commercial, and residential settings.
4. **Efficiency:** Ergonomic handles and controls optimize user comfort and operation.
5. **Safety Features:** Anti-slip surfaces and locking mechanisms prioritize user safety.

In conclusion, our research on innovative design and fabrication strategies for staircase climbing hand trolleys has yielded significant advancements, enhancing maneuverability, stability, efficiency, and safety compared to conventional models. Our findings underscore the practical benefits of the developed hand trolley design, offering cost-effective solutions for various industrial, commercial, and residential applications. While our contributions mark substantial progress in addressing challenges associated with staircase navigation and heavy-load transportation, there remain opportunities for further refinement. Challenges such as stability at higher loads and optimization of efficiency signal areas for future improvement. Embracing emerging technologies like automation and IoT presents promising avenues for enhancing hand trolley capabilities and usability in the future. Overall, our research underscores the importance of continuous innovation in enhancing productivity, safety, and user experience in the realm of staircase climbing hand trolleys.

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MECHANICAL DESIGN AND TACTICAL PLACEMENT TECHNIQUE OF ROBUST AND RELIABLE BATTERY TRAY FOR ELECTRIC VEHICLE

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Abstract:

The design and analysis of a reliable impact-resistant structure for the battery tray of electric vehicles (EVs) are crucial for ensuring the safety and long-term performance of the vehicle. This paper presents a comprehensive study on the design, analysis, and application of an aluminum honeycomb structure for protecting the battery in EVs. The battery tray is designed using computer-aided design (CAD) software and analyzed using finite element analysis (FEA) to evaluate its structural integrity and durability. The analysis incorporates both static and dynamic loading scenarios to simulate real-world operating conditions. The results demonstrate that the honeycomb-structured battery tray meets the required standards for strength, stiffness, and durability. This study concludes that FEA is an effective tool for designing and analyzing battery trays, ensuring the reliability of EVs.The increasing demand for electric vehicles has introduced new challenges in designing and analyzing robust battery trays. As a critical component of an EV, the battery tray secures the battery in place and protects it from damage during normal operation and in the event of an accident. The tray must be designed to withstand various loads, including impact, vibration, and thermal stresses, while ensuring the safety of both passengers and the vehicle.

Keywords: Mechanical design, Battery Tray, Aluminium Honeycomb Structure

INTRODUCTION

Electric vehicles (EVs) have emerged as a promising solution to reduce greenhouse gas emissions and combat climate change. One of the critical components powering these vehicles is the electric vehicle battery. Electric vehicle batteries have revolutionized the automotive industry by providing a cleaner and more sustainable alternative to internal combustion engines. An electric vehicle battery, commonly known as the traction battery, is a rechargeable energy storage system that stores electrical energy to power the electric motor and other vehicle functions. These batteries enable EVs to travel significant distances on a single charge and offer a viable alternative to traditional fossil fuel-powered vehicles.

In the world of electric vehicles (EVs), the battery tray plays a crucial role in housing and securing the electric vehicle battery pack. It serves as a structural component that supports the weight of the battery pack, protects it from external impacts, and provides thermal management to ensure optimal performance and safety.

The battery tray is typically made of lightweight and durable materials such as aluminum or high-strength steel. Its design and construction are engineered to withstand the vibrations, shocks, and

forces experienced during vehicle operation. By securely holding the battery pack in place, the tray prevents any movement or damage that could compromise the overall functionality of the EV. One of the primary functions of the battery tray is to distribute the weight of the battery pack evenly across the vehicle chassis. This helps maintain a low center of gravity, which is crucial for stability, handling, and overall driving dynamics. Additionally, the tray also assists in maintaining the structural integrity of the vehicle, contributing to its crashworthiness and occupant safety.

Moreover, the battery tray incorporates various features for effective thermal management. Electric vehicle batteries generate heat during operation, and it is essential to dissipate this heat efficiently to prevent overheating and ensure optimal battery performance and longevity. The tray may include cooling channels, heat sinks, or other thermal management components that facilitate the dissipation of excess heat and maintain the battery pack within the desired temperature range.

As the electric vehicle industry continues to evolve, battery tray designs are also evolving. Manufacturers are constantly seeking innovative ways to reduce weight, improve strength, and enhance overall efficiency. Advanced materials, such as carbon fiber composites or thermoplastics, are being explored to achieve lighter and more rigid battery trays without compromising safety and durability. Furthermore, the battery tray design must consider the ease of assembly and disassembly during manufacturing and maintenance processes. Efficient installation and serviceability are vital factors that help reduce production time and cost, as well as simplify battery pack replacements or upgrades in the future.

This paper aims to present a comprehensive study on the design and analysis of a battery tray with use of aluminum honeycomb structure for safety of electric vehicle's battery. The design process includes the use of computer-aided design (CAD) software, which allows for the creation of 3D models of the battery tray, and finite element analysis (FEA), which enables simulation of the tray's performance under different loading conditions. The FEA analysis includes static and dynamic loading scenarios to simulate real-world conditions, such as impacts from potholes, curbs, or collisions.

The CAD model and analysis of the electric vehicle battery tray play a crucial role in ensuring the structural integrity, weight optimization, thermal management, integration, and compliance of the tray. By accurately assessing and optimizing these factors, the battery tray can be designed to enhance the overall performance, efficiency, and safety of electric vehicles.

approach for making sure the reliability and protection of electric cars. The study demonstrates the importance of designing and analysing battery trays for electric vehicles to ensure their reliability and safety in various conditions.

LITERATURE REVIEW :

(1) Qiu-Sheng Chen, Han Zhao - This paper brings forward a method which is using material index to select suitable materials in different mechanical situations is of great significance for practice. The proposed approach in this paper involves using Aluminium alloy steel sheets with varying depths to replace the existing mild steel sheet design, resulting in a lighter weight tray body., it is proved that this method is robust and stable. This paper

demonstrates reduction of battery tray's weight without impairment of stiffness.

(2) A.J. Kadam and S. R. Sawant - This paper presented a study on the dynamic behaviour of a battery tray using finite element method (FEM). The study found that the battery tray experienced significant stress and deformation under dynamic loading conditions, especially during braking and cornering. The authors recommended that the battery tray should have high stiffness and strength to withstand such dynamic loads and that the battery tray design should incorporate vibration damping features to reduce the effect of road irregularities.

(3) Mrs. Jostna Ingalea, Prof. A.B. Dighewarb - This paper utilizes finite element analysis to conduct failure analysis and optimization of the current battery tray design. The cast iron is replaced with new material like aluminium and glass fibre also different thickness was considered for the presented research study.

(4) Pagadala Bhavek Santhosh, Mr. A. Soma Sunder - The paper is a research article that provides a comprehensive review of the design, analysis, and manufacturing of honeycomb structures. The paper aims to provide a comprehensive understanding of the underlying principles of honeycomb structures, their unique properties, and their applications in various engineering fields.

METHODOLOGY:

1) **Material selection:**
   1.1) **Battery tray:**
   Structural steel is currently used for battery trays, as has previously been implied. In addition, according to significant scientific research, the other frequent materials used in the automotive manufacturing business, particularly in automotive factories, were recognised.

On the basis of the application, the material is chosen. Instead of structural steel, materials like glass fibre and aluminium are sometimes used. Different materials are chosen using a straightforward decision matrix that takes requirements like light weight, stiffness, corrosion resistance, and affordability into account. The criteria are made for the all three materials with requirement it is found that the aluminium alloy is best suited with requirement.

Material	Density (g/cm³)	Yield Strength (MPa)	Tensile Strength (MPa)
Steel	7.86	200	300
Aluminium	2.71	280	295
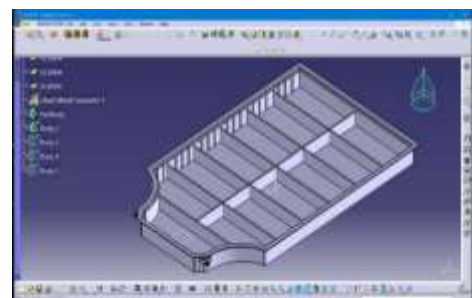
1.2) **Honeycomb Structure:**

Aluminium alloys are commonly used for honeycomb structures due to their high strength-to-weight ratio. Aluminium is often the most cost-effective option for honeycomb structures.
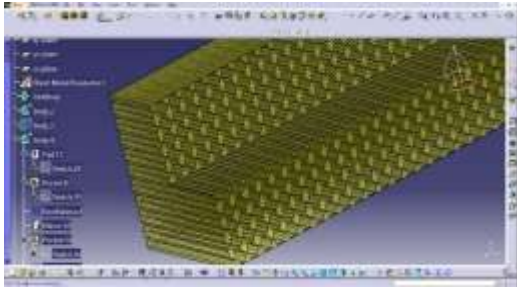
2) Dimensions:

For this project we have considered a battery of Tesla Model S

The Dimensions of Tesla Model S battery are:

Length: 1854.2 mm

Width: 1117.6 mm

Height: 127 mm

3) Design & Optimization:

CAD Software such as CATIA and Solidworks were used to create CAD designs.

By adjusting the shape and dimensions of the battery tray to align with the selected material properties, a stronger and more cost-effective design can be achieved. This optimization process ultimately results in a higher quality product that meets the required standards.
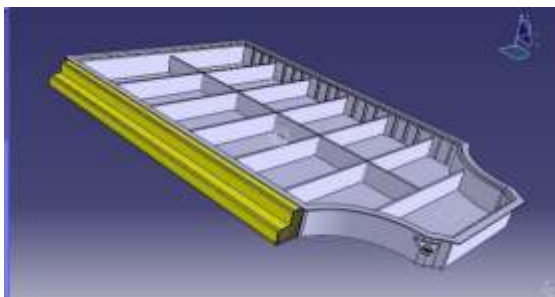
This project was created using the software CATIA for CAD model. Here the honeycomb structure is attached to the battery tray to both the sides. The yellow part indicates the honeycomb structure. The honeycomb structure will reduce the impact during crash and will protect the battery.

3) Analysis:

Impact testing on a car battery tray is an important safety test that evaluates the tray's ability to withstand mechanical shocks and impacts during vehicle use. The impact testing process involves subjecting the battery tray to a controlled impact using a pendulum or drop weight apparatus.
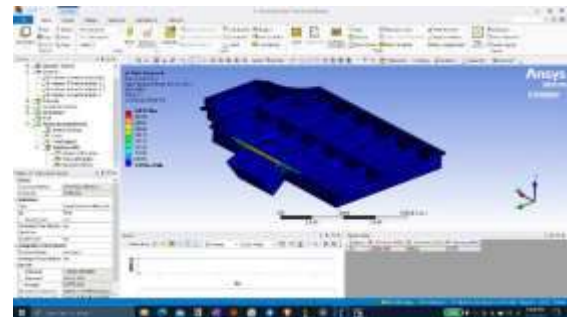
Without the honeycomb structure the stress created due to impact testing is of **548 MPa.**

With the honeycomb Structure, the stress created due to impact is of **32.3 MPa** with the same force applied. When applied 5 times force, the impact stress is of **161.53 MPa.**

By observing the above data, the yield stress of aluminium alloy is **280 MPa.** The maximum stress on the side member is

161.53 MPa and therefore the factor of safety is calculated as

Factor of safety = $\frac{Yield\ Strength}{Allowable\ or\ design\ Stress}$

$= \frac{280}{161.53}$ = **1.7**

Conclusion:

Impact testing on a car battery tray is an important safety test that evaluates the tray's ability to withstand mechanical shocks and impacts during vehicle use. The impact testing process helps manufacturers to determine if the battery tray is strong enough to withstand potential impacts and prevent battery damage, leakage, or even a dangerous short circuit. The analysis of the impact testing results can reveal important information about the battery tray's performance, such as its maximum deformation, fracture point, and energy absorption capacity.

The selected material for tray is aluminium alloy and for the honeycomb structure is aluminium. According to the above information, if the honeycomb structure is not present, the impact generates a stress of 548 MPa. However, in the presence of the honeycomb structure made of aluminium, the impact generates a stress of 161.53 MPa at the worst-case scenario. This shows a significant reduction in damage caused by the impact.

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EFFECT OF Mn-Zn SUBSTITUTION IN CALCIUM HEXAFERRITES ON STRUCTURAL, ELECTRICAL, MAGNETIC AND MECHANICAL BEHAVIOUR BY USING STANDARD CERAMIC TECHNIQUE

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ABSTRACT

The investigated samples with chemical formula $Ca_{1-x-y}(CoTi)_{0.5}Mn_xZn_yFe_{11}O_{19}$ with (x = y = 0 to 0.5) have been synthesized by using perfect stoichiometric proportions by using standard ceramic technique. The synthesized material pellets of 15 mm diameter have prepared and sintered at 1040°C(1313K) in air atmosphere for 106 H. The XRD, SEM, structural, electrical, magnetic and elastic studies of the studied samples have been carried out. Hexagonal Magnetoplumbite (M) structure have been investigated from the XRD studies of the samples. In this investigation the unit cell dimension 'a' and 'c' of these samples carried out and 'a' varies from 5 Å to 6Å and 'c' varies from 21Å to 23Å.Electrical conductivity of the studied samples have been carried out. Magnetic behaviour of the samples have been investigated by carried out coercivity, retentivity, saturation magnetization and Curie temperature. The elastic properties of the studied samples have been carried out by using ultrasonic pulse transmission technique at frequency 100 KHz and at temperature 300 K. Elastic moduli and Poisson's ratio have been investigated from the elastic properties.

Keywords: XRD, SEM, Saturation magnetization, Poisson's ratio.

INTRODUCTION

Calcium hexaferrite belongs to hexagonal magnetoplumbite (M-type) $AFe_{12}O_{19}$where A = Ca, Br, Sr, Pd with space group P6$_3$/mmcand ferromagnetic ceramic material with easy magnetization along c-axis.In addition, Calcium hexaferrite possesses a unique combination of desirable properties such as low production cost, high saturation magnetization, high coercive force, high Curie temperature, magnetocrystalline anisotropy along c-axis, chemically stable and corrosion resistant. Due to these stable and desirable properties, it is used in the wide range of applications in the high-performance permanent magnetic material, magnetic recording media, ferrofluids, sensors, microwave absorbing materials, ceramic magnets in loud speakers and rotors in small DC motors [1-5]. The intrinsic properties of Mn^{2+} and Zn^{2+} containing ferrites have been investigated, pertaining to high magnetic permeability and low loss [6].

In the present investigation, studies of XRD, SEM, electrical, magnetic and elastic studies of the prepared samples have been carried out. Hexagonal Magnetoplumbite (M) structure have been investigated from the XRD studies of the samples. In this investigation the unit cell dimension 'a' and

'c' of these samples carried out and 'a' varies from 5 Å to 6 Å and 'c' varies from 21 Å to 23 Å pertaining to space group $P6_3/mmc$ (No. 194). Electrical conductivity of the studied samples have been carried out by knowing the room temperature resistivity of the samples. Magnetic behaviour of the samples have been investigated by carried out coercivity, retentivity, saturation magnetization, magnetic moment and Curie temperature. The elastic properties of the studied samples have been carried out by using ultrasonic pulse transmission technique at frequency 100 KHz and at temperature 300 K. Elastic moduli and Poisson's ratio have been investigated from the elastic properties.

EXPERIMENTAL TECHNIQUE

The synthesis of polycrystalline $Ca_{1-x-y}(CoTi)_{0.5}Mn_xZn_yFe_{11}O_{19}$ with (x = y = 0 to 0.5) samples have been carried out by high temperature solid state diffusion reactions of stoichiometric mixtures of AR grade CaO, Fe_2O_3, TiO_2, MnO_2, CoO, ZnO oxides. The synthesis divided into two steps: (i) after calcination at 800°C for 2 H in air, the mixture was grinded and dried, compressed into pellets and (ii) finally pellets of 15 mm diameter have prepared and sintered at 1040°C(1313 K) in air atmosphere for 106 Hwith intermediate grinding and were quenched in air.

The XRD patterns have been taken to identify the phases formed and to confirm the chemical reaction by using Phillips X-ray diffractometer using CuKα − radiation. The X-ray diffraction pattern showed a single crystalline phase without traces of impurities. The patterns have been indexed to hexagonal magnetoplumbite structure pertaining to space group $P6_3/mmc$ (No. 194).

The lattice constants 'a' and 'c' and x-ray densities of the samples have been calculated from X-ray diffraction pattern. The bulk density have been determined by mass and bulk volume of the samples from which the porosity of each samples carried out.

The electrical conductivity measurements have been studied by two probe method from room temperature to 650 K using a LCR-Q meter-sortor (Aplab-4912). Electrical resistivity have been calculated by the method and equipment used as described elsewhere [7]. The conductivity have been calculated at various temperatures from 300-650 K.

The magnetic susceptibilities of the studied samples have been carried out by Gouy's method using mercury-tetra-thiocynato-cobaltate [HgCo(CNS)$_4$] as calibrant. The susceptibility measurements have been calculated in the temperature range 300-650 K and Curie temperature has been carried out [8].

The mechanical properties have been studied by using pulse transmission technique for the measurement of longitudinal wave velocity (v_l) and shear wave velocity (v_s) at 100 KHz. The radio frequency pulse generated

by a pulse oscillator which is applied to quartz transducer. The acoustic pulses have been converted into electrical signals by the receiving transducer. The output signals has been displayed on a digital oscilloscope (Textronic TDS 2014). The difference in time (ΔT) between two overlapping received pulse trains have been noted with the help of a timer. The sound velocity have been measured using the equation v = L/ΔT, where, v is sound velocity, L is length of sample and T is time [9-10].

RESULT AND DISCUSSION

1. Structural Properties:

(a) XRD: The morphological behavour of the studied compound have been investigated by X-ray diffraction patterns of Mn-Zn doped Calcium hexaferrites. These XRD pattern observed of the studied compound $Ca_{1-x-y}(CoTi)_{0.5}Mn_xZn_yFe_{11}O_{19}$ with (x = y = 0 to 0.5) sintered at 1040°Cfor 106 hrs which shows formation of hexaferrite along with some common planes such as (006), (106), (113), (200) etc. (Fig.1). andthey carries almost equal intensity. The existence of common planes is the indication of hexagonal M-type hexaferrites which belong to the space group $P6_3$/mmc [11].

The lattice constants 'a' and 'c' for different compositions have been calculated by using the values of d-spacing and Miller indices by using formula

$$\frac{1}{d^2} = \frac{4\,(h^2+k^2+kh)}{3a^2} + \frac{l^2}{c^2}$$

Finally, the values 'a' and 'c' calculated by using above formula compared to the values reported in JCPDS (Joint Committee on Powder diffraction Standards)were comparable. It has been observed that the values of 'a' and 'c' increases with the increasing concentration of Mn and Zn substituents (Table-1). This increase may be due to the difference of average value of ionic radii of Mn^{2+}(0.72 Å), Zn^{2+}(0.74 Å) which is slightly greater than Fe^{3+}(0.67Å) [12].
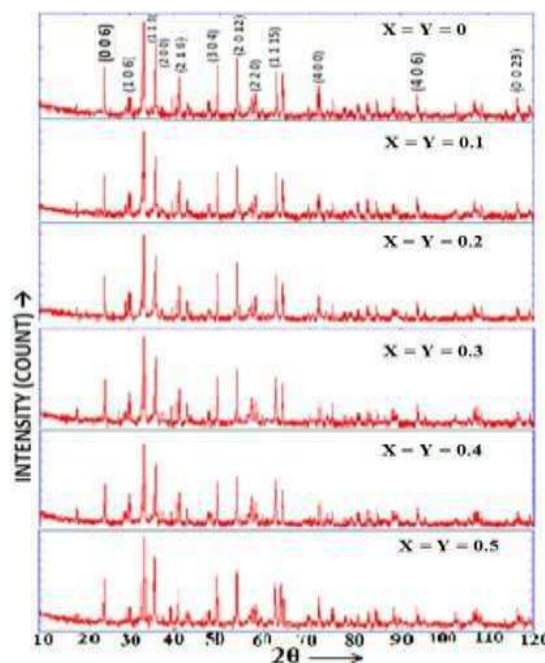
Fig.1: XRD of thecompounds $Ca_{1-x-y}(CoTi)_{0.5}Mn_xZn_yFe_{11}O_{19}$ (X = Y= 0.0 – 0.5)

Table-1: Lattice parameters 'a' and 'c' values, Particle size (D), Curie temperature (Tc) and activation Energies (Ferrimagnetic and Paramagnetic region) of the studied compounds $Ca_{1-x-y}(CoTi)_{0.5}Mn_xZn_yFe_{11}O_{19}(X = Y = 0 - 0.5)$

Compounds	a (Å)	c (Å)	Particle size (D) (ns)	Tc (K)	Activation Energy	
					Ferri (eV)	Para (eV)
$Ca(CoTi)_{0.5}Fe_{11}O_{19}$	5.8234	22.1118	29	568	0.397	0.595
$Ca_{0.8}(CoTi)_{0.5}Mn_{0.1}Zn_{0.1}Fe_{11}O_{19}$	5.8280	22.1346	33	530	0.357	0.581
$Ca_{0.6}(CoTi)_{0.5}Mn_{0.2}Zn_{0.2}Fe_{11}O_{19}$	5.8289	22.1388	38	506	0.330	0.570
$Ca_{0.4}(CoTi)_{0.5}Mn_{0.3}Zn_{0.3}Fe_{11}O_{19}$	5.8296	22.1256	42	480	0.301	0.567
$Ca_{0.2}(CoTi)_{0.5}Mn_{0.4}Zn_{0.4}Fe_{11}O_{19}$	5.8312	22.1526	56	467	0.297	0.529
$(CoTi)_{0.5}Mn_{0.5}Zn_{0.5}Fe_{11}O_{19}$	5.8312	22.1388	79	452	0.280	0.490

(b) SEM: The scanning electron microscopic study of the studied compounds have been investigated at different voltage and scale (Fig.2). The SEM and XRD analysis revealed that the concluded size of the molecules of these compounds are hexagonal in shape. From calculated data it has shown that the studied compounds are crack free, well packed continuous grain structure and continuous boundaries.

The particle size have been calculated from X-ray diffraction data by using formula

$$D = \frac{0.9\,\lambda}{\beta\,\cos\theta}$$ where, D is particle size, λ =

1.54439Å is wavelength of X-ray, β is width of peak at half of its maximum intensity of x-ray and θ is the location of the peak. The particle size is found in the range 29 nm to 79 nm of the studied compounds. The particle

size is found to be increases with the increase in doping concentration of Mn and Zn ions. It means that the size of the particle is very small and they are closely bound with each other in the crystal structure [13].

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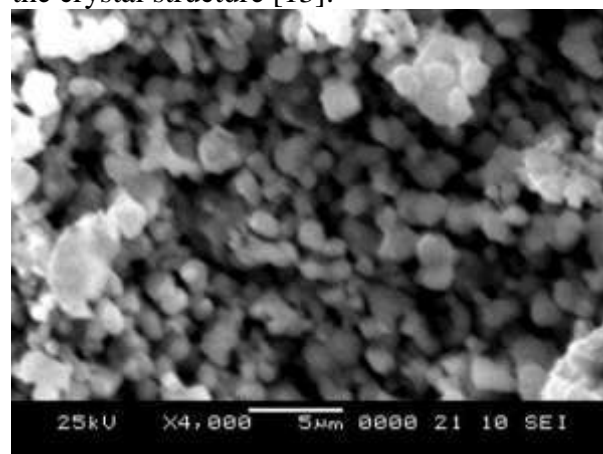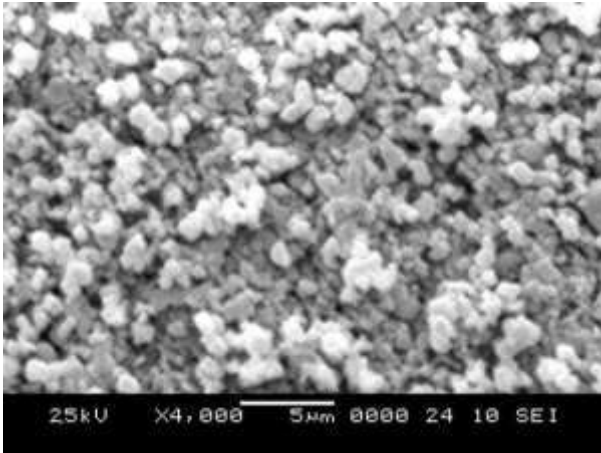
Fig.2:SEM Photographs of compounds $Ca_{1-x-y}(CoTi)_{0.5}Mn_xZn_yFe_{11}O_{19}(X = Y= 0.2, 0.3)$

2. Electrical Properties:

The electrical conductivity of the studied samples were measured gradually from room temperature to 850K. The plots of logarithmic conductivity versus inverse temperature for all the compounds are shown in Fig.3.It can be seen from the plots that the values of $\log\sigma$ decreases linearly with increasing reciprocal temperature up to transition temperature which is in neighbourhood of magnetic transition temperature (Curie temperature).It is observed from the graphs that there is change in slope after the transition temperature. It has been observed that in studied sample as the Mn and Zn doping concentration increases, resistivity increases and conductivity going on decreases which is shown in Table-1[14].

Activation energies of these six studied compounds Mn-Zn substituted calcium hexaferrites have been calculated from the slope of plots of electrical conductivity versus temperature above and below transition

temperature T_t, Table-1. It can be seen from the table that in the case of calcium ferrite the activation energy in paramagnetic region are higher than those in the ferrimagnetic region [15].
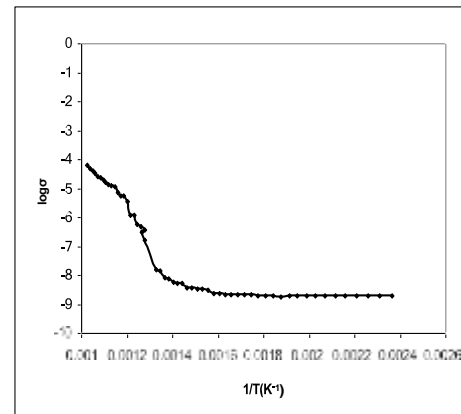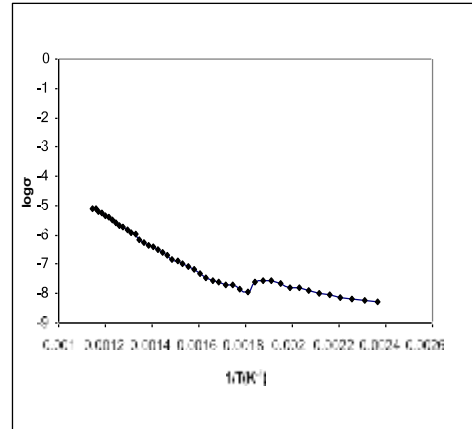
Fig.3: Plots of Electrical Conductivity Vs 1/T For compounds$Ca_{1-x-y}(CoTi)_{0.5}Mn_xZn_yFe_{11}O_{19}$ (X = Y= 0.2, 0.3)

4. Magnetic Properties:

The temperature dependence of the susceptibility measurement was carried out in the range 300-700K. The curves for variation of $1/\chi_m$ versus temperature (K) were shown in Fig.4. The compounds are ferrimagnetic nature upto certain temperature called as Curie temperature and above its behaviour is paramagnetic in nature. The determined Curie molar constant (C_M) are tabulated in Table-2.

The theoretically predicted values C_M of are in good agreement with experimentally observed values. The fair agreement in the values of C_M implies that, there is no change in valency distribution. As lattice contain both magnetic and ferrimagnetic ions with different site preferences. The value of Curie temperature found to be increase with additive contents of Mn and Zn ions [16].

Table-2: Curie Molar constants with Curie temperature of the studied compounds
$Ca_{1-x-y}(CoTi)_{0.5}Mn_xZn_yFe_{11}O_{19}(X = Y = 0 - 0.5)$

Compounds	C_{Mobs}	C_{Mcal}	Tc
$Ca(CoTi)_{0.5}Fe_{11}O_{19}$	49.0518	49.0625	568
$Ca_{0.8}(CoTi)_{0.5}Mn_{0.1}Zn_{0.1}Fe_{11}O_{19}$	49.2208	49.2500	530
$Ca_{0.6}(CoTi)_{0.5}Mn_{0.2}Zn_{0.2}Fe_{11}O_{19}$	49.3251	49.4375	506
$Ca_{0.4}(CoTi)_{0.5}Mn_{0.3}Zn_{0.3}Fe_{11}O_{19}$	49.5146	49.6250	480
$Ca_{0.2}(CoTi)_{0.5}Mn_{0.4}Zn_{0.4}Fe_{11}O_{19}$	49.8014	49.8125	467
$(CoTi)_{0.5}Mn_{0.5}Zn_{0.5}Fe_{11}O_{19}$	50.0112	50.0000	452

The hysteresis loop results of the series of sis studied compounds $Ca_{1-x-y}(CoTi)_{0.5}Mn_xZn_yFe_{11}O_{19}$ are carried out and samples for (X = Y = 0.2, 0.4) showshysteresis loops. The saturation magnetization, magnetic moment, coercivity and retentivity increases successively with increase of the Mn-Zn concentration and decreases the concentration of non-magnetic compound Calcium. Mn-Zn are ferrimagnetic materials, Fe is ferromagnetic material. But Fe contents are constant in this series and Mn-Zn content increases and Calcium content decreases continuously. Due to this magnetic properties such as saturation magnetization, coercivity,

Fig.4:Plots of Magnetic susceptibility Vs Temperature for compoundsCa$_{1-x-y}$(CoTi)$_{0.5}$Mn$_x$Zn$_y$Fe$_{11}$O$_{19}$(X = Y = 0.2, 0.4)

retentivity and magnetic moment increases successively in all six compounds [17].

In case of compound $Ca(CoTi)_{0.5}Fe_{11}O_{19}$, saturation magnetization is having less value than the compounds obtained by replacing Ca with Mn-Zn contents. The observed results can be explained on the basis of site distribution. In these compounds the magnetic moment from the octahedrally surrounded ferric ions in the spinel blocks and those in the trigonal bipyramidal sites are opposed by a minority of ferric ions in tetrahedral sites of the spinel block along with octahedral sites. While in case of compounds $Ca_{0.8}(CoTi)_{0.5}Mn_{0.1}Zn_{0.1}Fe_{11}O_{19}$,

$Ca_{0.6}(CoTi)_{0.5}Mn_{0.2}Zn_{0.2}Fe_{11}O_{19}$, $Ca_{0.4}(CoTi)_{0.5}Mn_{0.3}Zn_{0.3}Fe_{11}O_{19}$, $Ca_{0.2}(CoTi)_{0.5}Mn_{0.4}Zn_{0.4}Fe_{11}O_{19}$ and $(CoTi)_{0.5}Mn_{0.5}Zn_{0.5}Fe_{11}O_{19}$ have larger values of saturation magnetization are observed which as substitution of ferrimagnetic ions such as Mn-Zn in the spinel blocks of the M-structure occupying the octahedral sites (12K) shown in Table-3. The important role in these compounds to increase saturation magnetization is due to the presence of Fe^{+3} and $Mn^{+2}-Zn^{+2}$ ions which have high magnitude super-exchange interactions, particularly when all the 24 sites (2a, 2b, $4f_1$, $4f_2$ and 12K) are filled by magnetic and ferrimagnetic ions [18].

Table-3: Saturation magnetization (σ_s), Coercivity (Hc), Retentivity (Br), Magnetic moment (η_B) of the studied compounds $Ca_{1-x-y}(CoTi)_{0.5}Mn_xZn_yFe_{11}O_{19}$ (X = Y = 0 - 0.5)

Compounds	Hc (Oe)	Br (Gauss)	σ_s (Gauss-cm^3/g)	$4\pi Ms$ (Gauss)	η_B
$Ca(CoTi)_{0.5}Fe_{11}O_{19}$	21.73	141.92	31.36	1915.72	5.68
$Ca(CoTi)_{0.5}(MnZn)_{0.1}Fe_{10.8}O_{19}$	30.43	198.97	44.14	2706.00	8.00
$Ca_{0.8}(CoTi)_{0.5}Mn_{0.1}Zn_{0.1}Fe_{11}O_{19}$	41.29	232.00	56.67	3456.76	10.30
$Ca_{0.6}(CoTi)_{0.5}Mn_{0.2}Zn_{0.2}Fe_{11}O_{19}$	47.82	281.87	66.30	4040.17	12.10
$Ca_{0.4}(CoTi)_{0.5}Mn_{0.3}Zn_{0.3}Fe_{11}O_{19}$	58.68	338.22	75.98	4661.52	13.92
$Ca_{0.2}(CoTi)_{0.5}Mn_{0.4}Zn_{0.4}Fe_{11}O_{19}$	78.25	397.91	88.93	5497.51	16.36
$(CoTi)_{0.5}Mn_{0.5}Zn_{0.5}Fe_{11}O_{19}$	93.46	480.17	101.47	6330.79	18.75
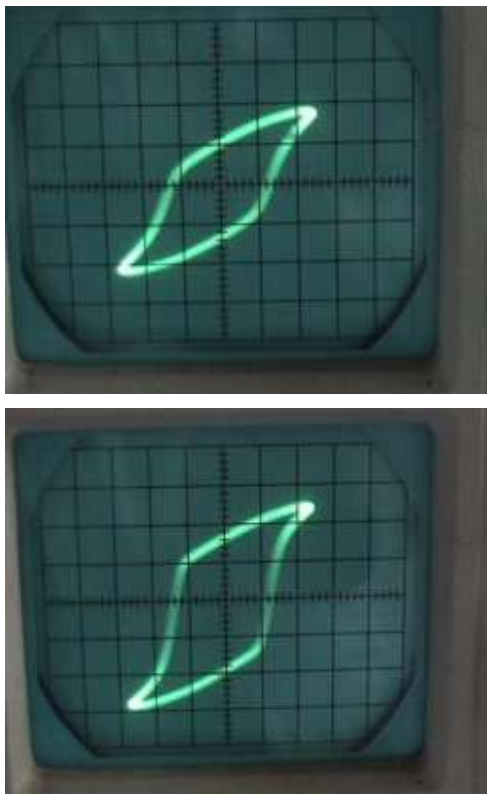
Fig. Hysteresis Loops of the compounds $Ca_{1-x-y}(CoTi)_{0.5}Mn_xZn_yFe_{11}O_{19}(X = Y= 0.2, 0.4)$

5. Elastic Properties:

The elastic modulies of the material have been determined by finding out the velocity of the longitudinal wave (v_l) and shear wave (v_s). The ultrasonic wave velocity, porosity and elastic modulies are enumerated in Table-4. The elastic modulies are co-related with interatomic forces, co-ordination changes, impact shock, fracture and crack growth [19]. The studiedcompounds are porosive in nature, therefore the co-relation between elastic moduli and velocity are complex. [S. Serabian (1980) and R. Green (1981)] reported microstructural factors such as grain shape, grain boundaries and texture have pronounced effect on elastic moduli and ultrasonic velocity. The interconnected pores of a sintered material provide an opportunity for free movement of oxygen into the bulk of a sample, as oxygen ions accommodated throughout the bulk of the sample. It suppress the internal stress resulting in obtaining less constrained polycrystalline materials. Thus, porosity plays an important role in governing certain elastic properties. For improved mechanical properties of ceramic materials it is utmost important to study the relationship between porosity and its elastic behaviour.

Table-4: Velocity of longitudinal wave (v_l), Velocity of shear wave (v_s), mean velocity (v_m), Debye temperature (θ) of the studied compounds $Ca_{1-x-y}(CoTi)_{0.5}Mn_xZn_yFe_{11}O_{19}(X = Y= 0 - 0.5)$

Compounds	v_l (m/s)	v_s (m/s)	v_m (m/s)	v_l/d (Kg^{-1}m^{4}s^{-1})	v_s/d (Kg^{-1}m^{4}s^{-1})	θ(K)
$Ca(CoTi)_{0.5}Fe_{11}O_{19}$	2333	1555	1700	0.48	0.32	1988.46
$Ca_{0.8}(CoTi)_{0.5}Mn_{0.1}Zn_{0.1}Fe_{11}O_{19}$	2400	1600	1749	0.50	0.33	2063.16
$Ca_{0.6}(CoTi)_{0.5}Mn_{0.2}Zn_{0.2}Fe_{11}O_{19}$	2500	1714	1866	0.51	0.35	2184.64
$Ca_{0.4}(CoTi)_{0.5}Mn_{0.3}Zn_{0.3}Fe_{11}O_{19}$	2619	1833	1991	0.53	0.37	1995.54
$Ca_{0.2}(CoTi)_{0.5}Mn_{0.4}Zn_{0.4}Fe_{11}O_{19}$	2750	1964	2126	0.56	0.39	2829.71
$(CoTi)_{0.5}Mn_{0.5}Zn_{0.5}Fe_{11}O_{19}$	2894	2037	2210	0.58	0.41	2846.94

Table-5 shows that addition of 0.1 mole of Mn and Zn concentration to $Ca_{1-x-y}(CoTi)_{0.5}Mn_xZn_yFe_{11}O_{19}$ rigidity modulus increases by 8.16%. In the present investigation, addition of small quantity of Mn and Zn increases the atomic bonding remarkably [20][21][22].

The ultrasonic velocities and elastic constants are related by the following equations, studied by [23].

Longitudinal modulus (L)   : $\rho(v_l)^2$

Rigidity modulus (G)   : $\rho(v_s)^2$

Bulk modulus (B)   : L-4/3 G

Poisson's ratio (σ)   : 3B-2G/6B+2G

Young's modulus (E)   : (1+ σ) 2G

The acoustic Debye temperature of materials used to explain the well-known solid state problem like lattice vibrations is determined using ultrasonic velocity. The relation is given as [24],

$$\theta = h/k_B \, [3N_AP/4\pi V]^{1/3} v_m$$

Where, h is Planck's constant, k_B isBoltzmann constant, $N_A$is Avogadro's number, V is volume calculated from the effective molecular weight and the density (i.e. M/V), P is number of atoms in the molecular formula and $v_m$is mean sound velocity defined by the relation [25],

$$v_m = [2/v_s^3 + 1/v_l^3 \, / \, 1/3]^{-1/3}$$

The elastic constants are related to interatomic forces, co-ordination changesetc and also the impact shock, fracture and crack growth studied [26]. For porous materials like cast metal, ceramics and most composites, the relation between elastic moduli and velocity are complex. The other microstructural factors such as grain shape, grain boundaries, texture and precipitates have pronounced effect on the relation between elastic moduli and velocity studied [27].

In order to improve the mechanical properties of ceramic materials it is essential to know the relationship between porosity and its elastic behaviour. The elastic moduli such as Young's modulus, Bulk modulus, Rigidity modulus, Poisson's ratio and Debye temperature values of various metallic elements were taken from the literature [28]

Table-5: Longitudinal modulus (L), Rigidity modulus (B), Bulk modulus (G), Young modulus (E) and Poisson's ratio (σ)and Porosity (P) of the studied compounds $Ca_{1-x-y}(CoTi)_{0.5}Mn_xZn_yFe_{11}O_{19}$ (X = Y= 0 - 0.5)

Compounds	L (GPa)	B (GPa)	G (GPa)	E (GPa)	Poisson's Ratio (σ)	Porosity (P)
$Ca(CoTi)_{0.5}Fe_{11}O_{19}$	26.46	10.79	11.75	25.86	0.1005	0.0602
$Ca_{0.8}(CoTi)_{0.5}Mn_{0.1}Zn_{0.1}Fe_{11}O_{19}$	27.97	11.39	12.43	27.34	0.0998	0.0628
$Ca_{0.6}(CoTi)_{0.5}Mn_{0.2}Zn_{0.2}Fe_{11}O_{19}$	30.32	11.32	14.25	30.11	0.0566	0.0670
$Ca_{0.4}(CoTi)_{0.5}Mn_{0.3}Zn_{0.3}Fe_{11}O_{19}$	33.51	11.63	16.41	33.48	0.0201	0.0643
$Ca_{0.2}(CoTi)_{0.5}Mn_{0.4}Zn_{0.4}Fe_{11}O_{19}$	37.21	11.90	18.98	37.17	0.0206	0.0596
$(CoTi)_{0.5}Mn_{0.5}Zn_{0.5}Fe_{11}O_{19}$	41.61	14.13	20.61	41.60	0.0092	0.0551

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CARBOXYBENZ-DERIVED SPIRO TRIONES AND THEIR BIOLOGICAL ACTIVITIES

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ABSTRACT:

Carboxyl compounds has been the subject of many investigations due to its antibacterial mode. Carboxylic acids constitute one of the oldest and most widely used classes of antimicrobial agents. Compounds with carboxyl group associated with vast variety of biological activity; e.g., anthelmintic analgesic aactivity. Barbituric acids have been reported to possess a wide spectrum of biological activities as sedatives, hypnotics, antitumor, antiviral, anti-inflammatory, antisclerotics, bacteriostatics and 1,3- Benzoxazolidine derivatives continues to draw the attention of synthetic organic chemists due to their varied biological activities. The incorporation of various heterocycles in pyrimidine nucleus enhances the biological potency of compounds. Spiro carbocyclic- compounds are bicyclic compounds help to enhance the biological activity of compounds by the incorporation of various heterocycles in pyrimidine like other nucleus. In view of various biological activities of barbituric acids, 1,3-benzoxazolidines, and importance of spiro structure and corboxyl moiety, it was proposed to synthesize new molecules 2, 3-(4$^{/}$-Carboxy benz)-1-oxo-4, 7, 9-triaza-/7-aryl-1-oxo- 4 ,7, 9-triaza-/ 7, 9-diaryl-1- oxo- 4, 7, 9- triaza-spiro [4, 5] deca-6, 8, 10-triones **4**. In present work, malonic acid undergoes condensation readily with ureas **1** to yield barbituric acids **2** which on bromination give 5,5-dibromobarbituric acids **3**. Interaction of 5,5-dibromobarbituric acid with 3-amino-4-hydroxy benzoic acid offred compound **4**. The structures of the products have been assigned on the basis of ^{1}H NMR, ^{13}C NMR, ES-MS, optical activity and elemental analysis. The compounds are found to have antibacterial and antifungal activities.

Key words: Barbituric acid, 5,5-dibromo barbituric acid, 1,3-benzoxazolidines, 3-amino-4-hydroxy benzoic acid, Spiro-barbiturates, triones.

1. INTRODUCTION

Carboxylic acids are the major sources of energy: most diet contains a great deal of fatty acids in the form of triacylglycerol. Some of our dietary carbohydrate is converted to fat stored as triacylglycerol in adipose; the fatty acids from this fat are released to provide energy for various aerobic tissue. They are precursor of essential substances in the body. Carboxylic acids itself are no longer an important disinfectant, but it is still the standard against which other antibacterial are measured in AOAC carboxylic acid coefficient and use dilution method. The antibacterial mode of action of carboxyl compounds has been the subject of many investigations. Carboxylic acids constitute one of the oldest and most widely used classes of antimicrobial agents.[1,2] Large number of compounds with carboxyl group associated with vast variety of biological activity, e.g., anthelmintic activity of asecolin-*p*-stibonabenzoic acid has been reported by Kartosonis et al.,[3] while Acetylsalicylsalicylic acid has shown activity as analgesic.[4].

1, 3-Oxazolidine is a tetrahydro five-membered heterocyclic compound and fusion of benzene ring

to the 4, 5-positions of oxazolidine ring gives benzoxazolidine. The Chemistry of 1, 3-Benzoxazolidine derivatives continues to draw the attention of synthetic organic chemists due to their varied biological activities. Shapiro and Coworkers[5] and Safak et al.,[6] demonstrated that some of benzoxazolidine derivatives possess analgesic, antiinflmmatory and anticonvolusant activities. Certain benzoxazolidine detivatives activity[7,8] have been reported to shown anticonvulusant. anticonvulusant, hypnotic, analgesic and pesticidal.

Barbituric acids have been reported to possess a wide spectrum of biological activities as sedatives, hypnotics, antitumor, antiviral, anti-inflammatory, antisclerotics and bacteriostatics.[9-11]. Aromatic amines are found to be present in many drugs which possess strong antipyretic and analgesic activity and also used in throat lozenges and surface anesthetic[12-13].

Spirocarbocyclic systems enhance the biological potency of compounds.[14,15] It has been found that incorporation of various heterocycles in pyrimidine nucleus enhances biological activities. Many Spiro compounds possess antiparasitic and analgesic activities.[16] Spiroheterocycles are also used as intermediates for aldose-reductase inhibitors, and some new spiroheterocycles are also found to have activity as herbicides and pesticides.[17]

With this end in view, herein we report the synthesis of novel fused spirosystem like (2, 3-4'-amino-β-D-glucopyranosyl benz)-1-oxo-4,7, 9-triaza-spiro [4, 5] deca-6, 8, 10-triones 6a-k) involving the molecules like 1, 3-benzoxazolidine,

barbituic acids, amino group and their glucosides along with their biological activities.

2. RESULTS AND DISCUSSION:

Substituted ureas **1** were prepared as described in the literature.[18] The barbituric acids **2** were prepared by the Biltz and Wittek method[19] in which ureas **1** are condensed with malonic acid in acetic acid-acetic anhydride. The rate of oxazolidine formation depends on the presence of substituents attached to nitrogen atoms in barbituric acids. It is fast in the case of 1-aryl and 1,3-diaryl barbituric acids. The replacement of N-hydrogen by aryl groups increases the solubility of barbituric acids in organic solvents. The compound 5, 5-Dibromo barbituric acids **3a** were prepared by adding bromine to barbituric acids in suitable solvents.[20,21] Glacial acetic acid was found to be the most convenient solvent for bromition of N-substituted barbituric acids. These acids gave a positive test for bromine. In the ^{1}H NMR spectrum, **3a** exhibited a singlet for NH at δ 11.68 ppm, while the ^{13}C NMR spectrum showed peaks at 165 (C-6, C-4,), 149 (C-2) and 45 ppm (C-5, C-Br). The IR spectrum showed absorption bands at 3203 (NH), 1714 (C=O), 1183 (C-N-C) and 587 cm^{-1} (C-Br). The reaction of 5,5-dibromo barbituric acid **3a** with 3-amino-4-hydroxy benzoic acid afforded 2, 3-(4'-Carboxybenz)-1-oxo-4,7,9-triaza-spiro[4,5]deca-6,8,10-trione **4a**. The compound **4a** gave negative test for bromine and positive orange red dye test. The product gave satisfactory elemental analyses and indicates its molecular formula.$C_{11}H_7N_3O_6$. FT-IR: The IR spectrum showed characteristic bands at 3314(OH), 3131

(NH), 2914 (Ar-NH$_2$) 2987, (Ar-CH), 1706 (C=O), 1468 (C-O-C) and 1367 cm^{-1} (C-N-C) groups. The ^{1}H NMR spectrum displayed signals at δ 11 (H, O-H), 10 (H, N-H), 6.76 - 7.34 (Ar-H) and 4 ppm (H, Ar-NH$_2$) groups. EI-Mass spectrum of titled compound showed a molecular ion peak at m/z 277. It also showed molecular ion peak at m/z 260, 232,119, 107, 91, 90 and 78.

In view of above results, the compound **4a** was assigned the structure 2,3-(4$^/$-Carboxybenz)-1-oxo-4,7,9-triaza-spiro [4,5] deca-6,8,10-trione.

2.1. Microbial activity:

2.1.1. Antimicrobial activity

The synthesized compounds were screened for their antibacterial activities by the using the cup-plate method [22] against B. *subtilis* (gram-positive) and E. *coli* (gram-negative) at concentrations of 100 µg/mL in DMF. Pure Norfloxacine was taken as standard antibiotic for the comparison of the results. The sterilized nutrient agar media (30 mL) was inoculated with the test organism and poured optically in to the Petridishes. Then four holes of 6 mm diameter were punched carefully by the using sterile cork-border and these were completely filled with different test solution. The plates were then incubated for 24 h at 37^{0}C and zones of inhibitions were measured. Similar procedure was adopted for pure Ciprofloxacin and the corresponding zone diameters were compared. The screening results indicate that compounds **4a-k** showed moderate to excellent bactericidal activities against both organisms **(Table-**

Antifungal activity

The antifungal activity of synthesized compounds was evaluated by the using above same method (cup-plate technique) against A. *niger* and C. *albicans* at concentration 100 µg/mL in DMF. The plates were incubated for 8 days at 37^{0}C. The zones of inhibitions were measured. Similarly a commercial fungicide Gentamycine was also tested under similar condition with a view of comparing the results. The compounds **4a-k** showed significant fungitoxicity against both the test fungi **(Table 7).**

3. CONCLUSION:

In present communication, a new class of spiro barbiturates with 1, 3-benzoxazolidine moiety was prepared through the spiro system by exploiting the reactivity of gem-dibromo functionality in 5, 5-dibromo barbituric acid with 3-amino-4-hydroxy benzoic acid. They show moderate to excellent antimicrobial activity.

4. EXPERIMENTAL:

4.1. General methods

Melting points were determined in open glass capillaries and are uncorrected. Optical rotations were measured at 29^{0}C. Elemental analysis ware determined using the Perkin Elmer 2400 CHN analyzer. FT-IR spectra were recorded using (KBr) disc on Perkin-Elmer spectrum Rx-I spectrometer. ^{1}H NMR and ^{13}C NMR on Brucker AC-300 F (300 MHz) NMR spectrometer by using DMSO and CDCl$_3$ as solvent and tetramethylsilane as an internal standard. Mass spectra were recorded on 70-S Mass spectrometer using *m*-nitro benzyl alcohol (NBA) matrix.

Substituted urea (1b and 1c):

In a round bottomed flask, a mixture of aniline hydrochloride (13g, 0.1 mol) and urea **1a** (24 g, 0. 4 mol) was dissolved in water (45 mL) with vigorous shaking until a clear solution was obtained. The mixture of HCl (1 mL) and glacial acetic acid (1 mL) was poured in to this solution and refluxed for about 2 hours. It was cooled and product obtained was the mixture of phenyl urea and 1, 3-diphenyl urea. This mixture was separated by using boiling water. Boiling water insoluble compound was 1, 3-diphenyl urea **1c**, collected and crystallized it from glacial acetic acid, mp 242^{0}C, yield 8 g (61%) while boiling water soluble compound was phenyl urea **1b**, collected after cooling the solution and crystallized it from water, mp 147^{0}C, 3 g (23%). Similarly, remaining 1-aryl-/ 1,3-diaryl ureas **1d-k** have been prepared[16] **(Table-1).**

Barbituric acid 2a:

Urea **1a** (0.9 g, 0.015 mol) and malonic acid (2.08 g, 0.02 mol) are dissolved in 5 mL of glacial acetic acid in a flask fitted with dropping funnel, reflux condenser and stirrer. The mixture was heated to 65^{0}C and 4 mL of acetic anhydride was added during 30 min. The reaction mixture was heated with stirring at 90^{0}C for 3 h. The solvent was removed by distillation under vacuum at 60^{0}C and the residue was treated with 0.2 N NaOH. The clear solution was acidified with 0.2 N HCl to obtained barbituric acid **2a**. mp 255^{0}C (water) (Yield 50 %). The satisfactory elemental analysis indicates its molecular formula.C$_4$H$_4$ O$_3$N$_3$.

Similarly, 1-aryl and 1,3-diaryl barbituric acids **2b- k (Table-2)** were prepared by the reaction of substituted ureas **(1b-k)** with malonic acid[17]. All Compounds gave satisfactory C, H and N analysis.

5,5-Dibromobarbituric acid 3a:

This was prepared by adding molecular bromine (2.55 g, 0.016 mol) to barbituric acids **2a** (1.28 g, 0.01mol) in H_2O (60 mL) at 50^0C with vigorous shaking. The compound was cooled, and filtered. The compound **3a** was crystallized from aq methanol, mp 235^0C (Yield 70 %); (Found: C, 16.93; H, 1.03; N, 9.97 %. $C_4H_2O_3N_2Br_2$ requires C, 16.78; H, 0.69; N, 9.79%). ν_{max} (KBr)/cm^{-1} 3202 (-NH), 1714 (C=O), 1183 (C-N-C), 587 (C-Br).λ_{max}/nm(ξ/M^{-1}cm^{-1}) (300 MHz, CDCl$_3$+DMSO- d$_6$). δ_H 11.68 (s, N-H). δ_C 165 (s, C-4, C-6), (s, C=O), 149 (s, C-2) (s, C=O), 45 (C-5) (C-Br).

Similarly, 5,5-dibromo-1-aryl-and 1,3-diaryl barbituric acids **(3b-k)** were prepared by adding bromine to 1-aryl-and 1,3-diaryl barbituric acids **(2b-k)** in suitable solvents[18-19] **(Table-3)**.

2, 3 - (4$^/$ - Carboxybenz) - 1 - oxo- 4, 7, 9-triaza- spiro[4,5]deca-6, 8,10–trione 4a:

A mixture of 5,5-dibromo barbituric acid **3a** (2.85 g, 0.01 mol), 3-amino-4-hydroxy benzoic acid. (1.53 g, 0.01 mol), pyridine (0.79 g, 0.01 mol) and alcohol (25 mL) was refluxed for 3 hours. The solvent was distilled off and the syrup poured on to crushed ice to yield the solid compound **4a**. It was washed with water, filtered, dried and crystallized from methanol, mp 240^0C (yield 80 %).

Scheme-I

1a-k　　　　**2a-k**　　　　**3a-k**

4a-k
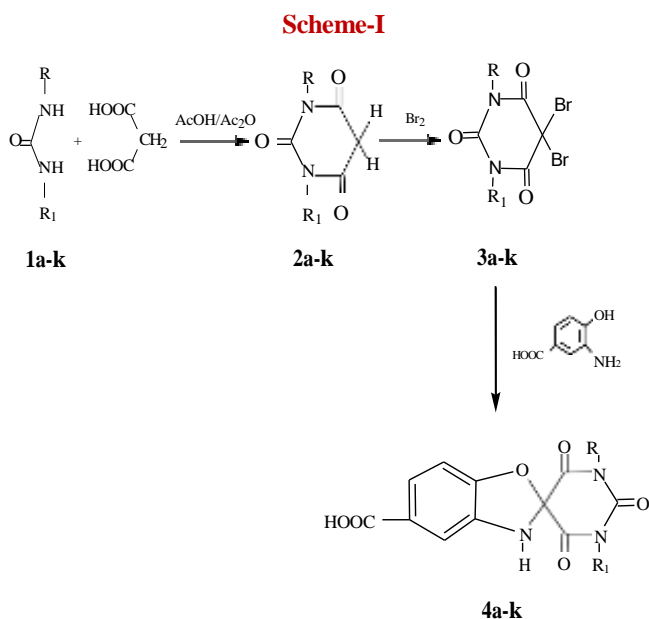
Where,

	R	Ri
a	H	H
b	Phenyl	H
c		Phenyl
d	*o*-tolyl	H
e	*o*-tolyl	*o*-tolyl
f	*p*-tolyl	H
g	*p*-tolyl	*p*-tolyl
h	*p*-anisyl	H
i	*o*-anisyl	*o*-anisyl
j	*p*-anisyl	H
k	*p*-anisyl	*p*-anisyl

Compound 4a-k: 2, 3-(4′-Carboxy benz)-1-oxo-4,7,9-triaza-/ 7-aryl-1-oxo- 4 ,7, 9-triaza-/ 7, 9-diaryl-1- oxo- 4, 7, 9- triaza-spiro [4,5] deca-6, 8, 10-triones.

The compound **4a** gave satisfactory elemental analyses and indicates its molecular formula.$C_{11}H_7N_3O_6$. The IR spectrum showed characteristic bands at 3314(OH), 3131 (NH), 2914 (Ar-NH$_2$) 2987, (Ar-CH), 1706 (C=O), 1468 (C-O- C) and 1367 cm^{-1} (C-N-C) groups. The ^{1}H NMR spectrum displayed signals at δ 11 (H, O-H), 10 (H, N-H), 6.76 - 7.34 (Ar-H) and 4 ppm (H, Ar-NH$_2$) groups.Similarly, when 3-amino-4-hydroxy benzoic acid. (1. 96 g, 0.01mol) refluxed with other substituted 5,5-dibromo-1-aryl-and 1,3-diaryl barbituric acids **(3b-k)** in presence of pyridine (0.79 g, 0.01 mol) and alcohol (25 mL), then other substituted 2, 3-(4′-Carboxy benz)-1-oxo-4, 7, 9-triaza-/7-aryl-1-oxo- 4 ,7, 9-triaza-/ 7, 9-diaryl-1- oxo- 4, 7, 9- triaza-spiro [4, 5] deca-6, 8, 10-triones **4b- k** has been synthesised (Table-**4**).

Table 1: Characterization data of urea and substituted 1-aryl-/ 1,3-diaryl ureas 1a-k.

$$R-NH-C(=O)-NH-R_1$$

Product	R	R_1	Mol. Formula	M.P. (^{0}C)	Solvent used for crystalization
a	H	H	CH_4ON_2	132	--
b	Phenyl	H	$C_7H_6ON_2$	147[a]	Compound crystallized from water
c	Phenyl	Phenyl	$C_{13}H_{10}ON_2$	242[b]	Compound crystallized from glacial acetic acid
d	o-tolyl	H	$C_8H_8ON_2$	198[a]	Compound crystallized from water
e	o-tolyl	o-tolyl	$C_{15}H_{14}ON_2$	253[b]	Compound crystallized from glacial acetic acid
f	p-tolyl	H	$C_8H_8ON_2$	180[a]	Compound crystallized from water
g	p-tolyl	p-tolyl	$C_{15}H_{14}ON_2$	254[b]	Compound crystallized from glacial acetic acid
h	p-anisyl	H	$C_8H_8O_2N_2$	168[a]	Compound crystallized from water
i	o-anisyl	o-anisyl	$C_{15}H_{14}O_3N_2$	184[b]	Compound crystallized from glacial acetic acid
j	p-anisyl	H	$C_8H_8O_2N_2$	168[a]	Compound crystallized from water
k	p-anisyl	p-anisyl	$C_{15}H_{14}O_3N_2$	234[b]	Compound crystallized from glacial acetic acid

Table 2: Characterization data barbituric acid and 1-aryl-/ 1,3-diaryl barbituric acids 2a-k
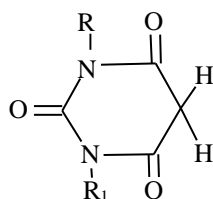
Product	R	R_1	Mol. Formula	M.P. (^{0}C)	Yield (%)	% found			% (calcd)		
						C	H	N	C	H	N
a	H	H	$C_4H_4O_3N_2$	255[a]	50	37.82	03.83	21.98	(37.50)	(03.12)	(21.87)
b	Phenyl	H	$C_{10}H_8O_3N_2$	262[b]	48	59.69	03.98	13.93	(59.40)	(03.96)	(13.86)
c	Phenyl	Phenyl	$C_{16}H_{12}O_3N_2$	238[b]	52	69.23	04.54	10.37	(69.06)	(04.31)	(10.07)
d	o-tolyl	H	$C_{11}H_{10}O_3N_2$	181[b]	44	33.69	02.84	07.39	(33.41)	(02.53)	(07.08)
e	o-tolyl	o-tolyl	$C_{18}H_{16}O_3N_2$	210[b]	47	44.91	03.72	05.86	(44.62)	(03.30)	(05.78)
f	p-tolyl	H	$C_{11}H_{10}O_3N_2$	243[b]	44	33.57	02.91	07.33	(33.41)	(02.53)	(07.08)
g	p-tolyl	p-tolyl	$C_{18}H_{16}O_3N_2$	233[c]	49	44.93	03.77	05.85	(44.62)	(03.30)	(05.78)
h	p-anisyl	H	$C_{11}H_{10}O_4N_2$	253[b]	41	32.42	02.76	06.97	(32.11)	(02.43)	(06.81)
i	o-anisyl	o-anisyl	$C_{18}H_{16}O_5N_2$	186[b]	43	41.96	03.42	05.84	(41.86)	(03.10)	(05.42)
j	p-anisyl	H	$C_{11}H_{10}O_4N_2$	190[c]	49	32.47	02.81	06.96	(32.11)	(02.43)	(06.81)
k	p-anisyl	p-anisyl	$C_{18}H_{16}O_5N_2$	220[b]	48	41.93	02.81	05.79	(41.86)	(03.10)	(05.42)

a	Crystallized from water	b	Crystallized from glacial acetic acid.	c	Crystallized from ethanal

Table 3: Characterization data 5,5-dibromobarbituric acid and 1-aryl-/ 1,3-diaryl-5,5-dibromo barbituric acids 3a-k.

Product	R	R_1	Mol. Formula	M.P. (^{0}C)	Yield (%)	% found C	% found H	% found N	% (calcd) C	% (calcd) H	% (calcd) N
a	H	H	$C_4H_2O_3N_2Br_2$	235 [a]	70	16.91	01.03	09.97	(16.78)	(00.69)	(09.79)
b	Phenyl	H	$C_{10}H_6O_3N_2Br_2$	184 [b]	68	33.54	01.89	07.93	(33.14)	(01.65)	(07.73)
c	Phenyl	Phenyl	$C_{16}H_{10}O_3N_2Br_2$	152 [c]	71	43.97	02.59	06.74	(43.82)	(02.48)	(06.59)
d	o-tolyl	H	$C_{11}H_8O_3N_2Br_2$	174 [b]	69	23.89	01.79	05.39	(23.78)	(01.44)	(05.04)
e	o-tolyl	o-tolyl	$C_{18}H_{14}O_3N_2Br_2$	190 [a]	71	33.82	02.41	04.67	(32.54)	(02.17)	04.34
f	p-tolyl	H	$C_{11}H_8O_3N_2Br_2$	105 [b]	69	23.87	01.81	05.42	(23.78)	(01.44)	(05.04)
g	p-tolyl	p-tolyl	$C_{18}H_{14}O_3N_2Br_2$	265 [b]	75	33.83	02.43	04.66	(32.54)	(02.17)	(04.34)
h	p-anisyl	H	$C_{11}H_8O_4N_2Br_2$	181 [c]	74	23.37	01.73	04.98	(23.11)	(01.40)	(04.90)
i	o-anisyl	o-anisyl	$C_{18}H_{14}O_4N_2Br_2$	164 [b]	72	31.99	02.37	04.34	(31.95)	(02.07)	(04.14)
j	p-anisyl	H	$C_{11}H_8O_4N_2Br_2$	166 [b]	76	23.39	02.79	04.97	(23.11)	(01.40)	(04.90)
k	p-anisyl	p-anisyl	$C_{18}H_{14}O_4N_2Br_2$	270 [b]	69	31.98	02.93	04.37	(31.95)	(02.07)	(04.14)

a	Crystallized from aq methanol.	b	Crystallized from glacial acetic acid.	c	Crystallized from benzene

Table 4: Characterization data of 2, 3-(4′-Carboxy benz)-1-oxo-4,7,9-triaza-/ 7-aryl-1-oxo- 4 ,7, 9-triaza-/ 7, 9-diaryl-1- oxo- 4, 7, 9- triaza-spiro [4,5] deca-6, 8, 10-triones. 4a-k.

Product	R	R_1	Mol. Formula	M.P. (^{0}C)	Yield (%)	% found C	% found H	% found N	% (calcd) C	% (calcd) H	% (calcd) N
a	H	H	$C_{11}H_7O_6N_3$	240 [a]	80	47.35	02.32	15.07	(47.66)	(02.55)	(15.16)
b	Phenyl	H	$C_{17}H_{11}O_6N_3$	164 [a]	82	57.68	03.04	11.58	(57.80)	(03.14)	(11.89)
c	Phenyl	Phenyl	$C_{23}H_{15}O_6N_3$	192 [a]	79	64.21	03.23	09.56	(54.34)	(03.52)	(07.89)
d	o-tolyl	H	$C_{18}H_{13}O_6N_3$	218 [b]	82	58.54	03.32	11.19	(58.86)	(03.57)	(11.44)
e	o-tolyl	o-tolyl	$C_{25}H_{19}O_6N_3$	256 [a]	78	65.32	04.02	09.03	(65.64)	(04.19)	(09.03)
f	p-tolyl	H	$C_{18}H_{13}O_6N_3$	125 [b]	81	58.54	03.32	18.19	(58.86)	(03.57)	(11.44)
g	p-tolyl	p-tolyl	$C_{25}H_{19}O_6N_3$	235 [a]	79	65.32	04.02	09.03	(65.64)	(04.19)	(09.03)
h	p-anisyl	H	$C_{18}H_{13}O_7N_3$	137 [a]	80	56.23	03.21	10.74	(56.40)	(03.42)	(10.96)
i	o-anisyl	o-anisyl	$C_{25}H_{19}O_6N_3$	138 [b]	81	61.21	03.59	08.26	(61.35)	(03.91)	(08.59)
j	p-anisyl	H	$C_{18}H_{13}O_7N_3$	166 [a]	76	56.23	03.21	10.74	(56.40)	(03.42)	(10.96)
k	p-anisyl	p-anisyl	$C_{25}H_{19}O_6N_3$	230 [a]	82	61.21	03.59	08.26	(61.35)	(03.91)	(08.59)

a	Crystallized from methanol	b	Crystallized from benzene.

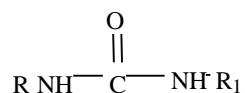**Table 5:** **Data for in vitro antibacterial and antifungal activities of 2, 3-(4$^{/}$-Carboxy benz)-1-oxo-4,7,9-triaza-/ 7-aryl-1-oxo- 4 ,7, 9-triaza-/ 7, 9-diaryl-1- oxo- 4, 7, 9- triaza-spiro [4,5] deca-6, 8, 10-triones. 4a-k.**

Diameter of inhibition zone (in mm) against bacterial Strains and fungal Strains

Products	Bacterial Strains		Fungal Strains	
	E.coli	B.subtilis	A. niger	C. albicans
4a	28	17		
4b	28	25	23	21
4c	21	15		
4d	19	26		
4e	21	21	22	20
4f	--	16	19	
4g	22	19	15	14
4h	14	16		
4i	19	--	21	20
4j	15	17	--	18
4k	16	--	22	21

- - = no inhibition of growth.

Diameter of zone of inhibition from 22-28 (in mm) shows excellent activity, that of 16-21 (in mm) exhibits moderate activity and that of 11-15 (in mm) shows poor activity for bacterial strains.

Diameter of zone of inhibition from 20-24 (in mm) shows excellent activity, that of 15-19 (in mm) exhibits moderate activity and that of 11-14 (in mm) shows poor activity for Fungal Strains.

Ciprofloxacine 100 μg/mL used as standard against E. *coli*, and *B. subtilis*, diameter of zone of inhibition is 35 and 29 respectively.

Gentamycine100 μg/mL used as standard against A. *niger* and *C. albicans,* diameter of zone of inhibition is 25 and 21 respectivrly.

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PRE-COLONIAL INDIAN ENGLISH LITERATURE

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Abstract:
Indian English Literature is an attempt of displaying the rare masterpieces of Indian English writing. The artist in India conquered the globe through their writings. Since Pre-Independence, the Indian dramatists, novelists, essayists and poets have made significant contribution in the literary world. Many literary awards have been won from Pulitzer to Bookers and the eminent artists made a history in publishing. Different genres like poetry, drama and prose have been tried by the writers who have dreamt to keep themselves abreast with the average readers.

Key Words: *colonization, nationalism, freedom struggle, reality*

The Indo-Anglian fiction is just a century old. The first Indian English novel emerged from Bengal, *Rajmohan's Wife* written by Bankim Chandra Chatterjee which was published in a weekly periodical as a series in 1864. This novel was Bankim's first attempt in English whose fame basically rests on his Bengali novels. Even by his biographer nephew; the existence of this novel has been forgotten for a long time. It has been stated by his nephew Sachin Chandra Chatterjee that this English novel is not finished by Bankim. While undergoing the flies of the prominent the Hindu patriot, Anglo-Bengal paper for 1684 discovered that the binder had tied all but first three of the Indian Field in which the novel of Bankim had appeared. In this manner this coincidental mistake of the strange binder brought into open the first Indian English novel. Bankim Chandra Chatterjee curved a nitche for himself with an excellent skill into a magnificent tool in respect of his stories and novels. For more than two thousand years, tales of romantic adventures, stories and fables had been known to India but as the term is known today, the novel is a western importation. Bankim Chandra Chatterjee's experiment made the western form a native writings which describe his supremacy extensively on his beneficiaries and contemporaries.

In the beginning, the Indian English novelists avoided any crucial connection. Progressing on parallel and liberated lines the novelist believed of not having two or three plots. S.M. Mitra's *Hindpore (1909)*deals with the theme of love of Lord Tata for princes Kamala but this fable is too much loaded with political discussions and ridicules British Saltanate and communal leaders. Various adventures have been stung in *One Thousand and One Nights*. The novel *Vasudev Shastri* published in the book form Rambles *in Vedanta* which is left unfinished by B. Rajam Iyer, attempts to depict the character of Vedantin, a truly great Brahmin but it is overburdened with an undercurrent of Vedentism. In addition to these deficiencies their limitations and range struck the individuals. These novels have very little inclusion of current topics, public affairs, mainstream thoughts and the art. The subjects of these novels never appeared significantly and clearly. The novelists could not prevent such arguments and thought process but in a very indirect way they appeared in these novels and they are not realistic also. The limitation of the subject lessens often the scope. The most successful creation, Narayan in *One Thousand and One Nights* and **Vasudev Shastri**, Barah in *The Prince of Destiny* are types instead of individuals and human behavior to be studied deeply. In these novels inner battle is a rare

phenomenon. The core issues which are of principal interest are characters in human life, lacks or are totally absent in Indian English novels of the times. The effect is that a fine portrayed character is a sheer idealized depiction and thus far from the real life characters. In case of Indian English novelists it would be very misleading a comparison with the western novelists compare with the certain standards of the west. Indian English literature was still in its crib and the novelists then had no idea of the novel as a genre. Most of the Indian English novelists did not reach to the level of their original speakers of the language. Although the medium of writing was English but the novelist could not adopt the imaginative perspectives of those writers. Proficient novelists were yet to appear and so the prior attempts paved the way of natural writings in English.

The writers in the early age, especially from the South of India were accolated by the British Raj and their words are copied from the works of Victorians or the English Romantics. Even the clear impact of Sir Walter Scott is featured thorough the historical novels of this are in form as well as structure. The stories however were weak in artistic efforts written in the nineteen and the first two decade of twentieth century. They featured social evils praised the beloved, qualities of Indian feminine and portrayed rural life of India. The things that affected every reader is that they are just on the track of early Victorian novelists. It would not be incorrect to say that there is a huge distinctness in moral values as depicted by the writers and some difference in subject matter and the range of subjects chosen were broadened by every writer. T. Ramkrishna's *Padmini* depicts a historical theme whereas S.K. Ghosh's *One Thousand and One Nights* is a romantic mimesis of the Arabian Nights. In this manner they have attempted miscellaneous subjects, their viewpoints or the uniqueness of vision being essentially Indian. But the distinctness is

much less than similarities from the literary point of view and the structure of the fiction. Secondly the principal patterns of the novels have individualized differences which are similar. These stories contain vast diversity of incidents and characters brought together around the lead character or a hero who is bound unitedly in a very quiet way by an intrigue and ending in a happy marriage. This is true with all be it Lihiri Kalikrishna's *Roshinara* or S.K. Ghosh's *Prince of Destiny* or T. Kamkrishna's *Dive for Death*; it is applicable to all novels of the time. For instance, in *Prince of Destiny* besides it individual indivertible difference, the central story runs in the same old perpetual rut- a prince, his loves and his ambitions and culmination with marriage bells. Incidents change, names change but the pattern remains common. The third excellent thing about the novels is that they consist a fantastic blend of strength and weakness. Some novels like *The Hindu Wife* are in all respect bad and most of the novels are average. Each one of them is distorted by false sentiments, melodrama and wooden characters, including the hero who himself is wooden. S.K. Ghosh's *Prince of Destiny* may be considered as the most significant novel of that time, the protagonist is Prince Bharath. The novel is crowded with a number of interesting discussions with comprehending the conflict in the projection of the point of view of the East and the West. But the character of Bharat is full of vitality and life.

The novel is in which the story is indicated as an organic whole of which each character and incident forms an inevitable part having a conventional plot. It also has and fills it along characters and a setting with which it has no organic relation. The conclusion is that the central interest of the novel lies in scenes and characters relevant to the stories. The story of Bharath in the *Prince of Destiny* is woven with a very delicate thread. It is studded with

unrealistic relations, political discussions, superstitious incidents and even imaginary love scenes.

Mainly the pre-independence social novels were connected with religious fervor and women redemption in social reform philosophy and propaganda rule these novels. In Indo- Anglian novels reflects the social life of those days. It was the period of liberation of women and religious reform. Political agitation was there but a burning desire for full freedom had captured the minds of the people who wanted home rule at the earliest. *Vasudev Shastri* depicts a common ideal Brahmin of those days which is true till date. Though *The Hindu Wife* attempts to keep before the readers the Indian ideal of the Hindu Wife, Nasrin and Sarata and Hingana express the troubles and loves of Indian families. The concept of love in love stories are all dominated families by the traditional of love in which the women even die for her lover. The novels like *The Fatal Garland*, *The Love of Kusuma* are the examples of the same. The politics of the day is reflected in some stories like *The Tales of Bengal* and the novel *Hindapore*. The reflection of the religious reform which was the course of the day finds it reflection in the novels like *Vasudev Shastri* and *Thillan Govindan*. It must be concealed that to portray the life of the day, high efforts were made but the novels remain far from being satisfactory and highly impractical. There were not any originality or touch of historical perspective in the pre-independence historical novels. They are to an extent and study required by the historical romances. The characteristics of such historical romances competently sums up by Uma Parameshwaram. The stories in these novels are of intrigues and murders, love and betrayed woven round some historical events. Before 1920 short stories were written but they were transformed artistically into the Indian English fiction which was almost nonexistence at that time. During the period

1920- 1947, which is known as the era of awakened national consciousness, short stories were written with an elited artistic quality in them. The notable writers like R.K. Narayan, Humayun Kabir, Mulk Raj Anand, S. Nagarjun, Venkatramani and other produced volumes after volumes of collected short stories that appeared in rapid progression and stories included in them were above average in literary merit as far as the matter of form, plot, technique and style is concern. This period truly bounced with a great number of short stories and novels of abiding literary merit and lot of these novels had preserved the taste of the time. But a void remains as till now the Indian English novel could not create the works which would have recognized the depth of human misery. Perhaps *Men and Rivers*, the novel written by Prof. Humayun Kabir is one of the best novels of this period and can stand excellently with any good English novel in comparison.

The impact of the First World War which ended in 1918 found its way in literature after 1921. The horrendous bloodshed had stirred the conscience of the whole world. The war doubly affected the Indian artists because it awakened the consciousness of the nation, independence and liberty were prizes worth fighting and dying for. The influenced of the freedom struggle led by Mahatma Gandhi spread all over India. In this era many a writers wrote the songs of martyrdom and freedom and also wrote novels and stories of the independence struggle. The war that startled mankind also introduced new sources of inspiration. All, these subjects were mirrored in the short stories and novels of Indian English writers. This era also produced heroic success and exciting experiments like the western writers, getting close to their literary standards. Initiators and swindlers shoved with men of originality and genius. It was a moment of transformation with highly skilled writings. The happenings all over the world jolted all especially the creative writers and their

emotions and creativity found its way in their works. This movement motivated not only the writers and artists but also made its space dramatically and deliberately. Old techniques, topics and ethical novels did not vanish with the new inventions on the contrary the old tradition continued along with the new ones. The realistic novel came into existence in its own right and with a purpose, bringing with it new vision, technique and inspiration.

Definitely there was a change in the themes of the novels. A man like Mulk Raj Anand would plug in the profundity of humble life and demonstrate majesty or dignity in the humanity of an *Untouchable* or a *Coolie*. Novelist like R.K Narayan would come up with topics of the humdrum life that often touched the souls and declared, 'the world of greatest age begins anew'. Ahmad Ali or Muhammad Habib would search his solution from fancy-lands forlorn in weaving sensual word picture; and yet another writer of the same age A.S.P. Ayyar alienated with the men of ancient Indian Gupta period from prevailing ordeals and currents of live. High flown prose, poetic and artistic narration of Raja Rao illuminated the glare novel. The writers like Mulk Raj Anand, D.F. Karaka, R.K. Narayan, Ahmad Ali, Ahmad Abbas and many others whose contribution to the progress of Indian English novel is of great order produced in this period. The use of the techniques in the Indian English novels is near to the most recent novel of the west. In Raja Rao's *Kanthapura*, the incidents of the freedom struggle are narrated by the village granny. Raja Rao utilized very well the autobiographical form of narration in analyzing the character so useful. His technique is Conradian and the grandmother takes the place of Marlow in this novel. In all his novels, Mulk Raj Anand applies an advanced technique of story-telling. In *Bombay Murder*, S.K. Chettur has produced a well turned out detective story on the lines of Agatha Christie. Simultaneously fighting for the cause of poor and the Pauper Karaka, Ahamad Abbas and the rest with their journalistic writing created such effective stories which gave an impression crisp fresh air of new and realistic writings.

Actually the Indian Independence movement was not solely a political struggle but for Indians rather an extensive emotional experience that was national in nature during the 1920s and 30s. This national evaluation could have been avoided by the Indian writers. During this century, the Indian English novels dealt with this national experience as theme or indirectly a personal narrative with a significant public background. The political movement in India was not only a political movement alone for freedom but it also linked difference forces which united for ushering India as a Sovereign Independent nation washed out of all evils like political, social, communal, economical which had eschewed very vital national life. Behind the backdrop of national unrest Gandhian ideology was the only moving force. The ideology of M.K. Gandhi not only became a life's philosophy but also a way of life. The writers in Indian English literature basked on the extensive and intensive use of the ideologies of Gandhi, with the evolution of the all Mahatma Gandhi's pervasive influence. These novels were dominated by the Gandhian thought and his recurring presence that suited the art of almost all the writers of the period. This very art was used in a distinctive way. He has been treated as a tangible reality, a symbol, a myth, an idea and a philanthropist. In some of the novels he appears in person while in most other novels his presence is invisible or incarnation of a character symbolizing Gandhi. The influence of Mahatma Gandhi on Indian literature has been two folded. First, the style he developed as a writer is pure, simple and lucid which influenced the modern writings. Secondly he influenced the content with a profound theme.

The novels of this period deals directly as the central theme with the national experience. The novels written during this period are clearly describes the various momentous events like the passive resistance movement of Mahatma Gandhi against Black Revolt Act, the Khalifat Movement in Amritsar, the inhuman massacre in Jalianwala Bagh, the boycott of Simon Commission, the famous Dandi March, the prohibition of the foreign goods, the emancipation of women, the Civil Disobedience Movement of 1930, The Government of India Act of 1935, the Quit India Movement of 1942 and a lot other facts of the movement of Mahatma Gandhi.

Raja Rao's *Kanthapura* which was published in 1938 is about Gandhi's Satyagraha Movement in a south Indian village. It is the most poetic novel which was launched by Mahatma Gandhi in 1920s to give freedom to India from the rule of British. His work reflects Raja Rao's eternal interest in philosophical themes. Raja Rao was greatly influenced by Gandhian thought in the early phase of his life. Raja Rao was so influenced by the way of living of Gandhiji that he spent a few days at Savagram in Wardha, Maharashtra in Mahatma Gandhi's Aashram. Raja Rao contributed in the Quit India Movement initiated by Mahatma Gandhi in 1942 which shows his interest and will to free India. A.V. Krishna aptly points out:

"Raja Rao has made an effective literary transcription of the Gandhian myt by artistically attuning the reality of his tale to the poetry of truth and its myriad miraculous transformation in the prism of historical consciousness."

Conclusion: Under the British rule, the society was squashed and provided the novelists different themes and forced them to think once again over the various national and social problems. It can also be said that it was a period of realization and of self-awareness. In fact, it was this period in which some of the most significant themes like East- west relationship, struggle for freedom, the exploitation of the underdog, quest for identity, the treatment to rural life, search for justice and fair play was displayed through the Indian English novel.

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Sustainable Mosquito Vector Control: Challenges and Opportunities

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Abstract

"Sustainability" refers to a system's, process's, or practice's ability to be sustained over time without depleting resources, damaging the environment, or jeopardising the well-being of current and future generations. In many endemic tropical and subtropical nations, mosquito-borne diseases impact millions of people, hampering economic progress. In many sections of these regions in the early 1900s, environmental management stood at the forefront of mosquito vector control. Alteration of the local environment after adequate understanding of mosquito vector ecology limits their favourable habitats, resulting in significantly reduced transmission of mosquito-borne diseases. Drugs and insecticides have fully supplanted environmental management as the most favoured mosquito-borne disease control techniques since the breakthrough of DDT and other organochlorines. However, uncontrolled application of these insecticides has developed resistance among mosquito vectors. Furthermore, the majority of these insecticides are constant organic pollutants with serious long-term harmful effects on human health and the surroundings. Over-dependence on chemical control measures in the mosquito control programme results in more losses than benefits and is thus very unsustainable. Though environmental management has the potential to be a powerful, cost-effective, and long-term vector-borne illness control approach, its effectiveness requires the collaboration of several public-sector organisations. Resistance among mosquito vectors has developed as a result of pesticide use. The use of natural predators, parasites, diseases, or competitors to govern mosquito populations and lower their numbers is referred to as biological control of mosquitoes. This method of mosquito management is environmentally friendly and sustainable since it relies on the natural systems of the ecosystem to manage mosquito populations. Biological control targets mosquito immature stages, particularly larvae, to disrupt their life cycle and impede their growth into adult mosquitoes. Biological control strategies necessitate a thorough study of local ecosystems and mosquito species, as well as careful consideration of non-target species impacts. When used effectively, biological control can provide effective and long-term mosquito population management while reducing the use of chemical pesticides and their associated environmental and human health problems. IMM is a comprehensive and holistic strategy to mosquito population management that minimises the use of chemical insecticides and the related environmental and health dangers.

Keywords: IMM, Larvicidal, Sustainable control, mosquito repellent, Environment management

Vectors are living organisms that spread infectious diseases from humans to animals. Many of them are bloodsucking insects that consume disease-causing bacteria during a blood meal from an infected host (human or animal) and then transmit the pathogen to a new victim once the pathogen has multiplied. When a vector becomes infected, it is often capable of transmitting the infection for the remainder of its life through each subsequent bite/blood meal. vector-borne diseases cause illnesses caused by parasites, viruses and bacteria conveyed by vectors. Due to diseases like Malaria, dengue, schistosomiasis, leishmaniasis, Chagas disease, yellow fever, human African trypanosomiasis, Japanese encephalitis, and onchocerciasis kill around 700,000 people each year [1]. These diseases are more prevalent in tropical and subtropical regions and they strangely cause problems to the poorest population. In numerous countries since 2014, significant epidemics of *chikungunya,* yellow fever, dengue, malaria and Zika have beset large populations and overwhelmed health systems. Other infections, such as *Chikungunya*, leishmaniasis and lymphatic filariasis, cause persistent pain, morbidity, disability, and shame. A complex collection of demographics, environmental, and societal factors influence the distribution of vector-borne diseases. Vector-borne infections account for more than 17% of all infectious diseases, killing over 700,000 people each year. They can be brought on by parasites, bacteria, or viruses. Malaria is a parasite disease spread by Anopheleline mosquitoes. It is responsible for an estimated 219 million illnesses worldwide and more than 400,000 fatalities each year. The majority of deaths occur in youngsters under the age of five. Dengue fever is the most common viral infection spread by Aedes mosquitoes. Dengue affects more than 3.9 billion people in 129 countries, resulting in an estimated 96 million symptomatic cases and 40,000 fatalities per year. Chikungunya fever, Zika virus fever, yellow fever, West Nile fever, Japanese

encephalitis (all transmitted by mosquitoes), and tick-borne encephalitis (delivered by ticks) are other viral diseases transmitted by vectors. Many vector-borne diseases can be avoided by taking precautions and mobilising the community. Table 1 shows the various diseases caused by mosquitoes [1]–[3].[4][5]–[7]

Table 1: List of various diseases caused by mosquitoes.

Vector		Disease caused	Type of pathoge n
Mosquit o	*Aed es*	Chikunguny a Dengue Lymphatic filariasis Rift Valley fever Yellow Fever Zika	Virus Virus Parasite Virus Virus Virus
	Ano phel e s	Lymphatic filariasis Malaria	Parasite Parasite
	Cul ex	Japanese encephalitis Lymphatic filariasis West Nile fever	Virus Parasite Virus

1. Significant Harmful effects of Mosquitoes

Mosquitoes are not only bothersome bugs, but they may also be dangerous to human health, animals, and the environment. Mosquitoes have the following negative effects:

1. Disease Transmission: Mosquitoes serve as vectors for a variety of dangerous diseases, including malaria, dengue fever, Zika virus, *chikungunya*, yellow fever, West Nile virus, and others. In humans, these diseases can cause serious illness, disability, and even death

also [8].

2. Economic impact: Mosquito-borne diseases can have a significant economic impact on communities and countries. Malaria and dengue fever outbreaks can result in increased healthcare expenses, lost productivity owing to illness, and decreased tourism and trade [9].

3. Impact on Livestock and Pets: Mosquitoes can transmit diseases to animals, hurting livestock and pets. Some mosquito species, for example, can spread heartworm illness to dogs, which can be fatal if untreated [10].

4. Allergic Reactions: Some persons are allergic to mosquito bites, resulting in localised swelling, redness, and itching [11].

5. Sleep disturbance: Mosquitoes are most active in the evening and at night, creating sleep disruptions and potentially contributing to sleep deprivation [8].

6. Impact on Wildlife: Mosquitoes can spread diseases to wildlife, impacting a variety of animal species and, in some circumstances, contributing to population decreases [12].

7. Impact on Agriculture: Certain mosquito species can cause crop damage by transferring plant viruses or destroying crops during their larval stages [13].

8. Biting nuisance: Mosquito bites can be annoying and cause discomfort even if they do not spread diseases.

9. Invasive Species: In some areas, some mosquito species have become invasive, affecting local ecosystems and outcompeting native species.Overuse of Insecticides: The need to reduce mosquito populations has resulted in the misuse of chemical insecticides, which can harm non-target creatures such as beneficial insects, aquatic life, and wildlife. [14].

2. Effects of Eradication of mosquitoes on ecosystem

If all mosquitoes were removed from an ecosystem, the food chain and ecological dynamics would suffer significantly. While mosquitoes are frequently seen as pests due to their role as disease carriers and their bothersome biting behaviour, they also perform vital ecological roles as a food supply for a variety of other creatures.

1. Disruption of Insectivores: Mosquitoes are a primary food source for many creatures, including birds, bats, amphibians, and some fish species. The removal of mosquitoes may result in a reduction in these insectivorous populations, impacting their survival and reproduction [15].

2. Predatory Behaviour Change: In mosquito- infested habitats, predators have evolved to include them in their diet. If mosquitoes were exterminated, predators would have to locate alternate food sources, which would cause behavioural changes and potentially harm their populations [16].

3. Changes in Insect Population Dynamics: Mosquitoes compete for resources with other insect species, and their absence could cause shifts in the numbers of other insects, resulting in ecosystem imbalances [17].

4. Mosquito larvae provide a vital food source for many aquatic species, including fish and insect larvae. Mosquito eradication may disturb the food web in freshwater settings [18].

5. Effects on Plant Pollination: Some mosquito species are known to pollinate specific plant species. Their absence may have an influence on plant reproduction as well as the total diversity of plant life in an area [19].

3. Application of various Mosquito repellents against vector borne disease

Mosquito repellents are often used to guard against mosquito bites as well as potential vector-borne diseases such as malaria, dengue fever, Zika virus, and West Nile virus. While they are efficient at repelling mosquitoes, several treatments on the market may be harmful if not used properly or in excess.

1. Many insect repellents contain chemicals such as DEET (N, N-Diethyl-meta-toluamide), picaridin, or permethrin. These substances can be dangerous if consumed, applied to broken skin, or exposed to the skin or eyes over an extended period of time [20].

2. Skin Irritation and Allergic Reactions: Some people, especially those with sensitive skin or a history of allergies, may develop skin irritation or allergic reactions after using certain mosquito repellents. Common symptoms include redness, itching, and rashes. Risks of Inhalation: One potential issue with liquid vaporizers is the inhalation of active substances or other chemicals released into the air. Inhaling these compounds in poorly ventilated areas or over extended periods of time may cause respiratory irritation, allergies, or other respiratory difficulties. Irritation, redness, and discomfort can occur if the vaporised repellent comes into contact with the eyes [21].

3. Toxicity to Pets: Some mosquito repellents contain ingredients that are hazardous to pets, especially if swallowed or applied directly to them [22].

4. Environmental Impact: The chemicals in mosquito repellents can harm the environment, especially water sources and wildlife [23].

5. Chemical Sensitivity: Some individuals may be more sensitive to the chemicals used in repelling fluids. If they are exposed to the vapours, they may develop headaches, dizziness, nausea, or other discomfort [24].

Overuse of certain repellents, particularly those with a single active ingredient, may result in mosquitoes acquiring resistance to the repellent's effects over time.

Mosquito repellents exist in a variety of forms and can be applied in a variety of ways. Here are some common mosquito repellent methods:

1. Topical Repellents: The most frequent type of mosquito repellent, which is applied directly to the skin. They are typically available in the form of lotions, creams, sprays, or sticks. These repellents' active chemicals, such as DEET, picaridin, IR3535, or oil of lemon eucalyptus (OLE), form a barrier that prevents mosquitoes from settling on the treated skin [25].

2. Repellents for clothing: Some repellents are designed to be applied directly to clothing rather than the skin. Permethrin is a typical active ingredient in textile repellents that can give protection even after several washes [26].

3. Mosquito coils are spirals or rings formed of a dried paste and powdered pesticide mixture. When lighted, they

emit smoke containing mosquito-repellent compounds. They are mostly used outside and can provide protection in a small area.[27].

4. Mosquito mats are little pads or sheets that contain insect repellent compounds. They are heated using specific gadgets or electric vaporizers to emit mosquito-repelling fumes. They, like coils, are better suited to interior or confined settings [28].

5. Electric liquid vaporizers are plug-in devices that require a liquid repellent refill. The device warms the liquid, causing a mosquito-repelling vapour to be released into the air. They are frequently used indoors [29].

6. Mosquito Repellent Candles: These are candles that have essential oils or chemicals that repel mosquitoes. When burned, they emit smoke that keeps mosquitoes at bay. They are more suited for outdoor use [30].

7. Wristbands and Clips for Mosquito Repellent: These are wearable objects impregnated with repellent substances, typically in the shape of bracelets or clips. They offer targeted protection but may be less effective than topical repellents [31].

8. Ultrasonic Repellents: Ultrasonic repellents use high-frequency sound waves that are inaudible to humans yet annoying to mosquitoes. However, their efficiency is still debatable, and empirical proof is scarce [32].

9. Natural or herbal repellents manufactured from plant extracts like as citronella, lemongrass, *neem*, lavender, or peppermint. These items are frequently in the shape of sprays, lotions, candles, or essential oils [33].

4. Sustainable mosquito control

The goal of sustainable mosquito management is to regulate mosquito populations while minimising environmental damage and promoting long-term efficacy. These methods are based on the principles of integrated pest management (IPM), which entail a variety of different strategies rather than relying exclusively on chemical insecticides. Here are some long-term mosquito control strategies [34].

1. Source Reduction: The most effective and environmentally benign method of mosquito control is source reduction. It entails locating and eradicating mosquito breeding grounds. This can be accomplished by emptying standing water from containers on a regular basis, clearing blocked gutters, and ensuring good drainage in the surrounding region [35].

2. When source reduction is not practicable or adequate, larvicides can be used to target mosquito larvae in bodies of water. Biological larvicides comprising bacteria (e.g., Bacillus thuringiensis israelensis or BTI) or insect growth regulators are desirable since they target mosquito larvae while causing no harm to other organisms [36].

3. Biological Control: By introducing natural predators or biological agents that feed on mosquito larvae or adults, mosquito populations can be reduced. Certain types of fish, dragonflies, and copepods are examples. Predatory Fish: Certain fish, such as Gambusia (mosquito fish) and some minnows, prey on mosquito larvae. By introducing these fish into bodies of water where mosquitoes thrive, the fish can efficiently consume the mosquito larvae, so naturally controlling mosquito populations. Dragonflies and damselflies: Adult dragonflies and damselflies are voracious mosquito predators. These insects

are drawn to mosquito breeding grounds and feed on both larvae and adult mosquitoes. Insect parasites and pathogens: Mosquito larvae can be infected and killed by a variety of species, including parasitic wasps, fungus, and nematodes. These natural enemies can be utilised to specifically target mosquito species in their nesting habitats. Copepods are little aquatic crustaceans that eat mosquito larvae. They are often utilised in natural mosquito control programmes because they are adept at digesting large quantities of mosquito larvae. Bacillus thuringiensis israelensis (BTI), a biological larvicide often used for mosquito control is not a natural predator. BTI is a bacteria that generates toxins that are toxic to mosquito larvae but not to humans, pets, or the majority of other species. It is sprayed into bodies of water to selectively target mosquito larvae [37], [38].

4. Modification of environments to prevent mosquito breeding can be useful. Creating wetland ecosystems that enhance the presence of natural mosquito predators, for example, or utilising landscaping techniques to reduce standing water, are two examples [39].

5. Mosquito Traps: A variety of mosquito traps that attract and collect mosquitoes are available. To attract mosquitoes, some traps use light, heat, or carbon dioxide, while others use chemical attractants. These traps can aid in the reduction of local mosquito populations without the use of chemical insecticides [40].

6. Repellents: Instead of using standard chemical repellents, try natural repellents made with plant-based essential oils like citronella, lemongrass, or eucalyptus. These can offer temporary protection from mosquito bites [41].

7. Community Involvement and Education: Raising awareness about mosquito breeding areas and the need of source reduction can inspire communities to pursue proactive mosquito control measures. Community involvement can help to ensure long-term

mosquito control operations [42].

8. Integrated Mosquito Management (IMM): IMM is carefully combining several control approaches to address specific mosquito species and their environments. This all-encompassing approach improves the effectiveness and long-term viability of mosquito control activities [43].

9. Monitoring mosquito populations and disease transmission is essential for early and focused action. Surveillance data can assist authorities in identifying high-risk regions and prioritising control actions [44].

4.1 Biotechnological control of mosquitoes

In addition to these relatively easy mosquito control techniques, new biotechnologically sophisticated approaches are being developed for use against vectors that transmit agents of human diseases. Th There are similarities between Wolbachia-based population replacement schemes and genetically modified control methods. Now that they have been transferred from their original host species to Aedes aegypti, several strains of the bacterial endosymbiont Wolbachia are able to prevent the spread of the dengue and Zika viruses. The release of Wolbachia-infected Ae. aegypti has been recorded in several field investigations. These mosquitoes are predicted to move from release locations and settle in the target population, offering a promising method for controlling arboviruses through modifying wild mosquito populations.ese approaches build on the successful use of existing simple mosquito control techniques against agricultural pests. The last 20 years or so have seen significant progress in these technologies, which include the application of genetic manipulation and Wolbachia endosymbionts. Regulatory hurdles, logistical constraints, technological

problems, social and cultural issues, which may affect acceptance of these technologies, and other significant obstacles still stand in the way of their general introduction, despite the tremendous prospects.

[45] Highlight one particular technical difficulty. It's conceivable that modified forms of an insect species will mate with wild species present in the target area after being released. If successful mating between modified and unmodified insects occurs, DNA from modified insects may penetrate the wild population. The authors go on the significance of strain selection as well as how background genetics may impact genetic pest management. They come to the conclusion that introgression is probably safe and might even enhance a release programme. Another exciting new tool for the management of mosquito-borne diseases is called "gene drive," which aims to transmit a genetic change through a population at higher rates of inheritance than usual. In the main sub-Saharan malaria vector, An. gambiae, gene-drive methods have recently been developed. The gene-drive system may be able to restrict a wild mosquito population or decrease its ability for transmission by dispersing genes that prevent parasite development, depending on the system's design. The ability of the Wolbachia strain to continue preventing virus transmission over many years is essential for the long-term efficacy of this strategy. Similar to genetic modification, population replacement techniques with Wolbachia rely on mosquito field releases. The Wolbachia infection will likely be lost once releases halt if release programmes aren't large enough to ensure that threshold prevalence is exceeded. Therefore, it has become important to create appropriate methods for the rearing and releasing of these mosquitoes. The sterile insect method (SIT), which is similar but normally on a much larger scale, includes mass-rearing a target species, sterilising them (commonly by exposure to radiation or chemosterilants), and releasing them into a wild population. If releases are sustained for enough generations, a target population may be reduced or even eradicated as a result of the subsequent induction of sterility in the wild population. SIT works best and is most cost-efficient when the sterile release populations are all male. Traditional mosquito sexing methods have focused on mechanical sorting that takes advantage of the size differences between male and female pupae. High throughput sex-sorting, however, may be able to improve accuracy and efficiency thanks to novel genetic techniques that make use of sex-linked markers [46], [47].

4.2 Challenges in facing mosquito Vector control

Pesticide Resistance: The overuse of chemical pesticides has resulted in the creation of mosquito populations that are resistant to these toxins. This reduces the effectiveness of standard control systems and necessitates the creation of new solutions [8].

Environmental Impact: Pesticides can harm non-target creatures, water bodies, and ecosystems. Water supplies can be contaminated and aquatic life harmed by runoff from treated regions [48].

Health Concerns: Pesticides used to control mosquitoes can be harmful to human health, especially when used for an extended period of time. Residents of affected areas may developrespiratory troubles, skin discomfort, and other health problems [49].

Short-Term Effect: Some traditional remedies only provide temporary relief from mosquito populations. For example, fogging may temporarily lower mosquito populations, but it does not address the underlying breeding sources.

6 Opportunities in facing mosquito Vector control

IPM (Integrated Pest Management): IPM combines several tactics, such as biological control, habitat alteration, and targeted pesticide usage, to reduce dependency on chemical pesticides. This strategy emphasises long-term solutions and ecological equilibrium. Biological Control: Introducing natural predators such as mosquito-eating fish, dragonflies, and specific bacteria species (e.g., Bacillus thuringiensis israelensis) can help control mosquito larvae without damaging the ecosystem. Communities can drastically reduce mosquito populations by eliminating or changing mosquito breeding habitats such as standing water containers and abandoned tyres. The introduction of genetically engineered mosquitoes with altered reproductive capacities (e.g., sterile male mosquitoes) can aid in mosquito population reduction without the requirement for large-scale chemical spraying. Local community education and involvement in mosquito control activities can improve the effectiveness and sustainability of control methods. People can take steps to reduce mosquito breeding in their surroundings. Researchers are investigating the use of pesticides produced from natural sources or less toxic compounds that target certain mosquito species while harming other organisms as little as possible. Remote sensing, geographic information systems (GIS), and predictive modelling can assist in identifying high-risk locations for mosquito-borne diseases, allowing for focused interventions. Investment in innovative control methods research and development, as well as studying mosquito behaviour and biology, can lead to more effective and sustainable tactics.[50], [51].

7. Summary and Conclusion

Sustainability is more than just an environmental idea; it is a multifaceted strategy that acknowledges the interdependence of environmental, social, and economic elements. The necessity of sustainability in all facets of life is becoming increasingly significant as worldwide awareness of environmental and social concerns develops. Combating mosquito-borne diseases and prevention necessitates a multifaceted approach that includes effective mosquito control measures, public health interventions, research into new control technologies, and public education about mosquito-borne diseases and prevention. The ecological ramifications of mosquito eradication are complicated, and they may have cascading effects on numerous levels of the food chain. It is difficult to correctly foresee all of the possible outcomes. Before attempting to eliminate any species from an ecosystem, it is critical to understand the potential unintended consequences. Rather than total eradication, a more sustainable approach would be to manage mosquito populations while keeping their ecological role and minimising their impact on other organisms. Integrated pest management tactics and research into targeted mosquito control measures could aid in striking this balance between public health and ecological conservation. Sustainable and integrated mosquito control solutions can aid in mosquito population management while minimising negative environmental and human health effects. Furthermore, ongoing research and disease surveillance are required to stay ahead of developing mosquito-borne diseases and limit their impact. Communities can effectively manage mosquito populations while protecting human health and the environmentby implementing long-term mosquito control techniques. To achieve the best outcomes, control techniques must be tailored to the specific mosquito species and local environmental conditions. Cooperation between local governments, public health agencies, and community members is critical for effective and long-term mosquito control. To achieve the most effective and environmentally responsible mosquito control outcomes, integrated pest management (IPM)

approaches frequently mix biological control strategies with other techniques such as source reduction. To establish a balanced and customised mosquito management plan, IMM emphasises the integration of multiple control strategies, such as biological, physical, chemical, and educational approaches. The goal is to keep mosquito populations under control while minimising the detrimental consequences on ecosystems and communities. Though environmental management has the potential to be a powerful, cost-effective, and long-term vector-borne illness control approach, its effectiveness requires the collaboration of several public-sector organisations. The planning process for infrastructure projects should identify and quantify negative health effects as early as possible, as well as recommend treatments. The current chapter expands on the significance of environmental management as a sustainable strategy of lowering vector-borne illness transmission risks in specific settings and as a malaria risk reduction alternative. In the absence of a malaria vaccine and increased resistance of malaria vectors to most pesticides, integrated management of all known sustainable vector control measures can reduce our reliance on insecticides. Sustainable vector-borne disease control can be achieved in many mosquito-borne disease endemic regions if environmental management is used as part of integrated vector management. However, environmental management necessitates a significant investment in qualified personnel and accompanying infrastructure. As a result, extensive research and planning are required to assess their cost-effectiveness in vector control programmes.

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Nanotechnology For Enhanced Plant Secondary Metabolite Production

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Abstract:

Primary metabolites were crucial for the essential life function, whereas, secondary metabolites were critical for adapting to the environment and surviving under abiotic and biotic stress situations. Numerous secondary metabolites, including Phenolic acids, glycosides, flavonoids, tannins, alkaloids, steroids, resins, terpenoids, and others, are thoroughly researched for their potential profitable uses in the greasepaints, pharmaceutical, nutraceutical, and nutrition productions. There is now a huge potential for improving plant secondary metabolite production to produce large harvest suitable for profitable usage. To fuel the production of secondary metabolites, many elicitation techniques are used, including vital (rhizobacteria and fungi) and nonvital (salt, metals, light, drought and temperatures) stimulant. Several studies led in recent years on the role of nanoparticles (NPs) as a novel provoker for the manufacture of bioactive compounds have demonstrated that the NPs may have an influence on the secondary metabolism of plants in both plant and tradition systems. By magnifying the nutraceutical and dietary value of plants, current research has demonstrated the possible applications of nanotechnology in cultivated construction. In the use of plants, secondary metabolites are significant. It was discovered that nanoparticles can, in addition to their function in pharmacological preparations, boost the quantity of plant secondary metabolites. Also, Nanotechnology has the ability to increase agricultural productivity without much inputs, supporting the goal of the evergreen revolution. It is growing as an important change and a viable device to start a new era of exact agricultural performances; therefore, it might offer a potential answer for harvest development smooth in difficult situations. Nanomaterials (NMs) can act as elicitors because they can promote the synthesis of secondary metabolites. NMs have the capability to enter a plant and interact with its organelles, cells, and tissues. It is believed that either the generation of reactive oxygen species or the change of gene expression induces this interaction. Initiation of the secondary metabolism and the generation and gathering of secondary metabolites are the outcomes in any circumstance. Elicitation can inhibit the production of important genes engaged in cellular activities at the biological and molecular levels involving signal molecules and regulate a huge number of control points. This mechanism boosts secondary metabolites while simultaneously triggering the immune system. Elicitors are of great interest to scientists since it is challenging to synthesize secondary metabolites due to their complex architectures. Additionally utilized as nano-pesticides, nano-fertilizers, nano-herbicides, biosensors, and quality boosters, nanoparticulated systems also produce higher concentrations of prized secondary metabolites and have a bigger impact on crop nutrition. Secondary metabolites serve as the primary building blocks for creating potent pharmaceuticals today. Inducing oxidative stress and acting as a unique and efficient elicitor, NPs help medicinal plants produce more secondary metabolites. Nanomaterials help to improve structural, biological aspects of medicinal plants as well as their growth by reducing biotic and abiotic stressors. The chapter highlights studies on the use of NPs to increase the production of secondaryplant metabolites in this

review. The above-mentioned research was done both in vitro and ex vivo, and it also looked at the impact of applying NPs after harvest.

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1 INTRODUCTION

Plant bioactive substances are referred to as phytochemicals. A bioactive compound is a material which possesses biological activity[1]. The prevention of long-lasting diseases like cancer and diabetes is one of the important impacts of bioactive substances on health[2]. These health advantages are associated with fruits and vegetables and are linked to the synergistic interactions of the bioactive substances found in the meal. [3]. In fruits, vegetables, and grains, over 5000 unique phytochemicals have been extracted and identified. Vitamin C, folate, provitamin A, potassium, calcium, magnesium, flavonoids, phenolic acids, alkaloids, carotenoids, and fibers are among the most important bioactive substances.

Bioactive molecules have probable uses in cosmetics, agrochemicals, pharmacology, food industry, and nanotechnology. Due to versatility Bioactive chemicals are also used in agro-alimentary, fragrances, Flavors, colours, and pharmaceutical preparations. The main function of secondary metabolites is to protect plants from illnesses, insects, animals, and other biotic or abiotic stressors. However, plants rarely produce natural pathways, and their ability to do so depends on a variety of factors, including their physiological state and stage of development[4]. Plant induction is another method for gradually boosting the synthesis of these chemicals[5]. Plants primarily produce active secondary metabolites in response to stress, which can be replicated by a variety of elicitors that also activate the plant's chemical defenses[6]. Biostimulants and abiotic stressors are two examples of these elicitors[7]. In addition, key techniques have been established for the synthesis of bioactive chemicals[8]. Nanoparticles (NPs), which have been shown

to work as an elicitor in plants, are a unique method.

Nanotechnology is a new branch of science that creates and synthesizes nanoparticles. NPs are materials with diameters ranging from 1 to 100 nm that can be produced or natural. In recent years, NPs shows different properties, which include morphology-aspect, chemical reactivity, competitive binding sites, and optical activity. NPs sizes, shapes, and structural characteristics may make them unique from the majority material and allow them to have greater features[9]. Applications for NPs include medicinal treatments, photosensitive devices, antibacterial, antifungal, beam technology, and a variety of ingredients that are frequently utilized in things like photographs and sunscreen[10]. Additionally, the special qualities of NPs have shown lot of properties in their application in agriculture. The principal application of nanomaterials in crop production is to reduce the use of agrochemicals and boost yield through the management of pests and nutrients. Recent researches have demonstrated how nanotechnology may be used to improve crop productivity, nutritional content, and nutraceutical value.

The influence of nanoparticles on plants at the physiological, biochemical and genetic levels has been examined by several authors. The impacts of nanoparticles on plants (such as fruits) and culture cells as possible elicitors under various philosophy settings and organizations are, however, thoroughly and analytically described in this research. Recent studies on how NPs affect plant's ability to produce secondary metabolites are included in this review[11].

2. Importance of Nanoparticles Under Stress Conditions

The main concern for agriculture manufacture is the rapid changes in environmental factors

like shortage of water, temperature, toxic metals, alkalinity and salinity in soil that have an impact on plant physiological & developmental processes & ultimately affect the yield of agricultural products. Hence, it is important to enhance agricultural production against biotic and abiotic stresses to deal with opposing environmental changes. to increase plant's capability to familiarize to changing climatic conditions, several studies have been conducted utilizing a variety of methodology, including cultural methodologies, traditional procedures, inheritances and genomics strategies among others. The nourishments and continuous irrigation increase the rising cost of agriculture production every year. In this context, nanotechnology may offer effective methods to raise crop productivity in the expression of biotic and abiotic stress[12].

2.1 Abiotic Strain

Abiotic strain is related to toxicity from heavy metals, strong temperatures, excessive salinity, and water stress. These strains result in an increase in responsive oxygen species, a decrease in photosynthetic efficiency, and an increase in cell wall and membrane damage. These will have an influence on a variety of physiological and molecular functions in plants, which will significantly reduce crop output and seed quality globally. Many approaches have been developed to overcome these abiotic stressors, including applying different nanoparticles[13].

2.2 Drought Strain and Nanoparticles

High temperatures and drought strain cause the soil's water content to evaporate. According to reports, drought stress lowers development, disrupts plant hormones, and causes oxidative strain, all of which contribute to undeveloped plant growth and decreased agricultural productivity[14].

The usage of nanoparticles prevent cell membrane damage, increase secondary metabolite production, improve photosynthesis and antioxidant enzyme activities to overcome the adverse drought stress. Silver, Silicon, titanium, zinc, selenium, and copper nanoparticles overcome drought stress by

improving the physiological parameters and the plant performance to improve the crop production[14].

When applied to the drought-stressed species Fragaria ananassa, selenium and selenium dioxide nanoparticles increased the amount of chlorophyll and the activity of antioxidant enzymes[15]. On the other hand, Dracocephalum moldavicum plants treated with titanium dioxide nanoparticles produced more secondary metabolites such apigenin-7-O-glucoside, rosmarinic acid, and chlorogenic acid helps to survive against Drought stress condition. In addition, applying copper nanoparticles to Zea mays against drought stress increased the chlorophyll, anthocyanin, and carotenoids and imparted tolerance to the plants. Under drought conditions, the exogenous administration of zinc and copper nanoparticles stabilized the photosynthetic pigments and enhanced water retention in Oryza sativa seedlings[16].
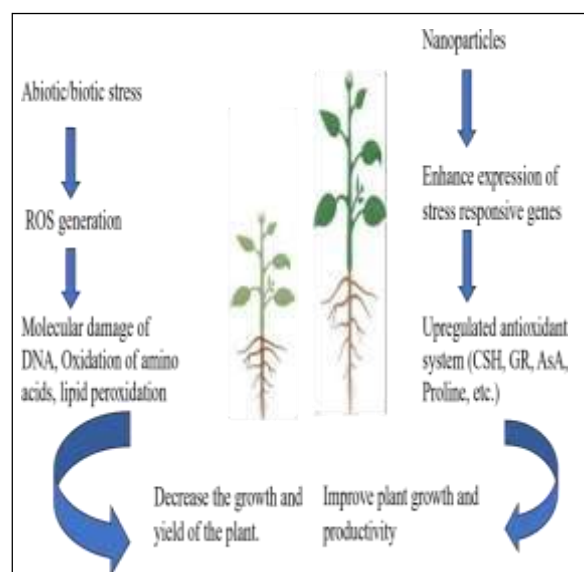
Figure 1: Comparative study Uptake, Translocation and consequences of nanomaterial on plant growth and stress adaptation

2.3 Metal Toxicity and Nanoparticles

Anthropogenic factors are responsible for the exponential global rise in metal toxicity. A significant element that influences agricultural yield and modifies the food chain, as well as the ecology and human health, is soil toxicity

with metals. There has been a lot of focus in the application of nanoparticles to the plants has decreased metal absorption and reduced the toxicity of heavy metals (Cd (II), Cr (VI), Cu (II), Pb (II), and Hg (II)), also increased the synthesis of defense related enzymes, proline and glutathione content.

The usage of copper nanoparticles reduced the translocation of cadmium from the soil and improved nutrient uptake and biomass in T. aestivum[17]. Similarly, the usage of silicon nanoparticles in Glycine max improved total chlorophyll content and decreased metal uptake under mercury toxicity. In addition, titanium dioxide nanoparticles were successfully applied to alter the movement and toxicity of heavy metals present in water and soil. Chitosan bound with titanium dioxide nanoparticles removed Cu (II) and Cd (II) from wastewater[18].

3. Interaction of Nanoparticles in Plants

3.1 Uptake and translocation of nanoparticles to plant cell

A relatively emerging area of research that has enormous potential and contributes to our understanding of the action mechanisms of nanoparticles is the interaction of nanoparticles with plants. Metal nanoparticles can be introduced directly, or they can be oxidized, dissolved in soil water, or introduced into plants as ions. However, a consensus is influenced by numerous factors like, the nature of nanoparticles (size and shape), environmental conditions, and the plant species, affecting the nanoparticles uptake. Nanoparticles with a diameter of 0.5 - 50 nm can migrate and gather inside plant cells.

Deep characterizing the entry, uptake, transport, accumulation, biotransformation, fate, and hazards of these materials inside plant cells, tissues, and organelles is important to properly comprehend the nature of nanoparticle-plant interactions. Many factors affect the plant uptake of nanoparticles such as exceptional characteristics of nanoparticles, interaction of the nanoparticles with the environment, and plant physiological indices.

When nanoparticles are localized into the xylem vessels, they may form complexes with root exudates or transporter plasma membrane proteins[19].

Physicochemical properties of nanomaterials such as surface hardness and charge, and hydrophobicity degree promote surface binding and the subsequent cellular uptake of nanoparticles. The entry and transportation of nanoparticles may happen via root to leaf/fruit (below - to aerial organs) or leaf to root (aerial to below -ground organs) pathways[20], a key point that makes both foliar and soil applications feasible in plant - soil ecosystems.

When exposed to plant roots (soil mixed - nanoparticles entry rout), nanoparticles transport may occur through both apoplastic and symplastic pathways[21]. In order to allow the direct penetration of nanoparticles, the cell wall pore size should be less than 20 nm in diameter[22], therefore; larger particles would have limited ability to enter epidermal cells. After penetrating the cell walls, nanoparticles may be diffused between cell walls and plasma membrane, and their subsequent movements may be regulated by two forces, osmotic pressure and capillary exchange. Other than transporter proteins (carriers) such as aquaporins (water channels) and the presence of ion channels, nanoparticles can also reach inside the cells through endocytosis or membrane piercing processes [23].

Specific receptor-ligand binding interactions lead to the process of endocytic uptake, a type of active transport. On the basis of their morphology, engineered nanomaterials such as carbon nanotubes are able to enter the cytoplasm of cells by directly piercing the membrane. Nanoparticles engage in dynamic interactions with their surroundings in the cytoplasm through a variety of forces, including van der Waals, electrostatic, hydrogen bonds, solvation forces, and interactions with steric polymers. Then, protein molecules bind to the surfaces of nanoparticles to form complex structures known as protein corona[24]. The cellular absorption, accumulation/aggregation, and destruction of the nanoparticles may be

influenced by the protein corona[25].Through tiny passage ways known as plasmodesmata, these ingested nanoparticles-endosome or nanoparticle protein complexes may spread to nearby plant cells. Exposure to nanoscale titanium dioxide (TiO_2) may prevent the cytoskeleton microfilaments from reorganizing, which would have an impact on how long plasmodesmata would last.

When applied to the foliage of the plant (aerosol -nanoparticles entry rout), nanoparticles were capable of penetrating leaves through stomatal pores[26].From the initial sites of exposure/entry, nanoparticles could be subsequently translocated to other parts and vascular tissues such as roots. The cellular internalization of nanoparticles in suspension culture systems, may occur through a mechanism primarily based on fluid phase pinocytosis, which is the inclusion of solutes from the apoplast to the vacuole occurred through vesicles formation at the plasma membrane[27].

After penetration into plant cells, nanoparticles interact with intracellular components/molecules, organelles and structures. The nature of interaction between nanoparticles and two target cell organelles namely chloroplasts and mitochondria, could be chemical or physical variations. Both type of nanomaterials (i.e., carbon -based and metal - based) are able to induce stress and produce excessive reactive oxygen species (ROS), which subsequently affect cell organelles and structures, DNA, proteins, carbohydrates, lipids, and secondary metabolites in plants[28].

3.2 Nanoparticle–Plant Interactions

The interaction between nanoparticles and plants might vary significantly in terms of the biochemistry, physiology, and molecular characteristics of the plants[29]. The treatment with nanoparticles will trigger various plant morphological changes like elongation of roots, germination rate, biomass, etc. Numerous nanoparticles have also been linked to harmful effects like phytotoxicity, which stop the growth and development of plants.

A thorough examination of the studies on nanoparticles showed that they influence many plant metabolisms by controlling, absorbing micronutrients, regulating gene expression, and interfering with other oxidative enzymes engaged in an oxidative burst[30] Exposure of nanoparticles in some plants shows a positive effect, whereas others are negatively affected by the same nanoparticles. Therefore, it is crucial to screen different nanoparticle types to positively impact plant growth and development.

Many different metal and metal oxide nanomaterials are proven to enhance the secondary metabolites (phenolics, terpenoids, alkaloids, etc.). It has been demonstrated to be one of the plant's best abiotic and biotic stress alleviation methods. For example, the silver nanoparticles enhanced growth of plants and development by augmenting the polyamines biosynthesis and the content of O. sativa seedling[31].

Nanoparticles are more effective when genes and cellular mechanisms are expressed; this impacts plant growth and development by changing how many genes involved in different biosynthetic processes are expressed. Additionally, microRNA (miR408 and miR398) expression, which regulates seed germination and the establishment of roots in Arabidopsis thaliana seedlings, is thought to be increased by nanoparticles[32].

The application of zinc oxide nanoparticles increased the expression of serotonin N-acetyltransferase, caffeic acid O-methyltransferase, and N-acetyl serotonin O-methyltransferase, genes involved in melatonin biosynthesis and antioxidative enzymes like catalase, ascorbate peroxidase, and superoxide dismutase to influence drought resistance in Zea mays.

It has been shown that a variety of nanomaterials cause oxidative stress in plants. The presence of prooxidant active groups on the nanoparticle's reactive surface, active redox cycling on those surfaces as a result of the transition of metal-based nanoparticles, and particle-cell interactions are the three main

factors involved in nanoparticle's induction of reactive oxygen species[33].

3.3 Role of Nanoparticles in Plant Secondary Metabolites

Phytochemical components underlies the wide range of nutraceuticals and pharmacological effects of all recognized medicinal plants[34]. These components are categorized into primary and secondary metabolites depending on their metabolic functions.

The primary metabolites participate in fundamental life processes that are directly related to healthy growth, development, and reproduction. In contrast, secondary metabolites are essential for adaptation of plants during a hostile environment. They are also used in pharmaceutical, cosmetics, and agricultural and food products. Secondary metabolites are classified into four main categories on the basis of their chemical structures: alkaloids, phenolic compounds, Sulphur-containing compounds and terpenoids. Secondary metabolite production has drawn interest for creating novel methods to improve it because of its enormous biological value[35].

The nanoparticles used are broadly metal nanoparticles, and some reports are available on engineered nanoparticles where secondary metabolites are usually converted into nano-formulations for effective agents for inducing secondary metabolite production and accumulation in the plants[36]. the various nanoparticles used for eliciting the secondary metabolites in different plants.

Silver nanoparticles (AgNPs) have been the most extensively used as elicitors of secondary metabolism in plants. the AgNPs (diameter 2–50 nm) synthesized using aqueous leaf extract of Acalypha indica L. were found to enhance total phenolic content (TPC) along with catalase and peroxidase activity in hydroponically treated Bacopa monnieri (Linn.) In Borago officinalis L. (borage) foliar application of AgNPs (diameter ~35 nm) was found to increase the phenol, tannin and alkaloid contents along with other vegetative and phytochemical properties, the most

effective concentration being 0.6 mM. Similar effects were observed in the medicinal herb Achillea millefolium L., which on elicitation with AgNPs (diameter 30–50 nm) and methyl jasmonate (MeJa) showed an increase of approximately 230% in essential oil content. There was an increase in flavonoids as well as some precious medicinal compounds such as anti-bacterial isoprenoids, namely camphor, allo-ocimene, germacrene, trans-caryophyllene and farnesol which possess anti-bacterial, anti-fungal, anti-inflammatory and anti-cancer properties. AgNPs (1–20 nm; 5 and 10 mg L^{-1}) were demonstrated to induce most of the genes related to secondary metabolism (glucosinolates, anthocyanin) in Brassica rapa ssp. rapa L. (turnip) seedlings along with an increase in the content of anthocyanin and malondialdehyde as well as hydrogen peroxide, indicating oxidative stress[37]. Similar gene induction and anti-oxidant activities were observed with AgNPs at higher concentrations (>250 mg L^{-1}) in Brassica rapa ssp. pekinensis (Chinese cabbage) seedlings[38].

Copper or copper oxide nanoparticles (Cu/CuO NPs) have also been reported to be effective elicitors of secondary metabolism in plants. Plantlets of Citrus reticulata, when germinated in vitro in media supplemented separately with CuO NPs (15–32 nm) and ZnO NPs (8–32 nm) (green synthesized using white leaves of Allium cepa L.) at concentrations of 30 μg ml^{-1}, showed significant enhancement of total phenolic and flavonoid contents as well as anti-oxidant capacity. Foliar application of CuO NPs (50 nm) in plants of Solanum lycopersicum L. (tomato) enhanced fruit quality by stimulating greater accumulation of bioactive compounds such as vitamin C , lycopene , total phenols and flavonoids in the fruits and enhancing anti-oxidant capacity along with increasing anti-oxidant enzymes CAT and SOD[39]. Foliar application of CuNPs (~50 nm) and Selenium NPs (2–20 nm) jointly in Solanum lycopersicum (tomato) decreased the severity of early blight disease caused by the fungus Alternaria solani, while simultaneously increasing vitamin C, glutathione, phenol and flavonoid content in

fruits, thereby improving fruit quality. The effect was correlated with the induction of the activity of the enzymes SOD, APX, GPX and PAL in the leaves, and the enzyme GPX in the fruit[40].

Lepidum sativum L. (cress), grown in sandy soil with little saline water, was found to contain significantly more secondary metabolites, such as essential oils, phenolics, and flavonoids when iron oxide (FeO) NPs (20 nm) were used in conjunction with gamma irradiation[41].

When applied to Salvia officinalis L. (sage) plants, titanium dioxide (TiO$_2$) NPs (10–15 nm) boosted secondary metabolites like phenolics, flavonoids, and essential oils, with the greatest increases occurring at dosages of 100 and 200 mg L^{-1}. Monoterpenes are the main component of essential oils and include Camphene, p-Cymene, 1,8-Cineol, cis-Thujene, and camphor. Plants exposed to 200 mg L^{-1} of these compounds experienced the greatest increases in cis-Thujene (34.5%) and 1,8-Cineol (21.2%)[42].

Zinc oxide (ZnO) NPs (12–24 nm) were found to inhibit seedling radical growth and promote the accumulation of phenolics, flavonoids, and tannins while improving the seedlings antioxidant capacity when applied to Capsicum annum L. seeds at concentrations of 100 ppm and higher before germination[43].

At concentrations of 30 g ml^{-1}, bimetallic alloy NPs of Au, Ag, and Cu were shown to enhance anti-oxidant capacity while inducing the production of secondary metabolites like phenolics and flavonoids in germinating seedlings of the medicinal plant Eruca sativa. While the effect of Cu in the NPs was more pronounced than that of Au and Ag, smaller NPs produced more harmful stress[44]. It was discovered that alloy Zn-Ag NPs (25-40 nm) in the molar ratios of 19:1 and 3:1 increased the withanolide content of the ayurvedic herb Withania somnifera L. Dunal (Ashwagandha). The rate of transpiration, photosynthesis, the Calvin cycle, and carbohydrate metabolism all had a positive correlation with the influence on withanolide synthesis[45]

Non-metal oxide nanoparticles like Silicon dioxide (SiO$_2$), 50 and 100 mg L^{-1} on foliar application, were demonstrated to significantly augment essential oil content in Mentha piperita L. (peppermint) while enriching the menthol content but decreasing menthone and menthyl acetate in the essential oil[46].

Carbon-based nanoparticles Chitosan nanoparticles (90 +/- 5 nm in diameter) enhanced phenolics, notably flavonoids, which was accompanied by gene upregulation and increased activity of the antioxidant enzymes SOD and catalase (CAT) as well as defense enzymes peroxidase, PPO, PAL, and 1,3-glucanase. Upregulation of the genes for flavonoid biosynthesis enzymes cinnamate 4 hydroxylase (C4H), flavonoid 3 hydroxylase (F3H), and anthocyanidin reductase (ANR) as well as PPO, 1,3-glucanase, PAL, thaumatin-like protein (TLP), and SOD and CAT was also seen [47].

Chitosan NPs were reported to improve the levels of soluble phenols, proline, and alkaloid while promoting organogenesis through micropropagation similar to growth promoters in cultures of Capsicum annuum L. The most effective dose was 1mgL^{-1}. The activity of the enzymes peroxidase, catalase, and PAL were also improved[48].

Multi-walled carbon nanotubes (MWCNT) were found to increase the content of secondary metabolites, such as phenolics, flavonoids, RA, and caffeic acid, as well as the activity of oxidative enzymes PPO, PAL, and peroxidase (POD), in callus cultures of the medicinal plant Satureja khuzestanica in B5 medium, with the most effective concentrations being 25 and 50 µg L^{-1}. MWCNT treatment increased alkaloid and phenol contents in seedlings of Catharanthus roseus (rose periwinkle) grown in MS basal medium by 1.7-fold and 23%, respectively. It also increased the activities of catalase, peroxidase, and PAL and upregulated the deacetylvindoline-4-O-acetyltransferase (DAT) gene[49]. Indicators of plant growth such total biomass, leaf breadth, area, and weight, root length, chlorophyll, carotenoid, and protein contents, as well as the

proliferation of calluses, increased along with this.

4. Ligand harvesting of plant secondary metabolites using nanoparticles

Interestingly, a novel application of NPs in secondary metabolite chemistry has opened up in the form of ligand fishing or ligand harvesting. Ligand fishing is an extraction technique based on the receptor theory. It is widely used to recover specific ligands from complex biological matrices using known or orphan receptors. The technique is widely used in protein purification. It is especially helpful to screen and harvest specific bioactive components from complicated plant extracts using nanoparticle-mediated ligand fishing. This method uses surface-modified NPs to directly collect plant secondary metabolites as conjugates from living plant cells without harming the host cells. The NPs, which are typically surface-conjugated with certain receptors, penetrate living plant cells and are removed after binding with specified secondary metabolites[50]. The advantages of this technique is that it avoids the use of organic solvents for extraction, keeps host cells viable and also permits spectrometric identification of isolated compounds. Four bioactive secondary metabolites, progenin II, progen III, dioscin, and gracillin, were quickly extracted from herbal extracts of the Chinese medicinal plant Dioscorea panthaica using human serum albumin functionalized magnetic nanoparticles (HSA-MNPs) with a diameter of 20 nm. Similarly, anatase TiO_2 NPs (2.8 +/- 1.4 nm in size) were used to harvest enediol and catechol-rich flavonoids, particularly quercetin-derivatives, from living cells of the plant Arabidopsis thaliana by forming flavonoid-NP conjugates, without affecting the viability of the source plant[51]. This technology is still in its infancy and needs further exploration and investigation.

5. Mechanism of action of nanoparticles on plant secondary metabolism

It must be emphasized that plants enhanced or de novo synthesis of secondary metabolites is a defence strategy in response to abiotic and biotic stress. Cellular and organismic responses to stress are both present in plants. The stress signal is first perceived by the receptors present on the cell membrane. This starts an extensive and intricate intracellular signalling cascade that produces secondary signal molecules. Phospholipase C (PLC), which hydrolyzes phosphatidylinositol 4,5-bisphosphate (PIP2) to produce inositol triphosphate (IP3) and diacylglycerol (DAG), might be activated by the stress signal first. Ca^{2+} ions are released from intracellular Ca^{2+} storage as a result of IP_3 diffusing into the cytosol, which raises the concentration of Ca^{2+} ions in the cytosol. Additionally, Ca^{2+} release happens often from extracellular sources (apoplastic space). Calcium-binding proteins (CaBP, calcium sensors) such as calmodulin (CaM), calmodulin-like proteins (CML), phospholipase D, annexins, calreticulin, calnexin, and pistil-expressed Ca^{2+} binding protein (PCP), as well as calcium-dependent protein kinases (CDPK), detect the elevated Ca^{2+} concentration. These sensors recognize and decode the information provided in the calcium signatures, relay the information downstream to initiate a phosphorylation cascade leading to regulation of gene expression. According to a number of studies, Ca^{2+} affects target gene transcription by modifying the phosphorylation state of particular transcription factors (TF). Another signalling molecule, phosphatidic acid (PA), is produced when DAG is phosphorylated by DAG kinase. Various other chemical signals including abscisic acid (ABA), salicylic acid (SA), polyamines, jasmonates (JA) and nitric oxide are involved in stress responses in plants, often through cross-talk. Many secondary metabolite's production is mediated by (methyl) jasmonate [(Me)JA], a hormone that plants release in response to stress. Developmental and tissue-specific factors or external signals regulate the expression of the biosynthetic genes, which in turn regulates the production of secondary metabolites[52]. In the resting state, a family of proteins called JAZ interacts and repress certain downstream TF (e.g., MYC2) to suppress JA responses. The F-box protein COI1 binds with and ubiquitinates JAZs in response to JA signals,

marking them for destruction through the 26S proteasome and releasing downstream transcription factors (TFs) to control gene expression and activate JA responses[53]. Nanoparticles are known to cause a certain degree of phytotoxicity, especially at high concentrations. NPs, depending on size, have a high degree of cell penetrability. They can enter the plant cell through the apoplast and cross the plasma membrane by endocytosis; subsequently, they can be translocated within the plant by the symplastic flow. Additionally, there is evidence that NPs are transported into subcellular organelles such as the nucleus, plastids, and vacuoles[54]. NPs can cause an oxidative burst and an accumulation of reactive oxidative species (ROS) such hydrogenperoxide (H_2O_2), superoxide anions (O_2^{-}), hydroxyl radicals ($OH^{.}$), and singlet oxygen ($^1O_2$) by interfering with the electron transport chain in chloroplasts and mitochondria. Induction of reactive nitrogen species (RNS) (NO nitric oxide), due to exposure of duckweed Spirodela punctata to Ag and ZnO NPs and of cultured tobacco by cells to Al_2O_3 NPs have also been reported. NO is known to be an important elicitor of plant secondary metabolism[55]. Metal and metal oxide NPs have been extensively studied for their toxic effects on plants which are thought to largely occur through (ROS) burst. ROS are known to interact with almost all cellular components causing protein modifications, lipid peroxidation and DNA damage[56]. Additionally, they stimulate the plant's natural and enzymatic antioxidant defenses. The main enzymes in the anti-oxidant defense response are glutathione S-transferases (GST), which catalyse the conjugation of the reduced form of glutathione (GSH) to xenobiotic substrates for detoxification. These enzymes include catalase, which decomposes H_2O_2 to water and O_2, as well as SOD, which catalyses the conversion of O_2 to either molecular oxygen (O_2) or H_2O.

Through membrane receptors or plasmodesmata, nanoparticles can enter plant cells and cause a burst of reactive oxygen species (ROS), which could damage the plasma membrane. Inositol triphosphate (IP3) and diacylglycerol (DAG) are produced as a result of the hydrolysis of phosphatidylinositol 4,5-bisphosphate (PIP_2) by phospholipase C (PLC), which is activated by ROS. DAG is phosphorylated by the enzyme DAG kinase to produce the signalling chemical phosphatidic acid (PA). IP_3 diffuses into the cytosol and subsequently causes a Ca^{2+} ion spike. Calcium-binding proteins (CaBP, a calcium sensor) or calcium-dependent protein kinases (CDPK), which recognize and decode the information provided in the calcium signatures, relay the information downstream to start a phosphorylation cascade, including the upregulation of mitogen-activated protein kinase (MAPK) cascades, are the two mechanisms by which the increased Ca^{2+} concentration is sensed[57]. Stress reactions contain a number of additional chemical signals, frequently through cross-talk, such as abscissic acid (ABA), salicylic acid (SA), polyamines, jasmonates (JA), and nitric oxide. By changing the phosphorylation state of particular transcription factors (TF), Ca^{2+} may influence the transcription of target genes. Secondary metabolism and antioxidant defense enzymes are typically transcriptionally upregulated as a result of MAPK phosphorylation and activation of downstream transcription factors like WRKY[58].

Dehydroascorbate reductase (DHAR) and monodehydroascorbate reductase (MDAR), enzymes that control the cellular Asc redox state, are also downregulated as part of the enzymatic antioxidant defense. ROS can either produce oxidative damage or function as biological signalling molecules, depending on the delicate balance between ROS formation and scavenging. It is well recognized that NADPH oxidases play an important signalling role in plant's ROS control network, which integrates various signal transduction pathways and mediates a variety of biological functions. JA, SA, ethylene, NO, and brassinosteroids are a few more inducers that are hypothesized to respond to ROS either directly or by acting as signals for them. According to theory, ROS production causes cytoplasmic Ca^{2+} to increase, upregulating

MAPK cascades similarly to other abiotic stressors[59]. NPs either mimic Ca^{2+} or signalling molecules in the cytosol to be sensed by calcium-binding proteins (CaBPs) or other NP-specific proteins[60]. MAPK phosphorylation and activation of downstream TF like WRKY generally lead to the transcriptional upregulation of secondary metabolism in plants[61].

6. Applications of Nanomaterial-Induced Secondary Metabolic Changes

6.1. NPs as Biostimulants

Plant biostimulation is a procedure that alters plant metabolism to make better use of the environment's resources, increase resiliency to environmental challenges, and boost production. Under stressful situations, NPs are used as novel biostimulants to encourage plant development. Stimulation of secondary metabolites such as alkaloids, terpenoids, phenolic compounds, glucosinolates and flavonoids reduces the deleterious effects of environmental stress in plants. For example, increased melatonin synthesis by application of ZnO NPs helped in controlling drought-induced damage in Zea mays[62]. Melatonin is a secondary metabolite that is known to increase antioxidant activity in plants, improving their ability to survive stress[63]. Spraying leaves with selenium NPs increased phenolic content and improved the quality of drought-affected fruits of P. granatum[64].

6.2. NPs as Elicitors of Phyto pharmaceuticals

A method to boost the production of significant secondary metabolites is controlled elicitation. Plants are able to recognize various NM types and activate their secondary metabolism, creating a new possibility to increase the production of chemicals with pharmacological value in medicinal plants[65]. It has been claimed that employing NPs, it is possible to extract numerous kinds of secondary metabolites, including glucosinolates, terpenes, and alkaloids. The chemical structure of some pharmaceutically

important secondary metabolites elicited using NMs[66]

Flavonoids: Flavonoids are natural bioactive compounds found predominantly in various parts of plants and have been attributed to various pharmacological and therapeutic properties[67]. In Momordica charantia L., an increase in flavonoid concentration induced by 5 mg/L Ag NPs was observed. Quercetin is an important and abundant flavonoid from plants with rich pharmaceutical properties such as antitumor, anti-infective, anti-inflammatory and antioxidant activities. Increased quercetin content was observed in shoots and roots of Nigella arvensis L. treated with 50 mg/L NiO NPs. The level of several flavonoid aglycones like apigenin, kaempferol and quercetin was increased upon treatment with the Ag, Au, Cu and Pd NPs treatment, whereas flavonoid glucosides like quercetin 3-O-hexoside or quercetin 3-O-malonylhexoside was elicited by CuO NPs treatment in H. perforatum L. cell suspension cultures[68]Another subclass of flavonoids are anthocyanins, which are significant to the nutraceutical, pharmaceutical, and food sectors.
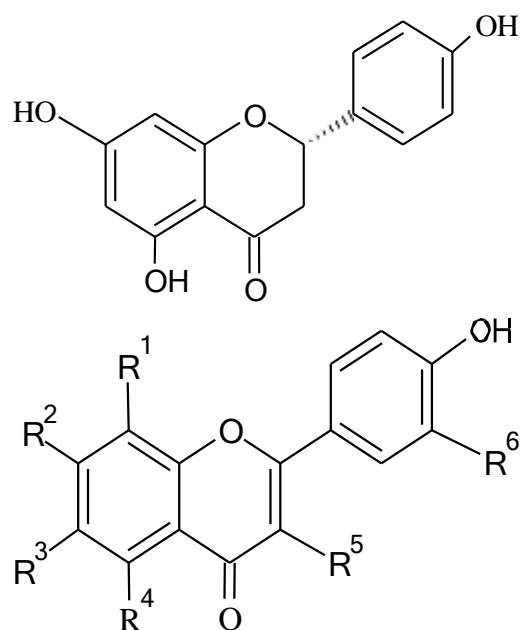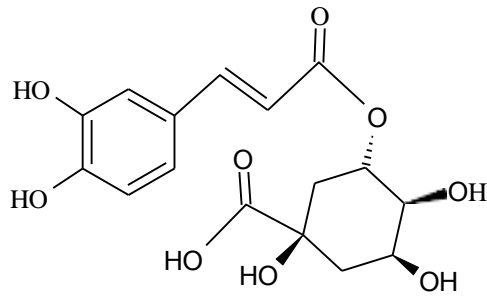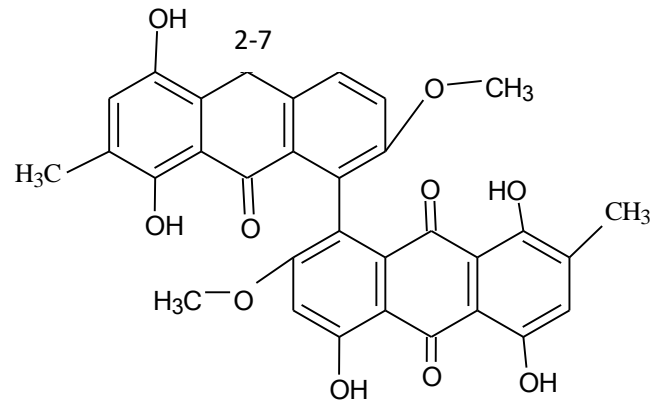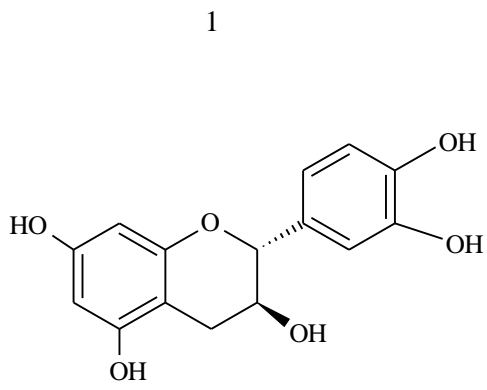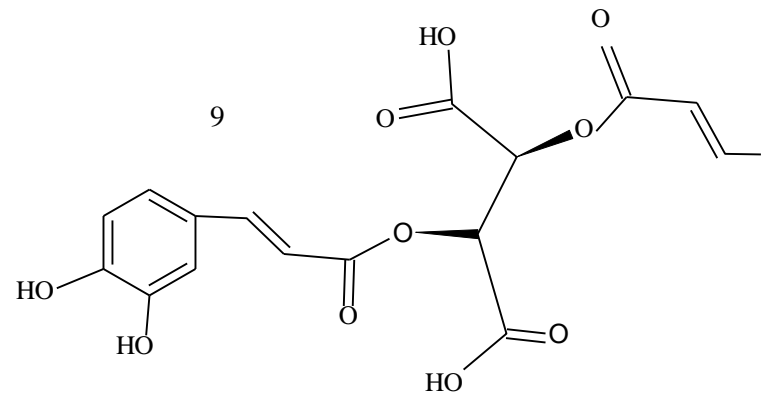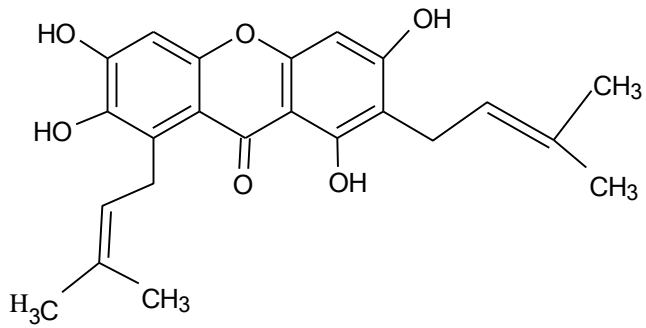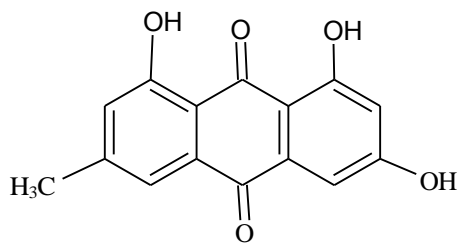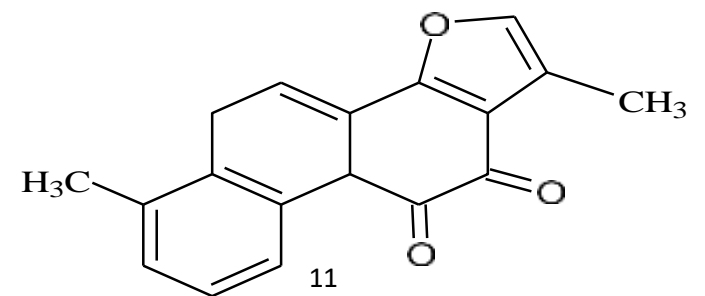
Phenolic acids : Phenolic acids are an important group of plant secondary metabolites with a wide range of bioactivities, including anticancer, anti-inflammatory, neuroprotective, antioxidant, and antimicrobial activities. The phenolic acids, such as chlorogenic acid, coumaric acid, gallic acid, and tannic acid, were accumulated after the callus of Prunella vulgaris L. was exposed to Ag, Au, and Ag/Au NPs.

Glucosinolates : Members of the Brassicaceae and allied families are the main sources of the category of hydrophilic secondary metabolites known as glucosinolates, which include sulphur[69]. Glucosinolates exhibit some pharmacological bioactivities such as anti-inflammatory, antimicrobial, cholinesterase inhibitory, antioxidant and anticancer properties[70]. In seedlings of Brassica rapa L., Ag NPs stimulated phenolic and glucosinolate production. Phenolic chemicals are involved in the response to pathogen attack[71].

Terpenoids: Terpenes and terpenoids are secondary metabolites of plants that are biogenic volatile organic molecules with strong biological activity against a variety of human ailments. Linalool and linalyl acetate synthesis in Mentha longifolia L. shoot cultures cultivated in the presence of cobalt (0.8 mg/L) and copper (0.5 mg/L) NPs[72]. In A. annua cell culture, 2.5 and 5 mg/L Co NPs promoted the production of artemisinin, one of the significant pharmacological chemicals used as an antimalarial.

Alkaloids: Alkaloids are a vast class of secondary metabolites found in plants that contain one or more nitrogen atoms and have a variety of bioactivities that are crucial for medicine[73].Ag NPs induced the biosynthesis of atropine alkaloid in hair root culture of Datura metal L. and the highest level of atropine was detected after 48 h of treatment. This NP -based elicitor was better than $AgNO_3$ and two other biotic elicitors. SiO_2 NPs triggered the production of tropane alkaloids (hyoscyamine and scopolamine) in hair root

cultures of two Hyoscyamus species namely, H. reticulatus and H. pusillus L[74].

Xanthones: Xanthones are bioactive secondary metabolites with potential to inhibit acetylcholinesterase, butyrylcholinesterase, and tyrosinase as well as have antibacterial and antifungal properties[75]**.** Xanthones also possess neuroprotective activities. Prenylated xanthone derivatives (such as-mangostin, garcinone B, and hyperxanthone C) were stimulated by Ag, Au, Cu, Pd, and CuO NPs while glycosylated xanthones (such as mangiferin, homomangiferin, and neomangiferin) were increased after Au, Cu, and Pd NPs treatment in the cell suspension system of H. perforatum L[76].

Anthraquinones: Antidepressant activities of H. perforatum L. extracts are attributed to naphthodianthrones/ anthraquinones such as hypericin or pseudohypericin[77]. TiO_2-perlite nanocomposite treatment increased the amount of hypericin in H. perforatum L. shoot cultures[78]. Emodin and emodin anthrone contents were respectively increased by Pd and CeO_2 NPs treatment in H. perforatum L. cell suspension cultures[79].

7. **Conclusions and Perspectives**

This review reveals that by eliciting bioactive chemicals, NPs can be a potential approach to enhance quality, quantity, and commercial aspects like storage life. Additionally, NP's influence as a novel elicitor is not just confined to stimulating plant's secondary metabolism; it can also enhance their primary metabolism[80].This effect is dependent on the application method, substance, NP's interaction with plant cells, including their secondary metabolic pathway, absorption, and translocation.

Enhanced synthesis of secondary metabolites production includes flavonoids, carotenoids, alkaloids, volatile oils, taxol and so forth; elicitation is recognized as the most practical strategy for increasing the production of desirable bioactive compounds. The improved production of bioactive compounds through nanoparticles as elicitors has unlocked a new area of research that could have a significant

impact on the food, pharmaceutical and medical industries[73].

The improvement of secondary metabolite production is the present emphasis of the use of nanoparticles as elicitors. However, recent studies have looked at an interesting and promising angle of research that incorporates the use of present-day elicitation choices with nanoparticles[68]. Additionally, the literature is still restricted to the investigation of the impact of nanoparticles on the development and growth of various plant tissues and cells, as well as the impact brought about in the pathways of secondary metabolism[81]. In particular, the employment of nanoparticles in medicinal plants as a method to boost the biological activity without phytotoxicity was demonstrated by the current research. Nanomaterials can be utilized as elicitors to improve the manufacture of bioactive chemicals[82]. More research is required on the possible impacts on ecosystems and human risk before using nanoparticles as an elicitor, too[83]. Furthermore, for large-scale field-like conditions, more studies on the interaction between plants and nanomaterials in terms of doses, time, type of exposure and others may be necessary[84].

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Advances in Medicinal Plant Tissue Culture and Future Direction

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Abstract

This chapter gives a broad overview of the topic of plant tissue culture, outlining its general background, subsequent advancements, and significant contributions made by a number of esteemed researchers. Research in a number of areas of plant biotechnology has been aided by the development of cell and tissue culture of plant organs. With regard to food security, secondary substance production for the pharmaceutical and biochemical industries, contemporary agriculture's progression, secondary substance production, and conservation of plant genetic resources, it has made major strides and contributions. Today, clonal propagation is only one of several applications for plant tissue culture. Somatic hybridization, virus eradication, somatic embryogenesis, and the use of bioreactors for mass propagation have all been added to the list of standard technologies. The greatest value of these tissue culture technologies may not be in their use for mass clonal multiplication, but rather in their position as the foundation for advancements and applications in molecular biology, bio processing, and plant improvement, as well as being a tool for basic research. The accomplishments and limitations of tissue culture, as well as some insights into current and potential future advances, are highlighted in this chapter along with some of the applications of plant tissue culture to horticulture. The overall acreages of fruits, vegetables, and different decorative plants have not been able to meet the needs of people in emerging countries due to rapid population expansion. The current state of plant tissue culture applications is briefly discussed in this chapter in Vietnam (a developing nation) as well as throughout the rest of the world. One of the key priorities in the development of agriculture, horticulture, and forestry in many developing nations will be the use of low-cost tissue culture technologies to generate high-quality crop materials at an inexpensive price without compromising the quality of the final products. Finally, this chapter discusses some probable future advancement in this area, such as the enormous potential of plant micropropagation and the growing significance of novel biological approaches.

Keywords: *Plant Tissue Culture, Medicinal plants, horticultural crops, somatic hybridization, clonal propagation.*

1. Introduction

In order to cultivate plant cells, tissues, or organs, a regulated, sterile environment is used in the scientific approach known as "plant tissue culture." By using this technique, plant growth and development may be precisely controlled and manipulated. Agribusiness, horticulture, and biotechnology all use it in a variety of ways. When cultivating plant tissues small plant samples are used in the experiment, such as stem segments or leaf explants, which are placed in a nutrient-rich medium with particular plant hormones[1]. These tissues grow and mature into complete plants under precisely controlled lighting, temperature, and humidity conditions. Tissue culture is employed for things like mass reproduction, genetic advancement, and the synthesis of beneficial substances in plants. It's an essential tool for protecting rare and threatened plant species and has revolutionized the fields of biotechnology and plant breeding. In order to grow, preserve, and work with plant cells, tissues, or organs in a controlled environment, a technique called plant tissue culture is employed in plant biology and agriculture[2]. It makes it possible for scientists and gardeners to create several; identical plants from a single parent plant, regenerate plants from cells, and add desired qualities through genetic engineering. Plant tissue culture, also known as cell, in vitro, axenic, or sterile culture, is a crucial tool for both fundamental and applied research as well as for practical use in industry[3]. Gottlieb Haberlandt's lecture to the German Academy of Science in 1902 on his findings on the culture of single cells served as the theoretical foundation for plant tissue culture. According to his opinion, no structured, systematic attempts to culture-isolate vegetative cells from higher plants have been made. However, the outcomes of these tests in culture ought to offer some intriguing insight into the traits and abilities that the cell, as a fundamental creature, possesses[4]. It would also reveal information about the interactions and supplementary influences that cells within a multicellular entire organism are subject to. He attempted to create artificial embryos from isolated photosynthetic leaf cells and other functionally distinct cells but was unsuccessful. Nevertheless, he anticipated that artificial embryos could be created from vegetative cells. Thus, he made the concept of totipotency very plain. He also made it clear that the technique of growing isolated plant cells in nutrient solution allows for the exploration of significant issues using a fresh line of experimentation[5]. Haberlandt is rightfully regarded as the originator of plant tissue culture in light of his 1902 presentation and his groundbreaking experiments both before and after. The culture of isolated root tips resulted from more research. This approach of using explants with meristematic cells produced the successful and indefinite culture of tomato root tips. Further work allowed for root culture on a completely defined medium. Such root cultures were used initially for viral studies and later as a major tool for physiological studies[6]. Success was also achieved with bud cultures. Barley embryos were used as the first embryos in embryo culture, which also began in the first decade of the previous century. One of the earliest uses of in vitro culture was the successful recovery of embryos from nonviable seeds of a hybrid between Linum perenne and Linum austriacum as well as for full embryo development in some early ripening species of fruit trees. Additionally, the precocious germination phenomena was noticed. Gautheret harvested the cambial tissue of Acer pseudoplatanus to create the first actual plant tissue cultures[7]. Using the same explants of Ulmus campestre, Robinia pseudo acacia, and Salix capraea along with an agar- solidified medium containing Knop's solution, glucose, and cysteine hydrochloride, he too

had success. Later, the availability of indole acetic acid and the addition of B vitamins allowed for the more or less simultaneous demonstrations with carrot root tissues and with tumour tissue of a Nicotiana glauca Nicotiana lagomorphic hybrid, which did not require auxin. These experiments showed that tissues could be continuously grown in culture and even made to differentiate roots and shoots[8]. Since ancient times, people have used medical plants—also referred to as herbal plants or medicinal herbs—for their curative qualities. Bioactive substances found in these plants have a variety of therapeutic effects on the human body. Traditional medical systems all throughout the world, including Ayurveda in India, Traditional Chinese Medicine (TCM) in China, and Native American healing traditions, have a long history of using medicinal plants. These systems have relied on the understanding of particular plants and how to employ them to cure various illnesses. Herbs, shrubs, trees, and even certain fungi are included in the diverse group of plant species known as medicinal plants. Ginseng, aloe vera, lavender, echinacea, and a host of other substances are examples[9]. The therapeutic qualities and uses of every plant are different. The presence of bioactive substances such alkaloids, flavonoids, terpenoids, and essential oils is thought to be the cause of medicinal plants' healing effects. Antioxidant, anti- inflammatory, anti-microbial, and other therapeutic benefits are possible with these substances. The use of medicinal plants for healing is deeply ingrained in many civilizations. Rituals and a holistic approach to health, which takes into account not just physical but also mental and spiritual well-being, are common elements of these traditions. Within the realm of scientific study, there has been a renaissance of interest in medicinal plants in recent decades[10]. The therapeutic potential of these plants has been recognized by modern medicine, and as a result, pharmaceutical medications based on their active components have been developed. Concerns about overharvesting and habitat

loss have been expressed as a result of the rising demand for medicinal herbs. The conservation of medicinal plant species that are in danger of extinction as well as sustainable production and harvesting methods are being promoted. Many nations have laws governing the use of medicinal herbs to ensure its efficacy and safety. When using therapeutic herbs, it is crucial to get advice from trained medical personnel or conventional healers because misuse might have unfavourable repercussions[11]. Human therapeutic practices have a long history of using medicinal plants, and they still play a vital part in modern healthcare. They provide a wide range of therapeutic options and serve as a link between conventional healing methods and contemporary medicine, with the possibility for more discoveries and developments in the area of natural medicine. For many civilizations around the world, medicinal plants have been an important source of traditional medicine. They contain a lot of bioactive substances, many of which have medicinal qualities. However, many medicinal plants are threatened by issues including overharvesting, habitat loss, and pollution. By offering a method for the controlled and sustained production of therapeutic plants, plant tissue culture offers a solution to these issues[12].

1.1 Objectives of Plant Tissue Culture

a) Cloning is the process of creating several, genetically identical plants from a single parent plant.

b) Increasing valuable or rare plants using micropropagation, including those with desired characteristics like disease resistance, accelerated growth, or increased production.

c) To recreate an entire plant from single plant cells, tissues, or organs is regeneration

d) Introducing new genetic material (genes) into plant cells in order to produce transgenic plants with desired features is known as genetic modification [13].

1.2 Basic steps of plant tissue culture

I. **Initialization**: Choosing an appropriate plant tissue (such as a stem, leaf, or embryo) and sterilizing it to remove impurities.

II. **Culture**: Adding the sterile tissue to a medium that includes sugar, necessary nutrients, and growth regulators (such as hormones).

III. **Proliferation**: promoting cellular or tissue growth and multiplication in a culture media.

IV. **Differentiation**: Creating specialized organs (such roots or shoots) from tissues or cells that have been

cultivated[14].

V. **Rooting**: The process of encouraging the development of roots in plants cultivated in tissue culture

VI. **Acclimatization**: The process by which plantlets are gradually adapted to their surroundings before being planted in soil. the elements of the culture medium.

VII. **Nutrients**: Important macronutrients like potassium, nitrogen, and phosphorus as well as micronutrients like iron and magnesium[15].

VIII. **Hormones**: Growth regulators that regulate the development of organs and cell growth, such as auxins, cytokinin's, and gibberellins as a

source of energy, sugar is often sucrose

IX. **Agar**: A gelling ingredient that helps the medium become solid[16].
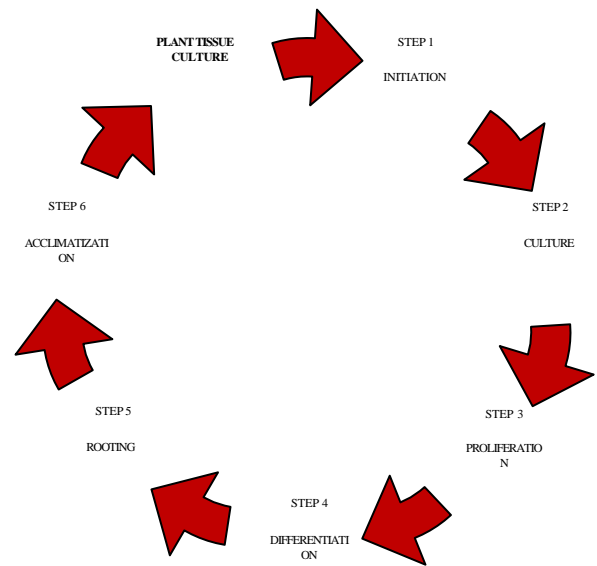
Fig. 1 Basic steps of Plant Tissue Culture.

1.3 Terminology used in Plant Tissue Culture

In the fields of biology and biotechnology known as tissue culture, commonly referred to as cell culture, cells, tissues, or organs are grown and maintained outside of their natural environments. Here are some **phrases** and **ideas** that are frequently used in tissue culture.

1) **Cell culture**: is the controlled process of culturing and preserving cells in vitro (outside the body).

2) **Culture Medium**: A nutrient-rich liquid known as a "culture medium" gives cells the nutrition, growth factors, and minerals they need for development and proliferation

3) **Cell line**: A collection of genetically identical cells that have one parent cell as their origin. Cell lines are frequently employed in biotechnology and research[17].

4) **Primary Culture:** The first culture of cells or tissues that have been taken directly from an organism is known as a primary culture. Numerous different cell types may be present in primary cultures.

5) **Cell**: Cells are sub cultured or moved from one culture vessel to another during the passage process in order to allow for continued growth and to avoid overpopulation

6) **Subculture**: Cells from one culture are moved to another with new culture media in a process known as subculture.

7) **Cell division**: It results in cell division, which results in an increase in the number of cells[18].

8) **Cell differentiation**: This is the process through which cells go from being unspecialized to becoming specialized and assuming particular traits and tasks

9) **Sterile Technique**: Techniques used to keep lab environments sterile (aseptic) and prevent cell cultures from being contaminated.

10) **Cryopreservation**: Cells can be kept alive for a long time via a procedure called cryopreservation, which involves maintaining them at extremely low temperatures (often in liquid nitrogen)[19].

11) **Passage**: When cells are sub cultured, they are moved from one culture vessel to another by a process called passage.

12) **Monolayer Culture**: An environment where cells develop in a single layer that is adhered to the surface of a culture vessel.

13) **Suspension Culture**: A culture in which cells are suspended in the culture media and do not cling to a surface is known as a suspension culture.

14) **Cell adhesion**: It is a cell's capacity to adhere to a surface or substrate[20].

15) **Cell viability**: The proportion of living, competent, and able to develop and function normally cells in a culture.

16) **Cell lysis**: It is the process of rupturing open cells, frequently in order to liberate their contents or to extract proteins and DNA

17) **Cell Passage Number**: A number reflecting how many subcultures or passages a cell line has undergone.

18) **Contamination**: A culture can become contaminated when unwelcome microbes or cells are added, which could cause the desirable cells to become harmed or overgrow[21].

19) **Serum**: To give vital growth factors and nutrients to culture media, blood serum or fetal bovine serum (FBS) is frequently added.

20) **Tissue engineering**: The process of using tissue culture methods to produce artificial organs or tissues for use in medicine.

21) **Adventitious**: the formation of tissues and calluses from shoot and root tissues into organs such as buds, leaves, roots, and shoots.

22) **Agar**: An algae-based natural gelling agent[22].

23) **Aseptic technique**: Techniques used to avoid cross-contamination of cultures and the addition of microorganisms like fungi, bacteria,

viruses, and phytoplasmas to cell, tissue, and organ cultures.

24) **Autoclave**: An autoclave is a device that can sterilize materials using steam and pressure.

25) **Axenic culture**: is a culture devoid of alien or undesirable living forms, yet it may also involve the purposeful co-culture of various cell, tissue, or organism types.

26) **Callus**: A callus is an ad hoc collection of differentiating plant cells[23].

27) **Chemically Defined Medium**: A nutritive solution or substrate for cell culture that is chemically defined as having only the ingredients that are needed.

28) **Clonal propagation**: It is the asexual division of plants from a single explant or individual.

29) **Clones**: Clones are a collection of plants that have been created by repeatedly propagating vegetative components from a single person. Clones have the same genetic makeup[24].

30) **Embryo Culture**: Isolated mature or immature embryos are cultured in vitro.

31) **Hormone**: a generic term for naturally occurring substances that significantly influence plant development.

32) **Explant**: To initiate a tissue culture part of plant used called explant[25].

These are some of the basic terminologies utilized in tissue culture, but the discipline is vast and may entail more specialized terminology based on the particular applications and procedures being used.

2. Culture Media

Different types of culture media are employed in medicinal plant tissue culture to assist the growth and development of plant tissues and cells. The individual needs of the plant species and the goal of the tissue culture determine the choice of culture media. Here are a few of the most popular categories of cultural media.

- **Murashige and Skoog (MS) Medium**: MS medium, also known as Murashige and Skoog medium, is one of the most used basal media for plant tissue culture. It includes vitamins, plant growth regulators, micronutrients, and macronutrients. It can be changed to accommodate the requirements of various medicinal plant species by varying the quantities of these components.

- **Woody Plant Medium (WPM):** A medium called Woody Plant Medium (WPM) is made specifically for growing woody plants like trees and shrubs. The growth of these plants is supported by the higher concentration of specific minerals and extra chemicals present there[26].

- **B5 Medium:** B5 medium is yet another widely used base medium for plant tissue culture. Many different plant species, including some that are therapeutic, are frequently cultivated there.

- **White's Medium:** For the cultivation of orchids and other challenging-to-culture plants, White's medium is utilized. It is a sophisticated medium with a wide range of nutrients and additives.

- **Schenk and Hildebrandt (SH) Medium:** SH medium serves as a foundational medium for the cultivation of a wide variety of plant species. Specific nutrients and growth regulators can be added to it to suit individual need

- **Vascular Plant Medium (VP):** It is designed for the culture of vascular

plants, such as trees and shrubs. It includes extra ingredients to aid in the growth of these plants[27].

- **Half-Strength MS Medium:** When a reduced nutritional concentration is necessary, tissue culture may occasionally employ a half-strength MS medium.

- **Liquid Media:** For the suspension culture of cells and callus, liquid media are also utilized in addition to solid agar-based media. It is possible to add specific nutrients and growth regulators to liquid media.

- **Hormone-Enriched Media:** To encourage roots, shoot multiplication, or callus formation, hormone-enriched media can be created with a specified concentration of auxins (for example, indole-3-acetic acid) and cytokinin's (for example, kinetin)[28].

- **Organogenesis Media:** These media, such as roots, shoots, or embryos, are designed to encourage the development of particular plant part.

- **Gametophyte and Spore Media:** Some medicinal plants have unusual life cycles that include gametophyte and sporophyte stages, such as ferns and mosses. Their culture uses specialized media.

Depending on the requirements and objectives of the tissue culture project for medicinal plants, the choice of culture medium and its make-up may change. In order to maximize growth and production of desirable secondary metabolites or plant components, researchers frequently test out various formulations[29].
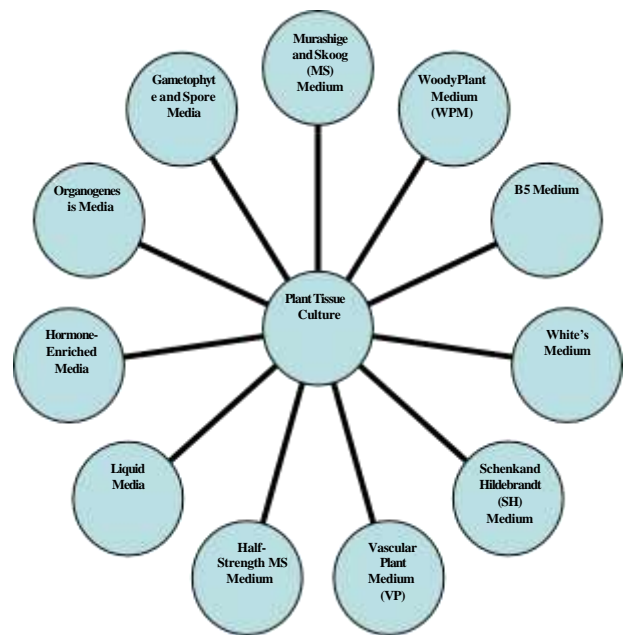
Fig. 2 Different type of culture media used in plant tissue culture

2.1 Developments and Advantages of Plant Tissue Culture

I. **Mass Propagation**: Plants can be rapidly and effectively multiplied via tissue culture from a tiny amount of starting material. This is especially beneficial for medicinal plants that are slow to reproduce or are endangered since it preserves their genetic variety and satisfies the demand for raw materials.

II. **Cultivation All Year Long**: Tissue culture allows for year-round cultivation of therapeutic plants in controlled surroundings, bypassing the constraints of seasonality and unfavourable weather. For the sectors of pharmaceuticals and herbal remedies, this reliable supply is essential.

III. **Disease free plants:** Plant free of disease can be obtained by tissue culture, which is a trusted method. Starting with aseptic cultures reduces

the possibility of introducing infections, resulting in the growth of disease-resistant, healthy plants[30].

IV. **Quality Control**: Tissue culture allows for careful control of the growing conditions, which promotes uniform plant growth and the generation of secondary metabolites (compounds with medicinal value) with a stable quality and yield.

V. **Micropropagation:** By producing little plantlets with efficiency, micropropagation enables the quick expansion of plant populations. For expensive and slowly developing medicinal plants, this is very helpful.

VI. **Production of Secondary Metabolites**: Alkaloids, flavonoids, and essential oils, which are frequently the active components in therapeutic plants, can all be produced more abundantly by tissue culture. This may result in higher yields of bioactive substances for use in pharmaceuticals[31].

VII. **Genetic Improvement:** Tissue culture can be used by scientists to identify and breed plants that have specific features they are looking for, such as larger yields of active chemicals or resistance to pests and diseases. This makes it easier to produce and breed new varieties of medicinal plants.

VIII. **Conservation:** Tissue culture is a method for the preservation of medicinal plant species that are in danger of extinction. Scientists can preserve genetic diversity and stop the extinction of these priceless species by keeping cultures in vitro.

IX. **Reduced Environmental Impact:** When compared to conventional farming techniques, controlled environment tissue culture systems utilize less water, land, and pesticides. This can lessen the negative effects of medicinal plant growth on the environment0[32].

X. **Customization:** It is possible with tissue culture to optimize the production of particular substances or to satisfy the needs of niche markets, such as those for organic or non-GMO products.

XI. **Cost reduction:** Tissue culture techniques have improved throughout time in terms of cost-effectiveness and efficiency, making a wider range of researchers and industries able to use them.

XII. **Reduced Land Needs:** Tissue culture can grow many plants in a small area, which decreases the requirement for a lot of land for cultivation. This is crucial in areas with a shortage of arable land[33].

Overall, the production, conservation, and marketing of medicinal plants have benefited greatly from medicinal plant tissue culture, which offers various advantages for both the pharmaceutical sector and practitioners of conventional herbal therapy.

3. Techniques Used in Plant Tissue Culture

➢ **Micropropagation** The selection of plant tissues (explants) from a strong, healthy mother plant is the first step in micropropagation. Any plant portion, including the leaf, apical meristem, bud, and root, may be used as an explant. The following steps, as seen in Stage 0, are frequently used to summarize the complete procedure.

Preparation of the donor plant during Stage 0: Any plant component is introduced frequently in vitro. In order to reduce contamination during stage I of the in vitro culture and increase the likelihood of success,

the mother plant should be ex vitro cultivated under ideal condition[34].

Initial stage I: An explant is surface sterilized and placed in a nutrition media during this stage. Application of bactericide and fungicide products together is typically advised. The choice of products is influenced by the type of explants to be used. Explants must be surface sterilized in chemical solutions in order to remove impurities while causing the least amount of harm to plant cells. The most often used disinfectants are mercury chloride ($HgCl_2$), hypochlorite, sodium hypochlorite, and ethanol. Depending on the method of propagation, the cultures are either incubated under light or dark conditions in the growth chamber.

The goal of Stage II: Multiplication is to increase the number of propagules. To do this, successive subcultures are used to multiply the number of propagules until the desired (or anticipated) number of plants is reached[35].

Stage III: The stage of rooting. The same culture material that was used for the explants' multiplication may contain the rooting stage concurrently. To promote rooting and the establishment of robust roots, it may occasionally be essential to modify the media, including nutritional modification and phytohormone composition.

Stage IV: The in vitro plants are weaned and toughened in Stage IV, which is called the acclimatization stage. From high to low humidity levels and from low to high candlepower levels, the hardening process is gradually finished. The plants are then moved to a suitable substrate (sand, peat, compost, etc.), and progressively toughened in the greenhouse[36].

➢ **Callus Culture**: A callus is an amorphous mass of cells that can be created from a variety of plant elements, including leaves, stems, or roots. Secondary metabolites, such as pharmaceutical chemicals, are frequently produced via callus culture.

It is possible to stimulate the differentiation of callus tissue into shoots, roots, or other plant parts[37].

➢ **Somatic Embryogenesis and organogenesis**. Somatic embryogenesis is a popular in vitro technique for plant tissue culture and a key biotechnological tool for long-term clonal propagation23. Through this process, somatic cells or tissues develop into differentiated embryos. These somatic embryos don't need to go through the process of sexual fertilization as zygotic embryos need in order to develop into whole plants. Somatic embryogenesis is frequently started either directly from explants or indirectly by the development of a callus, which is a mass of disorganized cells.

When a plant regenerates through somatic embryogenesis, embryogenic cultures are induced from zygotic seed, leaf, or stem segments, and the embryos are then multiplied[38]. Then mature embryos are cultivated for germination and plantlet development before being planted in the ground. In many plants, including trees and ornamental plants, somatic embryogenesis has been documented. some cactus species have shown this behaviour. The induction is impacted by a number of factors, including growth of somatic embryos in cell culture very high It has been reported that an effective strategy for somatic grapevine embryogenesis, which demonstrated higher plant adequate regeneration when the tissues were grown in fluid environment. Plant growth control agents are crucial play a part in somatic cell renewal and proliferation embryos[39]. Most effective embryonic callus efficiency was induced by cultivating rose hybrid nodal stem segments on medium alone or in combination with several PGR this embryonic callus displayed excellent germination, when raised on abscisic acid, the proportion of somatic embryos (ABA) by itself. Somatic embryogenesis encompasses

more than just the process of mass-produced plant regeneration. a crucial tool for both reproduction and genetic modification. The technique can also be used to genetically modify plants to introduce new genes and make them resistant to various ailments[40].

> **Organogenesis:** In plant tissue culture, the term "organogenesis" describes the induction and development of new organs from cultured plant cells or tissues, such as shoots, roots, or somatic embryos. Genetic engineering, the propagation of plants, and the creation of disease- free plants all make extensive use of this technology. An outline of the steps involved in organogenesis in plant tissue culture is provided below:

Starting the Culture: The process starts with choosing the plant material that will be cultured. Explants like leaf fragments, stem segments, or cotyledons might be a part of this. Surface sterilization is used to get rid of any impurities from these explants[41].

Callus Formation: After sterilization, the explants are placed on a nutritional media containing particular plant growth regulators (hormones), usually auxins like auxin-like 2,4-dichlorophenoxyacetic acid (2,4-D) or naphthalene acetic acid (NAA). These hormones encourage cell division and trigger the development of callus, which are undifferentiated, mass-like formations. The development of calluses is a crucial phase of organogenesis.

Subculture: The callus is periodically moved to new nutritional media with a well-balanced auxin and cytokinin ratio. Auxins encourage root production whereas cytokinin's encourage shoot development. The kind of organogenesis is influenced by the particular hormone balance.

Shoot Induction: In order to promote the development of new shoots, the nutritional medium's cytokinin concentration is elevated. Thus, the differentiation of callus cells into

shoots is promoted. A callus can develop into several shoots[42].

Root Induction: Auxin concentrations are raised while cytokinin concentrations are lowered during root induction in order to promote root organogenesis. Callus cell differentiation into roots is aided by this.

Acclimatization: It is removing shoots or roots from the callus after they have begun to take shape in order to place them in a rooting or hardening medium where they can continue to grow and become accustomed to their surroundings. For plantlets to be ready for soil transplantation, this step is essential.

Transplantation: Final step of the process is the transplantation of the plantlets into soil or another suitable growth medium where they can continue to develop into mature plants[43].

> **Cell Suspension Culture:** To obtain secondary metabolites in the current era, plant cells are massively cultivated in cell suspension culture systems. In order to establish a suspension culture, the relatively friable portion of the callus is placed into liquid media. This suspension culture is then maintained under the appropriate conditions for aeration, agitation, light, temperature, and other physical parameters. Cell cultures can not only produce defined standard phytochemicals in huge quantities, but they can also get rid of the interfering substances that naturally occur in field-grown plants. The benefit of this approach is that it can eventually offer an infinite, dependable source of natural product. The primary benefit of cell cultures is the production of bioactive secondary metabolites, which occurs in a controlled environment independent of soil and climate conditions[44]. Plant cells are

> mass-cultivated using a variety of different types of bioreactors. Shikon was produced using a cell culture of Lithospermum erythrorhizon80 as the

first commercial application of large-scale plant cell cultivation in stirred tank reactors with capacities of 200 and 750 liters. In a variety of bioreactors, cells from Catharanthusroseus, Dioscorea deltoidea, Digitalis lanata, Panax notoginseng, Taxus wallichiana, and Podophyllum hexandrum are cultivated for the production of secondary plant products. In diverse cultures of plant cell and tissues, a number of medicinally significant alkaloids, anticancer medications, recombinant proteins, and food additives are created[45]. Alkaloids, terpenoids, steroids, saponins, phenolics, flavonoids, and amino acids are just a few of the pharmaceuticals that may now be produced thanks to advancements in cell cultures for the assembly of medicinal molecules. A few of these are currently offered for sale on the market, including paclitaxel (Taxol) and shikonin. Antibodies, enzymes, edible vaccines, growth factors, and cytokines are among the 20 different recombinant proteins that have so far been generated in plant cell culture. Applications of plant cell cultures for the assembly of chemicals with a high added value have significantly increased as a result of improvements in scale-up methods and immobilization techniques. Table lists a few of the secondary plant products produced by various plants' cell suspension cultures[46].

Table 1   **List of Some Secondary Metabolites Produced by Cell Suspension culture**

Secondary Metabolites	Name of Plants
Vasine	Adhatoda vasica
Artemisinin	Artemisia annua
Azadirachtin	Azadirachta indica
Cathin	Brucea javanica
Sennosides	Cassia senna
Ajmalicine Secologanin Indole alkaloids Vincristine	Catharanthus roseus
Stilbenes	Lithospermum erythrorhizon
Berberin	Coscinium fenustratum
Sterols	Hyssopus officinalis
Shikonin	Lithospermum erythrorhizon
Ginseng saponin	Panax notoginseng
Podophyllotoxin	Podophyllum hexandrum
Taxane Paclitaxel	Taxus chinensis
Ajmalicine, vincristine, vinblastine	Catharanthus roseus
Picroside-1	Picrorhiza kurroa
Alkaloids (tropane)	Datura stramonium
Azadirachtin	Azadirachta indica
Codeine, morphine	Papaver somniferum
Diosgenin	Dioscorea deltoidea
Hyoscyamine, scopolamine	Hyoscyamus niger, H. muticus
Raucaffrincine	Rauwolfia canescens
Sesquiterpenes	Hyoscyamus muticus
Taxol	Taxus chinensis

- **Rhizogenesis:** Rhizogenesis is the process by which roots are induced to form in tissue cultures. It is crucial for the growth of medicinal plants with appropriate roots for therapeutic use. Secondary metabolites can also be produced using root culture.

- **Clonal Propagation:** Tissue culture enables the creation of genetically identical plants (clones) that preserve the favoured characteristics of the original plant. This is crucial in agriculture to preserve the genetic integrity of high-yielding, disease-resistant crops.[47].

- **Protoplast Culture:** Plant cells that have had their cell membranes removed are known as protoplasts. All of a plant cell's constituent parts, minus the cell wall, are referred to collectively as the protoplast or "naked plant cell". For fusion and other processes, protoplasts have been widely used physiological research, genetic engineering, and direct foreign DNA, cell components, bacteria, or viruses are taken in by the body across their plasma membrane, which is unprotected. Plant In terms of somatic cell biology, protoplasts present promising opportunities[48]. Crop enhancement through cell genetics. The process of Fusion of isolated somatic processes to produce hybrids the in vitro culture of protoplasts and subsequent their product's (heterokaryon) transformation into a hybrid. It is referred to as somatic hybridization. Using this method hybridization completely eliminates sexual processes. Consequently, the technique of protoplast fusion might the obstacles of incompatibility and

serves as a method for the modification of plant cell genetics. The process of protoplast cultivation entails separating protoplasts from plant tissues and regenerating them into whole plants. For plant species that are challenging to reproduce using conventional techniques, this strategy is especially helpful[49].

- **Cryopreservation:** Plant cells, tissues, or organs can be preserved for a long time by being frozen at extremely low temperatures, usually in liquid nitrogen (-196°C or -321°F). This process is known as cryopreservation in plant tissue culture. The preservation of priceless plant genetic resources, such as rare or endangered species, cultivars, and genetic variants, is made possible by this technique, which enables the keeping of plant germplasm (genetic material) in a viable form for an extended length of time. An overview of the method of plant tissue culture-based cryopreservation is given below:

Selection of Plant Material: The initial step in the cryopreservation process is the selection of the plant material. Seeds, embryos, shoot tips, nodal segments, and somatic embryos might all fall under this category.

Preculture: Plant material is frequently precultured on an appropriate medium in order to get it ready for cryopreservation. This process might entail developing the tissue in vitro to a certain developmental stage[50].

Dehydration: To eliminate water from the cells, which can lead to ice crystal formation and damage after freezing, the plant material is frequently exposed to dehydration in cryopreservation methods. Dehydration can be achieved using a variety of techniques, including osmotic treatments, air drying, and the use of cryoprotectants (chemicals that protect cells after freezing).

Freezing: The dehydrated plant material is quickly frozen at very low temperatures. Usually, this is accomplished by submerging the substance in liquid nitrogen. The quick-freezing aids in preventing the growth of potentially harmful ice crystals inside plant cells

Storage: The plant material is moved to long-term storage containers, usually in liquid nitrogen storage tanks, after it has been frozen. The biological material is preserved for long periods of time, possibly decades or more, in a stable, ultra-low temperature environment provided by liquid nitrogen[51].

Thawing and Recovery: When necessary, the cryopreserved plant material is quickly thawed and subsequently grown in a controlled environment to encourage tissue growth and regeneration. This can entail putting the sample on an appropriate culture medium that contains the right nutrients and growth inhibitors.

Evaluation of Viability: The regenerating tissue's viability and health are evaluated following thawing and recovery. In order to do this, it may be necessary to look for signals of growth, such as the development of shoots and roots, and to use molecular methods to verify genetic stability[52].

> **Genetic Transformation:** In order to introduce foreign genes into plant cells and produce genetically modified (GM) plants, genetic transformation in plant tissue culture is a biotechnology technique. By using this method, scientists can give plants desired features like increased nutrient content, resistance to pests and diseases, or increased tolerance to environmental stress. Here is a summary of the procedures involved in genetic modification in plant tissue culture.

Selection of Target Tissue: The first step in the genetic transformation process is the selection of the plant tissue that will be the target of the transformation. Utilizing immature, actively proliferating cells, including shoot tips, embryos, or callus tissue, is typical for plant tissue culture procedures.

Isolation and Culture of Target Cells: To remove any impurities, the chosen plant tissue is sterilized before being grown on an appropriate growth medium. This medium includes elements that are necessary for the growth and development of the cells, such as nutrients and hormones[53].

Preparation of DNA: The DNA that will be inserted into the plant cells has been prepared. Other plants, microorganisms, or laboratory synthesis are just a few examples of the sources from which this DNA can be extracted. The desired gene is typically carried by DNA, it brings about the necessary characteristics.

DNA Delivery to Plant Cells

a. Agrobacterium tumefaciens, a naturally occurring bacterium, is employed in a procedure known as "agrobacterium-mediated transformation," which is frequently used to transfer DNA into plant cells. The plant genome can contain the desired gene thanks to a transfer of agrobacterium's DNA, known as T-DNA, into the plant.

b. Biolistic transformation (Gene gun): With this technique, microscopic DNA-coated gold or tungsten particles are physically injected into plant cells[54].

c. Through the process of electroporation, DNA is able to enter plant cells after they have been exposed to an electric field for a limited period of time.

d. Protoplast transformation: After the cell wall is removed using enzymes, DNA is directly inserted into protoplasts (plant cells devoid of cell walls).

Selection and Regeneration: After the DNA is inserted into the plant cells, the cells are cultivated on a selective medium that only promotes the growth of the transformed cells.

This process is known as selection. This process makes certain that only cells carrying the appropriate gene will transform into plants.

Plant Regeneration: Whole plants are induced to develop from transformed cells that have made it through the selection process. This may entail growing full plants from the altered cells, including branches, roots, and finally shoots[55].

Confirmation of Transgene Integration: Molecular methods like PCR and gene expression analysis are used to demonstrate the existence and expression of the inserted gene in the regenerated plants.

Hardening and Acclimatization: Once the converted plants have successfully grown again, they are transferred from the in vitro setting to a greenhouse or a field where they can acclimate to the natural environment. This process is known as hardening and acclimatization.

Assessment and Field Trials: To gauge the effectiveness, stability, and security of transgenic plants, thorough field tests and evaluations are conducted[56].

> **Hairy Root Culture**: Within the last 20 years, the crown gall system supported inoculation with Agrobacterium rhizogenes has gained popularity as a method of producing secondary metabolites produced in plant roots. The generation of secondary metabolites can benefit greatly from organized cultures, especially root cultures. Transformed (hairy) roots have been the main focus of research projects that employ differentiated cultures rather than cell suspension cultures. Plants that have Agrobacterium rhizogenes produce crown gall disease. The fast rate of growth, genetic stability, and growth in hormone-free media are characteristics of the neoplastic (cancerous) roots that A. rhizogenes infection produces[57]. Hairy roots can be used as a beneficial biotechnological tool for the assembly

of plant secondary metabolites due to their high productivity and stability. These genetically modified root cultures can produce quantities of secondary metabolites that are comparable to those of unaltered plants. The technology used to create crown galls has greatly improved thanks to our growing understanding of the molecular processes that underlie their formation. To get a high production of secondary metabolites in crown gall cultures, nutritional composition must be optimized[58]. Table 2 displays some of the secondary plant products produced from the hairy root culture of several plants.

Table 2. List Of Some Secondary Metabolites Produced by Hairy Root Culture

Secondary Metabolites	Name of Plants
Rosmarinic Acid	Agastache rugosa
Deoursin	Angelica gigas
Resveratol	Arachys hypogaea
Tropane	Brugmansia candida
Asiaticoside	Centella asiatica
Rutin	Fagopyrum esculentum
Glucoside	Gentiana macrophylla
Glycyrrhizin	Glycyrrhiza glabra
Shikonin	Lithospermum erythrorhizon
Withanoloid A	Withania somnifera
Saponins	Agave amaniensis
Alliin	Allium sativum L.
Berberine	Coptis japonica
Tropane alkaloids	Duboisia leichhardtii
Secoiridoid glucosides	Gentiana sp.
Catharanthine	Catharanthus roseus
Gensenoside	Panax notoginseng
Morphine and codeine	Papaver somniferum
Taxol	Taxus mairei
Terpenes, sterols, flavonoids	Taxus spp.
Phenylpropanoid glycosides	Tecoma sambucifolium
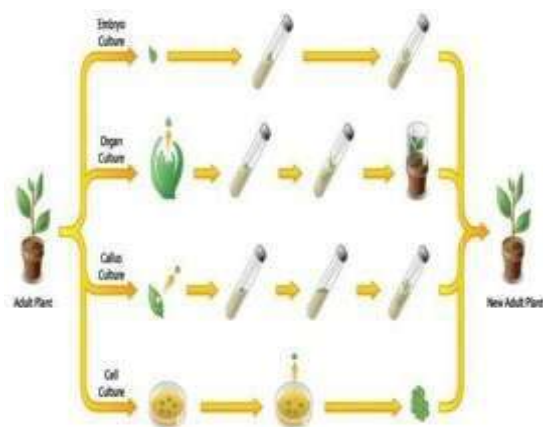
Fig. 3 Culture used in plant tissue culture

Depending on the particular plant species and the intended results, each of these procedures has distinct benefits and applications in the field of tissue culture of medicinal plants. Depending on their goals and the traits of the intended therapeutic plant, researchers and horticulturists choose the most suitable technique.

4. Future Direction of Plant Tissue Culture

For many years, plant tissue culture, sometimes referred to as in vitro plant propagation or micropropagation, has been a useful tool in horticulture, agriculture, and plant research. The future of plant tissue culture contains a number of intriguing opportunities and paths as science and technology continue to advance:

1. **Precision Agriculture**: Tissue culture can be included into precision agriculture, which allows for the efficient mass production of particular plant kinds with desired characteristics. By creating high-yielding, disease-resistant crops, this can aid in addressing issues with food security.

2. **Pharmaceutical Production:** Plant tissue culture can be used to produce pharmaceutical compounds, vaccines, and other high-value bioproducts. For example, plants can be engineered to produce vaccines, antibodies, or therapeutic proteins[59].

3. **Conservation and Biodiversity**: Tissue culture has the potential to be extremely important for the preservation of threatened plant species. In vitro propagation and preservation of rare and endangered plants can help preserve biodiversity.

4. **Climate-Resilient Crops:** As agricultural zones alter as a result of climate change, crop production faces new difficulties. To create crops that are more resistant to shifting environmental circumstances, tissue culture can be used.

5. **Rapid Crop Improvement**: Tissue culture enables expedited breeding programs while traditional breeding techniques might be time-consuming. In a short amount of time, scientists may produce a huge number of plantlets, allowing the creation of novel crop kinds.

6. **Nanotechnology Integration**: Tissue culture and nanotechnology can be coupled to improve disease detection, nutrition delivery, and plant growth monitoring and management[60].

7. **Automated Systems**: Technological advancements in automation and robotics can simplify tissue culture procedures, cutting labour costs and increasing the effectiveness of large-scale production.

8. **Customized Horticulture:** Tissue culture enables home gardeners and horticulturists to acquire a large range of plant species and cultivars that were previously difficult to find.

9. **Production of Secondary Metabolites:** Pharmaceuticals and nutraceuticals can be produced in huge quantities on a big scale using tissue culture. Future research might concentrate on improving culture conditions and genetic alterations to boost the output of these priceless chemicals[61].

In the future of pharmaceuticals, biotechnology, and herbal medicine, improvements in medicinal plant tissue culture are anticipated to be of utmost importance.

There are a number of potential directions and innovations in this sector that are anticipated as technology and scientific knowledge continue to advance:

10. **High-Throughput Screening:** Improving the effectiveness of tissue culture techniques will probably rely heavily on automation and robotics. Rapid and more cost-effective drug development can be achieved through high-throughput screening of plant cell cultures to find bioactive chemicals in therapeutic plants.

11. **Metabolomics and Omics Technologies:** Advanced omics technologies, like as genomics, transcriptomics, proteomics, and metabolomics, will make it possible to gain a deeper understanding of the biochemical processes and secondary metabolite synthesis in medicinal plants. This information can direct the improvement of tissue culture conditions for increased metabolite production[62].

12. **Synthetic Biology and Metabolic Engineering:** Synthetic biology and metabolic engineering will be used to alter plant cell cultures in order to produce certain pharmaceutical molecules. To increase the yield of desired bioactive chemicals, this may entail adding new biosynthetic pathways or improving already-existing metabolic processes.

13. **Bioreactors and Scale-Up:** The creation of affordable bioreactor systems for the large-scale manufacture of pharmaceutical substances in plant cell cultures will be a priority. As a result, pharmaceuticals and herbal medicines can be produced for sale without requiring a lot of land or other resources.

14. **Gene Editing Technologies:** CRISPR-Cas9 and other gene-editing technologies will make it possible to precisely modify the genetic makeup of therapeutic plants. These methods allow scientists to develop plant cell cultures with enhanced characteristics, such as

heightened pest or disease resistance or greater synthesis of medicinal substances[63].

15. **Cryopreservation and Germplasm Banking**: In order to effectively conserve the genetic variety of medicinal plants, cryopreservation techniques will be improved. Future research and conservation initiatives will benefit greatly from the availability of cryopreserved material in germplasm banks.

16. **Plant-Microbe Interactions:** Researching the interactions between medicinal plants and helpful microbes (endophytes and rhizospheric bacteria) might provide new insights into the production of secondary metabolites and may present chances to improve the synthesis of bioactive chemicals[64].

5. Summary and Conclusion:

In conclusion, the development of medicinal plant tissue culture has had a substantial impact on the study of plant biology and pharmacology. Numerous advantages have come from these developments, including the ability to preserve rare and endangered species, guarantee the year-round production of medical plants, uphold quality control, genetically modify plants, and maximize the production of valuable bioactive substances. Furthermore, plant science research and development have been facilitated by tissue culture techniques, which have also helped to eradicate diseases and lessen their negative environmental effects. The development of novel treatments and the sustainable cultivation of medical plants have both benefited from the advancements in tissue culture of medicinal plants. A growing desire for natural cures, developments in biotechnology and genomics, and the potential for more growth and innovation in the sector all point to this. Tissue cultivation of medicinal plants has a bright future in terms of preserving biodiversity and enhancing human health.

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Synthesis Techniques and Their Impact on the Properties of Hexagonal Ferrites: A Comprehensive Review

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ABSTRACT

Hexagonal ferrites are a class of ferrites possessing remarkable and unique magnetic properties with diverse applications in varied fields namely microwave absorption, permanent magnets, magnetic refrigeration, magnetic storage devices and transformer cores etc. The synthesis techniques of these ferrites are intricately linked with their magnetic and morphological characteristics. The present review therefore investigates and dissects the various synthesis methods namely sol-gel method, co-precipitation method, hydrothermal method, solid state reaction. It elucidates the key advantages and functional limitations of these techniques which have an impact on the characteristics of these solids. The comprehensive comparison and analysis of several synthesis techniques, we examine the complex interplay between the magnetic properties like saturation magnetisation, residual magnetisation, coercivity, magnetic susceptibility, Curie temperature and the magneto-crystalline anisotropy are seen to be affected and influenced by the synthesis method pathways. The variations in morphology of these compounds depicting the particle size, distribution, surface properties, porosity, defects, and shape of the particles with the synthesis techniques can be explored further. The discussion on the variations in the magnetic and morphological properties translating into diverse applications of the hexaferrites forms the concluding segment of this review. Lastly, the future directions for the optimization of synthesis of hexagonal ferrites for research and development is provided.

KEYWORDS: *Synthesis techniques, Sol-Gel, Magnetic Properties, Morphology, Sol-Gel, Co-precipitation.*

1. INTRODUCTION

Hexagonal ferrites are a captivating class of magnetic ferrites having hexagonal crystal structure having general formula $A_2Me_2Fe_{12}O_{22}$ (where A = Ba, Ca, Sr, or Pb, and Me = Fe, Co, Al, Ni, Mn, Zn or rare earth ions). There are six types of hexagonal ferrites namely Z, W, X, M, Y and U type. Table 1 depicts the structural stacking and chemical formulae of all six hexagonal ferrites. M-type hexagonal ferrites are extensively researched and investigated with Barium as the base ion.

Table 1: Structural Stacking and Molecular Formulae of Hexagonal Ferrites. [1]

Hexaferrite type	Combination	Molecular formula	Structural stacking
M	M	$BaFe_{12}O_{19}$	RSR*S*
Y	Y	$Ba_2Me_2Fe_{12}O_{22}$	TSTSTS
W	M+S	$BaCo_2Fe_{16}O_{27}$	RSSR*S*S*
Z	M+Y	$Ba_3Co_2Fe_{24}O_{41}$	RSTSR*S*T*S*
X	2M+S	$Ba_2Co_2Fe_{28}O_{46}$	RSR*S*S*
U	2M+Y	$Ba_4Co_2Fe_{36}O_{60}$	RSR*S*T*S*

Hexagonal Ferrites display a plethora of exceptional magnetic properties as they are endowed with a hexagonal crystal structure. Their saturation magnetisation, unique magneto-crsytalline anisotropy and tunable coercivity makes hexaferrites appealing materials for potential applications. These materials are quite versatile and are suitable compounds for potential applications in a variety range of fields of technology such as permanent magnets, microwave absorbers, magnetic storage, magnetic refrigeration, sensors etc. The synthesis methods of these compound materials impact greatly the magnetic and morphological characteristics of the hexaferrites and thereby varying their functionality. Hence, a critical review aiming at bridging the gaps, analysing various synthesis methods which influence the properties is utmost crucial. In this review, we carry out the comprehensive analysis of popular synthesis techniques highlighting their influence and impact on the above mentioned properties of hexagonal ferrites. This will enable tailoring of the materials to suit diverse applications.

2. SYNTHESIS TECHNIQUES

2.1 Sol-Gel Method

The sol-gel method involves metal salts which are dissolved in solvents (distilled water) to get a thick homogeneous gel, which is then dried and calcined. This technique has various advantages like lower synthesis temperatures, better homogeneity, and controlled particle size and morphology. However, the stoichiometry control and unwanted impurities removal can be of challenge. Figure 2.1 shows the process of synthesis in Sol-Gel technique. The sol-gel synthesis method uses the hydrolysis and condensation of precursors which are metal alkoxides to make a homogeneous sol. The sol is then thickened into a gel, dried, and given heat treatment by calcination to get the final hexagonal ferrite powder material. The novel sol- gel manufacturing techniques provides ultrafine particles without any changes in crystallography and a wide range particle size distribution is obtained. [2,3] In the synthesis of $BaFe_{12}O_{19}$, it was observed that the ratio of stoichiometry is 1:12 although the excess of barium is beneficial for the preparation of the compound. For high temperature synthesis, the excess of barium gets decreased as compared to low temperatures. Usually in sol-gel synthesis and co-precipitation techniques where the compounds are synthesised at high temperatures, the stoichiometric Ba:Fe ratio is kept 1:11 and in a few methods the ratio is 1:10. In hydrothermal synthesis method which is a low temperature reaction the ratio of Ba: Fe is 1:8.[4]
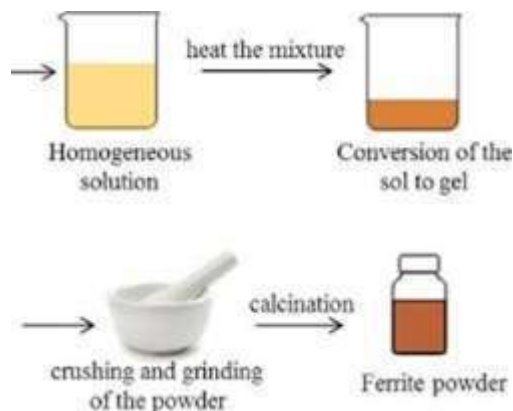
Figure 2.1 Sol-Gel Synthesis Process

2.1.1 Advantages of Sol-Gel Method
(i) It gives immensely pure and homogeneous nanoparticles after synthesis.
(ii) The particle size, composition and morphology can be altered and controlled in this technique.
(iii) It provides flexibility tailor the properties by adding dopants.

2.1.2 Disadvantages of Sol-Gel Method
(i) The process involves complex steps which needs proper control of precursors and the conditions of synthesis.
(ii) It is not a very cost effective method due to involvement of metal alkoxide used as precursor.
(iii) This method is not suitable for large scale production.

2.2 Microwave-Assisted Synthesis
Microwave-assisted technique makes use of the microwave irradiation to heat the reaction mixture. This emerging technique involves precise equipment and

control of all the microwave parameters. This method facilitates enhancement in the properties like mechanical, physical, magnetic and chemical properties coupled with important modifications in the microstructure of the material. [5] When compared with conventional synthesis techniques, microwave assisted techniques yield highly pure samples in less synthesis time and temperatures. The grain size achieved by this process is refined with narrow particle size distribution.

Dong Li-min etal. (2008) synthesized $BaFe_{12}O_{19}$ M-type ferrite using Microwave assisted synthesis method as well as with sol-gel method. The scanning electron microscope images of synthesized $BaFe_{12}O_{19}$ powders prepared by the above mentioned different heat treatment process are shown in Fig. 2.2 (a), (b) and (c). [6]
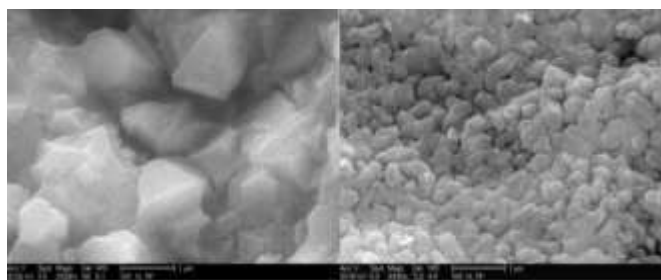
(a)   **(b)**

Figure 2.2 (a & b): SEM images of $BaFe_{12}O_{19}$ synthesized with Microwave-Assisted Method
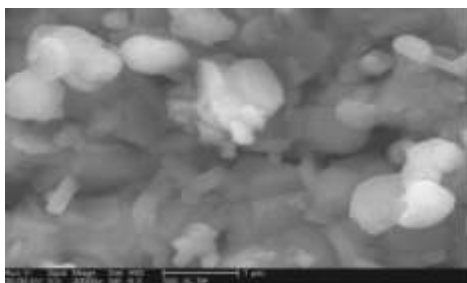
Figure 2.2 (c): SEM images of $BaFe_{12}O_{19}$ synthesized with Sol-Gel method

Figure 2.2 (a, b & c) indicate that as compared to sol-gel technique, the grains of uniform homogeneous size and distribution with microwave assisted heat treatment in the synthesis of $BaFe_{12}O_{19}$.In microwave assisted synthesis distribution of particle size varies from 700 nm to 900 nm in SEM micrograph 2.2.1 (a) and between 50 nm to 200 nm in SEM micrograph 2.2 (b) whereas conglomerated particles are observed in the sol-gel heat treatments of synthesis techniques as observed in SEM micrograph 2.2(c). The synthesis assumes less time and hence less energy consumption in comparison to conventional sol-gel method. In microwave assisted method fast nucleation takes place due to uniform heating and it yields powder of uniform size distribution.

2.2.1 Advantages of Microwave Assisted Synthesis Technique

(i)   It has a shorter synthesis time as compared to conventional techniques.

(ii)   The homogeneous heating reduces the consumption of energy in the process.

(iii)   The crystallinity is enhanced and purity of the product is increased.

2.2.2 Disadvantages of Microwave Assisted Synthesis Technique

(i)   There is requirement of microwave equipment and expert handling.

(ii)   The heating may not be homogeneous always.

(iii)   All hexagonal ferrites cannot be synthesised with this method.

2.3 Chemical Co-precipitation Method

In this method, the process involves mixing together the metal salts into solution with an agent of precipitation like NaOH under the conditions of moderated pH and temperatures. This method facilitates controlled morphology, low synthesis temperature and highly pure materials. The only added step in co-precipitation method is the after synthesis heat treatment required for crystallization. The synthesis process is demonstrated in the Figure 2.3 below. The metal hydroxides rapidly precipitating from the respective solutions is considered as an effective, fast and a cost effective route to achieve high purity homogeneous sample material. This process needs to be followed by calcination. However, synthesis of homogeneous, pure and desired crystallinity material is difficult to achieve.

In chemical co-precipitation method, it is possible to use nitrate or carbonate of cations instead of chloride to prepare hexagonal ferrite powder. But it is observed that the cations of carbonate like $SrCO_3$ later gets converted into chloride cations with the help of hydrochloric acid.

The precipitates developed are then washed several times by water and ethyl alcohol and then they are filtered to remove all traces of NaCl. The attempt is to make the pH value limited to less than 8 value. Thereafter the powders are dried and calcined at a temperature of 950^{0}C for nearly 3 hours as depicted in figure 2.3. [7]
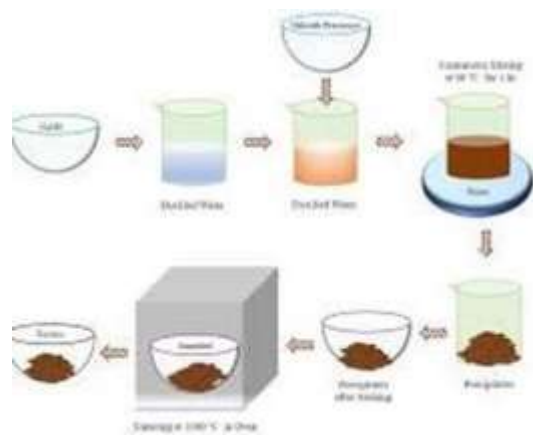
Figure 2.3: Synthesis Flowchart in Co-precipitation Method

2.3.1 Advantages of Co-precipitation Method
(i) Requires low synthesis temperatures as compared to the solid-state reaction method.
(ii) It yields fine, homogeneous and small size particles.
(iii) It gives control over crystallinity and morphology by changing the pH values, temperatures and doping.

2.3.2 Disadvantages of Co-precipitation Method
(i) Precipitation conditions needs proper control to avoid impurities.
(ii) The process of washing and drying makes it a time consuming technique.
(iii) The handling difficulties makes it unsuitable for large –scale production.

2.4 Hydrothermal Synthesis

This approach employs high-pressure and high-temperature aqueous solutions to facilitate the growth of crystals. It presents numerous benefits such as reduced processing temperatures, precise control over particle size and shape, and improved levels of purity. Nevertheless, the configuration of the necessary equipment can be costly, and the reaction time for the process may need to be extended. It frequently results in well-defined, monodisperse particles possessing customized morphologies. Nonetheless, the management of the reaction pathway and scalability may pose challenges. Ferrites synthesized by hydrothermal route exhibit various applications across diverse fields, like magnetic hyperthermia, microwave absorption, and nanocomposites, due to their modified morphology and magnetic characteristics.
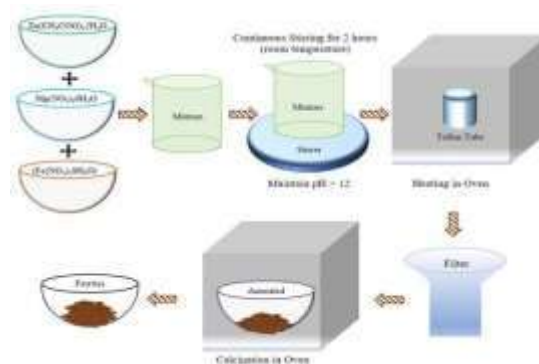
Figure 2.4: Method of Hydrothermal Synthesis. [7]

2.4.1 Advantages of Hydrothermal Synthesis Method

(i) The particles of high stability and controlled morphology can be yielded.

(ii) It offers excellent control over phase and stoichiometry.

(iii) Composite materials with complex structures can be prepared with this method.

2.4.2 Disadvantages of Hydrothermal Synthesis Method

(i) It can't be scaled beyond a certain limit.

(ii) This method is a bit more time consuming compared to others.

(iii) This method requires an autoclave and other specific equipment.

2.5 Solid State Reaction

Solid State Reaction method incorporates the heating of carbonates and metal oxides mixed together at higher

temperatures of more than 1000⁰C for an extended period of time. This process yields usually large particle size and the quality of the crystal is also compromised although it is a very easy and scalable method. Figure 2.5 reveals stepwise process of Solid State Reaction.

Figure 2.5: Method of Solid State Reaction. [8]

2.5.1 Advantages of Solid State Reaction Method

(i) This method is relatively simple and cost effective.

(ii) The process can be easily scaled for large production.

(iii) The stoichiometry can be efficiently controlled.

2.5.2 Disadvantages of Solid State Reaction Method

(i) There is very little control over the morphology and crystallinity.

(ii) The method may produce agglomerated and inhomogeneous particle size distribution.

(iii) The method requires high temperature heating for a long period of duration which leads to high consumption of energy resulting into phase transformation.

3. IMPACT OF SYNTHESIS TECHNIQUES ON PROPERTIES

3.1 Morphology

(i)   The sol-gel method enables manipulation of particle dimensions and geometrical characteristics, allowing for the formation of spherical, rod-shaped, or platelet-shaped structures.

(ii)   Co-precipitation frequently results in the formation of spherical particles characterized by tight size distributions.

(iii)   Hydrothermal synthesis facilitates the customization of particle dimensions, morphology, and pore characteristics.

(iv)   Solid-state reaction has the capability to generate irregular shapes of particles and induce agglomeration. Factors such as the temperature and duration of the reaction in Solid-state synthesis have the ability to exert an influence on the size and morphology of the particles. It is worth noting that Solid-state synthesis has the potential to induce the orientation of crystalline entities, which could have implications for the magnetic properties of the material. [9]

(v)   Microwave irradiation efficiently and swiftly warms the reaction mixture in a more consistent manner when juxtaposed with traditional heating. Such an approach has the potential to expedite the nucleation and crystallization processes, consequently influencing the dimensions and structure of the ultimate material. [10,11]

3.2 Magnetic Characteristics

(i)   Sol-gel methodologies have the capacity to increase coercivity and anisotropy, contingent upon the dopants utilized and the specific processing parameters employed.

(ii)   Co-precipitation may lead to reduced saturation magnetization and coercivity in comparison to alternative methodologies.

(iii)   Hydrothermal synthesis provides precise manipulation of magnetic characteristics by customizing morphologies and integrating dopants.

(iv) The phenomenon of solid-state reaction has the potential to result in elevated saturation magnetization levels and a moderate degree of coercivity. The influence of solid-state reaction extends to characteristics such as magnetization and the blocking temperature. Research findings have indicated that materials produced through solid-state reaction may demonstrate increased blocking temperatures in comparison to alternative synthesis routes. [12]

(v)   Microwave irradiation offers enhanced magnetic attributes. Microwave synthesis facilitates the uniformity in heat distribution within the reaction mixture in contrast to traditional heating techniques. Consequently, this has the potential to result in a higher level of consistency in the magnetic characteristics exhibited by the ultimate material. [13]

regulation of particle dimensions, thereby affecting magnetic characteristics and potentially resulting in applications related to magnetic drug delivery or catalysis. [14]

Property	Sol-Gel Method	Co-precipitation Method	Hydrothermal Method	Microwave Assisted	Solid-State Reaction Method
Particle size	High controllability, often leading to small and uniform particles	Moderate controllability, particle size distribution can be broad	High controllability, often leading to large and well-defined particles	Limited controllability	Limited controllability, often resulting in large and agglomerated particles
Crystallinity	High crystallinity achievable	Moderate crystallinity	High crystallinity achievable	Improved crystallinity	High crystallinity achievable
Purity	High purity achievable with proper purification steps	Moderate purity, may contain residual impurities	High purity achievable with proper precursor preparation	High purity achievable	Moderate purity, may contain unreacted starting materials
Cost	Relatively low cost	Low cost	Moderate cost	Low cost	High cost due to energy requirements
Scalability	Highly scalable	Highly scalable	Moderately scalable	Moderately scalable	Limited scalability

Table 1: The comparison between the parameters of these synthesis techniques.

4. APPLICATIONS OF SYNTHESIS TECHNIQUES

Solid-state-derived ferrites are deemed appropriate for utilization as permanent magnets and in microwave applications owing to their elevated saturation magnetization and moderate coercivity. Sol-gel-derived ferrites are employed in high-frequency magnetic devices and magnetic recording media due to their superior coercivity and anisotropic characteristics. Co-precipitation-derived ferrites are advantageous for gas sensing and catalytic processes due to their significant surface area and adjustable crystallinity. Hydrothermal-

5. RECENT ADVANCEMENTS

(i)   Green Synthesis: Employing plant extracts, microorganisms, or fungal species for the environmentally benign and sustainable fabrication of hexagonal ferrites.

(ii)   Doping and Nanocomposite Formation: Incorporating extraneous elements or amalgamating hexagonal ferrites with alternative materials to modify their characteristics for designated applications.

(iii)   Controlled Morphology Synthesis: Engineered fabrication of ferrites with specified geometries and dimensions (e.g., nanoparticles, nanotubes) to achieve superior performance.

6. CONCLUSION

The selection of a synthesis methodology for hexagonal ferrites is contingent upon a multitude of factors, encompassing the requisite particle dimensions, crystallinity, purity, economic considerations, and scalability. Each methodology presents distinct advantages and constraints, and a comprehensive comprehension of these factors is imperative for the optimization of the synthesis procedure and for attaining the requisite properties pertinent to specific applications. Additional research is warranted to establish innovative and enhanced synthesis methodologies for hexagonal ferrites, specifically aimed at achieving customized properties for advanced technological applications.

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Study of structural parameters and photoluminescence of LiBO$_2$:sm^{3+} phosphor synthesized by Solid State diffusion Method

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Abstract –

Phosphors of Lithium metaborate (LiBO$_2$) doped with Sm^{3+} was synthesized by using most popular and convenient method i.e., solid state diffusion. These phosphors characterized by using X-ray diffraction (XRD) and Photoluminescence (PL), which shows that prepared sample is crystalline in nature with a homogeneous form. In an X-RD characterization we observed that the average particle size of the phosphors was found to be 38.785 nm, which indicates the material was nanomaterial. In a photoluminescence, the emission spectra of phosphors shows efficient orange at 606 nm and it excited at 401 nm wavelength of ultraviolet light.From the characterization of lithium metaborate phosphors doped with Sm^{3+} elements is very useful in solid state lighting device application, which are the environmentally friendly lighting technology and also plays a vital role in food industries by reducing uses of harmful fertilizers.

Keywords – *lithium metaborate, photoluminescence, Sm^{3+} doped phosphors, solid state diffusion method, and lithiummetaborate doped with Sm^{3+}.*

➢ Introduction –

Photoluminescent materials, particularly rare-earth-doped phosphors, in recent years, these materials have attracted considerable attention because of their impressive optical characteristics, including high quantum efficiency, excellent stability, and tunable emission spectra. Among these, the incorporation of samarium (Sm^{3+}) ions into various host matrices has been widely investigated for their potential applications in lighting, display technologies, and scintillation. The choice of the host material plays a crucial role in determining the luminescent behavior, as it affects the absorption and emission characteristics of the dopant [3].Lithium borate (LiBO$_2$) is a promising host for phosphors due to its excellent thermal stability, low phonon

energy, and the ability to accommodate a variety of dopants. These properties make $LiBO_2$ a favorable Candidate for enhancing the luminescent performance of Sm^{3+} ions. The Photoluminescence of Sm^{3+} doped phosphors, specifically in the $LiBO_2$ matrix, exhibits a unique emission profile, typically characterized by sharp, well-defined peaks due to transitions between the energy levels of Sm^{3+} ions. However, the optimization of their luminescent properties requires careful control over the synthesis process.

In this study, we present the synthesis and detailed photoluminescence characterization of $LiBO_2$:Sm^{3+} phosphors prepared via the solid-state diffusion method. This approach is favored for its simplicity, cost-effectiveness, and ability to achieve uniform distributions of the dopant ions within the host matrix [4]. By exploring the effects of various synthesis parameters, including the doping concentration of Sm^{3+}, the reaction temperature, and the diffusion time, we aim to gain deeper insights into the Photo-luminescent properties and potential applications of $LiBO_2$:Sm^{3+} as an efficient phosphor for optoelectronic devices.

> ### Sample Preparation -

While alternative low-temperature synthesis methods, such as hydrothermal and microwave-assisted techniques, have been explored for the fabrication of phosphors, the solid-state reaction method remains one of the most preferred approaches. This preference arises from its cost-effectiveness, ease of scalability, and the capability to improve the intrinsic properties of the materials. Despite the growing interest in other synthesis techniques, the solid-state method continues to stand out, particularly in terms of economic feasibility and the optimization of material characteristics. In the context of modern optoelectronics, the demand for efficient ultraviolet (UV) light-emitting diode (LED) sources has surged, yet there remains a notable scarcity of suitable UV-LED illumination solutions. As such, investigating phosphors capable of efficient UV emission is of paramount importance for advancing UV-LED technologies and fulfilling the current technological gap.

The required stoichiometric amounts of the individual ingredients, based on their molar ratios, are carefully mixed and ground in an agate mortar to achieve a homogeneous mixture. This mixture is then transferred to a China basin and placed in a preheated muffle furnace, where it is sintered at 500°C for 5 hours. After sintering, the material is allowed to cool the room temperature inside a closed furnace [6]. Once cooled, the contents of the China basin are transferred to a mortar and ground for 30 minutes. The resulting powder is then placed in silica crucible and sintered again in a preheated muffle furnace at 700°C for 5 hours. After this second sintering, the material is once again cooled to room temperature inside the furnace. Finally, the phosphors are ground for another 30 minutes in a mortar and pestle.The samples were ground into a fine powder and tested using different techniques [1]. The crystal structure was examined with high-resolution X-ray diffraction (XRD). Luminescence spectra were recorded using a spectrofluorometer with a Xenon flash lamp as the excitation source, and all measurements were taken at room temperature [1].

> ### Results and Discussion –

1. PL Result-

The emission and excitation spectra of $LiBO_2$: Sm^{3+} for different concentration are shown in fig 1(A) and 1(B). The emission spectrum was measured by monitoring the emission wavelength at 606 nm. The excitation spectrum exhibited excitation peak at 401 nm which is assigned to the electronic transition 4f-4f of the Sm^{3+} ion

[2]. Under excitation of 401 nm the emission spectra of the phosphor show two main bonds at 606 nm (orange) corresponds to the transition $\rightarrow$ $^4F_{9/2}$ $^6H_{15/2}$ and 625 nm (red) associated with the transition $^4F_{9/2} \rightarrow$ $^6H_{13/2}$. The first transition $^4F_{9/2}$ $^4F_{9/2} \rightarrow$ $^6H_{15/2}$ is magnetic dipole transition and other one $^6H_{13/2}$ belongs to forced electric dipole transition [5]. It is found that intensity of Sm decreases with increase of the concentration of Sm^{3+} ion. It is found to be maximum for 0.5 mol % of Sm^{3+}.

Photoluminescence of LiBO$_2$:sm^{3+}
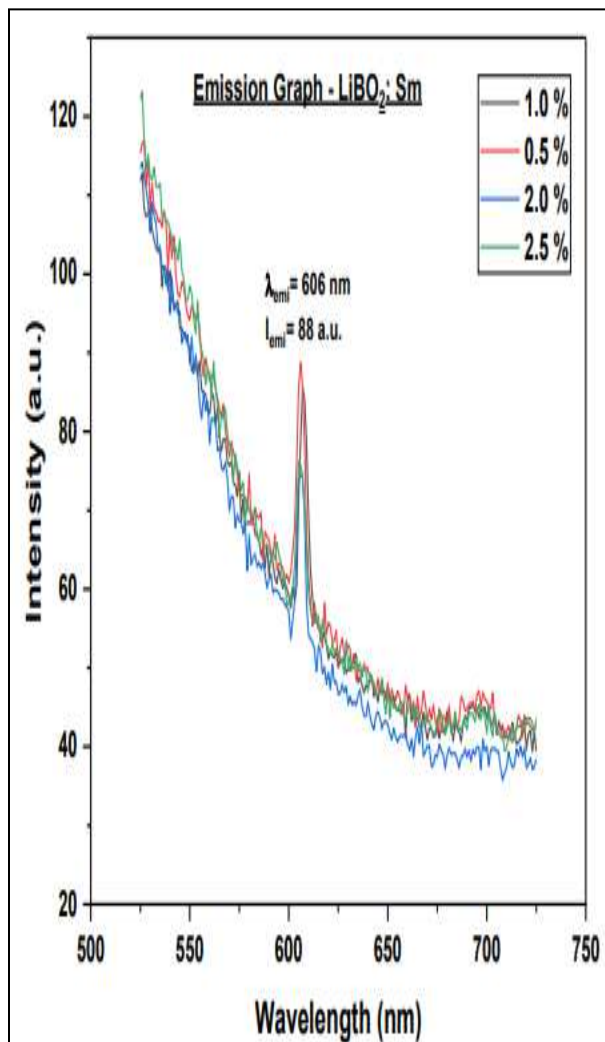
Figure 1(B): Excitation graph – LiBO$_2$: Sm^{3+}
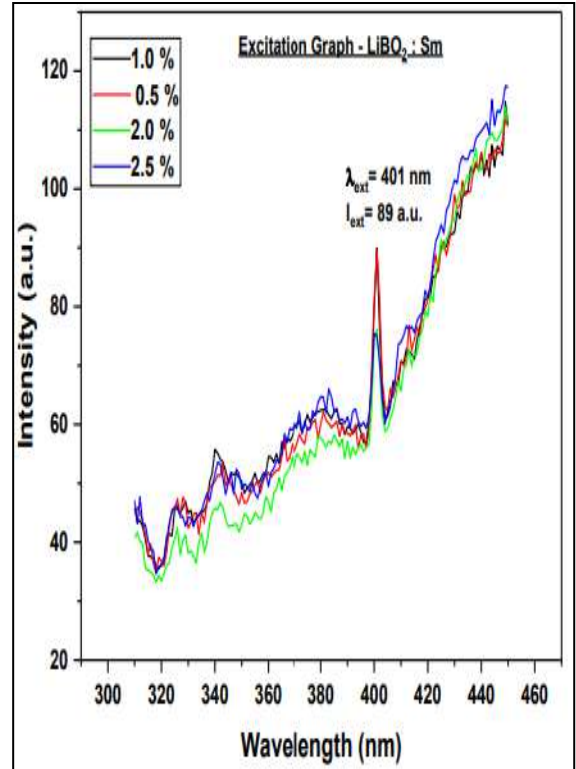
Figure 1(B): Excitation graph – LiBO$_2$: Sm^{3+}
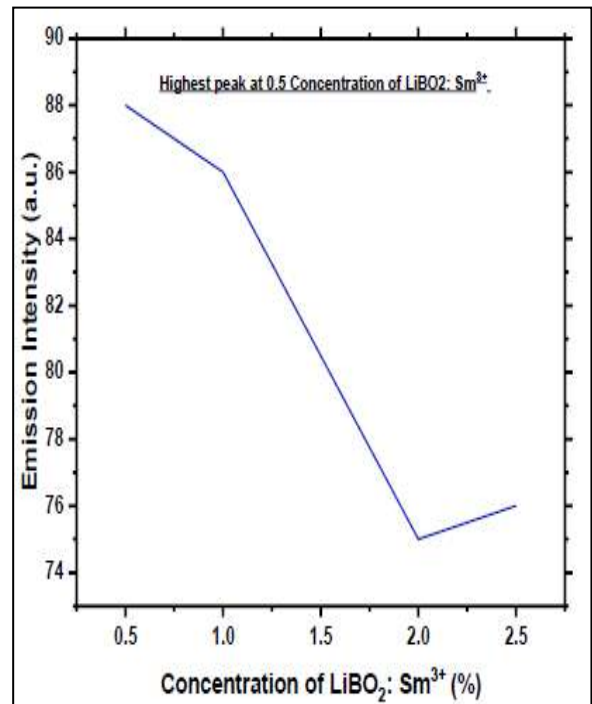
Figure 1 (C): Highest Emission graph of LiBO2: Sm^{3+}

Concentration LiBO2: Sm^{3+}	Emission Wavelength	Emission Intensity	Excitation Wavelength	Excitation Intensity
1.0 %	607 nm	86 a.u.	401 nm	89 a.u.
0.5 %	606 nm	88 a.u.	401 nm	88 a.u.
2.0 %	607 nm	75 a.u.	400 nm	76 a.u.
2.5%	605 nm	76 a.u.	400 nm	75 a.u.

2. X-RD Result-

The XRD results show that the final product is uniform and formed in a consistent way. The average particle size is 38.785 nm, indicating that the sample is a nanomaterial. The dislocation density is 5.797×10^{-4} nm^{-2}, and the strain is 2.912×10^{-3}. These results suggest that the phosphors have a crystalline structure.
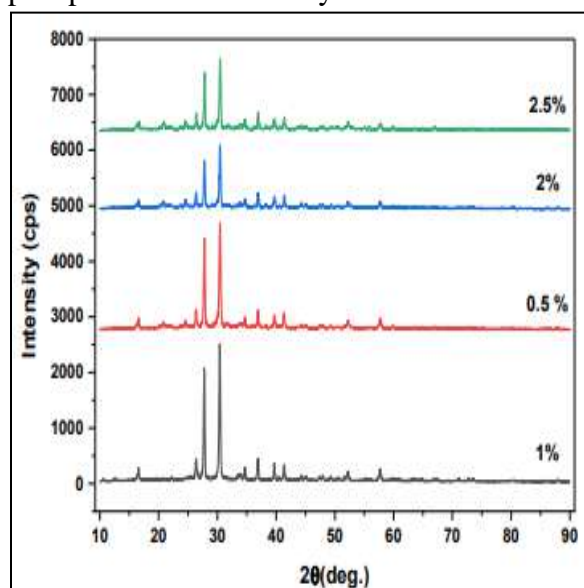
Figure 2(A): XRD graph for LiBO2: Sm^{3+} doped for different conc.
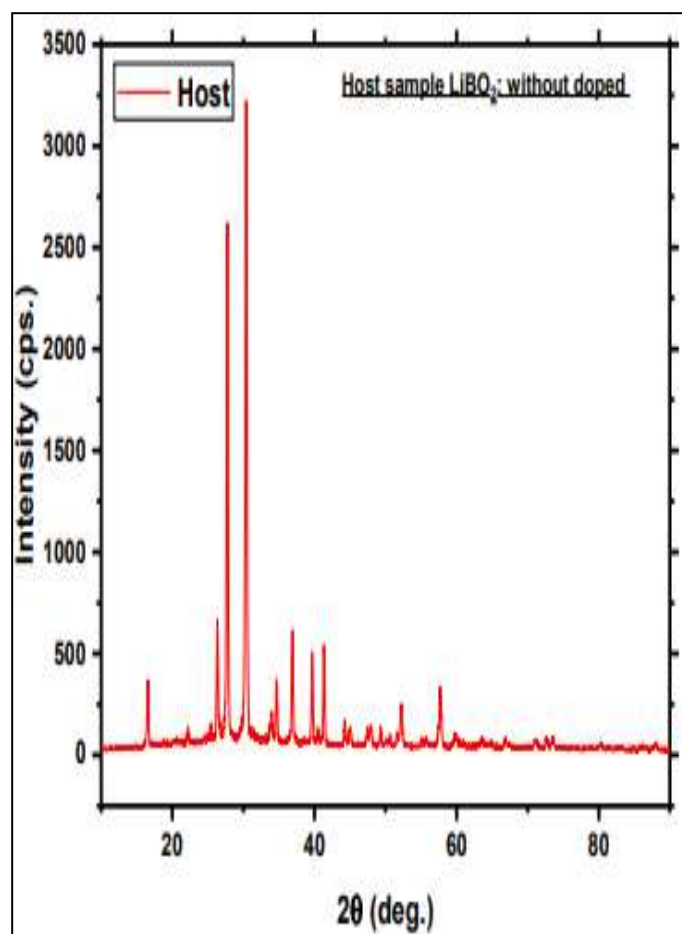
Figure 2(B): XRD graph for LiBO2: Sm^{3+} without doped

Sr. No.	2 theta (deg.)	d (ang.)	Height (eps.)	FWHM	Crystallite size (nm)	Strain	Dislocation density (nm^{-2})
1	26.348	3.3790	406	0.210	38.872	3.912×10^{-3}	6.618×10^{-4}
2	27.738	3.2136	1847	0.204	40.116	3.600×10^{-3}	6.214×10^{-4}
3	30.394	2.9385	2302	0.235	35.034	3.770×10^{-3}	8.147×10^{-4}
4	34.674	2.5850	221	0.216	38.534	3.017×10^{-3}	6.735×10^{-4}
5	36.898	2.4341	411	0.211	39.690	2.758×10^{-3}	6.348×10^{-4}
6	39.646	2.2715	341	0.191	44.218	2.310×10^{-3}	5.114×10^{-4}
7	41.326	2.1829	378	0.188	45.167	2.174×10^{-3}	4.901×10^{-4}
8	52. 198	1.7570	148	0.300	29.490	2.670×10^{-3}	1.149×10^{-4}
9	57.644	1.5978	19	0.239	37.944	1.890×10^{-3}	6.945×10^{-4}

➢ Conclusion –

In conclusion, the XRD analysis of $LiBO2:Sm^{3+}$ phosphors show that product is homogeneous with average particle size of 38.785 nm, confirming it as a nonmaterial. The dislocation density and strain values are 5.797×10^{-4} nm^{-2} and 2.912×10^{-3}, respectively. The emission spectra exhibit strong orange (606 nm) and red (650 nm) emissions when excited by 401 nm UV light, corresponding to the characteristic transitions of Sm^{3+} ions. These findings suggest that Sm-doped $LiBO_2$ phosphors are promising candidates for solid-state lighting applications.

➢ Future Scope –

Research into new and improved phosphors is crucial as they are key materials for the future. There is an urgent need for energy-Efficient and eco-friendly phosphors to replace current lighting systems in the search for more sustainable lighting technologies. Advancements in this field focus on areas such as high-resolution applications, stable emission profiles, new synthetic methods, and improved durability. Phosphorus is essential for food production, but we are depleting the Earth's supply of this vital element. Currently, phosphorus is mainly extracted from mined rock phosphate and used in fertilizers. However, these phosphate reserves may run out in the next 50-100 years, and the quality of remaining reserves is declining, leading to higher extraction and processing costs. To address this, responses may include higher prices, better resource efficiency, finding alternatives, and recycling phosphorus after use.

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Fractional Order Temperature Distribution In A One Dimensional Multilayer Composite Sphere

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Abstract:

This article presents a mathematical approach to analyzing time-fractional heat conduction in a one-dimensional multilayer sphere with internal heat generation. The heat conduction process is modeled using the fractional heat conduction equation, incorporating the Caputo time derivative. Each layer of the sphere is considered thermally isotropic, with perfect thermal contact between layers. The boundary and interface conditions are formulated using the Riemann-Liouville derivative. An analytical solution to the problem is derived.

Keywords: Composite one dimensional sphere, fractional order temperature, Caputo time derivative, heat source.

Introduction

The determination of temperature distribution under various conditions is a crucial aspect of research in boundary value problems (BVP) and thermoelasticity. In engineering applications, multilayer composite spherical bodies play a significant role. However, analyzing temperature distribution in a multilayer system with fractional-order heat conduction and an internal heat source presents several challenges. Understanding these problems is essential due to their wide range of engineering applications.

Analytical solutions are often preferred over numerical methods due to their precision and computational efficiency. Bulavin and Kashcheev [3] obtained solutions for transient heat conduction in a multilayer system with an internal heat source using the method of separation of variables and orthogonal expansion. Yener and Ozisik [1] studied the unsteady heat conduction problem in a one-dimensional multilayer structure. Wange and Gaikwad [6] investigated heat conduction and thermoelasticbehavior in a multilayer hollow sphere. Pawar et al. [8] explored the thermoelastic response of a composite multilayer sphere subjected to asymmetric surface temperatures and internal heat generation. More recently, Kukla and Siedlecka [9] provided solutions for time-fractional heat conduction in a radial direction.

This study focuses on determining the transient temperature distribution in a composite multilayer hollow sphere. The approach follows the methodology introduced by M. N. Ozisik [4], applying it to volumetric heat sources within each layer. The primary objective is to derive the

temperature field for a fractional-order multilayer composite hollow sphere with an internal heat source. Despite extensive literature searches, the results presented here appear to be novel and have not been previously reported.

Formulation of the Problem

The equation of heat conduction in one dimensional fractional order multilayer composite sphere [4],

$$\frac{\partial^2 u_i}{\partial r^2} + \frac{2}{r}\frac{\partial u_i}{\partial r} + \frac{g_i(r)}{k_i} = \frac{1}{a_i}\,{}_0^c D_t^a u_i(r,t)\,(1)$$

$$u_i = u_i(r,t),\ a \pounds r \pounds b,\ i = 1,2,3,4\ldots\ldots\ldots n$$

Where temperature distribution $u_i(K)$, thermal conductivity k_i and thermal diffusivity a_i

$$a_i = \frac{k_i}{r_i c_i}\ \text{where}\ r_i\,(Kg/m^3)\,\&\,c_i\,(J/Kg\,K)\quad\text{are}$$

density and specific heat of material of *ith* layer. The Caputo derivative is defined by [9]

$${}_0^c D_t^a h(t) = \frac{d^a}{dt^a} h(t) = \begin{cases} \dfrac{1}{|m-a|}\displaystyle\int_0^t \dfrac{h^{(m)}(t)}{(t-t)^{a+1-m}}dt\ ,m-1<a<m \\ h^{(m)}(t),a = m\hat{I}\ N \end{cases}$$

(2)

The Riemann-Liouville fractional derivative as

$$D_{RL}^b h(t) = \frac{d}{dt}\left[\frac{1}{|1-b|}\int_0^t \frac{h(t)}{(t-t)^b}dt\right],\quad 0 < b \pounds 1$$

(3)

Boundary conditions

$$u_i(r,t) = 0\ \text{at}\ r = a \qquad\qquad (4)$$

$$k_n D_{RL}^{1-b_n}\frac{\partial u_n(r_n,t)}{\partial r} + p_n u_n(r_n,t) = 0\ \text{at}\ r_n = b \quad (5)$$

Inner interface condition of the *ith* layer $(i = 2,3,4\ldots\ldots n)$

$$u_i(r_{i-1},t) = u_{i-1}(r_{i-1},t)$$

$$k_i D_{RL}^{1-b_i}\frac{\partial u_i(r_{i-1},t)}{\partial r} = k_{i-1} D_{RL}^{1-b_{i-1}}\frac{\partial u_{i-1}(r_{i-1},t)}{\partial r}\quad (6)$$

Outer interface condition of the *ith* layer $(i = 1,2,3,4\ldots\ldots n)$

$$u_i(r_i,t) = u_{i+1}(r_i,t)$$

$$k_i D_{RL}^{1-b_i}\frac{\partial u_i(r_i,t)}{\partial r} = k_{i+1} D_{RL}^{1-b_{i+1}}\frac{\partial u_{i+1}(r_i,t)}{\partial r}\qquad (7)$$

Initially at t=0

$$u_i(r,0) = f_i(r)\,(8)$$

The dimensionless form of variables is defined as follows:

$$(U, U_i, U_n) = (u, u_i, u_n)/u_0 \qquad\qquad (9)$$

$$(R, R_i, R_0, R_n) = (r, r_i, r_0, r_n)/r_n\ (10)$$

$$a_i = \frac{a_i}{a_0},\ k_i\cent = \frac{k_i}{k_0},\ t = \frac{a_0 t}{r_n^2},\ p_n = \frac{p_n r_n}{k_n}\qquad (11)$$

The dimensionless variable Introducing in (1-8) one get,

$$\frac{\partial^2 U_i}{\partial R^2} + \frac{2}{R}\frac{\partial U_i}{\partial R} + \frac{G_i(R)}{k_i\cent} = \frac{1}{a_i}\frac{\partial^a U_i}{\partial t^{a_i}},$$

$$\frac{r_0}{r_n} = R_0 \pounds R \pounds 1,\ R_{i-1} \pounds R \pounds R_i,\ t\,^3\,0\qquad (12)$$

Subjected to conditions

$$R = R_0\ ;\ U_i(R,t) = 0\qquad\qquad (13)$$

$$R = R_n = 1;\ D_{RL}^{1-b_n}\frac{\partial U_n(R_n,t)}{\partial R} + P_n U_n(R_n,t) = 0$$

(14)

Inner interface dimensionless condition of the *ith* layer $(i = 2,3,4\ldots\ldots n)$

$$R = R_{i-1}\ ;\ U_i(R_{i-1},t) = U_{i-1}(R_{i-1},t)$$

$$D_{RL}^{1-b_i}\frac{\partial U_i(R_{i-1},t)}{\partial R} = k_{i-1} D_{RL}^{1-b_{i-1}}\frac{\partial U_{i-1}(R_{i-1},t)}{\partial R}\quad (15)$$

Outer interface dimensionless condition of the *ith* layer $(i = 1,2,3,4\ldots\ldots n-1)$

$$R = R_i\ ;\ U_i(R_i,t) = U_{i+1}(R_i,U)$$

$$k_i D_{RL}^{1-b_i}\frac{\partial U_i(R_i,t)}{\partial R} = D_{RL}^{1-b_{i+1}}\frac{\partial U_{i+1}(R_i,t)}{\partial R}\qquad (16)$$

$$t = 0\ ;U_i(R,0) = \frac{f_i(R)}{T_0},(i = 1,2,3,4\ldots\ldots n)`\quad (17)$$

Where $k_{i-1} = \dfrac{k_{i-1}}{k_i}, i = 2,3\ldots n$ and

$$k_i = \frac{k_i}{k_{i+1}}, i = 1,2,\ldots n-1$$

Surface heat transfer coefficient $P_n = \dfrac{p_n r_n}{k_n}$ and

heat transfer parameter $G_i(R) = \dfrac{g_i(r) r_n^2}{k_0 T_0}$

The equation (12-17) are dimensionless variables.

Solution

Introducing new dependent variable $V_i(R,t)$ as [8]

$$V_i(R,t) = R U_i(R,t) \tag{18}$$

The equations (12-17) will take the form as

$$\frac{\partial^2 V_i}{\partial R^2} + \frac{R G_i(R)}{k_i'} = \frac{1}{a_i} \frac{\partial^{a_i} V_i}{\partial t^{a_i}} \tag{19}$$

$V_i = V_i(R,t)$, $R_0 \pounds R \pounds R_n$, $R_{i-1} \pounds R \pounds R_i$

Subjected to the conditions

$R = R_0$, $V_i(R,t) = 0$

$R = R_n = 1$,

$$D_{RL}^{1-b_n} \frac{\partial V_n(R_n,t)}{\partial R} + \left(P_n - \frac{1}{R} \right) V_n(R_n,t) = 0 \tag{20}$$

Inner interface condition of the *ith* layer $(i=2,3,4....n)$

$R = R_{i-1}$, $V_i(R_{i-1},t) = V_{i-1}(R_{i-1},t)$

$$D_{RL}^{1-b_i} \frac{\partial V_i(R_{i-1},t)}{\partial R} - \frac{V_i(R_{i-1},t)}{R} = k_{i-1}\left(D_{RL}^{1-b_{i-1}} \frac{\partial V_{i-1}(R_{i-1},t)}{\partial R} - \frac{V_{i-1}(R_{i-1},t)}{R} \right)$$

(21)

Outer interface condition of the *ith* layer $(i=1,2,3,4....n-1)$

$R = R_i$ $V_i(R_i,t) = V_{i+1}(R_i,t)$

$$k_i\left(D_{RL}^{1-b_i} \frac{\partial V_i(R_i,t)}{\partial R} - \frac{V_i(R_i,t)}{R} \right) = D_{RL}^{1-b_{i+1}} \frac{\partial V_{i+1}(R_i,t)}{\partial R} - \frac{V_{i+1}(R_i,t)}{R}$$

(22)

Initially

$$t = 0, \quad V_i(R,t) = \frac{R f_i(R)}{T_0} \tag{23}$$

dimensionless heat source parameter $G_i(R)$ and

initial temperature $V_i(R,0)$ which are the function of space variable R and hence the problem using the methodology as discussed by (M N Ozisik,1993) can be solved this type of problem by splitting into two parts i) nonhomogeneous steady state with volumetric **heat source** and ii) homogeneous transient problem will be written as,

$$V_i(R,t) = V_{s,i}(R) + V_{h,i}(R,t) \tag{24}$$

Nonhomogeneous steady state

$$\frac{\partial^2 V_{s,i}(R)}{\partial R^2} + \frac{R G_i(R)}{k_i'} = 0, \quad R_0 \pounds R \pounds R_n,$$

$R_{i-1} \pounds R \pounds R_i$ (25)

Subjected to the conditions

$R = R_0$, $V_{s,i}(R) = 0$

$R = R_n = 1$,

$$D_{RL}^{1-b_n} \frac{\partial V_{s,n}(R_n)}{\partial R} + \left(P_n - \frac{1}{R} \right) V_{s,n}(R_n) = 0$$

(26)

Inner interface of the *ith* layer $(i=2,3,4....n)$

$R = R_{i-1}$, $V_{s,i}(R_{i-1}) = V_{s,i-1}(R_{i-1})$

$$D_{RL}^{1-b_i} \frac{\partial V_{s,i}(R_{i-1})}{\partial R} - \frac{V_{s,i}(R_{i-1})}{R_{i-1}} = k_{i-1}\left(D_{RL}^{1-b_{i-1}} \frac{\partial V_{i-1}(R_{i-1})}{\partial R} - \frac{V_{i-1}(R_{i-1})}{R} \right)$$

(27)

Outer interface of the *ith* layer $(i=1,2,3,4....n-1)$

$R = R_i$ $V_{s,i}(R_i) = V_{s,i+1}(R_i)$

$$k_i\left(D_{RL}^{1-b_i} \frac{\partial V_{s,i}(R_i)}{\partial R} - \frac{V_{s,i}(R_i)}{R} \right) = D_{RL}^{1-b_{i+1}} \frac{\partial V_{s,i+1}(R_i)}{\partial R} - \frac{V_{s,i+1}(R_i)}{R}$$

(28)

By using variation of parameter method solution is obtained as

$$V_{s,i}(R) = c_{1s,i} + c_{2s,i} R + \frac{1}{k_i'}\int R^2 G_i(R)\,dR - \frac{R}{k_i'}\int R G_i(R)\,dR \tag{29}$$

Solution of Homogeneous Transient Problem

$$\frac{\partial^2 V_{h,i}(R,t)}{\partial R^2} = \frac{1}{a_i} \frac{\partial^{a_i} V_{h,i}(R,t)}{\partial t^{a_i}}, \quad R_0 \pounds R \pounds R_n,$$

$R_{i-1} \pounds R \pounds R_i$, (30)

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Subjected to the conditions

$$R = R_0, \qquad V_{h,i}\left(R,t\right)=0 \tag{31}$$

$$R = R_n = 1,$$

$$D_{RL}^{1-b_n}\frac{\P V_{h,n}\left(R_n\right)}{\P R}+\left(P_n-\frac{1}{R}\right)V_{h,n}\left(R_n\right)=0 \tag{32}$$

Inner interface of the ith layer $\left(i=2,3,4....n\right)$

$$R=R_{i-1}\ ,\quad V_{h,i}\left(R_{i-1},t\right)=V_{h,i-1}\left(R_{i-1},t\right)$$

$$D_{RL}^{1-b_i}\frac{\P V_{h,i}\left(R_{i-1},t\right)}{\P R}-\frac{V_{h,i}\left(R_{i-1},t\right)}{R_{i-1}}=k_{i-1}\left(D_{RL}^{1-b_{i-1}}\frac{\P V_{h,i-1}\left(R_{i-1},t\right)}{\P R}-\frac{V_{h,i-1}\left(R_{i-1},t\right)}{R_{i-1}}\right) \tag{33}$$

$$k_{i-1}=\frac{k'_{i+1}}{k'_i}$$

Outer interface of the i$^{\text{th}}$ layer $\left(i=1,2,3,4....n-1\right)$

$$R=R_i\ V_{h,i}\left(R_i,t\right)=V_{h,i+1}\left(R_i,t\right)$$

$$k_i\left(D_{RL}^{1-b_i}\frac{\P V_{h,i}\left(R_i,t\right)}{\P R}-\frac{V_{h,i}\left(R_i,t\right)}{R_i}\right)=D_{RL}^{1-b_{i+1}}\frac{\P V_{h,i+1}\left(R_i,t\right)}{\P R}-\frac{V_{h,i+1}\left(R_i,t\right)}{R_i} \tag{34}$$

$$k_i=\frac{k'_i}{k'_{i+1}}$$

$$t=0,\ V_{h,i}\left(R,t\right)=\frac{Rf_i\left(R\right)}{T_0}-V_{s,i}\left(R\right)=f_i^*\left(R\right) \tag{35}$$

Using the value of $U_{s,i}\left(R\right)$ from equation (29) one gets

$$V_{h,i}\left(R,0\right)=\frac{Rf_i\left(R\right)}{T_0}-c_{1s,i}-c_{2s,i}R-\frac{1}{k'_i}\int R^2 G_i\left(R\right)dR+\frac{R}{k'_i}\int RG_i\left(R\right)dR=f_i^*\left(R\right) \tag{36}$$

These functions fulfill the orthogonality condition

$$\sum_{i=1}^{n}\frac{k'_i}{a'_i}\int_{R_{i-1}}^{R_i}R_{im}\left(\frac{m_{im}}{\sqrt{a'_i}}R\right)R_{im'}\left(\frac{m_{im'}}{\sqrt{a'_i}}R\right)dR=\begin{cases}0,\ \text{for}\ m'\ne m'\\N,\ \text{for}\ m=m'\end{cases} \tag{37}$$

$$N\left(\frac{m_{im}}{\sqrt{a_i}}\right)=\sum_{i=1}^{n}\frac{k'_i}{a'_i}\int_{R_{i-1}}^{R}R_{im}^2\left(\frac{m_{im}}{\sqrt{a_i}}R\right)dR\ \text{for}\ m=m' \tag{38}$$

The differential equation (30) will be separated as

$$\frac{d^{a_i}G_i\left(t\right)}{dt^{a_i}}+m_{im}^2 G_i\left(t\right)=0$$

$$\frac{d^2 R_{im}\left(R\right)}{dR^2}+\frac{m_{im}^2}{a'_i}R_{im}\left(R\right)=0 \tag{39}$$

$$\tag{40}$$

m_{im} is a variable separation constant,

The solution in form of τ as

$$G\left(t\right)=\frac{1}{N\left(\frac{m_{im}}{\sqrt{a_i}}\right)}E_a\left(-m_{im}^2 t^a\right)\sum_{i=1}^{n}\frac{k'_i}{a'_i}\int_{R_{i-1}}^{R_i}R_{im}\left(\frac{m_{im}}{\sqrt{a_i}}R\right)f_i^*\left(R\right)dR \tag{41}$$

and the solution for $V_{h,i}\left(R,t\right)$ as

$$V_{h,i}\left(R,t\right)=\sum_{m=1}^{\infty}\frac{R_{im}\left(\frac{m_{im}}{\sqrt{a_i}}R\right)}{N\left(\frac{m_{im}}{\sqrt{a_i}}\right)}E_a\left(-m_{im}^2 t^a\right)\sum_{j=1}^{n}\frac{k'_j}{a'_j}\int_{R_{j-1}}^{R_j}R_{jm}\left(\frac{m_{jm}}{\sqrt{a_j}}R\right)f_j^*\left(R\right)dR$$

$$\tag{42}$$

Where $E_\alpha(z)$ is the Mittag-Leffler function defined by

$$E_a\left(z\right)=\sum_{m=0}^{\infty}\frac{z^m}{\left|\left(a\,m+1\right)\right.} \tag{43}$$

Hence the temperature distribution $V_i\left(R,t\right)$ is obtained by adding (27) & (40) as

$$V_i\left(R,t\right)=c_{1s,i}+c_{2s,i}R+\frac{1}{k'_i}\int R^2 G_i\left(R\right)dR-\frac{R}{k'_i}\int RG_i\left(R\right)dR$$

$$+\sum_{m=1}^{\infty}\frac{R_{im}\left(\frac{m_{im}}{\sqrt{a_i}}R\right)}{N\left(\frac{m_{im}}{\sqrt{a_i}}\right)}E_a\left(-m_{im}^2 t^a\right)\sum_{j=1}^{n}\frac{k'_j}{a'_j}\int_{R_{j-1}}^{R_j}R_{jm}\left(\frac{m_{jm}}{\sqrt{a_j}}R\right)f_j^*\left(R\right)dR$$

$$\tag{44}$$

To find the constants of $c_{1s,i}\ \&\ c_{2s,i}$

Applying the conditions (26) to (29) one gets the equations in terms of $c_{1s,i}\ \&\ c_{2s,i}$ as,

$$c_{1s,1}+c_{2s,1}R_0=-\frac{1}{k'_1}\int R^2 G_1\left(R\right)dR+\frac{R_0}{k'_1}\int RG_1\left(R\right)dR=X_1$$

$$c_{1s,1}+c_{2s,1}R_1-c_{1s,2}-c_{2s,2}R_1=-\frac{1}{k'_1}\int R^2 G_1\left(R\right)dR+\frac{R_1}{k'_1}\int RG_1\left(R\right)dR+\frac{1}{k'_2}\int R^2 G_2\left(R\right)dR$$

$$-\frac{R_1}{k'_2}\int RG_2\left(R\right)dR$$

$$=X_2$$

$$-\frac{k_1}{R_1}c_{1s,1}+\frac{1}{R_1}c_{2s,2}=\frac{1}{R_1 k'_2}\left[\int R^2 G_1\left(R\right)dR-\int R^2 G_2\left(R\right)dR\right]=X_3$$

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$$c_{1s,2} + c_{2s,2}R_2 - c_{1s,3} - c_{2s,3}R_2 = \frac{1}{k'_2}\int R^2 G_2(R)dR + \frac{R_2}{k'_2}\int R G_2(R)dR + \frac{1}{k'_3}\int R^2 G_3(R)dR$$

$$-\frac{R_2}{k'_3}\int R G_3(R)dR = X_4$$

$$-\frac{k_2}{R_2}c_{1s,2} + \frac{1}{R_2}c_{2s,3} = \frac{1}{R_2 k'_3}\left[\int R^2 G_2(R)dR - \int R^2 G_3(R)dR\right] = X_5$$

$$(P_n-1)c_{1s,n} + P_n c_{2s,n} = \frac{1}{k'_n}\int (P_n-1)R_n - 1)R G_n(R)dR - \frac{(P_n-1)}{k'_n}\int R^2 G_n(R)dR$$

$$= X_n$$

(45)

The system equations (45) is in a matrix form as

$$\begin{pmatrix} 1 & R_0 & 0 & 0 & 0 & . & . & . & 0 & 0 \\ 1 & R_1 & -1 & -R_1 & 0 & 0 & . & . & 0 & 0 \\ \frac{k_1}{R_1} & 0 & \frac{1}{R_1} & 0 & 0 & . & . & . & 0 & 0 \\ 0 & 0 & 1 & R_2 & -1 & -R_2 & 0 & . & 0 & 0 \\ 0 & 0 & -\frac{k_2}{R_2} & 0 & \frac{1}{R_2} & . & . & . & 0 & 0 \\ . & . & . & . & . & . & . & . & . & . \\ . & . & . & . & . & . & . & . & . & . \\ . & . & . & . & . & . & . & . & . & . \\ . & . & . & . & . & . & . & . & . & . \\ . & . & . & . & . & . & . & . & . & . \\ 0 & 0 & . & . & . & . & . & . & P_n-1 & P_n \end{pmatrix} \begin{pmatrix} c_{1s,1} \\ c_{2s,1} \\ c_{1s,2} \\ c_{2s,2} \\ c_{1s,3} \\ c_{2s,3} \\ . \\ . \\ . \\ c_{1s,n} \\ c_{2s,n} \end{pmatrix} = \begin{pmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ X_5 \\ . \\ . \\ . \\ . \\ X_n \end{pmatrix}$$

(46)

From (46) one gets the values of
$$c_{1s,1}, c_{2s,1}, c_{1s,2}, c_{2s,2}, c_{1s,3} \& c_{2s,3} \ldots c_{1s,n} \& c_{2s,n}$$

To find $R_{im}\left(\dfrac{m_{im}}{\sqrt{a'_i}}R\right)$, **the norm** $N\left(\dfrac{m_{im}}{\sqrt{a'_i}}\right)$ **and the eigen values** m_{im}

Now consider the following eigen value problem, we follow the method given by [4],

$$\frac{dR_{im}(R)}{dR} + \frac{m^2_{im}}{a'_i}R_{im}(R) = 0 \quad R_0 \le R \le R_n \quad ,$$

$$R_{i-1} \le R \le R_i \quad (47)$$

$$R = R_0, \quad R_{im}(R) = 0$$

Inner interface of the *ith* layer $(i = 2,3,4\ldots n)$
$$R = R_{i-1}, \quad R_{im}(R_{i-1}) = R_{i-1,m}(R_{i-1})$$

$$\frac{dR_{im}(R_{i-1})}{dR} - \frac{R_{im}(R_{i-1})}{R_{i-1}} = k_{i-1}\left(\frac{dR_{i-1,m}(R_{i-1})}{dR} - \frac{R_{i-1,m}(R_{i-1})}{R_{i-1}}\right)$$

$$k_{i-1} = \frac{k'_{i-1}}{k'_i}$$

Outer interface of the *ith* layer $(i = 1,2,3,4\ldots n-1)$
$$R = R_i, \quad R_{im}(R_i) = R_{i+1,m}(R_i)$$

$$k_i\left(\frac{dR_{im}(R_i)}{dR} - \frac{R_{im}(R_i)}{R_i}\right) = \frac{dR_{i+1,m}(R_i)}{dR} - \frac{R_{i+1,m}(R_i)}{R_i}$$

$$k_i = \frac{k'_i}{k'_{i+1}}$$

$$R = R_n = 1, \quad \frac{dR_{n,m}(R_n)}{dR} + \left(P_n - \frac{1}{R}\right)R_{n,m}(R_n) = 0$$

(48)

The eigen functions of eigen value problem (47-48) are given as

$$R_{im} = A_{im}\cos\left(\frac{m_{im}}{\sqrt{a'_i}}R\right) + B_{im}\sin\left(\frac{m_{im}}{\sqrt{a'_i}}R\right)$$

(49)

The r-direction eigen functions obtained by (49) satisfies the following orthogonality relation

$$\int_{R_{i-1}}^{R_i} R_{im}\left(\frac{m_{im}}{\sqrt{a'_i}}R\right)R_{ip}\left(\frac{m_{ip}}{\sqrt{a'_i}}R\right)dR = \begin{cases} 0 & m \ne p \\ N & m = p \end{cases}$$

(50)

Applying the boundary and interface conditions to (49) one gets following results
$$R = R_0, \quad R_{1m}(R_0) = 0$$

$$A_{1m}\cos\left(\frac{m_{1m}}{\sqrt{a'_1}}R_0\right) + B_{1m}\sin\left(\frac{m_{1m}}{\sqrt{a'_1}}R_0\right) = 0$$

$$R = R_{i-1} \quad i = 2$$
$$R = R_1$$
$$R_{2m}(R_1) = R_{1m}(R_1)$$

$$A_{2m}\cos\left(\frac{m_{2m}}{\sqrt{a'_2}}R_1\right) + B_{2m}\sin\left(\frac{m_{2m}}{\sqrt{a'_2}}R_1\right) = A_{1m}\cos\left(\frac{m_{1m}}{\sqrt{a'_1}}R_1\right) + B_{1m}\sin\left(\frac{m_{1m}}{\sqrt{a'_1}}R_1\right)$$

$$A_{1m}\cos\left(\frac{m_{1m}}{\sqrt{a'_1}}R\right) + B_{1m}\sin\left(\frac{m_{1m}}{\sqrt{a'_1}}R\right) - A_{2m}\cos\left(\frac{m_{2m}}{\sqrt{a'_2}}R\right) - B_{2m}\sin\left(\frac{m_{2m}}{\sqrt{a'_2}}R\right) = 0$$

$$\frac{dR_{2m}(R_1)}{dR} - \frac{R_{2m}(R_1)}{R_1} = k_1\left(\frac{dR_{1m}(R_1)}{dR} - \frac{R_{1m}(R_1)}{R_1}\right)$$

$$\frac{d}{dR}\left\{A_{2m}\cos\left(\frac{m_{2m}}{\sqrt{a_2'}}R\right)+B_{2m}\sin\left(\frac{m_{2m}}{\sqrt{a_2'}}R\right)\right\} - \frac{1}{R}\left\{A_{2m}\cos\left(\frac{m_{2m}}{\sqrt{a_2'}}R\right)+B_{2m}\sin\left(\frac{m_{2m}}{\sqrt{a_2'}}R\right)\right\}_{R=R_1}$$

$$= k_1\left[\frac{d}{dR}\left\{A_{1m}\cos\left(\frac{m_{1m}}{\sqrt{a_1'}}R\right)+B_{1m}\sin\left(\frac{m_{1m}}{\sqrt{a_1'}}R\right)\right\} - \frac{1}{R}\left\{A_{1m}\cos\left(\frac{m_{1m}}{\sqrt{a_1'}}R\right)+B_{1m}\sin\left(\frac{m_{1m}}{\sqrt{a_1'}}R\right)\right\}\right]_{R=R_1}$$

Solving one gets

$$A_{2m}\left[-k_1\frac{m_{2m}}{\sqrt{a_1'}}\sin\left(\frac{m_{2m}}{\sqrt{a_1'}}R\right)-\frac{k_1}{R}\cos\left(\frac{m_{2m}}{\sqrt{a_1'}}R\right)\right]+B_{2m}\left[k_1\frac{m_{2m}}{\sqrt{a_1'}}\cos\left(\frac{m_{2m}}{\sqrt{a_1'}}R\right)-\frac{k_1}{R}\sin\left(\frac{m_{2m}}{\sqrt{a_1'}}R\right)\right]$$

$$+A_{2m}\left[\frac{m_{2m}}{\sqrt{a_2'}}\sin\left(\frac{m_{2m}}{\sqrt{a_2'}}R\right)+\frac{1}{R}\cos\left(\frac{m_{2m}}{\sqrt{a_2'}}R\right)\right]+B_{2m}\left[-\frac{m_{2m}}{\sqrt{a_2'}}\cos\left(\frac{m_{2m}}{\sqrt{a_2'}}R\right)+\frac{1}{R}\sin\left(\frac{m_{2m}}{\sqrt{a_2'}}R\right)\right]=0$$

$$R = R_{i-1}\ \ i=3$$
$$R = R_2$$
$$R_{3m}(R_2)=R_{2m}(R_2)$$

$$A_{2m}\cos\left(\frac{m_{2m}}{\sqrt{a_2'}}R_2\right)+B_{2m}\sin\left(\frac{m_{2m}}{\sqrt{a_2'}}R_2\right)-A_{3m}\cos\left(\frac{m_{3m}}{\sqrt{a_3'}}R_2\right)-B_{3m}\sin\left(\frac{m_{3m}}{\sqrt{a_3'}}R_1\right)=0$$

$$\frac{dR_{3m}(R_2)}{dR} - \frac{R_{3m}(R_2)}{R_2} = k_2\left(\frac{dR_{2m}(R_2)}{dR} - \frac{R_{2m}(R_2)}{R_2}\right)$$

solving one gets

$$-A_{2m}\left[\frac{k_2 m_{2m}}{\sqrt{a_2'}}\sin\left(\frac{m_{2m}}{\sqrt{a_2'}}R_2\right)+\frac{k_2}{R_2}\cos\left(\frac{m_{2m}}{\sqrt{a_2'}}R_2\right)\right]+B_{2m}\left[\frac{k_2 m_{2m}}{\sqrt{a_2'}}\cos\left(\frac{m_{2m}}{\sqrt{a_2'}}R_2\right)-\frac{k_2}{R_2}\sin\left(\frac{m_{2m}}{\sqrt{a_2'}}R_2\right)\right]$$

$$+A_{3m}\left[\frac{m_{3m}}{\sqrt{a_3'}}\sin\left(\frac{m_{3m}}{\sqrt{a_3'}}R_2\right)+\frac{1}{R_2}\cos\left(\frac{m_{3m}}{\sqrt{a_3'}}R_2\right)\right]-B_{3m}\left[\frac{m_{3m}}{\sqrt{a_3'}}\cos\left(\frac{m_{3m}}{\sqrt{a_3'}}R_2\right)+\frac{1}{R_2}\sin\left(\frac{m_{3m}}{\sqrt{a_3'}}R_2\right)\right]=0$$

etc

On outer surface

$$R=R_n=1,\qquad \frac{dR_{n,m}(R_n)}{dR}+\left(P_n-\frac{1}{R_n}\right)R_{n,m}(R_n)=0$$

$$A_{nm}\left[\frac{m_{nm}}{\sqrt{a_n'}}\sin\left(\frac{m_{nm}}{\sqrt{a_n'}}\right)+(P_n-1)\cos\left(\frac{m_{nm}}{\sqrt{a_n'}}\right)\right]+B_{nm}\left[\frac{m_{nm}}{\sqrt{a_n'}}\cos\left(\frac{m_{nm}}{\sqrt{a_n'}}\right)+(P_n-1)\sin\left(\frac{m_{nm}}{\sqrt{a_n'}}\right)\right]=0$$

51)

Denote

$$b_{1in}=\cos\left(\frac{m_{1m}}{\sqrt{a_1'}}R_0\right),\quad b_{2in}=\sin\left(\frac{m_{1m}}{\sqrt{a_1'}}R_0\right)$$

$$x_{11}=\cos\left(\frac{m_{1m}}{\sqrt{a_1'}}R_1\right),\quad x_{12}=\sin\left(\frac{m_{1m}}{\sqrt{a_1'}}R_1\right),$$

$$x_{13}=-\cos\left(\frac{m_{2m}}{\sqrt{a_2'}}R_1\right),\quad x_{14}=-\sin\left(\frac{m_{2m}}{\sqrt{a_2'}}R_1\right)$$

$$y_{11}=-\frac{k_1 m_{1m}}{\sqrt{a_1'}}\sin\left(\frac{m_{1m}}{\sqrt{a_1'}}R_1\right)-\frac{k_1}{R_1}\cos\left(\frac{m_{1m}}{\sqrt{a_1'}}R_1\right),$$

$$y_{12}=\frac{k_1 m_{1m}}{\sqrt{a_1'}}\cos\left(\frac{m_{1m}}{\sqrt{a_1'}}R_1\right)-\frac{k_1}{R_1}\sin\left(\frac{m_{1m}}{\sqrt{a_1'}}R_1\right)$$

$$y_{13}=\frac{m_{2m}}{\sqrt{a_2'}}\sin\left(\frac{m_{2m}}{\sqrt{a_2'}}R_1\right)+\frac{1}{R_1}\cos\left(\frac{m_{2m}}{\sqrt{a_2'}}R_1\right),$$

$$y_{14}=-\frac{m_{2m}}{\sqrt{a_2'}}\cos\left(\frac{m_{2m}}{\sqrt{a_2'}}R_1\right)+\frac{1}{R_1}\sin\left(\frac{m_{2m}}{\sqrt{a_2'}}R_1\right)$$

$$x_{21}=\cos\left(\frac{m_{2m}}{\sqrt{a_2'}}R_2\right),\quad x_{22}=\sin\left(\frac{m_{2m}}{\sqrt{a_2'}}R_2\right),$$

$$x_{23}=-\cos\left(\frac{m_{3m}}{\sqrt{a_3'}}R_2\right),\quad x_{24}=-\sin\left(\frac{m_{3m}}{\sqrt{a_3'}}R_2\right)$$

$$y_{21}=-\frac{k_2 m_{2m}}{\sqrt{a_2'}}\sin\left(\frac{m_{2m}}{\sqrt{a_2'}}R_2\right)-\frac{k_2}{R_2}\cos\left(\frac{m_{2m}}{\sqrt{a_2'}}R_2\right),$$

$$y_{22}=\frac{k_2 m_{2m}}{\sqrt{a_2'}}\cos\left(\frac{m_{2m}}{\sqrt{a_2'}}R_2\right)-\frac{k_2}{R_2}\sin\left(\frac{m_{2m}}{\sqrt{a_2'}}R_2\right)$$

$$y_{23}=\frac{m_{3m}}{\sqrt{a_3'}}\sin\left(\frac{m_{3m}}{\sqrt{a_3'}}R_2\right)+\frac{1}{R_2}\cos\left(\frac{m_{3m}}{\sqrt{a_3'}}R_2\right),$$

$$y_{24}=-\frac{m_{3m}}{\sqrt{a_3'}}\cos\left(\frac{m_{3m}}{\sqrt{a_3'}}R_2\right)+\frac{1}{R_2}\sin\left(\frac{m_{3m}}{\sqrt{a_3'}}R_2\right)$$

$$b_{1out}=-\frac{m_{hm}}{\sqrt{a_n'}}\sin\left(\frac{m_{hm}}{\sqrt{a_n'}}\right)+(P_n-1)\cos\left(\frac{m_{hm}}{\sqrt{a_n'}}\right),$$

$$b_{2out}=\frac{m_{hm}}{\sqrt{a_n'}}\cos\left(\frac{m_{hm}}{\sqrt{a_n'}}\right)+(P_n-1)\sin\left(\frac{m_{hm}}{\sqrt{a_n'}}\right)$$

(52)

Thus the homogeneous system to obtain

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A_{im} & B_{im} and **assuming** $A_{1m} = 1$ and for heat flux to be continuous at the layer interfaces for all values of time t, $\eta_{im} = \eta_{m}\sqrt{\dfrac{a_1'}{a_i'}}$ *for* $i = 2,3,4....n$ is expressed in a matrix form as,

$$
\begin{bmatrix}
a_{1in} & b_{2in} & 0 & 0 & 0 & .. & .. & .. & 0 & 0 \\
x_{11} & x_{12} & x_{13} & x_{14} & 0 & .. & .. & .. & 0 & 0 \\
y_{11} & y_{12} & y_{13} & y_{14} & 0 & .. & .. & .. & 0 & 0 \\
.. & .. & .. & .. & .. & .. & .. & .. & 0 & 0 \\
0 & 0 & 0 & .. & x_{i1} & x_{i2} & x_{i3} & x_{i4} & .. & 0 \\
0 & 0 & 0 & .. & y_{i1} & y_{i2} & y_{i3} & y_{i4} & .. & 0 \\
.. & .. & .. & .. & .. & .. & .. & .. & .. & 0 \\
.. & .. & .. & .. & .. & .. & .. & .. & .. & .. \\
0 & 0 & .. & .. & .. & .. & y_{n-1,1} & y_{n-1,2} & y_{n-1,3} & y_{n-1,4} \\
0 & 0 & .. & .. & .. & .. & .. & .. & b_{1out} & b_{2out}
\end{bmatrix}
\begin{Bmatrix}
B_{1m} \\ A_{2m} \\ B_{2m} \\ A_{3m} \\ B_{3m} \\ . \\ . \\ . \\ A_{nm} \\ B_{nm}
\end{Bmatrix}
=
\begin{Bmatrix}
1 \\ 0 \\ 0 \\ 0 \\ 0 \\ . \\ . \\ . \\ 0 \\ 0
\end{Bmatrix}
$$

(53)

The number of n - 1 equations used to find the coefficients A_{im} & B_{im}

$$
\begin{bmatrix}
a_{2in} & 0 & 0 & 0 & .. & .. & .. & 0 & 0 \\
x_{12} & x_{13} & x_{14} & 0 & 0 & .. & .. & .. & 0 & 0 \\
y_{12} & y_{13} & y_{14} & 0 & 0 & .. & .. & .. & 0 & 0 \\
.. & .. & .. & .. & .. & .. & 0 & 0 \\
0 & 0 & 0 & .. & x_{i1} & x_{i2} & x_{i3} & x_{i4} & .. & 0 \\
0 & 0 & 0 & .. & y_{i1} & y_{i2} & y_{i3} & y_{i4} & .. & 0 \\
.. & .. & .. & .. & .. & .. & 0 \\
.. & .. & .. & .. & .. & .. & .. & .. \\
0 & 0 & .. & .. & .. & .. & y_{n-1,1} & y_{n-1,2} & y_{n-1,3} & y_{n-1,4} \\
0 & 0 & .. & .. & .. & .. & .. & b_{1out} & b_{2out}
\end{bmatrix}
\begin{Bmatrix}
B_{1m} \\ A_{2m} \\ B_{2m} \\ A_{3m} \\ B_{3m} \\ . \\ . \\ . \\ A_{nm} \\ B_{nm}
\end{Bmatrix}
=
\begin{Bmatrix}
b_{1in} \\ -x_{11} \\ -y_{11} \\ .. \\ .. \\ . \\ . \\ . \\ .. \\ ..
\end{Bmatrix}
$$

(54)

The solution of above matrix gives (n-1) coefficients $B_{1m}, A_{2m}, B_{2m}, A_{3m}, B_{3m}. ....A_{nm}$ & B_{nm}. The transcendental equation to find the eigen values η_m *i.e.* $\eta_1 < \eta_2 < \eta_3 < ...... < \eta_m < ..,$

Temperature Distribution

$$
V_i(R,t) = a_{s,i} + b_{s,i}R - \frac{G_0 R^4}{12 k_i} + \sum_{m=1}^{\infty} \frac{e^{-\eta_{im}^2 \alpha_i t}\left[A_{im}\cos\left(\frac{\eta_{im}}{\sqrt{a_i}}R\right) + B_{im}\sin\left(\frac{\eta_{im}}{\sqrt{a_i}}R\right)\right]}{N(\eta_{im})} \sum_{i=1}^{3}\frac{k_i}{a_i}
$$

$$
A_{im} = \begin{cases}
(1 - b_{s,i})\left\{\frac{\sqrt{a_i}}{\eta_m}\left[R_i\sin\left(\frac{\eta_{im}}{\sqrt{a_i}}R_i\right) - R_{i-1}\sin\left(\frac{\eta_{im}}{\sqrt{a_i}}R_{i-1}\right)\right] + \frac{a_i}{\eta_m^2}\left[\cos\left(\frac{\eta_{im}}{\sqrt{a_i}}R_i\right) - \cos\left(\frac{\eta_{im}}{\sqrt{a_i}}R_{i-1}\right)\right]\right\} \\[2mm]
+ a_{s,i}\frac{\sqrt{a_i}}{\eta_m}\left\{\sin\left(\frac{\eta_{im}}{\sqrt{a_i}}R_i\right) - \sin\left(\frac{\eta_{im}}{\sqrt{a_i}}R_{i-1}\right)\right\} + \\[2mm]
\frac{G_0}{12 k_i}\left\{\left(\frac{\sqrt{a_i}R_i^4}{\eta_m} - \frac{12 a_i^{\frac{3}{2}}R_i^2}{\eta_m^3} + \frac{24 a_i^{\frac{5}{2}}}{\eta_m^5}\right)\sin\left(\frac{\eta_{im}}{\sqrt{a_i}}R_i\right) - \left(\frac{\sqrt{a_i}R_{i-1}^4}{\eta_m} - \frac{12 a_i^{\frac{3}{2}}R_{i-1}^2}{\eta_m^3} + \frac{24 a_i^{\frac{5}{2}}}{\eta_m^5}\right)\sin\left(\frac{\eta_{im}}{\sqrt{a_i}}R_{i-1}\right)\right. \\[2mm]
\left.+\left(\frac{4 a_i R_i^3}{\eta_m^2} - \frac{24 R_i^2}{\eta_m^4}\right)\cos\left(\frac{\eta_{im}}{\sqrt{a_i}}R_i\right) - \left(\frac{4 a_i R_{i-1}^3}{\eta_m^2} - \frac{24 R_{i-1}}{\eta_m^4}\right)\cos\left(\frac{\eta_{im}}{\sqrt{a_i}}R_{i-1}\right)\right\}
\end{cases}
$$

$$
B_{im} = \begin{cases}
(1 - b_{s,i})\left\{\frac{-\sqrt{a_i}}{\eta_m}\left[R_i\cos\left(\frac{\eta_{im}}{\sqrt{a_i}}R_i\right) - R_{i-1}\cos\left(\frac{\eta_{im}}{\sqrt{a_i}}R_{i-1}\right)\right] + \frac{a_i}{\eta_m^2}\left[\sin\left(\frac{\eta_{im}}{\sqrt{a_i}}R_i\right) - \sin\left(\frac{\eta_{im}}{\sqrt{a_i}}R_{i-1}\right)\right]\right\} \\[2mm]
+ B_{im} + a_{s,i}\frac{\sqrt{a_i}}{\eta_m}\left\{\cos\left(\frac{\eta_{im}}{\sqrt{a_i}}R_i\right) - \cos\left(\frac{\eta_{im}}{\sqrt{a_i}}R_{i-1}\right)\right\} + \\[2mm]
\frac{G_0}{12 k_i}\left\{\left(\frac{\sqrt{a_i}R_i^4}{\eta_m} + \frac{12 R_i^2}{\eta_m^3} - \frac{24}{\eta_m^5}\right)\cos\left(\frac{\eta_{im}}{\sqrt{a_i}}R_i\right) - \left(\frac{\sqrt{a_i}R_{i-1}^4}{\eta_m} + \frac{12 R_{i-1}^2}{\eta_m^3} - \frac{24}{\eta_m^5}\right)\cos\left(\frac{\eta_{im}}{\sqrt{a_i}}R_{i-1}\right)\right. \\[2mm]
\left.+\left(\frac{4 a_i R_i^3}{\eta_m^2} - \frac{24 R_i}{\eta_m^4}\right)\sin\left(\frac{\eta_{im}}{\sqrt{a_i}}R_i\right) - \left(\frac{4 a_i R_{i-1}^3}{\eta_m^2} - \frac{24 R_{i-1}}{\eta_m^4}\right)\sin\left(\frac{\eta_{im}}{\sqrt{a_i}}R_{i-1}\right)\right\}
\end{cases}
$$

Where,

$$
N\left(\frac{\eta_{im}}{\sqrt{a_i}}\right) = \sum_{i=1}^{3}\frac{k_i}{a_i}\begin{bmatrix}
\left(\frac{A_{im}^2 + B_{im}^2}{2}\right)(R_i - R_{i-1}) + \left(\frac{A_{im}^2 - B_{im}^2}{4\eta_{im}}\right)\left[\sin 2\left(\frac{\eta_{im}}{\sqrt{a_i}}R_i\right) - \sin 2\left(\frac{\eta_{im}}{\sqrt{a_i}}R_{i-1}\right)\right] \\[2mm]
\frac{A_{im}B_{im}\sqrt{a_i}}{2\eta_{im}}\left\{\cos 2\left(\frac{\eta_{im}}{\sqrt{a_i}}R_i\right) - \cos 2\left(\frac{\eta_{im}}{\sqrt{a_i}}R_{i-1}\right)\right\}
\end{bmatrix}
$$

Conclusion

The transient temperature distribution in a fractional-order multilayered composite hollow sphere with an internal volumetric heat source is analyzed. An exact analytical solution for the fractional-order temperature distribution is obtained by decomposing the problem into two components: (i) the homogeneous transient part and (ii) the nonhomogeneous steady-state part.

The solution for the homogeneous transient component is derived using an eigenfunction expansion in a series form, incorporating the

fractional-order time derivative represented by the Mittag-Leffler function. The nonhomogeneity in the problem arises due to the internal heat source and the initial temperature distribution, which is a function of the radial coordinate.

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Solar Rooftop Market In India: Government Policies, Challenges &Future Potential.

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ABSTRACT

India has a growing population experiencing daily increases in energy consumption and stages of industrial and financial growth. As a result of the disappearance of resources, thermal energy costs are gradually increasing (coal and fossil fuel). Indian customers are drawn to solar energy because it gives them flexibility and an edge in lowering energy prices and being environmentally friendly, all while maintaining this energy management situation and caring for the environment and public safety.

In the Indian market, the government actively promotes solar products to the local population to save energy and open up a new market for solar entrepreneurs. To save energy and create a new market for solar items that would appeal to budding entrepreneurs, the Indian government also promotes and launches solar products on the local market. To save energy while developing a new solar market for aspiring business owners, the Indian government also actively promotes solar products to the local market. To save energy and open up a new solar market for aspiring business owners, the Indian government also promotes and launches solar items on the local market.

Keywords: *Solar rooftop, Government strategical support, green energy, Nagpur city.*

INTRODUCTION:

In light of the country's high rate of energy consumption growth, high coal consumption, significant reliance on imports to satisfy its needs for petroleum fuels, and volatile global oil prices, India has placed a high priority on promoting renewable energy. China, Pakistan, and India are the three countries that produce the most coal used to generate electricity in these countries. However, because coal is a natural resource that has reached its limit, other countries have discovered ways to produce electricity, and research is still ongoing to find these other sources. In addition, the Indian government supports green energy initiatives that lower the price of actual power.

1.1   Global Solar Scenario: NZE projects that by 2030, there will be over 100 million households using solar energy from photovoltaics (PV), up from 25 million at present. Since PV is becoming more and more competitive and there is a growing demand for clean energy sources, a minimum of 190 GW will be installed every year beginning in 2022. Distributed solar energy systems make up about 40% of the 1 TW installed, with over a third of them being used in residences.Residents have set up roughly 25 million PV systems, or 130 GW, in total. This figure needs to be put four times, and 100 million units will be generated by 2030. The yearly installation rate of today could be kept to achieve this. The increasing consumption of electricity by

households for electric mobility, heating, and cooling (primarily due to the introduction of heat pumps) will boost the demand for at-home embedded electricity production. (IEA (2022),)

1.2 The current solar scenario in India:

India, home to nearly two billion individuals while possessing among the largest nations worldwide, has strengthened its position as the dominant nation, in green energy. Because of its large territory, which covers an area of about 3.3 million square kilometers, India has been gifted with abundant renewable energy resources. Having set up 163 gigawatts of green energy capacity as of 2022, India ranks fourth worldwide in terms of green energy power. Furthermore, between 2012 and 2022, the Asian nation's electricity production from renewable sources increased by two.

1.3 Despite these advancements, thermal energy derived from coal and oil continued to take over India's overall energy mix. But shortly, there will be a move in the energy sector to energy from renewable sourcesPrime Minister Narendra Modi announced that he planned to add 500 GW of renewable energy capacity by 2030 during the 2021 COP26 environment summit in Glasgow. The primary approach to accomplishing this will be major nationwide growth in wind and solar power setups.
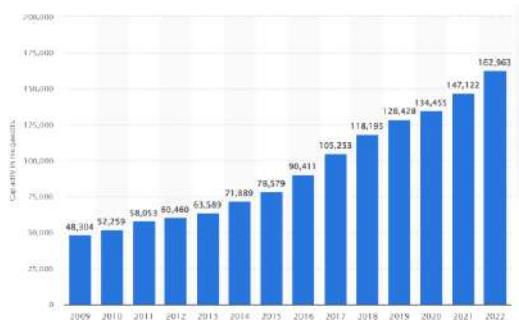
1.4 National Tariff Policy 2016: The policy focuses on various aspects of energy, including energy security. Since power is a key factor in the economy's expansion, achieving equitable expansion requires providing access to power to all of the nation's citizens. Through the goal of "Power for All," the Tariff Policy of 2016 contains provisions in this respect.

1.5 Tariff rules are as follows:

a) To ensure the availability of services at high and reasonable rates to consumers;

b) To promote economic viability and attract investment.

c) To promote transparency, continuity, and predictability in regulatory affairs.

d) Operations Management: Consolidation of data, data collection, and quality improvement;

e) Use of renewable energy sources and energy production; renewable, renewable, and various renewable energy sources.

f) To contribute to Hydropower generation with Pooled Storage Projects (PSP)

g) Developing a dynamic and robust integrated infrastructure for better consumer services.

h) Production, transmission, and distribution of goods to consumers;

i) Determine the H-level structure with the accumulation of % in the distribution(Authority et al., 2017)

1.6 Electricity Act 2003: An Act to unify the regulations about power production, transmission, distribution, dealings, and useadditionally, to take broad action to support the growth of the electrical power industry, encourage rivalry in the sector, safeguard the interests of consumers and ensure universal access to electricity; rationalize electrical power tariffs; ensure honest policies about subsidies; encourage the growth of effective and green policies.(The Electricity Act, 2003)

a) **National Action Plan on Climate Change(NAPCC):**Solar power is a huge source of immediately useful electricity, in addition to producing biomass, wind, hydropower, and wave energy. Even though there are some notable variations depending on longitude and period, most of the planet's

surface is exposed to sufficient sunlight to permit inadequate climate change in buildings and the water. In lower latitudes, simple equipment might be able to focus solar energy enough to run turbines that generate steam as well as prepare meals. Light energy may move electrons in some semiconducting materials. Large amounts of electricity may be generated by that sunlight effect. However, very large areas are required to satisfy the demand for electricity due to the low efficiency of solar PV cells today. The only source of green energy is the use of direct solar power. with the potential to eventually replace the world's current fossil fuel-based supply of electricity, but it will cost at least 50,000 square kilometres of land to do so.(Environment & Change, 2022)

b) **Jawaharlal Nehru National Solar Mission(JNNSM):**A single national priority that could eventually meet all of the nation's energy needs is the use of solar energy. It takes the place of coal and petroleum as an alternative source of energy. The benefits could contribute to the advancement of national development, even if they are not readily apparent. However, how organizations and the government is supporting solar tasks has sparked debate about the course in addition to the composition of the green energy industry. Along with a greater understanding of the fundamental facts of the country, changes in the power sector are also required.India is finding it challenging to build the fundamental amenities and facilities required to strengthen its financial system. However, the government must be deeply concerned about the societal problems that lie at the heart of the nation's challenges, how to make the program's goals available to the poor, and the best way to create avenues for growth that is fair. India requires equal growth, which means that all facets of the populace must be able to take part and benefit.

The technological mission must be changed to one that is social, and new, economical, andeffective technology should take the place of the careless and unnecessary use of outdated equipment. With JNNSM's launch, India pledged to support environmentally friendly growth while also meeting its energy needs for future economic growth. The long-term strategic plan to accomplish these goals was made available. The JNNSM established goals, deadlines, and goals; it also arranged for collaboration with other agencies. In addition, the JNNSM looks for market backing as well as assistance from R&D, which could assist with creating its workforce. support and assistance from R&D, which could help in staffing the company. As was previously mentioned, India unveiled several initiatives to meet the 100 GW goal. The government made the market for electricity available to connections for shipment, the next, and dissemination as well as for collaboration between the many agencies involved. (Sawhnet 2019)

During Phase II of JNNSM, government agencies especially investigated all of the options accessible including public bidding, e-reverse auctions, bundling, generation-based incentives (GBI), existence gap money (VGF), and more. Perhaps the federal government could achieve even more of its current goals through these innovative approaches. The federal government may be able to meet its just announced, ill-considered 4500 GW of renewable energy focuses by 2030 if it keeps going on this path. Finally, it might be necessary to implement reforms in the energy industry in addition to having a deeper comprehension of the nation's fundamental realities. While India struggles to develop services and build the necessary infrastructure to support its economic development, the government ought to act more actively to prevent

ingrained social issues, make the program's objectives accessible to underprivileged and marginalized groups, and open up opportunities for equitable development.(Upadhyay & Singh, 2021)

1.7REVIEW OF LITERATURE:

The sale of solarrooftops was the focus of a thorough literature review, but no particular research on this PV aspect has been done. There is a chapter in the Energy Research Organization of India Report discussing the way the commercialization of photovoltaic rooftops can help PV grow in India. The literature listed below represents research studies on various aspects of solar photovoltaics (PV) that can advance our understanding and facilitate the commoditization of solar roofs in our nation.

a) According to **Gautam Rainaa , Sunanda Sinhab**,The need for adequate resources in countries that are developing like India is affected by several variables, such as the creation of money, growth in society, and major health problems brought on by the use of firewood, charcoal, etc. There has always been a trend indicating that industrialized nations emit significantly more greenhouse gas than developing economies.(Raina & Sinha, 2019)

b) According to **Karan Kapoor a , Krishan K. Pandey a,n , A.K. Jain a , Ashish Nandan**,Among the top nations with good express Normal Irradiance2 (DNI) is India. DNI is influenced by several elements, such as location, the movement of the Earth's, The tilt of its rotating axis, and outside attenuation from suspended particles. An estimated 5000 billion dollars kWh of solar power might be generated every year in India. As one of its eight assignments under the National Action Plan on Climate Change (NAPCC–2008), the Indian government established the Jawaharlal Nehru National Solar Mission (JNNSM) on January 11, 2010. The initiative aims to construct 22,000 MW of off-grid or grid-dependent thermal power plants.(Kapoor et al., 2014)

c) According to **Vidhi Tyagi1, Prasoom Dwivedi2, Anshuman Gupta,**All in all, it can be argued that state solar laws and prominent initiatives such as the federal government's JNNSM have proved effective in generating solar-powered power projects; that being said, the small solar rooftop market is yet to experience significant expansion. One advantage is that the solar photovoltaic (PV) sector in a nation such as India has enormous potential to grow. At a time when the country is making noises about cutting emissions of greenhouse gases and highlighting green technologies, solar rooftop remedies can be extremely beneficial in grabbing the attention of customers. Considering commercial models that will promote the expansion of the rooftop solar energy market is therefore vital. (Tyagi et al., 2008)

d) According to **Kausar Suraiya Quraishi, and Dr. Salma Ahmed,** The nation is currently a net importer of electricity, removing its energy deficit. By MNRE, India has the fifth-highest capacity for solar power around the world. Grid parity could be reached in three to four years in several Indian states with abundant sunlight and currently high electricity rates if RTS expenses keep falling and fossil fuel prices rise. With more people living in cities, the construction of homes is growing quickly. RTS can take the place of the grid during warm hours. Domestic consumers usually have loads between 5 and 20 kW, but since there are fewer domestic consumers in the 20 kW category, the average load will be 10 kW. (Quraishi & Ahmed, 2019)

e) According to **Neelam Rathore, N.L Panwar,**Systems for producing electricity using fossil fuels aren't considered sustainable due to their adverse impacts on the natural world. However, as awareness of climate change problems develops, renewable energy sources are being promoted as the best manner to address the centuries-old problem of environmentally friendly ability. However, an array of socioeconomic, technical, and ecological barriers remain that limit the adoption of solar energy technologies.

As a result, the authors gave an in-depth analysis of the many user-available policies and incentives in addition to the vital steps that can be carried out to get past the challenges that users might run into. The essays covered a wide range of solutions to challenges like land availability, technical difficulty, hazards and unpredictability, useless government policies, inefficient fiscal incentives, insufficient government agencies' liability, etc. (Rathore & Panwar, 2022)

f) According to **Naveen Kumar Sharma, Prashant Kumar Tiwari, and Yog Raj Sood**, India is reeling from an extensive blackout of electricity. Massive capacity increases must happen to keep up with the growing needs of its rapidly growing economy. By diversifying the supply, decreasing dependence on purchases, and reducing the volatility of fuel costs, the Security of energy can be enhanced by the expansion of renewable power, because it's distributed, domestic, and possesses a relatively low cost of the next. India's advancement in renewable energy sources is anticipated to be a useful tool for promoting the economic development of the region.(Sharma et al., 2012)

g) According to **J.Priyadharshini, and M.Selladurai,**solar power is The only way to address the electricity crisis. Solar electricity is a free and overtime fix for the electrical issue. In India, the prospect of renewable energy is huge. India is leading the world in its green energy program, and this advance is made attainable by helpful economic and legal policies. Even though India's green energy situation is still in its earliest stages, the trend has grown quickly. The regulations and policies in place have allowed the expansion of this sector. A developed India driven by sunlight will serve as a model for the entire world. (Priyadharshini & Selladurai, 2016)

h) According to **N.Sasikumar,&Dr.P.Jayasubramaniam** The advancement of solar technology, including the study and creation of solar energy storage and testing facilities, is encouraged. It will also be pushed for technology demonstrations on creative projects in collaboration with reputable organizations. To achieve the objectives outlined in this policy, the Tamil Nadu Energy Development Agency (TEDA) is going to promote the development of solar power capacity.(N.Sasikumar, 2013)

1.8 The Nagpur Municipal Corporation (NMC) support for solar consumers: The Nagpur Municipal Corporation (NMC) provides homeowners who install rooftop solar systems with a 5% property tax discount toencourage the adoption of renewable energy sources. However, according to company paperwork, the business's properties and amenities have a yearly power bill of nearly Rs 100 crore (or Rs 10,000.58 lakh, to be exact). It discovered that the largest energy consumers are roadways, pumping stations, and water treatment facilities, all of which can be operated by sunlight collected on the roof.

According to **Sunil S. Navghare Sir,** an engineer in the electricity department of the NMC the municipality planned to install a 42-megawatt peak power solar photovoltaic installation in 2018. The installation was to be spread among water purification plants, pumping stations, street lights, buildings, and gardens. But there has been a nearly two-year delay in the project. "We have pressed out almost all issues now and believe this year it will be up and running," Navghare stated.Given that Nagpur has 300 sunny days annually and a ranking as one of the country's 60 solar cities to advance green power, the lack of interest in clean energy is noteworthy. It also clarifies why, despite its strong push for a significant transition to sustainable energy, India remains behind in meeting its target for roof solar energy. As per India's 2015 According to its Nationally Determined Input, the whole country wants to generate 2022, 175 GW of green energy. Of this, up to 100 GW will come from sunlight, and 40 GW of that will arrive from photovoltaic cells mounted on solar rooftops.

The rooftop solar manufacturing is far from reaching this objective, as the government is aware. The Ministry of New and Renewable Energy updated the Lok Sabha in February 2021 that 2,071 MW have been installed during the first phase (2015–2020), with an objective of 4,200 MW by January 31, 2021. (Khandekar, 29 July 2021)

1.9National action plan on climate change:(National Solar Mission): The National Solar Mission seeks to greatly raise the percentage of direct sunlight in the power plant as a whole, while also recognizing that we must enlarge the use of other sustainable and non-fossil alternatives such as wind, nuclear, and biomass energy. India is a tropical country where there is an abundance of sun that endures for longer periods every single day. As a result, solar power has tremendous potential for use as an eventual source of energy. It also has the benefit of enabling a distributed energy distribution, which empowers individuals at the local level. With advancements in technology, solar energy cells are getting more affordable.

More recent technologies based on reflectors may make it possible to build megawatt-scale solar power plants all over the nation. An additional facet of the Solar The mission would involve initiating a significant research and development initiative, potentially utilizing global collaboration, to encourage the creation of more affordable and aesthetically pleasing renewable energy sources and to foster advancements that facilitate the retention of solar energy for extended periods.(Upadhyay & Singh, 2021)

2.0 Policy measure taken for financial support: The JNNSM's two target markets are residential rooftop plants (40 GW) and large-scale solar installations (60 GW). A reverse asking the sale is included in each team and stage in which it is used. Consequently, bidders offer the hourly rate at which they are willing to sell electricity at the greatest price that they are willing to make. The most recent sale was for JNNSM Phase II Batch IV.((Uncategorized, 2017))

2.1Maharashtra's current solar energy plan The JNNSM's two target markets are large-scale solar installations (60 GW) and housing rooftop plants (40 GW). There is an opposing question about the sale in each phase and the group in which it is used. Participants consequently make the highest possible offer at the rate per hour at which

they are willing to sell the authority. The most recent auction was Phase II Batch IV of the JNNSM. (Policy for Grid Connected Solar Power Projects - English (1))

Maharashtra's Annual Targets For Rooftop Solar
Total (2015-22): 4,700 MW
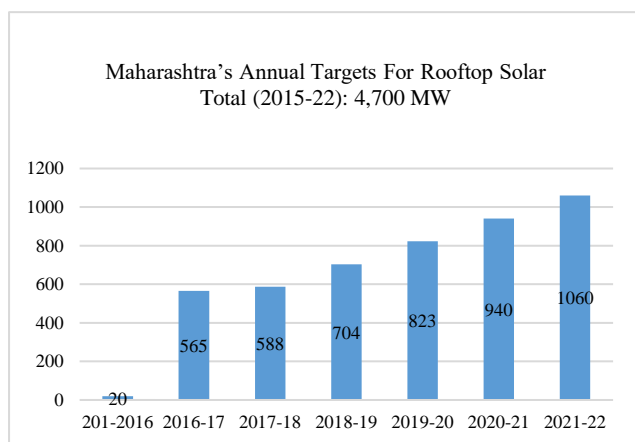
Source: <u>Ministry of New and Renewable Energy</u>

2.2 Stakeholder

a) **Discom/ Mahavitaran/ Mahadiscom/MSEDCL:** The Maharashtra State Electricity Board owns all of the shares in (Maharashtra State Electricity Distribution Company Limited). It is the biggest utility in India for the distribution of electricity and, after SGCC, the second largest worldwide. All of Maharashtra is supplied with electricity by MSEDCL, except a few areas of Mumbai, where Adani Electricity Mumbai Limited, Tata Power, and Brihanmumbai Electric Supply and Transport are the distributors.(The State Electricity Distribution Company of Maharashtra, Limited, 2012) (May 2015)

The "Electricity Act (Amendment) Bill, 2020" draft has been accepted by the Central Government, bringing significant changes in the nation's electrical industry. The "Direct Benefit Transfer" (DBT) system for allocating subsidies, the legitimacy of power distribution companies (discoms), prices determined by cost, the creation and fortification of the regulatory framework, and other changes are among the most notable ones in this draft. This part clarifies the different obstacles that must be overcome to fulfill ability addition targets, which makes the idea of solar electricity challenging.(Rathore & Panwar, 2022)

b) **MNRE (The Ministry of New and Renewable Energy)**: Under the current Union Cabinet Minister Raj Kumar Singh, the Ministry of New and Renewable Energy (MNRE) of the Government of India is primarily in charge of patent protection, research and development, and worldwide cooperation, advertising, and oversight in the field of renewable energy sources, including wind, small hydro, solar, and biogas.

The main goal of the department is togrow and put into operation new, sources of energy that is renewable to help India connect its energy needs. Bhupinder Singh Bhalla is the ministry's secretary at the moment. The ministry's main office is located in New Delhi on Lodhi Road. The Ministry's annual report for 2016–17 states that the nation of India has achieved notable progress in several green energy sectors, including hydroelectricity, wind power, and solar energy. (Ministry of New and Renewable Energy, n.d.)

c) **SECI (Solar Energy Corporation of India Limited):**Established on September 20, 2011, "Solar Energy Corporation of India Ltd" (SECI) is a CPSU under the Ministry of New and Renewable Energy's (MNRE) managerial authority. Its primary objective is to assist in carrying out the National Solar Mission (NSM) and

accomplish every one of its objectives. It is the only CPSU that is exclusively focused on green energy. It was initially incorporated as a section 25 (not-for-profit) organization under the Companies Act of 1956.Yet the Indian government altered the company in 2015 so that it would fall in the 2013 Companies Act and be classified as a Section-3 company. Furthermore, the company's requirementsare being expanded to include the entire solar power industry.The current situation for the RE sector indicates that SECI is essential to the sector's expansion. The business is among the nodal entities. for carrying out various MNRE applications. Additionally, SECI has had success with developing turnkey solar projects for several PSUs and governmental organizations. (Introduction, n.d.)

d) **IREDA(Indian Renewable Energy Development Agency Limited):** The Ministry of New and Renewable Energy (MNRE) is in charge of the Indian Renewable Energy Development Agency Limited (IREDA), a Mini Ratna (Category I) Government of India Company. IREDA, a Public Limited Government organization, was founded in 1987 as a financial company that is not a bank and operates under its tagline "ENERGY FOR EVER." Assistance with economic development, and promotion for the start-up of initiatives about energy savings, storage, and renewable energy sources that are novel are among the things it does.Section 4'A' of the Companies Act, 1956 has notified IREDA as a "Public Financial Institution," and the Reserve Bank of India (RBI) has registered IREDA as a Non-Banking Financial Company (NBFC).

As the champion for self-sufficient investments in energy efficiency, environmental technology, and green energy production for long-term prosperity, take the lead in securing funding and promoting these areas. It serves as IREDA's declaration of purpose.(Indian Renewable Energy Development Agency Limited, 2022)

2.3 Challenges facing establishingthe solar market:

a) **GovernmentPolicy Uncertainty** Investors, developers,and financiers may find it difficult to make long-term commitments due to frequent changes or uncertainties in government policy frameworks.

b) **Land Acquisition:**Due to conflicting land uses, legal obstacles, and bureaucratic red tape, finding appropriate land for solar projects can be difficult. Policies for effective land management are essential to the development of projects.

c) **Discom Financial Health:**The distributioncompany's (discoms) financial problems may cause payments to solar generators to be delayed, which could have an impact on the cash flow and overall viability of projects.

d) **Import Dependency:**In terms of solar equipment, India has been dependent on imports. The solar industry needs policies that support homegrown manufacturing and lessen reliance on imports to remain sustainable.(Singh(YKS), 2023)

Conclusion:

The goals of solar PV installations must also be met with the aid of innovations in technology. The process of generating solar energy has the potential to accelerate India's growth path with aggressive study

and development, suitable legislation implementation, and financial programs that effectively deal with the financing of solar power installations.Since independence, India's solar industry has been developing thanks to several efforts.

In India, Solar Energy witnessed the shift from a simple duty to improve the community to more robust possibilities for social and economic development. All things considered, it can be said that state solar regulations and high-profile programs like the federal government's JNNSM have proved effective in igniting solar-powered power projects; however, the small-scale solar rooftop market in particular has not yet taken off. The bright side is that there is a ton of room for expansion in the rooftop solar energy market in a nation like India.

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Assessing the Efficacy of Skill Development Initiatives at RTMNU Nagpur University: A Study on Enhanced Job Placement and Entrepreneurial Outcomes.

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ABSTRACT:

The growth and development of a nation are heavily reliant on the dynamic duo of skills and knowledge. Countries with higher skills are better equipped to tackle the challenges and opportunities that arise in the workforce. As India continues to evolve into a knowledge-based economy, the country must prioritizedeveloping skills relevant to the changing economic landscape.(Sharma and Nagendra, 2016) To achieve sustainable economic growth and inclusive development, India's GDP must consistently grow at a rate of 8-9% per annum. This necessitates significant advancements in various sectors, including infrastructure development, agricultural productivity, financial sector growth, and a favorable business environment, all of which are contingent upon a skilled and competent workforce.(salman bashir memon, Dhar, 2021)The Planning Commission has been instrumental in promoting capacity building, educational accessibility, and overall human development. The allocation of resources has significantly contributed to the growth of the higher education sector, enabling the establishment of prestigious institutions such as IITs and IIMs(Bal, 2014) This study examines the implementation of the National Education Policy (NEP) 2020 by RTMNU, focusing on awareness among the educational community. The university has initiated a comprehensive plan, including workshops and training programs, and designed a student-centric curriculum prioritizing employability and skill development.

Keywords: Skills and knowledge Skill development program, job placement, self-employment, Nagpur region

INTRODUCTION:

The cultivation of a skilled workforce is a pressing imperative and a complex undertaking for policymakers, necessitating a robust education system and targeted training initiatives.(Aithal and Aithal, 2020) In today's economic landscape, the demand is not simply for human capital, but rather for specialized and adaptable professionals across various industries, which can be achieved through the development of innovative skill sets and curricula that address emerging needs.(Inwaeke and Obiekwe, 2017)Implementing skill development courses requires a new syllabus, trained instructors, and adequate infrastructure.

However, many educational institutions struggle to meet the high demand for specific skills due to limitations in training facilities, policy, and availability of qualified trainers, resulting in a shortage of skilled workers in areas like construction.(Oyebade, 2012)

By 2007, India's employment demand is expected to reach 800 million, with a majority requiring youth with technical and soft skills.(Heckman and Kautz, 2012)To thrive in a rapidly changing economy, workers will need to possess a range of adaptable skills, including the ability to think critically, collaborate effectively, communicate in multiple languages, and prioritize customer

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satisfaction, as emphasized by the Planning Commission.(Bal, 2014)

Unlike developed nations, where a significant majority of the workforce possesses specialized skills, India's skill development landscape is marked by fragmentation. A stark contrast exists, with only a small fraction of India's young workforce (20-24 years) holding formal vocational skills, highlighting the need for a swift overhaul of the country's skill development and entrepreneurship ecosystem. Currently, over 20 central government ministries and departments are implementing more than 70 skill development schemes, underscoring the need for a more streamlined and coordinated approach that addresses the industry's needs and enables a better quality of life for the population.(Bhardwaj and Jindal, 2016)The Indian skill development ecosystem is plagued by inadequate training facilities, subpar quality, and ineffective outcomes, further exacerbated by a lack of consideration for workers' career goals, standardized credentials, and the needs of the informal sector. In an effort to address these shortcomings, the government introduced skill development programs in 2009. To enhance coordination and cooperation among stakeholders, the Department of Skill Development and Entrepreneurship was inaugurated on July 31, 2014, ultimately leading to the establishment of the Ministry of Skill Development and Entrepreneurship on November 10, 2014. Since then, the Ministry has devised a multifaceted plan to scale up entrepreneurial initiatives across the country, seeking to narrow the skills deficit and drive economic progress.

The goal is to foster a thriving entrepreneurial environment by championing and promoting entrepreneurial spirit, while providing access to high-quality entrepreneurial resources, including cutting-edge curricula, expert guidance, and proven strategies. This will be achieved by developing innovative, technology-driven educational content, supported by local mentors and incubation networks, which will empower entrepreneurs with the skills and knowledge needed to succeed.(Saini, 2015)Consider a craftsman attempting to construct a sturdy edifice, armed with an abundance of raw materials but lacking the essential tools of the trade. A fragile hammer and a diminutive screwdriver cannot transform the raw materials into usable components. Similarly, the government

of Maharashtra has established a comprehensive framework for skill development across the state, extending to the district level. With an ambitious goal of producing 45 million skilled workers by 2022, the state has constituted the State Management Committee for Skill Development Initiative in Maharashtra, as well as Sectoral Skill Committees under the aegis of the Department of Higher and Technical Education.(Niharika Minz and Chandra Mehta, 2022)

Key skill development initiatives taken by the Government so far include:

A. **Sectoral Skill Development Committees**: Maharashtra's Sectoral Skill Development Committees have identified 11 high-growth trades, with comprehensive reports published for 9 sectors. The Maharashtra State Skill Development Society oversees skill development initiatives, responsible for updating the State Skill Gap Assessment Report and State Skill Development Plan. The society also accredits training providers and supports district and divisional committees in implementing Annual Action Plans.((MSSDS), Maharashtra State Skill Development Society (MSSDS), 2011)

B. **Knowledge Management Centre:** The Knowledge Management Centre on Skill Development has been proposed to be established at Yashada, Pune (Yashdha, 2024)

C. **Directorate of Establishment & Self Employment** has set up a dynamic Labour Market Information System (LMIS)(Meena and Pareek, 2020)

Various skill development programs:

Many government departments run skill development programs. Some of these are as follows:

A. **Employment Promotion Program (EPP):**The Department of Employment & Self Employment, Maharashtra runs the Earn and Learn Program (EPP), a stipend-based scheme providing on-the-job training for educated unemployed persons. The stipend ranges from Rs.300 to Rs.1000/month based on qualifications, and the 6-month program

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may lead to job absorption.(Gulavani, 2022)(9)

B. **Apprenticeship Training Program:**The Directorate of Vocational Education & Training, Maharashtra runs an apprenticeship training program, supplying skilled manpower to industry. The program covers 238 trades, with training durations ranging from 6 months to 4 years, and includes a stipend.

C. **Entrepreneurial Development & Training Program:**The Directorate of Industries, Maharashtra runs a program to motivate and train educated unemployed youth for self-employment, offered through institutions like MITCON and MCED, covering Entrepreneurship Development and Technical Training.(Ganguly, Gulati and von Braun, 2019)

Job Placement:
Placement is a crucial HR function that involves assigning the right person to the right job, as mismatching can cause significant damage to the organization.(Dymock, 2007)

LITERATURE REVIEW:
Employee training and development is crucial for organizational success in a competitive and changing business environment. Without training, employees become a liability, unable to adapt to new methods and processes, leading to obsolescence and inflexibility, which can hinder an organization's ability to innovate and compete. Acquiring skills, empowering youth, and promoting employment are proven ways to create opportunities and reduce unemployment. 13NEP 2020 aims to revamp India's higher education by incorporating international expertise and ICT to meet post-COVID needs, updating the outdated system to produce skilled manpower that meets global demands.(Sharma and Nagendra, 2016)Skilled India initiatives should prioritize entrepreneurship skills to boost job creation. Govt. schemes like PMKVY, DDU-GKY, and Skill India aim to make Indian youth skilled and employable, and they should be aware of and utilize these opportunities.(Prasad and Hod, 2016)(b)A skilled workforce is crucial for India's international competitiveness and economic growth, especially

as it transitions to a knowledge economy, requiring relevant skills that match emerging economic needs.(Turap *et al.*, no date)Skill development programs in Arts and Science universities offer numerous benefits, including improved job prospects, personal growth, and bridging the education-work skills gap, ultimately leading to long-term success and broader economic and societal advantages.(d)(Inwaeke and Obiekwe, 2017)

Importance of Skill Development Program:
Skill development programs enhance employability by teaching industry-relevant technical and soft skills, making students adaptable, resourceful, and job-ready.(Lee and McLoughlin, 2010)(12)Nagpur has a thriving skill development ecosystem, with initiatives like the Government of Maharashtra's Skill Development Centre (SDC) offering job-oriented programs like vocational training and apprenticeships.(Ugoani and Ibeenwo, 2015)(13)Top Nagpur institutes like VNIT and RTMNU have partnered with industry experts to create market-driven skill development programs in areas like engineering, IT, and healthcare.(India, 2009)

Impact of Skill Development Program on Job Placement:
The implementation of skill development initiatives in Nagpur has positively impacted job placement opportunities, as students who have undergone these programs are more likely to be preferred by employers due to their practical experience and relevant skills (Conningarth Economists, 2013)(14). Skill development initiatives in Nagpur give students a competitive edge, increasing their employability. Industries involved in these initiatives provide students with practical experience through guest lectures, industrial visits, and internships, making them more attractive to recruiters who value their knowledge and competence.(Nangare, Society and Ayarekar, 2022)Skill development programs in Nagpur also focus on entrepreneurship, promoting self-reliance and encouraging students to start their ventures, thereby creating job opportunities for themselves and others in the local economy.

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Review of the NEP Program Implemented by RTMNU:

Following are the Assessment of Skill Development Courses

- **A) The National Education Policy (NEP):**This review assesses the implementation of skill development courses by RTMNU under the National Education Policy (NEP), which prioritizes skill development in Indian education. The review involves analyzing RTMNU's NEP program through surveys, interviews, and secondary data from official documents and research articles.(Jackson, 2015)
- **B) Curriculum Design and Relevance:** RTMNU's NEP program offers a range of skill development courses across disciplines, with a well-structured curriculum that meets industry needs, providing practical knowledge and employability skills to make students market-ready.(Ganjapure, 2023)
- **C) Faculty Competence:** RTMNU's skill development courses benefit from industry experts as visiting faculty, who bring practical knowledge and experience to the classroom, complementing the academic qualifications of the faculty, and providing students with comprehensive learning experiences.(Sharna, 2019)
- **D) Infrastructure and Resources:**RTMNU has invested in modern facilities, labs, and resources, providing students with hands-on experience and practical skills. However, further investment is needed to enhance infrastructure for skill development courses.(Vigneshkumar, 2024)
- **E) Industry Collaboration and Placement Opportunities:**RTMNU's NEP program fosters industry partnerships, offering internships, visits, lectures, and placements, boosting student employability. The university has partnered with top companies, but continuous efforts are needed to strengthen these ties and provide more student exposure.(Khobragade and Zade, 2023)

RESEARCH METHODOLOGY

The study "Assessing the Efficacy of Skill Development Initiatives at RTMNU Nagpur University: A Study on Enhanced Job Placement and Entrepreneurial Outcomes" researches the impact of skill development courses on job placements in Nagpur. It combines quantitative and qualitative methods, using a survey questionnaire for random and judgmental data collection from Nagpur farmers (sample size=100 Students)

RESEARCH QUESTIONS:

- **A)** Have you heard of the term "skill development program"?
- **B)** Is a skill development program effective for Job placement?
- **C)** What level of student perception about Sill development of the program
- **D)** Is the a need to implement a Skill development program under NEP in certain university

OBJECTIVES OF THE STUDY:

- **A)** To know the need for a skill development program Nagpur region.
- **B)** To understand how a skill development program is helpful for job placement and job enhancement.
- **C)** To learn how Students feel and react to skill development programs run by the government and Under the university throughout NEP.
- **D)** To know the difference between skill development programs and traditional learning.

DATA ANALYSIS:

Analysis:1Education of Respondents * Have you heard of the term "skill development program in the education sector Under NEP before?

Have you heard of the term "skill development program in the education sector Under NEP before?						
Count						
		Have you heard of the term "Skill development program " before?				
		Not familiar at all	Heard of it, but not familiar with it	Neutral	Somewhat familiar	Yes, very familiar	Total
Education of Respondents	Higher Secondary	0	0	0	8	7	15
	Graduation	1	3	2	8	12	26
	Post-Graduation	0	2	5	14	38	59
Total		1	5	7	30	57	100

Table 1:Table 1- Composition of Education with Level of Awareness Skill Development Program.

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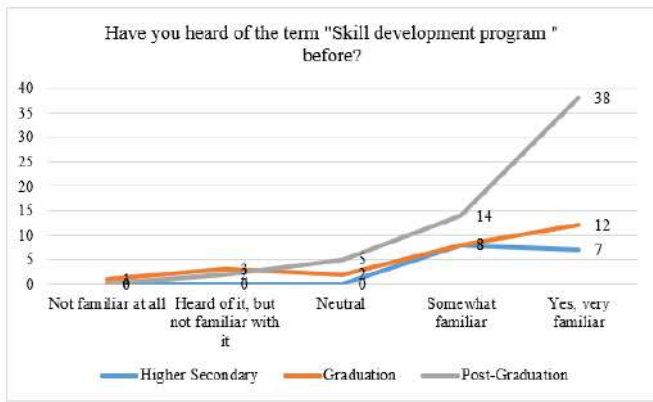
Graph 1: Composition of Education with Level of Awareness Skill Development Program.

Most responses in the study came from postgraduates and graduate students, who value Education with a Level of Awareness of Skill Development Programs in India. These programs enhance education quality, promote sustainability, and support personal and social growth, focusing on personal development, stress reduction, environmental awareness, and social responsibility.

Analysis 2: Is that any need to run a skill development program by the Government or RTMNU

		Is that any need to run a skill development program					
		Not familiar at all	Heard of it, but not familiar with it	Neutral	Somewhat familiar	Yes, very familiar	Total
Education of Respondents	Higher Secondary	0	0	0	2	3	5
	Graduation	0	0	4	12	28	44
	Post-Graduation	0	0	7	13	31	51
Total		0	0	11	27	62	100

Table 2: Is that any need to run a skill development program by the Government or RTMNU?
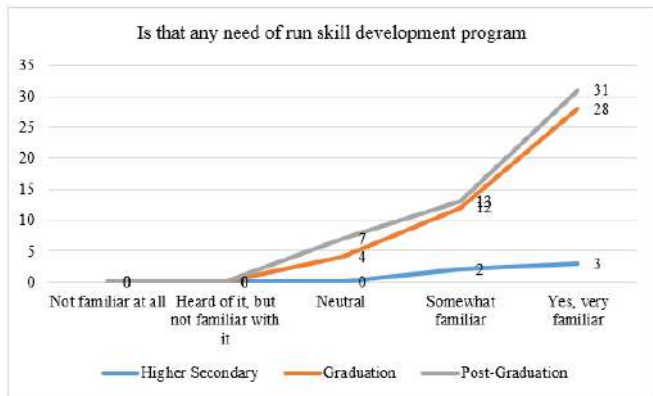
Graph 2: Composition of question, Is that any need to run a skill development program By the Government or RTMNU

The Government and RTMNU have established a Technical Skill Development Centre to address the need for skill development, providing opportunities for students and researchers to engage with new technologies and promoting rural development, innovation, and technological advancement.

Analysis 3: Is a skill development program effective for Job placement *?

		Is that any need to run a skill development program					
		Not familiar at all	Heard of it, but not familiar with it	Neutral	Somewhat familiar	Yes, very familiar	Total
Education of Respondents	Higher Secondary	0	0	0	0	0	0
	Graduation	0	0	4	11	16	31
	Post-Graduation	0	0	7	14	48	69
Total		0	0	11	25	64	100

Table 3:Is a skill development program effective for Job placement

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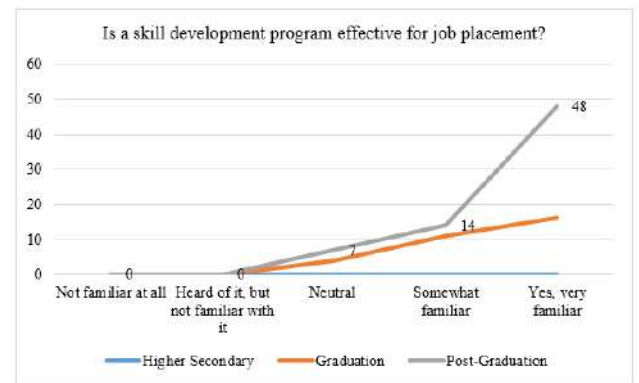
*Graph 3:Is a skill development program effective for Job placement *?*

Skill development programs can effectively bridge the skills gap, increase competitiveness, and foster economic growth by enhancing workforce skills, knowledge, and capabilities, ultimately leading to job placement and reduced unemployment.

Analysis 4: Is the a need to implement a Skill development program under NEP in certain

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university

Is the a need to implement a Skill development program under NEP at RTMNU University?							
		Count					
		Is that any need of run a skill development program					
		Not familiar at all	Heard of it, but not familiar with it	Neutral	Somewhat familiar	Yes, very familiar	Total
Education of Respondents	Higher Secondary	0	0	0	2	1	3
	Graduation	0	0	2	8	23	33
	Post-Graduation	0	0	3	12	49	64
Total		0	0	5	22	73	100

Table 4:Is the a need to implement a Skill development program under NEP at RTMNU University?
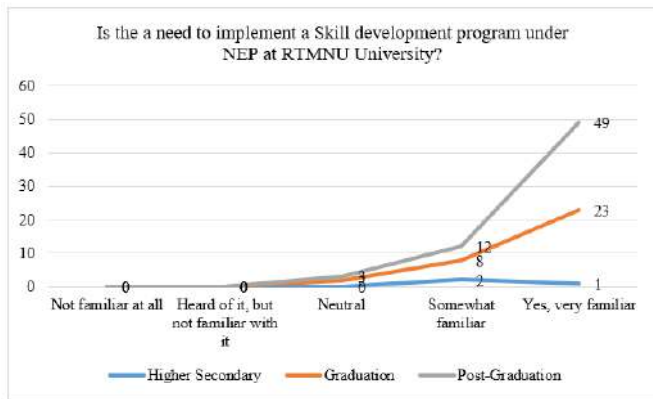
Graph 4:Is the a need to implement a Skill development program under NEP at RTMNU University?

The National Education Policy prioritizes skill development, industry connections, and holistic education to produce industry-ready graduates with domain expertise, digital literacy, and entrepreneurial spirit.

CONCLUSION:

Skill development programs in Nagpur have produced industry-ready professionals, bridging the gap between academic learning and workplace demands. Collaboration between industry players, educational institutions, and government is essential to continue supporting these initiatives and fostering a robust job market and sustainable economic growth.(Journal, Advance and Wachasundar, 2022)

Overall, the NEP program implemented by RTMNU demonstrates commendable efforts in imparting skill development courses to college students. The curriculum design, faculty competence, infrastructure, and industry collaborations contribute significantly to the effectiveness of these courses. With continued investment and refinement, RTMNU can further strengthen its skill development program and ensure that students are adequately prepared to meet the demands of the modern workforce. The NEP program implemented by RTMNU represents a significant step towards ensuring the holistic development of college students. The review concludes that the university has successfully integrated skill development courses into its curriculum. The efforts made by RTMNU deserve recognition for fostering the growth of competent individuals who possess industry-relevant skills. However, ongoing commitment is necessary to sustain and improve these initiatives. RTMNU must continue to adapt in response to changing industry needs and strive for excellence in skill development education.(Mardikar, 2023)

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The Impact of AI and Automation on HR Functions and Workforce Planning

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ABSTRACT

The quick headway of Fake Insights (AI) and mechanization is changing Human Asset Administration (HRM), reshaping conventional HR capacities and workforce arranging methodologies. This paper investigates the affect of AI-driven advances on key HR forms, counting ability procurement, execution administration, worker engagement, and workforce analytics. AI-powered enlistment instruments improve enlisting proficiency by robotizing continue screening and candidate evaluation, diminishing predispositions, and progressing decision-making. In execution administration, AI-driven analytics give real-time criticism and prescient experiences to optimize worker efficiency and maintenance procedures. Moreover, mechanization streamlines schedule regulatory errands such as finance handling, benefits organization, and compliance following, permitting HR experts to center on key activities. In any case, in spite of these points of interest, AI appropriation in HRM moreover raises concerns related to information protection, moral suggestions, and potential work uprooting. Organizations must adjust mechanical progressions with human-centric approaches to preserve representative believe and engagement. The ponder highlights the require for reskilling activities to get ready the workforce for AI-driven changes and emphasizes the part of HR in encouraging a smooth move. By leveraging AI mindfully, businesses can improve HR proficiency, drive data-informed choices, and make a more spry workforce. The paper concludes by suggesting best hones for joining AI into HRM whereas guaranteeing moral contemplations and workforce versatility.

KEYWORDS:*AI in HRM, robotization, workforce arranging, HR analytics, representative engagement, ability procurement, execution administration, work relocation, advanced change, moral AI.*

INTRODUCTION

Artificial Intelligence (AI) and robotization are revolutionizing Human Resource Management (HRM), in a general sense changing how organizations draw in, oversee, and hold ability. As businesses progressively embrace computerized change

techniques, AI-driven HR advances are playing a vital part in streamlining authoritative forms, improving decision-making, and moving forward workforce arranging. From mechanized continue screening to prescient workforce analytics, AI is reshaping conventional HR capacities, making them more productive and data-driven.

One of the foremost noteworthy impacts of AI in HRM is in ability procurement. Computerized enrollment devices, such as AI-powered applicant tracking systems (ATS), offer assistance HR experts screen resumes, evaluate candidate reasonableness, and indeed conduct introductory meet rounds utilizing chatbots. These advancements not as it were diminish enlisting time but too minimize human predispositions, driving to more assorted and comprehensive contracting hones. Additionally, AI-driven analytics help HR supervisors in foreseeing worker turnover, recognizing aptitude crevices, and defining proactive ability maintenance procedures.

Past enrollment, AI and robotization upgrade worker engagement and execution administration. Machine learning calculations can analyze worker behavior, giving personalized input and advancement plans to make strides work fulfillment and efficiency. Mechanized HR frameworks handle schedule errands such as finance preparing, benefits organization, and compliance following, liberating HR experts to center on vital activities such as representative well-being, learning and advancement, and organizational culture.

In spite of these focal points, the integration of AI in HRM moreover presents challenges. Moral concerns, such as information security, predisposition in AI calculations, and the potential relocation of human employments, must be tended to to guarantee dependable AI appropriation. Besides, as mechanization takes over tedious errands, HR experts must adjust by upskilling and grasping modern parts that emphasize human-centered authority and strategic workforce arranging.

This paper analyzes the transformative affect of AI and computerization on HRM capacities and workforce arranging. It investigates the benefits, challenges, and moral contemplations related with AI-driven HR innovations and gives suggestions for organizations to effectively coordinated AI whereas keeping up a human-centric approach. By leveraging AI capably, HR pioneers can improve productivity, move forward representative encounters, and construct a future-ready workforce within the computerized age.

OBJECTIVES

The integration of Counterfeit Insights (AI) and computerization in Human Asset Administration (HRM) is reshaping conventional workforce hones and driving a move toward data-driven decision-making. This consider points to investigate the transformative affect of AI on HR capacities and workforce arranging by tending to key targets:

1. To Analyze the Part of AI in Ability Procurement andEnrollment

• AI-powered enlistment instruments, such as Candidate Following Frameworks (ATS) and AI-driven chatbots, streamline the contracting handle by robotizing continue screening, candidate appraisals, and beginning meet rounds. This objective looks at how AI upgrades enrollment proficiency, diminishes inclinations, and progresses the by and large candidate involvement.

2. To Assess the Affect of AI on Execution Administration and Worker Engagement

• AI-driven HR analytics play a significant part in following worker execution, giving real-time input, and anticipating workforce patterns. This ponder points to survey how robotization progresses worker engagement, inspiration, and efficiency by advertising personalized career improvement experiences and preparing suggestions.

3. To Explore the Utilize of AI in Workforce Arranging and Prescient Analytics

• AI and mechanization encourage workforce arranging by analyzing representative information to foresee turnover rates, ability crevices, and future workforce requests. This objective investigates how prescient analytics offer assistance HR experts create proactive ability administration techniques, guaranteeing long-term commerce maintainability.

4. To Look at the Productivity of AI in HR AuthoritativeCapacities

• Schedule HR assignments, counting

finance handling, benefits organization, and compliance administration, can be robotized utilizing AI, decreasing mistakes and progressing effectiveness. This think about assesses how robotization empowersHR experts to center on key activities, such as representative well-being and administration advancement.

5. To Recognize Moral and Protection Concerns Related to AI in HRM

• Whereas AI offers various benefits, concerns approximately information security, security, algorithmic predisposition, and moral AI utilization remain significant. This objective points to highlight the dangers related with AI in HR and propose measures to guarantee moral and straightforward AI selection.

6. To Evaluate the Require for Reskilling and Upskilling HR Experts and Workers

• As AI and mechanization reshape HR parts, HR experts and representatives must adjust by securing unused abilities. This think about looks for to investigate the significance of reskilling activities and deep rooted learning to guarantee workforce flexibility in an AI-driven HR biological**system**.

7. To Supply Proposals for the Capable Integration of AI in HRM

• The think about points to offer best hones for organizations to viably actualize AI-driven HR arrangements whereas keeping up a human-centric approach. These suggestions will offer assistance businesses use AI dependably to improve HR effectiveness, progress worker encounters, and foster workforce strength within the advanced time.

PROBLEM STATEMENT

The fast integration of Fake Insights (AI) and computerization in Human Resource Management (HRM) is changing conventional workforce hones, essentially affecting ability procurement, execution administration, worker engagement, and workforce arranging. Whereas AI-driven advances offer expanded proficiency, taken a toll reserve funds, and data-driven decision-making, their far reaching selection presents a few challenges that must be tended to to guarantee economical and moral usage.

One major concern is the potential for inclination in AI-driven enlistment frameworks. In spite of the fact that AI points to decrease human predispositions, imperfect calculations and one-sided preparing information can lead to oppressive enlisting choices, influencing differences and incorporation endeavors. Moreover, AI-powered ability procurement apparatuses may need the human touch required for successful candidate assessment, driving to potential bungles between work searchers and parts.

Another critical challenge is the affect of robotization on work uprooting and workforce rebuilding. As tedious HR errands, such as finance preparing, benefits organization, and compliance following, gotten to be mechanized, HR experts must adjust by upskilling to stay pertinent. Be that as it may, numerous organizations need comprehensive reskilling methodologies, which may result in workforce redundancies and work uncertainty.

Furthermore, information protection and moral concerns emerge with AI-driven HR analytics, as organizations collect and analyze tremendous sums of worker information. The hazard of information breaches, abuse of individual data, and need of straightforwardness in AI decision-making forms raise moral problems that may affect representative believe and working environment resolve.

Moreover, the need of clear administrative systems administering AI selection in HRM makes it troublesome for businesses to set up best hones. Organizations battle to adjust AI proficiency with human-centered HR strategies, ensuring that computerization improves instead of replaces basic human intelligent.

This ponder points to investigate these challenges and give experiences into how businesses can capably coordinated AI into HR capacities and workforce arranging whereas tending to moral concerns, advancing worker well-being, and guaranteeing a future-ready workforce. By analyzing both the openings and risks related with AI-driven HRM, this inquire about looks for to supply vital proposals for organizations looking to tackle AI's potential whereas keeping up a human-centric approach to workforce

administration.

NEED OF THE STUDY

The expanding selection of Artificial Intelligence (AI) and computerization in Human Resource Management (HRM) is changing conventional HR capacities and workforce arranging. As businesses endeavor for effectiveness, AI-powered arrangements are being coordinates into enlistment, execution administration, worker engagement, and prescient workforce analytics. In any case, in spite of its benefits, AI selection moreover raises critical challenges that have to be be investigated. One major concern is algorithmic inclination and decency in AI-driven enlisting forms, which may inadvertently strengthen segregation in the event that not appropriately overseen. Also, the robotization of HR assignments such as finance handling and compliance following leads to concerns around work uprooting and the require for HR experts to reskill and upskill.

In addition, information protection and moral concerns are getting to be progressively important as AI frameworks handle tremendous sums of delicate representative data.

Organizations must guarantee that AI execution adjusts with legitimate and moral benchmarks to preserve worker believe.

This consider is vital to analyze how businesses can capably coordinated AI into HRM, maximizing proficiency whereas tending to dangers such as predisposition, work uprooting, and moral challenges. By looking at AI's affect on workforce arranging, this inquire about will offer assistance organizations create feasible HR techniques, guaranteeing a adjusted approach between innovation and human-centric HR administration.

PROPOSED WORK

This think about points to investigate the transformative affect of Artificial Intelligence (AI) and robotization on Human Resource Management (HRM) capacities and workforce arranging. The inquire about will analyze how AI-driven innovations are reshaping ability securing, execution administration, worker engagement, and HR decision-making forms.

The proposed work will include:
1. Writing Survey: A comprehensive examination of existing thinks about on AI applications in HRM, highlighting key patterns, challenges,and best hones.
2. Information Collection: Gathering subjective and quantitative information from organizations that have executed AI in HR capacities through overviews, case ponders, and master interviews.
3. AI-Powered HR Arrangements Assessment: Evaluating the viability of AI-driven enlistment devices, execution following frameworks, and workforce arranging calculations.
4. Moral Contemplations: Exploring challenges such as algorithmic predisposition, information security concerns, and work uprooting dangers.
5. Affect Appraisal: Assessing how AI selection makes strides HR productivity, representative fulfillment, and key workforce arranging.
6. Suggestions: Proposing best hones for capable AI integration, emphasizing human-AI collaboration, decency, and moral compliance.

By analyzing these components, this think about will give vital experiences for businesses to use AI successfully whereas guaranteeing a adjusted, human-centric approach to HRM within the computerized period.

SYSTEM ARCHITECTURE

The framework engineering for AI and robotization in HRM comprises of different coordinates components that streamline HR capacities, improve decision-making, and optimize workforce arranging. The design is outlined to handle, analyze, and translate HR information proficiently whereas guaranteeing security and moral AI appropriation.

1. Information Collection Layer
- Sources: Representative records, resumes, execution surveys, finance information, studies, and outside work showcase patterns.
- Apparatuses: AI-powered Candidate Following Frameworks (ATS), HR Data Frameworks (HRIS), and cloud databases.

2. Information Preparing & AI Analytics Layer
- Machine Learning Calculations: Analyze workforce patterns, foresee whittling

down, and optimize enrollment forms.
- Common Dialect Preparing (NLP): Robotizes continue screening, chatbots for worker inquiries, and opinion investigation.
- Prescient Analytics: Figures workforce request, ability holes, and worker execution patterns.

3. Decision-Making & Mechanization Layer
- AI-Powered Enrollment Frameworks: Robotized candidate screening, meet planning, and differing qualities examination.
- Execution Administration & Input Frameworks: AI-driven execution following and personalized worker improvement plans.
- Chatbots & Virtual Collaborators: Mechanize HR questions, onboarding forms, and real-time representative back.

4. Security & Moral Compliance Layer
- Information Security Instruments: Secure encryption, get to control, and compliance with GDPR and HR directions.
- Predisposition & Reasonableness Observing: AI examining frameworks to identify and moderate algorithmic inclination in enlisting and advancements.

5. Client Interface & HR Engagement Layer
- Intelligently dashboards for HR experts to track workforce measurements and create reports.
- Representative self-service entrances for getting to HR administrations, finance, and learning modules.

This engineering guarantees productivity, straightforwardness, and decency in AI-driven HRM whereas keeping up a adjust between computerization and human oversight.

METHODOLOGY

This study will embrace a mixed-method approach, combining both subjective and quantitative inquire about procedures to analyze the affect of AI and robotization on HR capacities and workforce arranging.

1. Literature Review:
- A comprehensive survey of existing investigate, scholastic papers, industry reports, and case thinks about on AI-driven HRM hones.
- Distinguishing proof of key patterns, challenges, and best hones in AI appropriation for HR capacities.

2. Information Collection:
- Essential Information: Studies and organized interviews with HR experts, AI specialists, and representatives from organizations utilizing AI-driven HR frameworks.
- Auxiliary Information: Examination of HR analytics reports, company case considers, and government labor insights on workforce computerization patterns.

3. Information Investigation:
- Quantitative Examination: Measurable assessment of study reactions to degree AI's affect on HR effectiveness, representative engagement, and workforce arranging.
- Subjective Examination: Topical examination of interviews to get it challenges, moral concerns, and best hones in AI-driven HR decision-making.

4. Discoveries & Proposals:
- Distinguishing proof of AI's benefits and dangers in HRM.
- Improvement of vital proposals for moral and successful AI integration in HR.

This technique guarantees a comprehensive, data-driven understanding of AI's part in cutting edge HRM, adjusting mechanical headways with human-centric workforce techniques.

FUTURE SCOPE

The future of AI and robotization in Human Resource Management (HRM) is anticipated to bring critical progressions, changing workforce arranging and HR capacities. As AI proceeds to advance, its applications in ability securing, execution administration, representative engagement, and workforce analytics will ended up more refined and effective.

One key zone of future improvement is AI-driven

prescient workforce arranging, where machine learning models will forecast ability deficiencies, representative turnover, and required aptitude sets. This will empower organizations to create proactive contracting and reskilling choices, guaranteeing commerce progression. Moreover, AI-powered chatbots and virtual HR colleagues will ended up more modern, giving representatives with real-time bolster, personalized career advancement proposals, and mental wellbeing help.

Another critical zone is the moral and reasonable utilize of AI in HR. Future investigate and improvement will center on bias-free AI models that guarantee decency in contracting, advancements, and execution assessments. Also, reasonable AI (XAI) will improve straightforwardness, permitting HR experts and workers to get it how AI-driven choices are made. Coordination blockchain with AI may too improve information security and confirmation forms, guaranteeing security and compliance in HR operations.

As AI takes over schedule HR errands, HR experts will move to vital parts, centering on human-AI collaboration, ethical workforce administration, and representative well-being. Future investigate ought to investigate AI's long-term affect on work structures, vital reskilling programs, and the adjust between robotization and human oversight to make a maintainable and comprehensive workforce.

CONCLUSION

The integration of Artificial Intelligence (AI) and computerization in Human Resource Management (HRM) is revolutionizing conventional workforce hones, improving productivity, and empowering data-driven decision-making. AI-driven devices are changing ability securing, execution administration, worker engagement, and workforce arranging, permitting HR experts to center on vital activities instead of schedule regulatory errands.

Whereas AI and mechanization offer noteworthy benefits, such as progressed enrollment effectiveness, real-time execution bits of knowledge, and prescient workforce analytics, they moreover show challenges. Concerns related to algorithmic inclination, information protection, work uprooting, and moral AI usage must be carefully tended to to guarantee

dependable and reasonable selection. Organizations must create bias-free AI models, upgrade straightforwardness in AI decision-making, and prioritize moral contemplations to preserve representative believe.

Also, the quick selection of AI requires reskilling and upskilling of HR experts and workers to adjust to advancing workforce requests. A balanced approach, where AI complements human decision-making instead of supplanting it, is basic for maintainable HR change. This consider highlights the significance of capable AI integration in HRM, emphasizing reasonableness, straightforwardness, and human-AI collaboration. By leveraging AI viably, organizations can optimize workforce administration, upgrade worker experiences, and construct a future-ready HR environment whereas keeping up a human-centric approach within the computerized period.

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The Impact of Online Marketing on Start-ups and Small Businesses

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ABSTRACT

Over the past decade, online marketing has emerged as a crucial element in the promotion of products and services referred to as Internet marketing, it utilizes interactive virtual spaces to promote and sell products and services. The emergence of internet-based communication technologies has profoundly transformed numerous economic sectors, including marketing. In a highly competitive marketing landscape, many start-ups and small companies fail quickly, primarily due to the selection of ineffective marketing strategies. Internet marketing provides startups and small companies with creative ways to connect with their target audience. The purpose of this study is to investigate how internet marketing helps small and startup companies grow and expand their operations.

This paper looks at the significance and effects of digital marketing on the competitive launch of new companies.Further investigation into whether digital marketing may significantly impact startup growth, improve brand awareness, increase consumer loyalty, and fortify customer connections is planned for this study. There has not yet been any prior research on this idea. The hypothesis that social media positively fosters creativity in startup firms is supported by the correlation between social media and innovation in startups.—was the only relevant study we could find. Using a qualitative methodology, the study examined five startup companies. Semi-structured interviews are the main method of data collection used in this thesis, with the goal of examining the importance and effects of digital perspectives. Additionally, secondary data for the study was acquired from peer-reviewed papers, journals, and websites. The study comes to the conclusion that building, maintaining, and forging consumer relationships may be done creatively and effectively with digital marketing. The most advantageous online channels and platforms for startups have been demonstrated to include websites, forums, and industry-specific sources. It also suggests that by increasing customer knowledge, building trust, and boosting brand recognition, digital marketing may help a new company grow dramatically. Nevertheless, most startup companies are reluctant to employ digital marketing strategies when they initially launch. Our findings will be beneficial.Some startups are thinking about using digital marketing into their campaigns. A related but more thorough study contains recommendations for additional research.

Keywords:Online Marketing, Start-ups, Compact Businesses, Technology, Conventional Marketing.

INTRODUCTION:

Today, online presence is an integral aspect of daily life. People remain connected to the internet around the clock via smartphones and desktops, while social media platforms keep them actively engaged. Recent studies reveal that India ranks second in terms of internet marketing market after China, with forecasts suggesting the country will reach 1 billion users by 2025. As of early 2020,

internet penetration in India had reached 50%, significantly changing marketing practices by shifting from traditional media like newspapers to online and social media platforms. Businesses have also adapted to this change, as it is crucial to reach a large customer base. While traditional marketing remains important, integrating with online channels and aligning with business objectives is essential for standing out and achieving success.

Online marketing enables companies to creatively convey product awareness and usage to a broad audience. It provides various tools that enhance customer engagement by incorporating

Graphics and animated content into online ads, thereby attracting attention and boosting brand visibility. Also referred to as Internet marketing, In order to attract customers and entice them to consider making a purchase when they come across the brand online, this area of digital marketing focuses on developing and conveying the value of a product or service.While Digital marketing builds on traditional marketing strategies, a successful approach requires a balance between online and traditional methods. Companies that have effectively embraced online marketing, often outperforming competitors with minimal or vague online presence, gain a significant competitive advantage

Figure: Customer Lifecycle Marketing touch point Summary For a Busies-To-BusinessOrganisations

Our surroundings are always changing and evolving in which we live. The world is changing constantly, and technological growth is one major factor. Nearly everyone has some sort of connection to digital technologies. Hours are rapidly passed by as people use their laptops, tablets, and phones. This presents a range of advantages for businesses looking to transition to digital. .It makes sense, then, that marketing strategies have evolved significantly from advertising in newspapers and on television to marketing through Internet and digital media.

Regardless of size, digital marketing is the cornerstone of any company's marketing strategy. Nobody starts a business without first creating a thorough plan for digital marketing. The most widely used marketing strategy in contemporary technology is digital marketing (Kamal, 2016).

According to Dwivedi et al. (2020), digital marketing for startups facilitates the adaptation of new enterprises to the marketing strategies and plans of their target audience while abiding by the dynamic complexity of consumer behavior. In the current day, creating a corporate identity is a crucial strategic requirement for startups. (Mingione&Abratt, 2020).

The relevance of startup enterprises has grown significantly over the past 20 years, as they are increasingly vital to the expansion of the economy (Mingione&Abratt, 2020). Global governments have encouraged and provided incentives for new businesses to sustain a competitive edge (Glaeser et al., 2010).

LITERATURE REVIEW:

A) Linking the possible impacts of prolonged digital marketing to the expansion of startups: creating a macrodynamic framework of digital marketing-supported startup growth drivers, AneeshZutshi, Antonio Grilo, TaherehNodehi, and BelmaRizvanovi', 2023 As it expands its impact potential to address various growth difficulties, the current market places digital marketing as a powerful mediator between effective digital interaction, opportunities for data interpretation, and corporate success.

B) By leveraging the low cost of entry and dynamic features of digital marketing tools, it is possible to support positive digital interactions

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that have an impact on startup growth, as most startups have limited funding and struggle with client acquisition, retention, and other growth issues. Consequently, these connections have outlined the broader scope of digital marketing's influence in areas that support sales and marketing as well as growth-related elements including customer interaction, product and market testing, and alliance formation.

C) Marketing viewpoints on digital business models: An introduction and summary of the particular topic, Tammo and Peter C. Verhoef H.A. Bijmolt (2019). Markets are shifting due to digital solid advances, and businesses may choose to implement a digital business strategy in response. These digital business concepts are the subject of this special edition. In this editorial, we address the applicability of digital business models, put forth a theoretical framework, and talk about the ways in which they impact markets, firms, and company performance. We provide an overview of the papers in this issue and demonstrate how they mesh with the overall idea. We talk about four important directions for further study.

D) Towards a Framework for Business Resilience in Startups Leo Aldianto, Ian O. Williamson, GrisnaAnggadwita, AnggraeniPermatasari, and IstiRaafaldiniMirzanti, 2021 Covid-19 has significantly changed how the world economy operates. is being disrupted, especially for new firms. This motivates business owners to engage in a constant process of innovation in order to improve their ambidexterity and future-proof their enterprise. By analyzing knowledge (knowledge stock), conduct (agile leadership), and capacity (innovation ambidexterity, dynamic capability, and technological competence) in startup firms , the article seeks to create a paradigm for company

resilience. In order to gain a deeper understanding of startup resilience and its application, this study synthesizes existing material.

E) Heading toward a revolution in digital platforms? An explanation of the causes, variables, and theoretical structure of offline B2B networks AoSchwengberPeruchi, Diego Falc Carla ten Caten, Bruna Villa Todeschini, Diego Augusto de Jesus Pacheco, 2022 Building fruitful networking connections with businesses both inside and outside the value chain makes the company more competitive. Today, these networked relationships are made possible by the continuous revolution in digital platforms. However, even if recent technical developments have made business contacts easier, there still has to be greater clarity surrounding the ways in which offline B2B networks use digital platform solutions. Furthermore, there has to be a greater understanding in the literature of the antecedents and variables that propel their engagement.

F) The Impact of Internet Marketing on a Small Enterprise Mia Musso (2017) The goal of this assignment is to examine the social media methods now used by Ambiance, a local company, and determine which strategy will work best for reaching the most amount of consumers. Given that the target market is expanding in tandem with emerging technological advancements, I'm interested in finding out if our present marketing strategies are reaching the greatest number of potential clients. I'll find out which approach works best for our target market by setting up a poll that focuses on email and social media usage. Given the wide age range of our clientele, Ambiance and other small businesses might gain from knowing where clients want to see a business's marketing.

G) the Impact of Internet Marketing on

New and Small Enterprises 2020 Dr. Ch. Nirmal Chand, Ms. G. YaminiOnline marketing has grown to be one of the most important aspects of product and service marketing in the last ten years. Another name for online marketing is internet marketing. It entails using interactive online environments to market and sell products and services. Marketing is one of the numerous economic areas that has undergone transformation as a result of internet-based communication technology. Due to the intense rivalry in the marketing space, a large number of small and startup businesses are failing rapidly. Selecting the incorrect marketing strategy is the cause of this failure. Online marketing, then, aids small and startup companies in creatively reaching clients. The aim of this research is to ascertain the ways in which internet marketing facilitates the growth of small and startup businesses.

RESEARCH OBJECTIVE:

A) To assess the significance of online marketing.
B) To determine the reasons behind the failure of start-ups and small businesses.
C) To evaluate how internet marketing techniques affect small enterprises.
D) To explore techniques that start-ups and small businesses can use to enhance awareness and boost sales.

METHODOLOGY:

The study used a quantitative research approach to investigate the influence of internet marketing on the prosperity of small and startup enterprises. The purpose of this study is to examine how these companies may expand and increase product sales. Secondary data is gathered from a variety of sources, including renowned organizations' websites, publications, and research papers, which serve as sources of reference for the data collecting process.

The objective of the qualitative descriptive case study was to provide an account of the time and financial resources allocated to marketing by microbusiness owners.

The microbusiness owner also gave an overview of her experience in marketing. The three factors of time, money, and marketing skill were then connected with the microbusiness owner's evaluation of the sales performance. Furthermore, various facets of microbusiness marketing including resources like time, money, and marketing knowledge were investigated and explained. Prior studies have specifically mentioned networking, word-of-mouth, personal sales, digital marketing, Building relationships and developing a brand are two marketing strategies that may be carried out on a lower budget.

The best methodology for this research was determined to be a qualitative descriptive case study. According to Yin (2017), case study research was preferred when the focus was on a contemporary phenomenon and How and why the researcher had no influence over the study events was the subject of the research inquiries. The research on limited resources—time, money, and marketing expertise—focuses on the how and why of marketing because the researcher cannot control the events. It is compatible with Yin's concepts to explain how microbusinesses address these issues in day-to-day marketing.

The following three research approaches were assessed: mixed methodologies, quantitative, and qualitative. This study tool will examine the effects of digital marketing on small-scale startup enterprises using both qualitative and quantitative research approaches.

We'll use the following research techniques:

1. **Surveys**: To get information about small-scale startup companies' present digital marketing plans and methods as well as their perceptions of their influence on the expansion and prosperity of their enterprises, a survey will be administered to them. Demographic information about the businesses, including size, industry, and location, will also be gathered through the survey.
2. **Case Studies:** A number of case studies on prosperous small-scale startups employing efficient digital

marketing techniques will be carried out. The case studies will look at these companies' tactics and how they affect the expansion and success of their companies.

3. **Expert Interviews:** To obtain information and viewpoints regarding the effects of digital marketing on small-scale startup enterprises, there will be a number of professional interviews with industry experts, small company owners, and digital marketing specialists. The semi-structured interview questions are intended to elicit in-depth answers on particular digital marketing-related subjects.

4. **Data Analysis:** Data from surveys, case studies, and expert interviews will be analyzed using both qualitative and quantitative methods. Qualitative data analysis concentrates on identifying themes and patterns in the data, whereas quantitative data analysis includes statistical analysis of the survey data.

LIMITATION:

The research aims to analyze digital marketing tactics specifically for small enterprises and start-ups. The scope of the study is limited to examining marketing techniques employed by these businesses. The following limitations were found for startup small business throughout online.

A) **Startup and small business:** A start-up company is launched with the aim of creating a new product and generating demand for it. Its main goals are to achieve rapid growth and establish a unique position in the market, thereby drawing attention from other businesses. In contrast, small enterprises operate on a smaller scale, involving lower capital investment, fewer employees, and minimal machinery. They typically begin by focusing on a specific customer group and, once they establish a foothold, seek to grow their business. Each day, new brands enter the marketplace, facing competition from established companies and numerous marketing campaigns. For start-ups and small businesses, several factors can hinder their growth and sustainability. According to surveys, a lot of firms collapse two years after they are established. Several causes contribute to these failures, including the following:

B) **Insufficient funding:** If you've launched a company and things aren't progressing as planned, and you have limited capital while your business is struggling, it may be challenging to secure another loan. It's Crucial to have started with a realistic financial plan, ensuring that you have enough funds to sustain your business until it becomes operational and starts generating revenue. Inadequate initial funding can indicate that the business may not be viable, leading to continued financial difficulties and the burden of repaying existing debt.

C) **Poor location and inadequate online presence:** A poor business location often involves targeting specific customer groups in remote areas and relying heavily on traditional marketing methods. This approach can be problematic if there is also a weak online presence. Today, a strong presence on the internet and social media is as crucial as a company's physical address. An effective digital presence allows potential customers to discover and engage with your business. To ensure marketing efforts are successful, they must not only reach a broad audience but also target the right people. Therefore, companies should prioritize on both conventional and digital marketing strategies.

D) **Limited prominence:** If potential customers are unable to locate your business, they are unlikely to become actual customers. Therefore, it's essential to ensure strong business visibility.

E) **Insufficient marketing knowledge:** Without a strong grasp of market dynamics, making informed decisions becomes difficult, which can adversely affect a business. Consequently, companies frequently depend on their marketers' expertise

and decision-making skills.

F) **Market rivalry:**In today's competitive Industry with ever-evolving trends, starting and growing a small business presents significant challenges. Small business owners must navigate historical data, current trends, future planning, and daily unexpected interruptions. Companies must time their business launch carefully.

G) **Influence of Online Marketing:**Online marketing has become a crucial element for driving business expansion and building brand identity, especially as the number of online users continues to rise, expanding the potential target audience. The pool of potential customers online is significantly larger than what traditional methods might attract. Marketing strategies have rapidly evolved, with many businesses investing in online marketing to facilitate interaction and communication with customers, thereby fostering business development. Compared to traditional marketing, the online market has less competition since each business employs its own unique approach to online promotion. Today, online marketing is essential in today's marketing landscape, providing innovative methods to connect with and meet customer needs while delivering real- time services. It also offers greater accessibility to customers than traditional marketing approaches.

H) **Increased conversion rates with an effective strategy:**The conversion rate is the proportion of website visitors that complete a targeted activity. Online marketing companies help organizations increase the amount of visitors who meet their goals by using tactics for conversion rate optimization. Regardless of the business type the primary objective for any expanding business is toGenerate sales leads through the promotion of products or services. These leads, in turn, enhance sales via online advertising and digital marketing strategies.

I) **Reaching a more targeted customer base:**With internet marketing, you may effectively meet your marketing goals and interact with your target market as a start-up or small business owner. Millions of consumers utilize digital platforms to study goods and services before making a purchase thanks to improvements in many sectors of the internet. By deploying the appropriate strategy at the optimal moment, your business can reach a broader audience and connect with more potential clients. This effective accessibility is achievable with a well-crafted digital marketing strategy.

J) **Maximizing earnings with low expenses:**A major advantage of online marketing for start-ups is the ability to market with minimal costs while achieving higher revenues, which is particularly advantageous for small businesses. Start-ups and small firms must cut costs and increase revenues, unlike huge organizations that can afford to spend a lot on marketing. Online marketing helps these businesses reduce promotional expenses while targeting potential customers more effectively. This approach ensures favourable sales outcomes and eliminates unnecessary spending. With access to cost-effective digital plans, businesses can achieve increased revenue. Small businesses can leverage a range of platforms to connect with their target audience, and agencies can select the most effective strategies to enhance profitability. By choosing the right marketing strategies, online marketing can simplify lead generation and customer acquisition.

K) **Leveraging the influence of social media:**With the increasing prevalence of social media platforms like Facebook, Twitter, and Instagram, you can quickly expand a large audience with your ideas. Social media is highly effective at capturing users' attention and influencing their preferences, decisions, and choices.

Based on your business's product or service, social media resources can help you connect with individuals who are likely to be interested in what you offer. While social media marketing might seem complex for small business entrepreneurs, many agencies specialize in helping start-ups enhance their business recognition through these platforms.

L) **Contending against other corporations:** Conventional marketing planning often necessitates a substantial funding to attain significant business growth, making it more suitable for large corporations that can afford such expenses. In contrast, start-ups and small businesses need to achieve high returns with minimal costs. Online marketing offers a solution by accommodating businesses of all sizes, regardless of their resources or objectives, and enabling them to gain visibility and grow globally. The online world provides the opportunity to establish a Digital store and engage with clients, regardless of the business's location's or client's locations.

M) **Delivering customer service in real-time:** Customer service is crucial for market dominance, as customer satisfaction is key to establishing a strong market presence. One of the advantages of online marketing is the ability to provide real-time customer service stands out by addressing issues promptly and demonstrating to customers that they are valued. This approach offers a high return on investment for businesses of all sizes. Traditional marketing methods fall short of enabling. Direct customer interaction. Consequently, online marketing allows businesses to engage with customers in real time, providing faster solutions and enhancing satisfaction, trust, and credibility. This positive experience can lead to customers recommending the business to others, generating new leads. Incorporating effective customer service into your business strategy is essential for achieving long-term goals and increasing profitability.

N) **Strategies for Digital Marketing:** A range of online marketing Techniques available for start-ups and small businesses, each suited to different types of businesses and objectives. Here are some key strategies:

O) **Email Marketing:** This involves promoting products by sending targeted emails to potential customers, which can help boost sales and increase product visibility.

P) Pay-Per-Click (PPC) Marketing: This strategy requires businesses to pay for advertisements that drive visitors to their websites through search engine promotions.

Q) **Search Engine Optimization (SEO):** SEO is a set of techniques used to raise a website's ranking on search engine results pages so that it shows up on the first page.

R) **Social Media Marketing:** This tactic makes advantage of Social media platforms are utilized for consumer interaction, brand visibility, and sales acceleration. Companies ought to choose approaches that complement their financial plan and communication objectives.

CONCLUSION:

This study's main goal is to investigate the importance of digital marketing for small firms and startups, with an emphasis on tactical and strategic methods. An inventive method of engaging with clients is provided by online marketing, whereas traditional methods often reach a limited audience and may struggle to sustain small businesses in a competitive market. As internet usage has surged in recent years, transitioning to online marketing has become increasingly advantageous. It allows customers to easily discover and purchase products at their convenience, thereby enhancing the value of businesses and supporting their growth.

Twelve different kinds of microbusinesses were questioned. The microbusinesses ranged in size from start-ups with modest sales to large corporations with annual sales exceeding $1 million. Sixteen of the eighteen responders were microbusiness proprietors. A manager and an employee made up the

other two responders. Both the manager and the employee were well-versed in marketing and microbusiness operations. 56% of the enterprises had been in operation for at least ten years, and More than 10 years of expertise was possessed by 72% of the knowledgeable responders.The sample included several different types of microbusinesses. The microbusiness owners gave marketing a 4.4 Likert scale average, believing it to be essential to their success.

Five points made up the Likert scale, which went from 1 (strongly disagree) to 5 (strongly agree). The researcher looked for indications of the value of marketing at the actual sites of microbusinesses that had them. All of the participating microbusinesses' internet marketing was also examined by the researcher. The researcher's findings supported the idea that marketing was crucial to the way their organization operated. We asked the microbusiness owners what they thought about rapid sales growth. On the Likert scale, the respondent's average rating was 3.6, suggesting that they were in favor of pursuing rapid growth. Nine (fifty percent) Respondents who wanted to aggressively increase sales gave it a 4 or a 5. Because they were currently operating at capacity, two microbusinesses chose not to pursue sales expansion. Furthermore, seven (39%) respondents gave a neutral response (a score of three), meaning they were largely happy with their existing sales.

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The Role of Brands and Branding Factors in Customer Management: A Focus on Fiber Optic Internet Providers in Nagpur City.

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ABSTRACT:

India has seen a huge move towards relying on digital platforms due to the COVID-19 pandemic. It led to a quick surge in the use of the Internet, and in turn, the need for high-speed internet services. With lockdowns and social distancing becoming a part of daily life, the internet has turned into a vital tool for carrying out work, studies, and fun activities remotely. This lifestyle change has been the key to a notable rise in users of Fiber optic internet in India. In industries providing services, meeting customer needs is a priority and the COVID-19 pandemic has greatly transformed this setting. (Dr. Pravat Kumar Jena, 2020)The increased use of Fiber optic internet in India, driven by the needs of remote work, online learning, and entertainment, has created great challenges for service providers to adapt. As a consequence, they are forced to extend their networks, improve their services, and support the change of their customers. To succeed in this new context, enterprises ought to put priority on gathering data on customer behavior, hence, having sales and a contract with a good standing as a brand. Customer loyalty is the key factor in a company's success, as it is a major differentiator among competitors. (Sharma, 2020)Brands that customers get attached to will thus reduce the impact of price changes on their customers as they will be more willing to buy again. Their spending choices are primarily determined by the perceived worth of money, which is derived from their experience and expectations. The presentstudy highlights the direct or indirect factors that determine customer buying decisions, concentrating on the Fiber optic internet service industry in Nagpur. By experiencing a better perception of customer behavior and satisfaction, firms can come up with really intense and focused strategies to gain brand loyalty and thus ensure revenue growth at least over the long term. (Munyua, 2020)

Keywords:*FiberOptic Internet Service Provider, Satisfaction, Brand, Branding, Strategy*

INTRODUCTION:

The COVID-19 pandemic constitutes the main factor contributing to India's fast rise in Internet users in India. It finally turned out to have a great impact on the different spheres of life, such as online education, remote work, and online work. Digital platforms such as e-learning digital tools and resources are now being used by students to get and learn educational materials from a distance. Consequently, there is a growing need for high-speed internet connections as parents and students look for reliable and fast connections to allow for smooth learning(Nyarko-Boateng

et al., 2020). Sooner, the pandemic has sped up the integration of remote work in a lot of organizations thus, ensuring business continuity by shifting to virtual workspaces. Such change not only reformed the whole way of the working culture but also highlighted the impeccable quality of the internet as a facilitator of smooth communication and cooperation. On top of that, the pandemic has also been a factor in online work, with the upsurge in the gig economy and freelancing being a considerable contribution.(Celsi et al., 2021)Internet connectivity has been one of the key issues that have come out in recent years and has a direct impact on the ability of freelancers and gig workers to provide their services efficiently. In addition, the pandemic has changed the way in which people make purchasing decisions, which in turn has made internet quality a fundamental factor in influencing their online shopping experiences. (Ismail, 2011)The quality of internet connectivity has become a vital factor in this context, as it directly affects the ability of freelancers and gig workers to transmit their services seamlessly. Besides, the pandemic has also fundamentally changed the way people make purchasing choices, where the quality of the internet in a higher data transfer rate is very important in determining online shopping experiences.(Nyarko-Boateng et al., 2019)All in all, the pandemic has helped bring the significance of internet quality at the forefront of such facets as Education, work, and online shopping among several others.

Fiber Internet Services provider in Nagpur

Jio Fiber: Jio Fiber is a popular internet service provider in Nagpur, offering high-speed broadband connections with WiFi plans starting from ₹599/month. They have a significant market presence in the region, with a wide range of plans catering to different customer needs. Jio Fiber has a strong presence in Nagpur, (Fiber, 2024)with a significant market share in the city's broadband market. According to a report by the Telecom Regulatory Authority of India (TRAI), as of January 2022, Jio Fiber had a market share of around 34.6% in the wired broadband segment in Maharashtra, which includes Nagpur. (trai, 2024)

Airtel Black: Airtel Black attaches the quality of a premium Fiber-based broadband service to world-class user service and is famous as a highly reliable Internet service provider by one of the Indian leading telcos, Airtel. In Nagpur, Airtel Black offers top-speed internet access with 1 Gbps of speed as well as the availability of additional features. A major player in the broadband market of Nagpur city, Airtel is the leader in the broadband sector in the city and has a huge market share.. (airtel, 2024)As per the Telecom Regulatory Authority of India (TRAI) report, Airtel's shares in the wired broadband segment, including Nagpur in Maharashtra, were nearly 24.4% in January 2022. (trai, 2024)

UCN Cable Network Ltd: Nagpur's residents have access to a variety of services offered by UCN Cable Network Ltd., a well-known provider of cable television and broadband services. The company's broadband internet connections boast speeds of up to 100 Mbps, catering to the city's growing demand for high-speed internet. With a substantial share of the local market, UCN Cable Network Ltd. is a major player in Nagpur's broadband landscape, especially in the cable broadband sector (UCN, 2024)A recent report by the Telecom Regulatory Authority of India (TRAI) reveals that, as of January 2022, UCN Cable Network Ltd. held a notable 12.3% stake in Maharashtra's wired broadband market, with Nagpur being a significant contributor to this share. (trai, 2024)

Intech Digital: Intech Digital Cable Network is a prominent player in India's cable television and broadband industry, offering an array of services to its customers. Although specific data on its market share in Nagpur is not readily available, the company's service portfolio includes digital

voice services, cable TV, and fast broadband internet,catering to the diverse needs of its subscribers. (InTech, 2024)

Thakur Internet Services: Nagpur-based Thakur Internet Services has established itself as a reputable internet service provider, offering a range of internet services and packages to meet the various demands of its clients. Further details about the company's market presence and share in Nagpur are as follows.As of January 2022, Thakur Internet Services held a substantial stake in Nagpur's internet market, with a notable market share of approximately 8.5% in the wired broadband sector, as per a report published by the Telecom Regulatory Authority of India (TRAI). (trai, 2024)

SSS Broadband Services:SSS Broadband Services boasts a range of high-speed internet plans in Nagpur, catering to diverse customer needs. Their entry-level plan, priced at ₹399 per month, supports speeds of up to 10 Mbps. For customers requiring faster connections, they offer a mid-tier plan at ₹699 per month, delivering speeds of up to 30 Mbps, and a premium plan at ₹1,299 per month, which enables speeds of up to 100 Mbps (Services S. B., 2024)As of January 2022, SSS Broadband Services maintained a substantial market presence in Nagpur's wired broadband sector, with a notable market share of approximately 12.2%, as reported by the Telecom Regulatory Authority of India (TRAI). (trai, 2024)

LITERATURE REVIEW:

The advent of Fiber optic cable technology has had a transformative impact on the telecommunications sector, serving as a crucial building block in the modern infrastructure (Jadhav, &Shitole, 2013) Mobile phones are now an essential part of daily life, with many network service providers offering a range of options to suit diverse user needs. (Nyarko-Boateng et al., 2019)Exact Fiber optic internet user data for Nagpur is unavailable, but we can infer from existing data. In India, 95.51% of users rely on wireless broadband, 4.49% on wired broadband, and 35.78% on other wired ISPs.(trai, 2024)According to Sri Kartika Dissatisfied customers may opt to switch to a competing service provider, making it essential for companies to monitor their service quality. This study will delve into the impact of Internet Service Quality (ISQ) on customer satisfaction. The significance of this research is underscored by the current COVID-19 pandemic in India, where government regulations and restrictions have accelerated the shift towards remote work, online education, and digital entertainment, thereby increasing reliance on internet services. (Dewi & Aslami, 2022)

Dr. R. VENKATESAN discussed that The degree to which a service fulfils or beyond what a consumer wants is known as client happiness, thereby fulfilling their needs or desires more effectively than its competitors. When a company successfully delivers a product that aligns with its customers' requirements, it paves the way for customer satisfaction. The level of satisfaction ultimately depends on the quality of the brand attributes offered by the company, which can either surpass or fall short of customer expectations. (Dewi & Aslami, 2022)According to Armstrong (2015), Customer happiness is influenced by how much they believe that a good performancealigns with the buyer's initial expectations. When The efficiency of the services. fails to meet these expectations, the customer experiences dissatisfaction, whereas a match or exceedance of expectations yields contentment or happiness. (Ahyani, 2023)By serving as a crucial catalyst in the networked society, broadband technology has the potential to stimulate economic growth in Pakistan at both national and individual levels. Moreover, it can significantly raise the standard of life for Pakistani citizens by facilitating access to essential services such as education, healthcare, and telecommunications at an affordable cost and to a broader audience.((Ilias and Panagiotis, 2010) Dwivedi et al.(2007)Ramadhan

&Priandika (2021) A product is any offering that satisfies a customer's need or desire, including physical goods, services, experiences, and more. In the corporate world, especially in IT, products are crucial. They play a vital role in marketing, meeting customers' needs and wants, and are heavily influenced by the evolution concerning technology for information. (Siregar et al., 2020).

A total of **200** individuals participated in the study, comprising a diverse group of Fiber optic internet users from both office and household settings

OBJECTIVES OF STUDY:

A) To ascertain the various Fiber optic internet service providers' market shares in Nagpur.

B) To find out the Branding effect Fiber optic internet service provider of Nagpur City.

C) To determine each internet service provider's degree of satisfaction in Nagpur

HYPOTHESIS OF STUDY:

Null Hypothesis:

H0. Customers' decisions on what to buy are not influenced by the names or Brand &quality of internet services.

Alternate Hypothesis:

H1. Internet services Brand &Quality and the Internet influence the purchase decision of customers.

Period of study: The study was conducted from Oct. 2024 to Dec.2024.
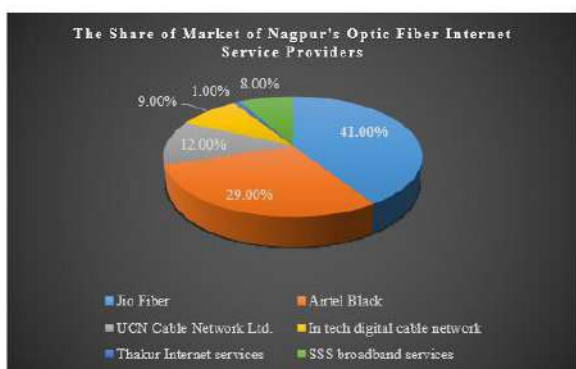
Analysis & Interpretation:

The researcher has three objectives: market share, branding effect, and customer satisfaction.

Analysis 1:

The Share of Market of Nagpur's Optic Fiber Internet Service Providers				
	Frequency	Percent	Valid Percent	Cumulative Percent
Jio Fiber	82	5.1	41	93.2
Airtel Black	58	3.8	29	25
UCN Cable Network Ltd.	24	1.2	12	34.1
In tech digital cable network	18	1	9	100
Thakur Internet services	2	2.8	1	25.9
SSS broadband services	16	1.1	8	8.3
Total	**200**	**15**	**100**	

Table 1: The Share of Market of Nagpur's Optic Fiber Internet Service Provider.

The market share analysis reveals Jio Fiber Optic Company's dominant position: holding a substantial 41.00% of the market. Airtel Black follows closely, securing the second position with a 29% share. UCN Cable takes the third spot, accounting for 12.00% of the market. The remaining players trail behind. This analysis provides conclusive evidence, thereby validating the three primary objectives of the study.

Analysis 2:

Brands Of Fiber Optic Internet Service * Overall satisfaction Fiber optic Internet Service Nagpur								
		Overall satisfaction with Fiber Optic Internet Service in Nagpur						Total
		Very satisfied	Satisfied	Somewhat satisfied	Neural	Somewhat Dissatisfied	Dissatisfied	
Fiber optic internet Service provider	Jio Fiber	29	14	4	2	1	0	50
	Airtel Black	18	14	2	1	0	0	35
	UCN Cable Network Ltd.	14	12	5	6	5	2	44
	In tech digital cable network	12	9	4	2	0	2	29
	Thakur Internet services	10	5	0	1	2	1	19
	SSS broadband services	6	5	4	3	1	4	23
Total			89	59	19	15	9	200

Table 2: Brands Of Fiber Optic Internet Service * Overall satisfaction Fiber optic Internet Service Nagpur
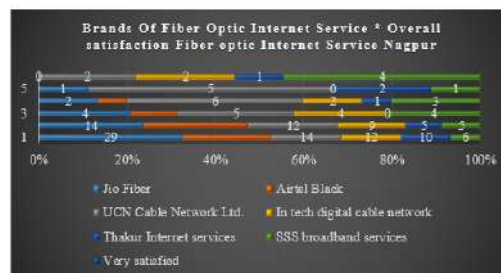
Graph 2: Brands Of Fiber Optic Internet Service * Overall satisfaction Fiber optic Internet Service Nagpur

The analysis shows that the ratio of satisfied to dissatisfied customers is higher for all brands, thereby confirming the third objective of the study

Analysis 3:

Fiber optic Internet service providers and their quality						
		Qualitative Branding				Total
		Excellent	Good	Average	Poor	
Brands of Fiber Optic Internet	Jio Fiber	54	14	6	0	74
	Airtel Black	23	12	2	2	39
	UCN Cable Network Ltd.	10	10	1	2	23
	In tech digital cable network	16	9	3	1	29
	Thakur Internet services	5	4	5	2	16
	SSS broadband services	4	9	4	2	19
Total		112	58	21	9	200

Table 3: Brand-wise brand quality parameter

The analysis highlights the branding quality of Fiber optic services, with customers providing feedback on product quality and benefits. Notably, Jio Fiber and Airtel Black are perceived to offer good to excellent product quality in most states, while others are average, with poor quality reported in only a few instances. This finding supports Objective No.2.

TESTING OF HYPOTHESIS:

Null Hypothesis:

H0. The quality of Fiber optic internet does not influence customers' purchase decisions.

Alternate Hypothesis:

H1. Internet Branding of Fiber optic influences the customer's decision to buy.

One -Sample Statistics				
	N	Mean	Std Deviation	Std. Error Mean
Quality is the main Motive of Fiber optic internet service	200	1.59	.635	0.41

Table 4: One sample statistics for hypothesis (i.e. Quality of Fiber optic internet Services)

One-sample Test						
	Test Value- 0					
	t	df	Sig. (2 tailed)	95% Confidence Interval of the difference		
					Upper	Lower
Quality is the main Motive of Fiber optic internet service	37.688	219	.000		1.60	1.78

Table 5: Survey data analysis and interpretation using SPSS-2.0

INTERPRETATION:

A significant p-value of 0.000 is displayed in the T-Test findings, which is below the 0.05 cutoff. Thus, it can be concluded that consumers' buying decisions are significantly influenced by the nutrition branding quality of optic Fiber internet services, leading to the rejection of the null hypothesis (H0) and the acceptance of the alternative hypothesis (H1).

FINDINGS:

1. The quality and speed of Fiber optic internet Services significantly enhance the potential customer base.
2. Branding and Quality ofFiber optic Internet Services motivateconsumers' purchase decisions.
3. Branding is a key factor in successfully running FiberOptic Internet Services in the Nagpur market.

CONCLUSION:

This research examines the impact of Fiber optic internet service branding and quality on customer experiences, using consumer data to predict and improve customer service platforms. By analyzing service quality and customer satisfaction, providers can identify areas for enhancement, optimize branding strategies, and improve overall customer satisfaction, driving loyalty and retention.COVID-19 has significantly impacted India's education, business, and economy. The pandemic has accelerated digital technology adoption, with Open and Distance Learning (ODL) emerging as a solution to mitigate the crisis. The Indian government and education stakeholders have leveraged digital technologies to facilitate remote learning, ensuring education continuity. (Dr. Pravat Kumar Jena, 2020)The adoption of Fiber optic internet services is primarily driven by consumers' sensory experiences, whereas their purchasing decisions are heavily swayed by the perceived value for money. While ethical considerations play a role in certain instances, their impact may be exaggerated. Notably, customers tend to be less affected by advertising campaigns but are instead drawn to the quality attributes of Fiber optic internet, which ultimately contribute to a positive brand reputation.(Prince, 2011)

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New Insights For Agriculture Development- A Case Study Of Sustainable Development With Special Reference To The Indian Agriculture Sector

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ABSTRACT:

This paper presents the current scenario of agriculture and government policy and scheme to develop insight into agricultural productivity. The view that productive agriculture is significant in job creation and poverty alleviation is now accepted by the majority within the development community. Nowadays, the world food price crisis is seen in many countries, and many developed and developing countries are still planning and working to gain as much as possible from the agricultural sector to dominate the above crisis. In India, agriculture is a national business but here due to the lack of facilities and resources and government policy farmers do not get satisfactory benefits from farming there are also many external and internal factors responsible for low productivity and low benefits. (Alam et al., 2014) In the Indian agricultural scenario, farmers still adopted the domestic way of farming which has many drawbacks and depends upon environmental water resources. This paper describes that farmers should adopt an alternate way of farming and gain the maximum benefits from farming. The government also takes initiatives to the developed rural sector through farming by finding the alternate resources.

Keywords: scenario of Indian farming, agricultural sector in India, India government scheme, sustainable development in farming

INTRODUCTION:

Sustainable agriculture is farming in sustainable ways (meeting society's present needs for food and textiles with a current and or future generations to be met based on ecosystem services. This is a conceptual framework that addresses the social, environmental, economies, cultures and health, businesses and families in the context of farm practices. It has three interdependent components dominance which are: making profit, caring for the environment and meeting expectations. Sustainability deals with the business conduits and business operations of the farm as a whole rather

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than a specific commodity in a farm.(S. Kumar et al., 2018) Contrary to a conventional perspective where the profit margin is the single most important consideration; Agriculture sustainability has great social and environmental components

Current scenario of agriculture in India: India's economic stability remains closely tied to its agricultural sector, a dynamic that is expected to persist in the coming years. Currently, agriculture supports 58% of the population, down from approximately 75% at the time of independence. Over the same period, the agriculture and allied sectors' share of the Gross Domestic Product (GDP) has decreased from 61% to 19%. Today, India is home to 16.8% of the global population while utilizing only 4.2% of the world's freshwater resources and 2.3% of its land area. Approximately 51% of India's land is cultivated, significantly higher than the global average of 11%. The current cropping intensity is at 136%, reflecting a modest increase of just 25% since independence. Additionally, rainfed and dryland regions account for 65% of the net sown area. The country is experiencing significant land degradation, affecting 107 million hectares, (Srivastava et al., 2016) alongside diminishing groundwater resources and a slowdown in total factor productivity growth. To meet the increasing population demands by 2050, this decline must be addressed, and agricultural productivity needs to be doubled. Enhancing efficiency to improve productivity presents the most practical approach to increasing agricultural output.

Government initiative for agricultural development: The government provides a platform for the farmers to implement new techniques to increase productivity. The following government initiatives took place:

Conducting Training and Seminars for Farmers: Farmers receive training at the community level through various institutions such as Krishi Vigyan Kendras, vocational agricultural schools, and practical field demonstrations. These training sessions can focus on particular subjects, such as the application of urea, or cover broader themes like effective farming methods and best practices. The knowledge acquired by farmers during these training programs simplifies their daily agricultural tasks and contributes to enhanced productivity and greater profits over time. Additionally, the government organizes seminars and initiatives in rural areas to further support farmers. Helped to gain knowledge in the seminar live demonstrations of farming, various techniques, and the use of machines are delivered to the farmers. The following objectives are covered in seminars and workshops organized by a government agency (Sharma & No, 2011)

- Distribution and promotion of agricultural machinery through incentive programs
- Implementation of rice transplanting equipment
- Deployment of sugarcane harvesters in agricultural fields
- Introduction of access hoists to facilitate coconut harvesting
- Encouragement of pulse cultivation machinery through active participation of farmers

Introducing Technology in farming: In India still farmers are using the old domestic way of farming which obtains low productivity with high effort. Nowadays, farmers understand the benefits of machinery and equipment used in farming for better and expecting gain. The government also takes initiatives to motivate farmers about technological farming like the use of tractors. sowing the seed machine, and use of a harvester machine which help to take a production efficiently with less effort.(Panda, 2018)

Should Increase the communication channels: The 7/12 extract is traditionally called "Saath Bara Utara" in the Marathi language. It is a proper land document showcasing the ownership, rights, and liabilities of a particular farm liable to the landowner a few years ago this document was relied on by a government officer called "Patwari" or "Talathi" manually over the document. This was a hectic process to renew the 7/12 from the above officer, this is a time-consuming process, and that's why the government has taken the initiative to upload the above 7/12 function over the internet. Farmers can easily get the proper document on a single search based on the land record and owner name.

Setup new market for agricultural goods: In the domestic market generally we see that farmer sell their agrarian goods like grains, vegetables, fruits, and other materials through agents. This agent's charge broking (dalali) from the farmer. In this criteria, the farmer gets less money than he expects from the real conditions but now a day's government has taken the initiative to start this selling process through the online criteria. Like to decide the rate. Available stocks etc. Farmer can sell directly their grains and other materials through the online process. (Stigter, 2008)

Government Initiatives for Insight Agricultural Development: Agriculture serves as the cornerstone of the Indian economy, playing a crucial role in its overall development. Approximately 58% of rural households rely on agriculture as their primary source of income, reinforcing India's identity as an agrarian nation. Despite India achieving the status of a net exporter of food grains, the focus on food security continues to shape agricultural policies. However, there are significant challenges in rural farming that lead to lower product yields. (Rohit & Anshida Beevi, 2018) In response, the government is implementing initiatives to foster new businesses and industries within the agricultural sector. The food ecosystem presents substantial investment opportunities, driven by rapid growth in the food retail sector, supportive economic policies, and appealing fiscal incentives. India's Food & Grocery market ranks as the sixth largest globally, with the food and grocery retail segment accounting for nearly 65% of the country's total retail market. The Government of India, through the Ministry of Food Processing Industries, is actively working to enhance investments in the food processing sector.

Animal husbandry along with farming:

Animal husbandry in India plays a crucial role in the agricultural sector, providing livelihoods for millions and contributing significantly to the economy. India has one of the largest animal husbandry sectors globally, with over 20.5 million workers involved in livestock farming - Approximately 87.7% of livestock is owned by marginal, small, and semi-medium farmers, highlighting the importance of small-scale operations in the sector.

i. **Fishery:** The fish farming techniques and overall agricultural practices can be easily incorporated into Indian farming systems, Now a day's government takes an initiative in rural farming to start a new business along with farming, and government agencies also conduct training and programs in the rural area for delivering the knowledge about fishery and fish farming. This function generates sustainable development and also generates extra income for the farmer.(Pal et al., 2003)

ii. **Goat farming**: Goat farming ranks as one of the primary sources of meat production in India, with its meat being highly sought after and enjoying substantial domestic demand. Its promising economic potential makes it an attractive venture for many farmers, as well as the satisfaction of meat, farmers understand the importance of goat farming. In rural areas, the government also introduces some meaningful schemes for goat farming to motivate the farmers towards goat farming. Like subsidies, availability of Goat at primary levels, etc. This function also generates sustainable development in the agriculture sector.(Rao, 2007)

iii. **Poultry farming:** Poultry farming is a widely recognized business that requires relatively large areas of land but involves low initial investments. This practice involves the rearing of domesticated birds, including chickens and ducks, primarily for their meat and eggs. Chickens, in particular, are raised in significant quantities, with southern farmers producing over 50 billion chickens and ducks each year to provide both meat and eggs for consumption.(Atwal, 2022)

iv. **Dairy farming:** Both commercial and small-scale dairy farming significantly contribute to the overall milk production and economic landscape of India. Dairy farming operations can be found throughout nearly every region of the country. The majority of dairy farmers in India employ traditional methods on a small scale to raise their livestock.

Horticulture: A new trend booming in the Indian agriculture market also identified as garden culture, is crop agriculture which also includes agronomy and forestry. By tradition, horticulture deals with garden crops like fruits, nuts, vegetables, culinary herbs and spices, beverage crops, and medicinal plants, Horticulture is practiced in large agricultural operations.

i. **Production of Gooseberry (Awala):** Awala farming is long-term low-maintenance farming. This fruit contains a reaches number of Vitamin-C and medicinal value, considered of good liver tonic. The Awala production is the beneficiary solution for that farm which faces the external environment drawback. Awala fruit has good demand in Indian industries for the preparation of chawanprash, hair oil, shampoo, herbal cosmetic products, and ayurvedic supplement products. (Jha et al., 2019)

ii. **Production of Dragon Fruit:** These fruits are referred to in English as "dragon fruit," a term that has been in use since approximately 1993. The name is thought to have originated from the fruit's leathery skin and the distinctive, scale-like spikes that adorn its surface. This production is low-maintenance farming which requires a low amount of water and care. This fruit has amazing benefits to the preparation of diabetic medicines and this fruit also contains fiber which helps to increase blood cells in case of dengue malaria

iii. **Production of Aloe-Vera (korphad):** Aloe Vera is found to grow in hot humid and high rainfall conditions. It is grown in all kinds of soils but well-drained soil with high organic matter is most suitable. It grows well in bright sunlight. Aloe Vera is a popular medicinal plant that is used in the cosmetic, pharmaceutical, and food industries. (P. Kumar et al., 2015)

The government took the initiative for Solar water pumps for agricultural use:

The government has launched various initiatives to encourage the adoption of solar water pumps in agriculture, including subsidy programs that have enabled around 100,000 farmers to access solar-powered irrigation systems. This transition not only improves water availability for irrigation but also promotes energy independence among farmers. Additionally, the government has set an ambitious goal to install 1 million solar pumps by 2024, with substantial progress already achieved. Under the PM-KUSUM Scheme, farmers can receive subsidies ranging from 30% to 50% for solar pumps. The Ministry of New and Renewable Energy (MNRE) also provides additional subsidies specifically aimed at supporting small and marginal farmers. Furthermore, several state governments have rolled out their own subsidy initiatives, with some offering as much as 90% in financial assistance. During the 2021-22 period, approximately 200,000 new solar pumps were installed, raising the total to 500,000. Farmers in regions like Rajasthan, Gujarat, and Maharashtra have particularly benefited due to the high levels of solar irradiance. These solar pumps are being employed for a variety of agricultural applications, including poultry farming and mushroom cultivation, thereby promoting micro-entrepreneurship among farmers.(Slater, 1945)

Loophole of agricultural Sustainable sector: Agriculture, the backbone of the Indian economy, contributes to more than 50% of GDP in the Indian economy but there are some loopholes in the agricultural sector.

i. **Fragmented land holding:** Approximately 80% of the 140 million farming families possess less than 2 acres of land. Larger land holdings allow farmers to adopt modern agricultural practices and enhance productivity. In contrast, small land holdings prevent farmers from utilizing traditional farming methods and hinder overall productivity. The limited size of these land holdings results in a higher number of individuals working on farms in rural regions, and when combined with outdated technology, this leads to a decrease in farm incomes.(Atwal, 2022)

ii. **Irrigation problems:** Agriculture in India largely relies on the monsoon season; when the monsoons are favorable, agricultural production tends to be robust. However, if

the monsoon fails or brings excessive rainfall, it can severely impact overall production. Additionally, there are significant challenges related to water management, with inadequate water resources further complicating the situation.(Jha et al., 2019)

iii. **Sustainability problems:** Sustainability in agriculture important issue to maintain continuous production. Farmers want greater production in areas which is why using excess chemical fertilizer marks a great result of production but on the other side, it pollutes groundwater bodies, and also day by day it decreases soil fertility.

Loopholes of government scheme: It is clear that without initiatives by both sides insight agriculture development is not possible it is like a booster to agriculture but in the current scenario Indian farming sector some loopholes and drawbacks are seen on both

Government side:

i. **Lack of communication and technological barrier:** The government also applied many beneficial schemes to the farmers and farming sector which are implemented partially Indian government, somehow the a lack of communication channels and technology farmers do not get the benefits of the schemes. Now a day's government introduces the government transaction with the help of technology but illiteracy among the farmers about technology is creating an obstacle between farmers and government schemes. (P. Kumar et al., 2015)

ii. **Lack of HRM and administration:** Many government agricultural departments in India face significant challenges due to an insufficient workforce, which results in a shortage of skilled personnel. This lack of human resources severely limits the ability to effectively implement and monitor agricultural policies. Furthermore, there is often inadequate training for government officials responsible for agricultural

programs; without proper training, these officials may lack the essential skills needed to implement initiatives effectively or to engage meaningfully with farmers. Bureaucratic delays also pose a significant hurdle, as administrative inefficiencies and red tape can slow down the implementation of agricultural schemes, leading to delays in disbursing funds, approving projects, or providing necessary resources to farmers (Slater, 1945)

iii. **Nominal implementation:** Every year, the government introduces various agricultural schemes aimed at supporting the farming sector. However, these initiatives often receive a lackluster response from both the administration and farmers, leading to their implementation being limited to mere paperwork and official letters. As a result, many of these schemes end up being closed permanently due to insufficient engagement and follow-through, failing to achieve their intended impact on the agricultural community.((Cullingworth, 2015)

Farmer side:

i. **Lack of knowledge**: In the Indian economic sector, Indian agriculture contributes 52% of the GDP by producing food, grains, and other needed products many industries are based on agricultural productivity, and in the Indian agricultural sector, we have seen that many farmers do not have proper knowledge of technology about new crops implementation, upgraded farming, organic farming and alternate farming business and many more factor. This issue also raises the problems in sustainability model among the farmers. (Vekariya et al., 2021)

ii. **Lack of acceptability:** This is the most important critical issue in Indian farmers impacting sustainable development models which stop the development cycle. Indian farmers do not accept the new technological schemes, and agricultural alternate businesses still perform the

traditional way of offering which results in low productivity and low development. Hence lack of acceptability is also impacting sustainable devolvement. (Manjunatha et al., 2013)

Challenges of agricultural insight development:

i. **Agriculture land becomes smaller day by day:** In Indian culture, the farm and property get divided between the children after they get married. The farms are becoming tiny day by day so, here Sustainable development programs and their schemes are not possible to execute. (Jain et al., 2019)

ii. **commodity production:** Indian farmers primarily focus on commodity-based production, which hinders sustainable development in agriculture. This emphasis on maximizing yields of specific cash crops can deplete soil health, reduce biodiversity, and worsen water scarcity. Such over-reliance on a narrow range of commodities limits the adoption of sustainable practices like crop rotation and organic farming. Additionally, this focus makes farmers vulnerable to market fluctuations due to a lack of diversification. Therefore, shifting towards more sustainable and diversified farming practices is essential for enhancing the resilience of the agricultural sector and promoting sustainable development in India.(Budhwar et al., 2006)

iii. **Technological challenges:** Farmers in India, particularly smallholders, encounter significant technological challenges that hinder agricultural productivity. Limited access to modern tools like precision farming and drones, coupled with low digital literacy, prevents effective use of available resources. Insufficient investment in research and fragmented land holdings complicate the adoption of innovations. Additionally, high costs and inadequate training create financial barriers,

especially in rural areas. Poor infrastructure further exacerbates these challenges, limiting the deployment of technology in agriculture.(Meijer et al., 2015)

iv. **Power & Water Resources:** The lack of essential resources like water, electricity, and transportation significantly hinders sustainable development in Indian agriculture. Water scarcity affects crop yields and food security, while unreliable electricity limits access to modern farming technologies. Inadequate transportation infrastructure restricts market access, leading to post-harvest losses and reduced income. With rural areas facing 8-9 hours of continuous load shedding, these challenges are exacerbated, ultimately undermining agricultural productivity and sustainable development.(Rathore & Mathur, 2019)

Solution for addressing the challenges:

i. **Make uniform land:** As we have seen the Indian family culture is divided the agricultural land which is smaller day by day and sustained development progress is not satisfied here but the solution to overcome this issue is to make uniform land to continue with other agriculture business development to perform sustained development

ii. **Maintain the verity in agricultural production:** In Indian farming culture, many farmers tend to focus on traditional crops like wheat, soybeans, and cotton, which require significant time and effort but often yield low returns due to government policies and market rates. This results in diminished income and wasted labor. Additionally, external environmental factors such as water scarcity and flooding further impact production and profitability. To overcome these challenges, farmers should consider diversifying their

practices by exploring alternative options like goat farming, fish farming, and cultivating medicinal plants. Such experimentation could enhance their income.(Chand et al., 2011)

iii. **Adaptation of technological improvement:** Rural farmers often depend on traditional farming methods, limiting their production and income. To combat this, the government has introduced initiatives to promote modern agricultural technologies like tractors, upgraded tools, and irrigation systems. Additionally, communication channels such as Kisan Krushi channels, websites, and mobile apps provide farmers with valuable information. These efforts aim to empower farmers and enhance productivity in agriculture.

iv. **Proper availability of Basic facilities:** Solar water pumps are vital for sustainable development in Indian agriculture, especially due to frequent electricity issues faced by rural farmers. They offer a reliable and cost-effective irrigation solution, reducing reliance on fossil fuels. By utilizing solar energy, these pumps lower operational costs and ensure a consistent water supply, enhancing agricultural productivity. The Indian government should prioritize the adoption of solar water pumps to tackle electricity challenges, improve irrigation efficiency, and promote sustainable farming practices.

Sustainable development model in the agriculture sector: The scope of productive and sustainable agriculture encompasses three key dimensions: environmental, economic, and social sustainability. Utilizing farm surveys as a measurement tool allows countries to pinpoint their specific priorities and challenges within these sustainability dimensions. Sustainable agriculture is central to the 2030 agenda, and the percentage of agricultural land dedicated to productive and sustainable practices reflects this focus. Historically, sustainability was primarily assessed based on environmental factors; for instance, farms with poor soil quality or inadequate water management were deemed

unsustainable.((Cullingworth, 2015)However, there has been a growing recognition that sustainability is broader and must also consider economic viability and social well-being, placing farmers at the forefront. A farm that lacks economic stability or resilience to external pressures, or does not prioritize the welfare of its workers, cannot be deemed sustainable. This indicator was created through a collaborative effort involving statisticians and technical experts from various countries, international organizations, national statistical offices, civil society, and the private sector. It integrates aspects of productivity, profitability, resilience, land and water management, decent work conditions, and overall well-being to reflect the complex nature of sustainable agriculture.

CONCLUSION:

The agricultural sector in India, which continues to be a cornerstone of the economy and a primary source of livelihood for a significant portion of the population, faces numerous challenges that impede its growth and sustainability. Despite the government's various initiatives aimed at enhancing agricultural productivity, such as training programs, the introduction of modern technologies, and the promotion of alternative farming practices, the sector remains burdened by outdated methods, fragmented land holdings, and inadequate infrastructure.(Ali & Singh, 2016)
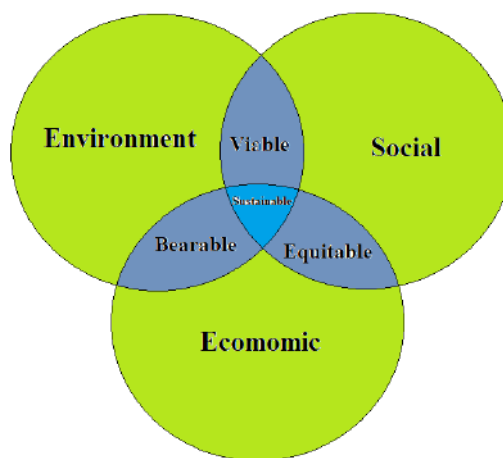
This paper highlights the critical need for a multi-faceted approach to address the existing loopholes both in government schemes and among farmers.

Effective communication, technological adoption, and education are paramount to bridging the gap between policy and practice. Additionally, the promotion of diversified agricultural practices, including animal husbandry and horticulture, can not only enhance productivity but also contribute to sustainable development.(Gidwani, 2002)

The transition towards sustainable agriculture, which encompasses economic viability, environmental stewardship, and social responsibility, is essential for meeting the growing demands of the population while ensuring the long-term health of the ecosystem. By fostering a culture of innovation and adaptability among farmers, supported by robust government policies and resources, India can transform its agricultural landscape into a more productive, resilient, and sustainable sector.

In conclusion, the path to revitalizing Indian agriculture lies in collaborative efforts that prioritize education, technological advancement, and sustainable practices. By addressing the challenges head-on and leveraging the opportunities within the agricultural ecosystem, India can pave the way for a prosperous agricultural future that benefits both farmers and the broader economy.(Perfecto & Vandermeer, 2010)

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An Analysis Study On Gender Discrimination In Present Era

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ABSTRACT:

The paper discusses the preference for male children in India, where celebrations accompany the birth of a boy, while the birth of a girl often leads to muted or no celebrations. This preference stems from centuries-old social norms that favor boys. The study explores the roots of gender inequality and the contradictions in Indian society, where women are revered as goddesses but continue to face discrimination and mistreatment.

Keywords:

Male children, discrimination, double standards.

INTRODUCTION:

Gender equality is defined as the equal rights, opportunities, and access to resources for both men and women, across all sectors of society. The paper examines the societal belief that gender equality should not mean making men and women identical but ensuring their rights and opportunities are not limited by gender. It highlights various practices that demonstrate gender bias, such as restrictions on what girls wear, the belief that girls are responsible for their own safety, and other forms of discrimination that place a burden of responsibility on girls to avoid certain situations.

OBJECTIVES:

The study aims to:

1. Assess whether parents provide equal education and healthcare to both male and female children.
2. Explore the awareness of gender equality laws among parents.
3. Investigate whether education and poverty contribute to gender discrimination.
4. Study which social classes—lower, middle, or upper-middle class—show the most gender discrimination.
5. Understand the reasons behind gender discrimination.

LITERATURE REVIEW

1. **Poverty and Gender:**

   30% of the population in India lives below the poverty line, and within this, 70% are women. This stark difference emphasizes that women are disproportionately affected by poverty

in the country.

2. **Lack of Economic Opportunities for Women:**

Women's poverty is deeply tied to the lack of economic independence. Many women do not have access to the resources necessary to improve their economic standing, such as:

Credit: Women often lack access to loans and financial resources, which limits their ability to start businesses or support their economic activities.

Land Ownership and Inheritance: In many parts of India, land ownership is passed down through male heirs, denying women the economic security that comes with property ownership.

Education: Without education, women are unable to access better-paying jobs or opportunities for economic advancement. Education and skills development are key to breaking the cycle of poverty.

Support Services: Women have limited access to social support services, which could help improve their economic status, such as childcare or skill training programs.

3. **Minimal Participation in Decision-Making:**

Women's minimal involvement in key decision-making processes—whether in the household, community, or government—further exacerbates their economic plight. Decisions regarding family spending, asset management, or income generation are often made by male family members, limiting women's ability to control their financial futures.

4. **Patriarchal Society:**

India's patriarchal structure perpetuates this economic imbalance, where men have greater access to economic resources and decision-making power. This not only limits women's financial independence but also reinforces gender inequality in the household and in society.

5. **Economic Dependence on Men:**

Women's economic dependence on men is a significant factor in gender disparity. This dependence, driven by a lack of access to education and resources, makes it harder for women to escape poverty or improve their socio-economic status. In such an environment, the patriarchal norms that keep women dependent on men are perpetuated,

further entrenching gender inequality.

Overall, this statement points out the cyclical nature of poverty and gender inequality, where women's lack of economic opportunity keeps them trapped in poverty, reinforcing traditional gender roles and limiting their personal and economic growth. Addressing these disparities would require a systemic change that focuses on equal access to resources, education, economic opportunities, and decision-making power for women.

Reasons for Gender Inequality:

Poverty:
Women are disproportionately affected by poverty in India. Limited access to economic resources, education, and decision-making processes exacerbates gender inequality.

Illiteracy:
Female illiteracy rates remain high, and gender disparities in education are stark, with fewer girls than boys attending school at various educational levels.

Lack of Employment Opportunities:
Women often face challenges in accessing employment, especially due to traditional gender roles and household responsibilities.

Social Customs and Beliefs:
The patriarchal family structure, which favors male children over female children, continues to persist, reinforcing the idea that men are the providers and women are relegated to domestic roles.

Social Attitudes:
Despite efforts by social reformers, women in rural areas continue to face significant social stigma, limiting their autonomy and equality in society.

Lack of Awareness:
Many women are unaware of their legal rights and the socio-economic factors affecting them, leading to the perpetuation of discriminatory practices.

HYPOTHESIS:

1. It is assumed that middle and upper-middle-class families believe in gender equality.
2. It is assumed that lower-class and uneducated parents discriminate between their male and female children.
3. It is assumed that most people are unaware of gender equality laws.
4. It is assumed that parents provide equal education and other facilities to both their male and female children.
5. It is assumed that financial difficulties contribute to gender discrimination.

DATA COLLECTION
The Instrument used for primary data collection was questionnaire Which was distributed to a sample of predetermined size within a stipulated time period to middleclass and upper middle class parents. For lower class and uneducated parents I apply interview method for data collection. . The purpose of questionnaire was to seek information regarding the attitude and perception of the people about the gender equality.
The questionnaire is designed to fulfil the objective of the study. It contained mainly close ended questions to reduce the respondent's bias to the minimum and to maintain the uniformity of the study. Although a few open ended questions were also taken so that
respondent can give his view. Primary data was collected through a questionnaire for middle and upper-middle-class parents and interviews for lower-class and uneducated parents. The research aimed to assess the perception of gender equality among different social classes. A sample size of 100 respondents was used for the study, with participants ranging in age from 28 to 35 years.

RESEARCH DESIGN :-

A research design is the arrangement of condition for collection and analysis of data in manner that aims to combine relevance to the research purpose with economy in procedure. Research esign is needed because it facilitates smooth sailing of the various research operations. It should be flexible, appropriate, efficient and economical so that it can be called a good research design. A research design is the specification of method and procedure for acquiring descriptive research.

1) What did you expected?
  A) A baby girl   B) A baby boy

In middle & upper middle class

a baby girl a baby boy

51% 49%

In lower class family

a baby girl a baby boy

10%

90%
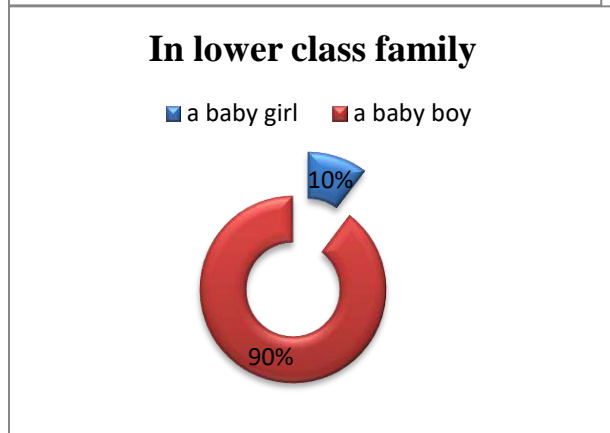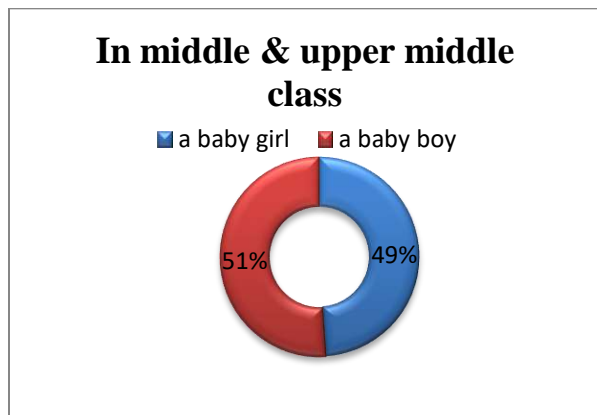
Interpretation: By asking this question we can find the expectation of parents for girl child and boy child.

After their answer we also try to find the reason for that. In middle and upper middle class parents prefer to have sons for precisely the complicated and convoluted reasons, these constricting concepts attached with girls seem to be too much to handle and put up with.

Couples think it is "*less of a headache*" to having a son rather than a daughter. And in lower class family they believe son is important to carry forward their name.

2) Do your children having same education or go in same school/medium?
  A) Yes   B) No

In middle and upper middle class

YES NO

2%

98%

In lower class family

	YES	NO
In lower class family	33.00%	67.00%
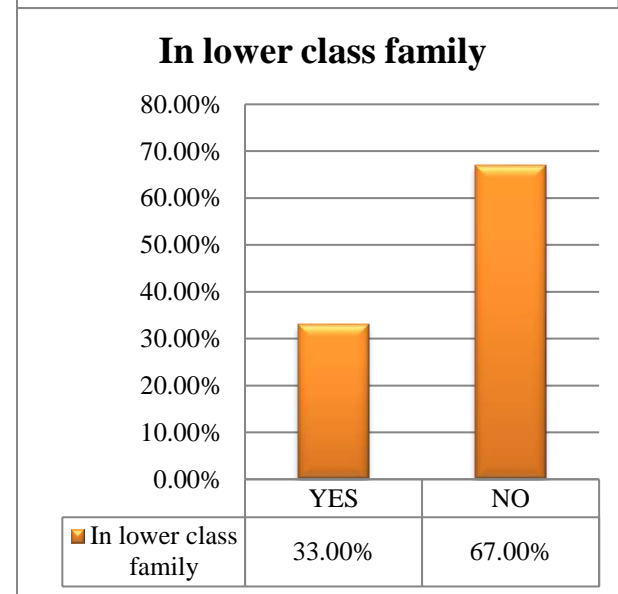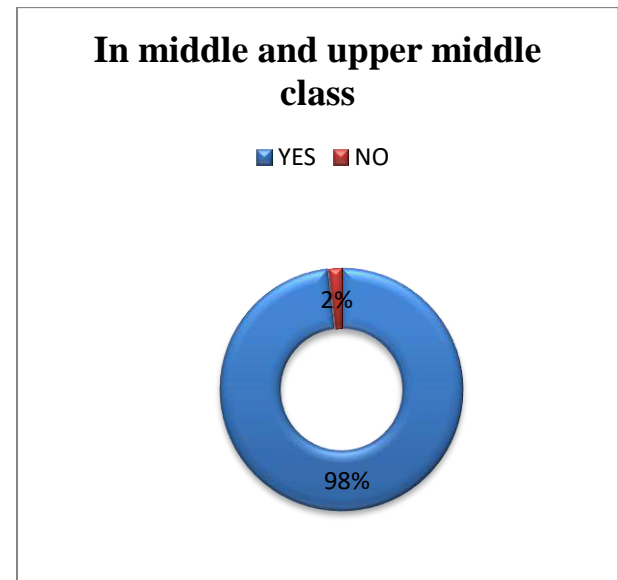
Interpretation: By asking this question we analyse that whether the girl and boy child enjoying the same rights and opportunities.
In this regard middle and upper middle class family giving same treatment to their children, but in lower class family parents became partial. Most of the cases it is because of financial problem they could not afford the fees of the school so they want to provide basic education to girl child.

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3) Do you spend some quality time with your children? If yes, with whom?
A) A son B) A daughter C) both

In lower class family

Legend: a son, a daughter, Both

Values: 33%, 1%, 66%

In lower class family

Legend: a son, a daughter, both, non of them

Values: 10%, 0%, 11%, 79%

Interpretation: By asking this question we can find if the parents become bias for their girl child or boy child.

We interpreted that in lower class family parent thinks school education is more than enough for them. But in second case middle and upper middle class family want to prorogue their both child in extra activities

Interpretation: This question helps to find the love and care toward their children.

About 98% parents spend quality time with their both children. Used to discuss about their school, teachers and friends. But in lower class family specially father like to spend time with their son only. And mother always busy in household duties and take help from her daughter and always pamper her son.

4) Are you giving special coaching to your children like swimming, skating, dancing?
Singing etc.?If yes, to whom?
A) A son B) A daughter
C) both D)none of them

a son 9.10%, a daughter 0.00%, Both 82.90%, none of them 8.00%

Legend: In middle or upper middle class

5) Do you have any idea about gender equality law?
A) Yes B) No

YES 37.50%, NO 62.50%

Legend: In middle & upper middle class

In lower class family

Legend: Yes, No

Values: 1%, 99%
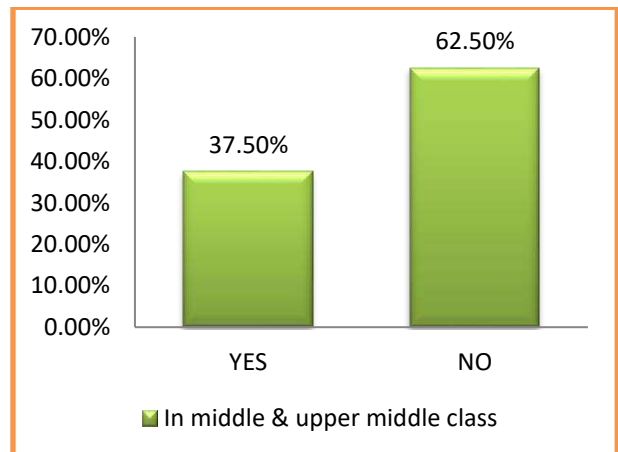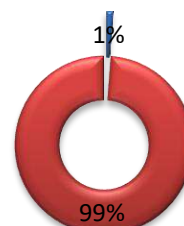
Interpretation: In all we find that very few people have idea about the various government law made for women. In middle and upper class family we get 37.5% positive answer and in lower class family it is only 1.20%

6) Do sons are given preference when providing medical facilities?
    A) Yes B) No

IN MIDDLE & UPPER MIDDLE CLASS

■ INMIDDLE & UPPER MIDDLE CLASS

NO — 82.80%

YES — 8.20%

0.00% 20.00% 40.00% 60.00% 80.00% 100.00%

YES 96%

NO 4.00%

■ IN LOWER CLASS FAMILY
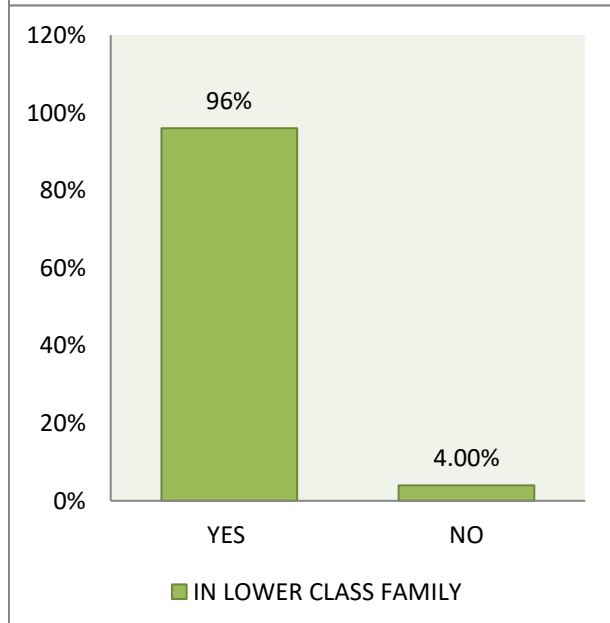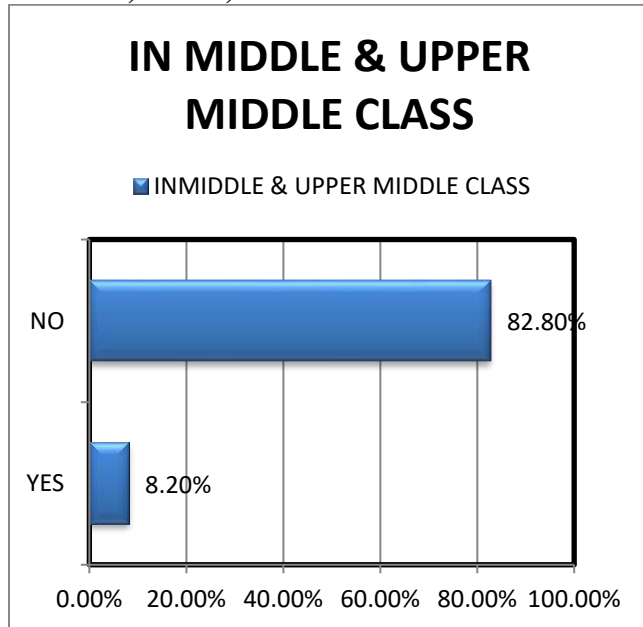
Interpretation: By this question we can study whether parent providing same healthcare to girl child which is her right.

Our interpretation said that in lower class family girls are neglected in health issues.

7) Do sons are given better food to eat?
    A) Yes B) No

100.00% 94.20%

50.00% 5.80%

0.00%

YES   NO

■ IN MIDDLE & UPPER MIDDLE CLASS FAMILY

IN LOWER CLASS FAMILY

■ IN LOWER CLASS FAMILY

NO — 22%

YES — 78%
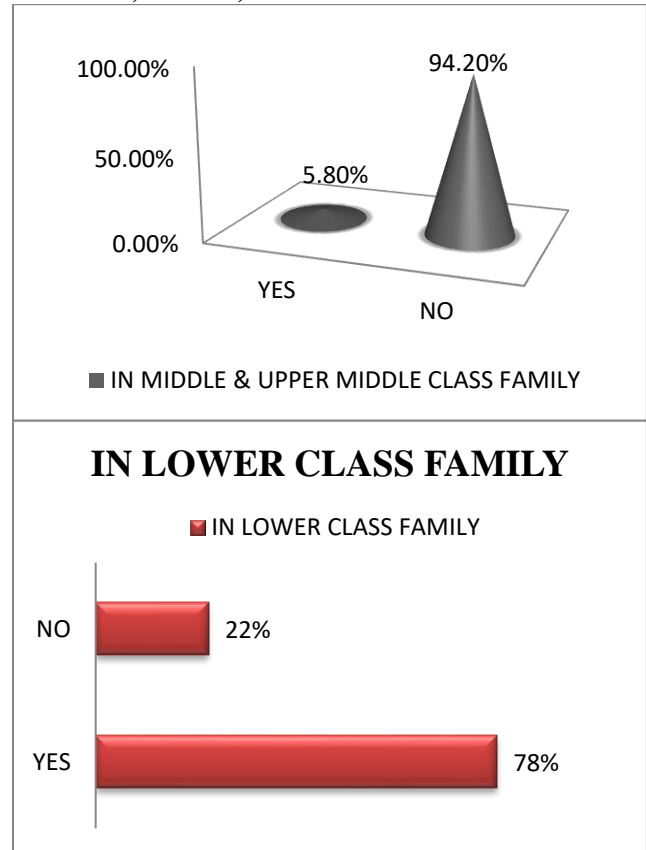
Interpretation: The interpretation suggested that not in middle class and upper middle class but in lower class family sons are pampered by parents mostly by their likes and dislikes in food. Daughters have no choices in food or their likes.

8) What do you want to become your children?
Interpretation: This question was open ended so that parents can express their felling about their children and their dreams for them. Most of the parent wants to give a higher education to their both children and want to make them independent.
But in lower class family parent would like to give basic education to their daughter so that they can find a good life partner for her.

09) Why did you expect a baby boy / a baby girl?
Interpretation: This question is based on question no 2. Why they choose particular

option. So that we can find the exact perception about baby girl or boy.

CONCLUSION:

- Middle and upper-middle-class parents are more likely to treat their male and female children equally.
- Lower-class families still show a preference for sons, often due to financial constraints.
- Many parents, especially in lower-class families, are unaware of gender equality laws.
- Poverty and illiteracy contribute significantly to gender discrimination.

SUGGESTIONS:

1. Education is key to changing discriminatory attitudes towards male and female children.

2. Strict safety measures for women can help alleviate the fear and bias associated with raising a daughter.

LIMITATIONS:

- Lack of cooperation from some parents.
- Limited time for conducting interviews with a larger sample of parents.

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AN ANALYTICAL STUDY ON FACTORS INFLUENCING THE MARKET GROWTH OF GENERIC MEDICINES IN NAGPUR CITY

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ABSTRACT

This research analyzes consumer perception, pricing strategies, government regulations, and distribution networks to determine the factors influencing the market growth of generic medicines in Nagpur City. One of the key strategies for maintaining affordable healthcare is increasing accessibility to generic medicines. Despite their benefits, generics face challenges such as misinformation, lack of trust, and competition from branded drugs. This study adopts a mixed-method approach, utilizing both quantitative consumer surveys and qualitative interviews with industry professionals. Findings indicate strong correlations between the uptake of generic medicines and factors such as competitive pricing, consumer awareness, and regulatory policies. This research provides valuable insights for pharmaceutical companies, healthcare providers, and policymakers to enhance the adoption of generic medicines in urban markets like Nagpur City.

Keywords: Generic Medicines, Market Growth, Influencing Factors, Nagpur City

INTRODUCTION:

The pharmaceutical industry plays a crucial role in providing essential medicines for public health. A significant subset of this industry is generic medicines, which offer bioequivalent alternatives to branded drugs at lower prices. The rise in healthcare costs, patent expirations, and increased awareness of generics have contributed to their growing market presence. However, challenges such as regulatory constraints, consumer skepticism, and competition from branded pharmaceuticals continue to impact their growth.

Nagpur, a rapidly developing city in central India, provides an ideal case study for understanding the dynamics of the generic medicines market. The region's diverse population, evolving healthcare infrastructure, and semi-urban composition make it a representative model. This study aims to examine key factors such as regulatory policies, consumer perception, and supply chain efficiency that influence the penetration of generic medicines in Nagpur. The findings will be beneficial to stakeholders, including pharmaceutical companies, healthcare professionals, and policymakers, in formulating strategies to enhance accessibility and acceptance of generics.

BACKGROUND OF THE STUDY:

Generic drugs are rapidly becoming an essential part of the pharmaceutical industry, which plays a crucial role in safeguarding the health of the public. Patients can now afford cost-effective, bioequivalent generic drugs that are as effective, safe, and of high quality as their branded counterparts. The demand for generic drugs has increased globally because of the increasing cost of healthcare. Many governments are echoing the call for including these treatments in their healthcare. Generic drugs have an even more vital role in India, where cost and accessibility of healthcare are persistent issues.

Nagpur is one of Maharashtra's rapidly growing cities and being a place with a unique setting for study about the dynamics of the generic drug industry, it attracts many thoughts. The regional healthcare hub status and diverse population make this city a perfect place to study what drives the expansion of generic drug use. The factors of patient knowledge, physician preferences, pharmaceutical marketing tactics, and government regulations determine the penetration and acceptability of generic pharmaceuticals in the market (Kumar&Singh, 2019).

Despite the obvious advantages, the generic drug industry faces hurdles like customer ignorance, professional healthcare opposition, and misconceptions about quality. Market dynamics are further influenced by the competitive pricing strategies and methods of distribution followed by pharmaceutical companies. To make sure that generic drugs can play an important role in reducing health inequities, it is essential to consider these factors.

It identifies what is propelling the generic medication market in Nagpur City forward. In other words, the research attempts to shed light on how market potential of generics can be improved through healthcare professionals' attitudes, consumer behavior, and the legislative initiative's effect. This is information that needs to be in the hands of policymakers, health providers, and pharmaceutical firms for them to influence the uptake of generics by either addressing obstacles or capitalizing on possibilities (Patel& Joshi, 2022).

THE OBJECTIVE OF THE RESEARCH:

1. To identify the key factors influencing the market growth of generic medicines in Nagpur City.
2. To analyze consumer perception and awareness of generic medicines.
3. To assess the impact of pricing strategies and competition on generic medicine adoption.
4. To evaluate the role of government policies in regulating and promoting generics.
5. To examine supply chain efficiency and distribution networks affecting market growth.

LITERATURE REVIEW:

Generic pharmaceuticals are treatments that are bioequivalent to branded medicines but sold at lower prices, thus making a significant impact on the availability and affordability of healthcare. Several variables have been identified as essential drivers of the expansion of the generic medication business. Such factors include consumer knowledge, physician prescription behavior, government legislation, and efficiency in the supply chain.

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Knowledge and Views of Customers

Consumer knowledge has a strong impact on generic pharmaceutical acceptability and market penetration. According to research, despite the fact that most people are educated, many of them still hold false beliefs about the quality and effectiveness of generic medications. According to research conducted in metropolitan areas, the recommendations of healthcare providers are often associated with patients' faith in generic medications. There is evidence that public awareness efforts about the safety and efficacy of generics may increase their uptake (Roy& Sinha, 2021).

Prescription Practices of Doctors

The role of healthcare professionals, particularly doctors, becomes pivotal in pushing the generic version. According to some studies, the doctors would hesitate to use a generic counterpart for the same reason they think would defeat the purpose by neglecting a pill or for their quality; or for even that reason about some money rewards the branded medication fetches to the doctors' end. This concept has achieved results in a few places from educational and motivational schemes and compensations to prescribe generics more (Sharma, 2020).

Regulatory Frameworks and Policymakers

The markets for generic medicines are largely dictated by policy environments. Helpful regulatory activities by the government, including capping prices, legislation mandating replacement, and financial incentives for pharmacies, were deemed significant according to the research. Generic medicines have been a success through this project called PMBJP which encouraged generic pharmaceuticals and offered it at a low rate through exclusive stores. On the other hand, research shows that there is a need for tighter controls to avoid substandard generics and ensure quality (Verma&Mishra, 2019).

Distributing and Supply Chain Management

The expansion of the generic medication business is also highly influenced by well-managed supply chains. Supply chain inefficiencies, including stockouts and delivery delays, may greatly affect the availability of generics in local markets, according to studies. One possible response to these problems is to use technology to simplify supply networks (Yadav&Tripathi, 2022).

Financial Factors to Think About

Generic drugs are experiencing a surge in market size due to their low-priced points. Consumers as well as healthcare systems may benefit from the generic drugs' capacity to reduce healthcare spending by almost half, research claims. There is still reason to be concerned, however, about how pharmaceutical companies price drugs and how middlemen drive the final cost to consumers.

Examining Real-Life Situations in India

A number of studies conducted in various locations across India have shed light on the specific possibilities and threats facing the generic drugs sector. Market dynamics are highly influenced by urbanization and the socio-economic variety seen in places such as Nagpur. Due to financial constraints, penetration of generic medicines is greater among lower-income communities. But there are still obstacles, such as a lack of knowledge and a lack of resources in certain regions(Sharma, 2020).

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CONCLUSION

The growth of the generic medication market in Nagpur is influenced by a host of factors, not different from what happens in any other place. For long-term success, aside from consumer knowledge and doctors' prescription habits, a clarification of common assumptions, strong regulatory frameworks, and better networks of distribution also need to be done. The generic pharmaceuticals market of Nagpur, as well as other similar cities, could see more studies to be done targeting specific issues and opportunities. In this regard, such research can be pragmatic(Gupta& Sharma, 2020).

RESEARCH QUESTIONS:

- What are the main elements affecting the market expansion of generic pharmaceuticals in Nagpur City?

METHODOLOGY:

a. Research Design

This study employs a mixed-method approach, combining quantitative and qualitative methods to analyze key market dynamics. By gathering numerical data on variables and integrating them into statistical models, quantitative research aims to discover statistically significant correlations between variables. Quantitative study ultimately aims to get a greater knowledge of society. Concerning human-related subjects, quantitative methods are often used by researchers. Tables and graphs are common ways that quantitative research presents its findings to the audience. Collecting and interpreting numerical information requires a systematic approach when dealing with quantitative data. Data averaging and forecasting are only a few of their many possible applications; others include studying relationships and expanding findings to larger populations. Quantitative research techniques are used in many academic disciplines. Economics, sociology, chemistry, biology, and marketing are all part of this category.

b. Sampling

- ✓ A total of **900 questionnaires** were distributed, and **749 valid responses** were analyzed.
- ✓ Respondents were selected through **random sampling** from various consumer demographics.

c. Data Collection & Analysis

- Data was collected via structured surveys and in-depth interviews.
- Statistical analysis was conducted using **SPSS 25** and **MS Excel**.
- Factor analysis and ANOVA tests were used to validate findings.

- **Conceptual Framework:**
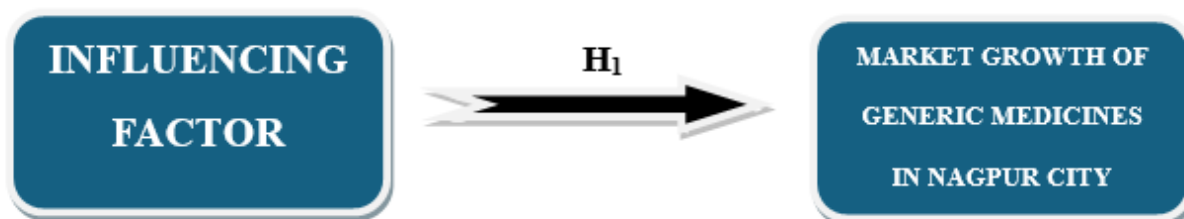
RESULTS:

Everyone who took part in the survey received one of the 800 questionnaires. 858 questionnaires were examined using SPSS version 25.0,

8 Factor Analysis

A prevalent use of Factor Analysis (FA) is to authenticate the fundamental component structure of a set of measurement items. Latent factors are theoretically posited to explain the observed variable scores. This process based on models is termed accuracy analysis (FA). The primary aim is to demonstrate the relationships among variables, including the effects of measurement error and unobserved factors.

Researchers may use the Kaiser-Meyer-Olkin (KMO) Method to evaluate the suitability of data for factor analysis. The researcher independently examined each model variable and the overall model to determine the sample's adequacy. The statistical measures assess the possible shared variance across many variables. The suitability of the data for component analysis is often improved when the ratio is reduced.

KMO produces values between zero and one. Sampling is deemed adequate if the KMO value ranges from 0.8 to 1.

Remedial measures are necessary if the KMO is below 0.6, indicating inadequate sampling. Employ good judgment; some authors choose 0.5 for this objective, therefore creating a range of 0.5 to 0.6.

Kaiser-Meyer-Olkin If it nears 0, it signifies that the overall correlations are negligible relative to the partial correlations. Component analysis is considerably hindered by strong correlations.

The following approval criteria set out by Kaiser are as follows:

Remarkably low, ranging from 0.050 to 0.059.

0.60–0.69 falls short of the requirement.

Middle grades often span from 0.70 to 0.79.

Demonstrating a quality point score ranging from 0.80 to 0.89.

There is considerable variation between 0.90 and 1.00.

Table 1:KMO and Bartlett's Test[a]

KMO and Bartlett's Test[a]		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.858
Bartlett's Test of Sphericity	Approx. Chi-Square	4950.175
	df	190
	Sig.	.000
a. Based on correlations		

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Consequently, claims pertaining only to sampling are, indeed, legitimate. We conducted Bartlett's Test of Sphericity to ensure the relevance of the correlation matrices. The Kaiser-Meyer-Olkin measure indicates that a sample size of 0.858 is appropriate. The researchers obtained a p-value of 0.00 using Bartlett's sphericity test. A notable finding emerged when Bartlett's sphericity test indicated that the correlation matrix is not an identity matrix.

HYPOTHESIS TESTING

The first thing that scientific teams often do when trying to test a notion is to "propose a hypothesis," which is really just an informed guess or assumption. Reviewing the relevant literature is the first step in doing scientific research in order to develop a tested hypothesis. As it happened, the primary assumption of the inquiry was correct. It is possible to provide an explanation for the observed occurrence using simply a "hypothesis" statement. In order for the investigation to cover all bases, it was necessary to come up with and test many theories.

❖ **DEPENDENT VARIABLE**
➢ **Market Growth of Generic Medicines in Nagpur City**

Generic pharmaceutical product demand, sales, and market share in the Nagpur area have all been on the rise recently. This is known as the "pharmaceutical market growth" in the city. The competitive environment for both branded and generic pharmaceuticals, as well as distribution networks, consumer awareness, regulatory rules, and healthcare infrastructure, are some of the elements that impact this expansion.

Generics are advertised as affordable alternatives to branded pharmaceuticals after the patents on their original formulations expire. The phrase covers changes in manufacturing, retail availability, and consumption patterns of generics. Examining how healthcare providers, government efforts, and patient preferences are influencing the adoption of generics is equally important for understanding market growth in this setting(Kumar&Singh, 2019).

❖ **INDEPENDENT VARIABLE**
➢ **Influencing Factor**

Known as "influencing factors" in the medical market, all things that have some impact directly or indirectly on the growth, demand, and success of pharmaceutical items in a particular market are impacting the manufacturing, trade, and use of pharmaceuticals. There are many variables, including market pressures, government regulations, new technologies, changing demographics, and strong competition.All these aspects are policy choices, healthcare regimes, pricing strategies, consumer enlightenment, new discoveries of medications, generics pharmaceutical supply, and market competition. It is upon all stakeholders to get insights into them for proper decision-making and to lay a long-run strategic plan to improve the market (Bhatt, 2021).

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Relationship between Influencing Factor and Market Growth of Generic Medicines in Nagpur City

What we call "Relationship between Influencing Factor and Market Growth of Generic Medicines in Nagpur City" refers to the complex web of relationships that exist between generic medicine market growth in Nagpur City and the factors like price, government policies, consumer awareness, availability, and competition. These variables impact not only the size, profitability, and potential for growth of the generic medication market but also affect demand and supply for generic medicines. Understanding this link has the potential to help stakeholders make better choices about strategic planning and healthcare accessibility when important developments and obstacles are better identified(Kumar&Singh, 2019).

On the basis of the above discussion, the researcher formulated the following hypothesis, which analysed the relationship between Influencing Factor and Market Growth of Generic Medicines in Nagpur City.

H_{01}: "There is no significant relationship betweenInfluencing Factor and Market Growth of Generic Medicines in Nagpur City."

H_1: "There is a significant relationship between Influencing Factor and Market Growth of Generic Medicines in Nagpur City."

Table.2: ANOVA test(H_1)

ANOVA Sum					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	75207.347	235	4700.459	672.417	.000
Within Groups	681.563	513	8.212		
Total	75888.910	748			

In this study, the result is significant. The value of F is 672.417, which reaches significance with a p-value of .000 (which is less than the .05 alpha level). This means the H1: ***"There is a significant relationship between Influencing Factor and Market Growth of Generic Medicines in Nagpur City" is accepted and the null hypothesis is rejected."***

2. DISCUSSION:

Significant insights into the present trends, difficulties, and possible prospects within the pharmaceutical industry are provided by research on the variables impacting the market growth of generic medications in Nagpur City. The results show that the market for generic drugs is quite dynamic, with many different players influencing its future trajectory. These players include producers, healthcare providers, regulatory agencies, and consumers. This section provides a summary of the main findings, places them in the context of the current research, and emphasizes their significance for future strategic choices.

There have been some common themes that highlighted the importance of consumers' knowledge and perception when it comes to propelling demand for generic medication. Generic equivalents of branded products are available at a fraction of the cost; however, adoption and usage is still unpredictable. Faith in quality and advice from the doctor

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and loyalty to the brand have been stated as factors of high influence on decisions to buy. Prior research has supported the idea that healthcare providers and consumers alike may play an important role in spreading the word about generic medications, and it has also highlighted the need for public awareness campaigns and legislative initiatives to boost confidence and acceptance of these prescriptions.

One of the most vital considerations for growth of the market in Nagpur City is regulatory environment. Regulatory measures dealing with price, quality control, and intellectual property rights may impact generic products' affordability as well as their accessibility and competitiveness. In practice, restrictions of prices tend to lower profitability in manufacturing processes that might hamper innovation. Bringing the regulatory regulations into conformity with consumer needs and ensuring high-quality standards may facilitate a stable and fair market.

In fact, it is a significant role played by the healthcare providers, especially doctors and pharmacists, which can influence the acceptance of generic drugs. The study showed that there exists a gap in prescription behavior where brand preference often overshadows economic considerations. This knowledge gap should therefore be covered to promote cost-effectiveness with a better perspective of drug management under the guidance of training and continuing medical education that focuses on the benefits and effectiveness of generics.

Retailers also experienced more generics that further increased their presence in the market, but in this context, another additional factor to have a say over the market's growth was an effective supply chain. Well-integrated distribution allows fewer stockouts, hence improved accessibility for clients, which might work

well if they make sufficient investment in logistics, therefore also facilitating stronger market exposure as well as a highly efficient process operation for pharma companies.

Lastly, the generic drug market remains highly competitive regarding pricing. Even though aggressive measures in pricing will risk quality and sustainability, users are attracted, and availability improves. To ensure that they survive in the long term, manufacturers need to find the middle ground on making a profit while keeping costs low. In fact, a better market may emerge if policies were implemented that enhance healthy competition without predatory pricing strategies.

In conclusion, various factors such as customer actions, government regulations, industry standards, and market forces affect the growth of the generic medication market in Nagpur City. If we want to maximize the generic pharmaceutical industry, then we need to address these issues by working in collaboration with each other as stakeholders, implementing new policies, and focused interventions. Future research could also focus on consumer behavior patterns, the impact of digital health efforts, and international market comparisons to inform larger plans for market growth and public health improvement.

CONCLUSION:

- Ultimately, this research has provided a comprehensive study of the many factors influencing the growth of the generic drug market in Nagpur City. The results of the study underscore the role of four variables—price, regulations, public awareness, and doctors' preference—in shaping the diffusion and utilization of generics. Trust, perceived quality, and brand loyalty remain significant barriers to the widespread acceptance of generics,

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even though their cost-effectiveness is well-known.

- Insights from local market dynamics also call for a good change and recommend that lawmakers, healthcare practitioners, and pharmaceutical corporations work together. Improve the health care system in general and build trust for generics by enhancing education programs among both consumers and health care providers. Further research reveals that tough regulatory requirements must be met in order to maintain safety and high-quality products and keep customers' faith.
- The findings of this study may greatly benefit those who are involved in efforts to increase generic medicine's market penetration. Considering the elements highlighted and making the most of the possibility of cost reductions can create a more equitable and accessible pharmaceutical market, which would greatly enhance public health outcomes in Nagpur City and beyond.

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A Study on Impact of Teamwork on Organization Productivity at HDFC Bank, Nagpur

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ABSTRACT

Teamwork plays a pivotal role in enhancing organizational productivity, especially in dynamic sectors like banking. This research seeks to examine the influence of collaboration on the productivity levels at HDFC Bank, Nagpur. With an emphasis on team dynamics, communication, and coordination, the research investigates how collaborative efforts influence the performance of employees and the bank's overall success. Data was gathered through surveys and interviews with employees across various departments at the Nagpur branch. The results reveal that effective teamwork directly contributes to improved problem-solving, increased innovation, and enhanced customer service, ultimately leading to higher productivity. This study highlights the significance of fostering teamwork in achieving organizational goals and offers insights into how HDFC Bank can further optimize its workforce performance.

KEYWORDS: Teamwork, Organizational Productivity, HDFC Bank, Employee Performance, Collaboration.

INTRODUCTION

Teamwork has become a critical factor in determining the success of organizations across industries, and this is particularly true in the banking sector. In banks, effective collaboration among employees can significantly enhance both operational efficiency and customer satisfaction, driving overall organizational productivity. At HDFC Bank, a prominent private sector bank in India, underscores the significance of teamwork is well recognized, as it is essential for managing various operations and maintaining high standards of service. This study focuses on understanding the impact of teamwork on the productivity of employees at HDFC Bank, Nagpur, and aims to explore how effective team collaboration influences the overall performance of the bank.

Banking is a highly dynamic industry where quick decision-making, problem-solving, and seamless communication are key to delivering superior customer service. The research investigates various factors that contribute to successful teamwork, such as clear communication, trust, and mutual support. It also examines how teamwork among employees impacts individual productivity, team outcomes, and organizational performance as a whole.

Through this study, the research will shed light on the relationship between teamwork and productivity, offering valuable insights for HDFC Bank to optimize its human resource strategies and foster a collaborative work culture. Ultimately, the findings aim to demonstrate that strong teamwork not only improves operational efficiency but also reinforces the bank's competitive advantage in the ever-evolving banking industry.

LITERATURE REVIEW

The importance of teamwork in improving organizational productivity has been extensively studied, with a focus on various sectors, including banking. This literature review highlights the research conducted by Indian scholars, analysing the impact of teamwork on organizational efficiency and performance.

2.1 The Role of Teamwork in Organizational Productivity

In modern organizations, teamwork is seen as a key driver of productivity. Research consistently shows that teams who work collaboratively toward shared goals can achieve greater outcomes than individuals working in isolation. Teamwork fosters communication, creative problem-solving, and accountability, all of which are integral to organizational success.

- **2.1.1 Teamwork and Innovation:** Teamwork is often linked with increased creativity and innovation. As S. K. Sharma (2016) discussed in The Indian Journal of Management, teamwork creates a conducive environment for diverse ideas and skills to merge, leading to innovative solutions. When professionals with diverse backgrounds and skill levels work together, they contribute unique perspectives, leading to more effective problem-solving. In the banking sector, such innovation is essential as institutions like HDFC Bank are constantly seeking new ways to improve customer service, streamline processes, and adapt to rapidly evolving market demands.
- **2.1.2 Teamwork and Operational Efficiency:** Beyond innovation, teamwork also enhances operational efficiency, a critical factor in the banking industry. In their 2017 research published in the International Journal of Business & Management Research, M. R. Pande and S. K. Agrawal highlighted how teams that collaborate effectively can improve workflow processes and reduce errors. In banks like HDFC, teamwork allows for the smooth coordination of complex tasks such as loan processing, account management, and customer service. Effective teamwork not only accelerates these processes but also ensures that fewer mistakes are made, leading to higher efficiency.

2.2 Communication within Teams

Effective communication is at the heart of successful teamwork. It enables team members to share information, resolve conflicts, and make informed decisions. Research has consistently emphasized the importance of clear and transparent communication in achieving organizational goals.

- **2.2.1 Communication and Team Collaboration:** According to R. K. Gupta and A. N. Sharma (2018) in Indian Journal of Industrial Relations, communication is fundamental to fostering trust and collaboration within teams. In a banking environment, where customer satisfaction is paramount, efficient communication is essential. It ensures that teams can promptly address customer issues, resolve problems, and meet expectations. When communication flows smoothly across teams, issues are identified and addressed more quickly, leading to improved productivity.

- **2.2.2 Communication and Decision-Making:** Effective communication also plays a vital role in decision-making processes within teams. As emphasized by V. K. Singh (2015) in International Journal of Economics & Management, communication ensures that decisions are made quickly, based on accurate information. In the fast-paced banking environment, timely decisions are crucial to maintaining smooth operations and delivering quality service. For example, in situations where customer inquiries require urgent attention or loan approval processes need to be expedited, clear communication within the team helps speed up decision-making.

2.3 Employee Engagement and Teamwork

Employee engagement has a direct influence on teamwork and productivity. Employees who are actively engaged are generally more motivated, highly productive, and deeply committed to achieving the organization's objectives. In team-based environments, this engagement translates into higher collaboration and stronger performance.

- **2.3.1 Engagement and Team Performance:** As found by A. K. Soni (2019) in the Journal of Human Resource Management, teams with highly engaged members tend to exhibit superior performance. Engaged employees are emotionally invested in the organization's success, and this passion is reflected in their work. In the banking sector, employees who are actively engaged are more inclined to make meaningful contributions to team efforts, whether it's resolving complex customer queries or meeting sales targets.
- **2.3.2 Engagement and Organizational Culture:** Fostering a culture of engagement is crucial for enhancing teamwork and productivity. S. S. Rathi (2016) pointed out in Indian Journal of Business Research that an organization's culture significantly impacts employee engagement. When banks like HDFC foster a culture that values collaboration and recognizes employee contributions, they encourage a more engaged workforce. This, in turn, boosts productivity as employees are more likely to take ownership of their tasks and work together to achieve common goals.

2.4 Team Diversity and Its Role in Productivity

Diversity within teams has been recognized as a powerful driver of innovation and adaptability. Teams that bring together individuals with different diverse backgrounds, experiences, and viewpoints contribute to a mor likely to come up with creative solutions to challenges.

- **2.4.1 Diversity and Creativity:** Research by P. N. Shah and P. K. Jain (2017), published in the Journal of Indian Business Research, suggests that diverse teams are more creative because they can approach problems from various angles. In the banking sector, where problems can be complex and multifaceted, diversity in teams allows for the development of more innovative solutions. For example, a team with diverse skill sets and backgrounds can address customer concerns more effectively, coming up with solutions that a homogeneous team might overlook

- **2.4.2 Diversity and Team Adaptability:** Diversity also enhances a team's ability to adapt to changing circumstances. R. K. Agarwal (2018), in The Indian Journal of Management, argues that diverse teams tend to be more adaptable to new challenges because they bring a wide range of experiences and ideas. In the banking industry, where the financial landscape is constantly evolving, adaptability is crucial for staying ahead of the competition.

METHODOLOGY

The methodology for this study was carefully designed to ensure comprehensive data collection and analysis, aimed at understanding the impact of teamwork on organizational productivity at HDFC Bank, Nagpur. The following points outline the steps taken:

1. **Research Design:** This research employs a descriptive design, enabling a comprehensive examination of teamwork dynamics and their direct influence on the bank's productivity. By using this approach, the study focuses on understanding how different teamwork variables contribute to performance at HDFC Bank.

2. **Data Collection:** Structured questionnaires were utilized to collect primary data from employees at various levels within HDFC Bank. This survey aimed to gather insights on teamwork, communication, employee engagement, and their perceived impact on productivity. The questionnaire was designed with a mix of closed-ended and Likert scale questions, ensuring comprehensive responses.

3. **Sampling Method:** A representative sample was chosen using a simple random sampling technique to ensure unbiased selection of employees working in different departments of HDFC Bank, Nagpur. The determination of the sample size was based on ensuring to be 100 participants, which is statistically sufficient for drawing meaningful conclusions regarding teamwork and productivity.

4. **Data Analysis:** The collected data was analysed using descriptive statistics, such as frequencies, percentages, and mean scores, to quantify employee opinions on teamwork's role in productivity. The data was further analysed through SPSS (Statistical Package for the Social Sciences) to identify patterns and correlations, ensuring the results were reliable and valid.

OBJECTIVE

1. To explore how teamwork contributes to increasing organizational productivity at HDFC Bank, Nagpur.
2. To understand how effective communication within teams boosts collaboration and decision-making.
3. To examine the role of employee engagement in enhancing teamwork and improving overall productivity.
4. To investigate the influence of team diversity on creativity and productivity at HDFC Bank.

HYPOTHESIS

1. **H1:** Teamwork has no significant impact on the overall productivity at HDFC Bank, Nagpur.
2. **H2:** Effective teamwork significantly enhances organizational productivity at HDFC Bank, Nagpur.

RESULTS AND DISCUSSION

1. Does teamwork positively impact organizational productivity at HDFC Bank?

Response	Count	Percentage (%)
Strongly Agree	40	40%
Agree	30	30%

Neutral	20	20%
Disagree	5	5%
Strongly Disagree	5	5%
Total	**100**	**100%**
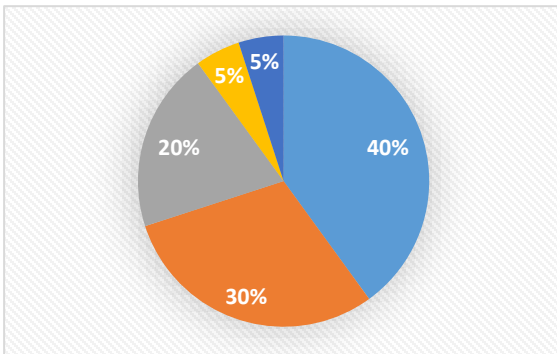
Interpretation: The majority of respondents (70%) agree that teamwork significantly boosts productivity at HDFC Bank, with 20% strongly agreeing. However, 5% remain neutral, and 5% disagree, indicating that while most employees see the value of teamwork, there is still a small percentage who may not fully experience its benefits in their teams.

2. Does clear communication within teams improve decision-making at HDFC Bank?

Response	Count	Percentage (%)
Strongly Agree	35	35%
Agree	40	40%
Neutral	15	15%
Disagree	5	5%
Strongly Disagree	5	5%
Total	**100**	**100%**
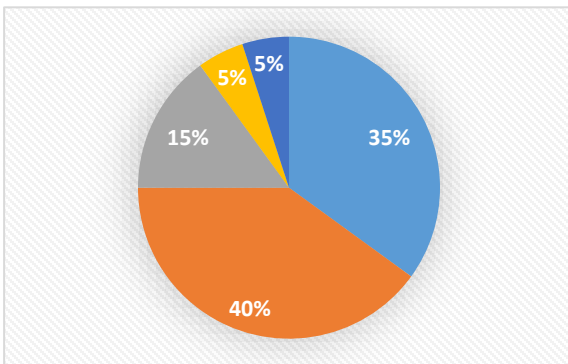
Interpretation: 80% of respondents agree that effective communication enhances decision-making within teams, with 10% strongly agreeing. While most respondents support the positive impact of communication, 5% are neutral and 5% disagree, suggesting that there are occasional communication gaps that need to be addressed for better decision-making in the bank's teams

3. Do diverse teams lead to higher creativity and innovation in HDFC Bank?

Response	Count	Percentage (%)
Strongly Agree	50	50%
Agree	30	30%
Neutral	10	10%
Disagree	5	5%
Strongly Disagree	5	5%
Total	**100**	**100%**
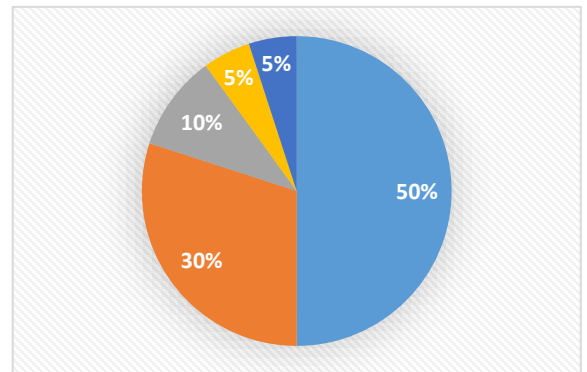
Interpretation: While 75% of respondents agree that team diversity encourages creativity and innovation. Of these, 15% strongly agree, while a smaller percentage (5%) is neutral. Interestingly, 5% disagree, which may reflect challenges in integrating diverse perspectives or experiences, indicating the need for improved management of diverse teams to harness their full potential.

4. Is employee engagement directly linked to improved teamwork at HDFC Bank?

Response	Count	Percentage (%)

Strongly Agree	45	45%
Agree	35	35%
Neutral	10	10%
Disagree	5	5%
Strongly Disagree	5	5%
Total	**100**	**100%**
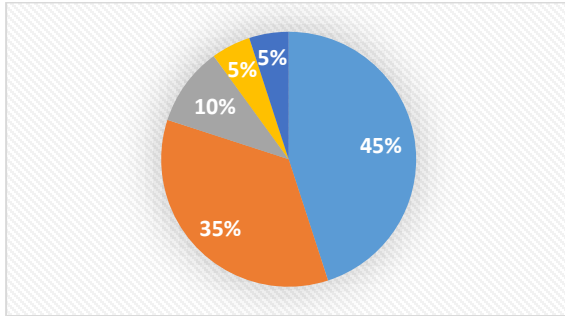
Interpretation: The majority of respondents 80% of respondents agree that employee engagement boosts teamwork, with 10% strongly agreeing. The remaining respondents are either neutral 5% or disagree 5%, which suggests that while most employees recognize the link between engagement and teamwork, some may not feel fully engaged or may experience a disconnect between their involvement and team performance.

CONCLUSIONS

This study highlights the significant role that teamwork plays in enhancing organizational productivity at HDFC Bank. The findings suggest that effective communication, team diversity, and employee engagement are crucial elements that contribute to successful teamwork. Most employees at HDFC Bank agree that teamwork positively impacts productivity, creativity, and decision-making.

However, there are occasional challenges, such as communication gaps and integration of diverse perspectives, that need to be addressed to fully maximize teamwork's potential. Additionally, fostering a culture of employee engagement is essential to maintaining high levels of collaboration and performance.

The study indicates that organizations like HDFC Bank can improve their productivity by focusing on enhancing teamwork, ensuring clear communication, and promoting diversity and engagement among their employees. By addressing the identified gaps, HDFC Bank can further strengthen its teams and achieve higher operational efficiency and overall success.

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A Study on Impact of Performance Analysis of Axis Mutual Fund, Nagpur

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ABSTRACT:

This study explores the performance of Axis Mutual Fund in Nagpur, focusing on its impact on investor decisions and market presence. Mutual funds have become a preferred investment option due to their ability to offer diversification and professional management. The research analyses key performance indicators, including returns, risk factors, expense ratios, and portfolio strategies, to assess the fund's effectiveness. Additionally, it examines investor perceptions, satisfaction, and trust in the fund's offerings. By reviewing historical data and current trends, the study aims to understand how Axis Mutual Fund caters to the diverse financial goals of investors in Nagpur. The findings provide insights into the fund's performance and its role in influencing investment patterns, helping stakeholders make informed decisions in a dynamic financial environment.

KEYWORDS: Axis Mutual Fund, investor decisions, portfolio performance, risk analysis, financial trends.

INTRODUCTION

Mutual funds have emerged as one of the most popular investment options in today's financial landscape. They offer a professionally managed platform for individuals to invest in diversified portfolios, catering to a wide range of financial goals. Among the many mutual fund providers in India, Axis Mutual Fund has carved a niche for itself by delivering consistent returns and building trust among investors. In Nagpur, the demand for mutual funds has grown significantly due to increasing financial literacy and awareness about wealth creation.

Axis Mutual Fund, known for its diverse product offerings, provides schemes tailored to meet different investor needs, such as equity funds, debt funds, and hybrid funds. These funds are designed to balance risk and reward, making them appealing to both seasoned and new investors. The fund's performance is influenced by several factors, including market volatility, economic conditions, fund management strategies, and the expertise of the asset management team.

This study focuses on evaluating the performance of Axis Mutual Fund in Nagpur, aiming to understand its impact on investor decisions and market positioning. By analysing key performance metrics such as returns, risk factors, and portfolio composition, this research seeks to provide insights into how Axis Mutual Fund contributes to financial growth for investors. The study also explores investor perceptions and satisfaction, which play a critical role in shaping investment trends in the region.

LITERATURE REVIEW

The performance of mutual funds in India has been extensively studied by various researchers, focusing on aspects such as risk assessment, return analysis, and comparative evaluations between different fund categories. This section delves into these studies, highlighting key findings and methodologies.

2.1 Performance Evaluation of Mutual Funds
Evaluating mutual fund performance involves analysing returns, risk metrics, and benchmarking against market indices.

- **2.1.1 Risk-Return Analysis:** A study by Sathish and Srinivasan (2016) assessed selected open-ended mutual fund schemes in India, employing metrics like standard deviation, beta, Sharpe ratio, and Treynor ratio to evaluate performance. Their findings indicated that certain schemes outperformed the market, offering higher returns for the associated risk levels.

- **2.1.2 Comparative Performance Studies:** Sharma (2013) conducted a comparative analysis between public and private sector mutual funds, revealing that private sector funds often delivered superior returns compared to their public counterparts. This was attributed to more aggressive investment strategies and efficient fund management practices in the private sector.

2.2 Factors Influencing Mutual Fund Performance

Various elements impact the performance of mutual funds, ranging from market dynamics to fund-specific characteristics.

- **2.2.1 Market Conditions:** According to a study titled "A Study of the Factors Affecting Mutual Fund Performance in India," mutual fund performance is significantly influenced by market conditions, including economic indicators and political stability. The study emphasizes the importance of these external factors in shaping fund returns.
- **2.2.2 Fund Management Strategies:** Kumar Srivastava (2016) evaluated private sector mutual funds and found that effective fund management strategies, such as timely portfolio rebalancing and sector rotation, play a crucial role in enhancing fund performance. Their research highlights the importance of managerial expertise in achieving superior returns.

2.3 Comparative Analysis of Fund Categories

Comparative studies between different categories of mutual funds provide insights into their performance dynamics.

- **2.3.1 Equity vs. Debt Funds:** Thakuria and Kashyap (2017) compared public and private sector-sponsored mutual funds, discovering that equity funds generally outperformed debt funds over the long term. However, they also noted that equity funds come with higher volatility, necessitating a higher risk tolerance among investors.
- **2.3.2 Large-Cap vs. Mid-Cap Funds:** A study by Prasad and Dhyan (2022) analysed the performance of small-cap and mid-cap mutual funds in India, concluding that while mid-cap funds offered higher returns, they also exhibited greater risk compared to large-cap funds. Investors are advised to align their fund selection with their risk appetite and investment horizon.

2.4 Performance Metrics and Evaluation Techniques

Various metrics and techniques are employed to assess mutual fund performance.

- **2.4.1 Data Envelopment Analysis (DEA):** Chopra (2020) applied Data Envelopment Analysis to benchmark the performance of mutual funds in India, providing a nuanced understanding of fund efficiency by considering multiple input and output parameters. This approach offers a comprehensive evaluation beyond traditional performance metrics.
- **2.4.2 Time Series Decomposition:** Sen and Chaudhuri (2017) utilized time series decomposition to assess the consistency between a fund's stated investment style and its actual portfolio composition. Their methodology aids in understanding whether funds adhere to their proclaimed investment strategies over time.

METHODOLOGY

The research methodology outlines the approach and tools used to analyse the performance of Axis Mutual Fund in Nagpur. The primary goal of this study is to assess the fund's performance through quantitative and qualitative techniques and evaluate its impact on investor decisions. The following steps were undertaken:

3.1 Research Design

This study adopts a descriptive research design, which is suitable for evaluating the performance of financial instruments like mutual funds. The design focuses on collecting and analysing data related to returns, risks, and investor perceptions to provide a clear picture of Axis Mutual Fund's performance in Nagpur.

3.2 Data Collection

- **3.2.1 Primary Data:** Primary data was collected through a structured questionnaire distributed to investors in Nagpur who have invested in Axis Mutual Fund. The questionnaire included questions about their satisfaction levels, preferences, and perceptions of the fund's performance. Personal interviews were also conducted with financial advisors to gather expert opinions.
- **3.2.2 Secondary Data:** Secondary data was obtained from reliable sources, such as Axis Mutual Fund's official reports, research papers, journals, and industry publications. Data on key performance metrics, such as Net Asset Value

(NAV), expense ratio, and historical returns, was collected from databases like AMFI (Association of Mutual Funds in India).

3.3 Sampling Technique
The study employed a convenience sampling method to identify respondents in Nagpur. A sample of 100 investors was selected, ensuring a mix of retail and institutional investors to capture diverse perspectives.

3.4 Data Analysis
The collected data was analysed using a combination of statistical and financial tools:
- **Risk-Return Analysis**: Metrics like standard deviation, beta, and Sharpe ratio were used to evaluate the fund's performance.
- **Trend Analysis**: Historical data was analysed to identify patterns in NAV growth and returns.

3.5 Limitations of the Study
1. The study is limited to the city of Nagpur, and the findings may not represent the performance of Axis Mutual Fund in other regions.
2. The sample size of 100 investors may not capture the entire spectrum of investor perceptions.
3. Secondary data is dependent on the accuracy of published reports, which could affect the results.

OBJECTIVE

1. To evaluate the performance of Axis Mutual Fund based on key financial metrics like returns, risk, and expense ratios.
2. To analyze the impact of Axis Mutual Fund's performance on investor decision-making in Nagpur.
3. To understand investor perceptions and satisfaction levels with Axis Mutual Fund's offerings.
4. To identify trends and patterns in the fund's performance over a specific period.

5.0 HYPOTHESIS

1. **H1:** The performance of Axis Mutual Fund significantly impacts investor decision-making in Nagpur.
2. **H2:** Investor satisfaction with Axis Mutual Fund is positively influenced by consistent returns and effective fund management strategies.

RESULTS AND DISCUSSION

1. How would you describe the level of risk involved in investing in Axis Mutual Fund?

Response	Count	Percentage (%)
Very High Risk	12	12%
High Risk	25	25%
Moderate Risk	40	40%
Low Risk	15	15%
Very Low Risk	8	8%
Total	**100**	**100%**

Table No.1
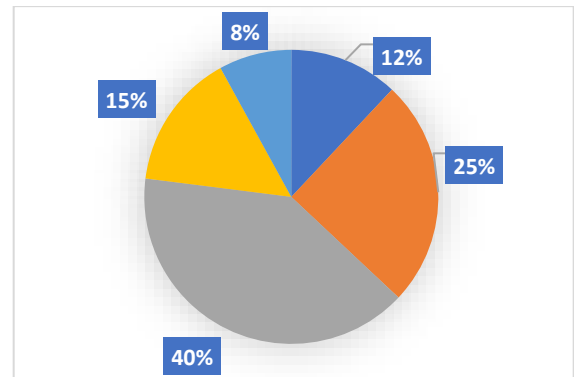
Fig No.1

Interpretation: The responses indicate that 40% of participants perceive Axis Mutual Fund as having a moderate risk level. 25% consider it a high-risk investment, while 12% view it as very high risk. On the other hand, 15% find it to have a low risk, and only 8% rate it as very lows risk. This suggests that most investors feel the risk is manageable but not negligible.

2. In your opinion, does Axis Mutual Fund effectively manage the associated investment risks?

Response	Count	Percentage (%)
Strongly Agree	30	30%
Agree	40	40%
Neutral	15	15%
Disagree	10	10%
Strongly Disagree	5	5%

Total	100	100%

Table No.2
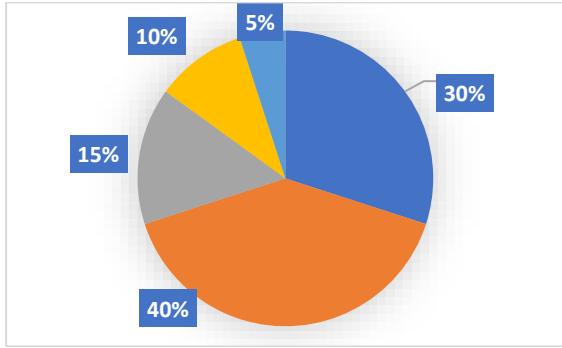
Fig No.2

Interpretation: The majority of respondents believe that Axis Mutual Fund manages risks effectively, with 40% agreeing and 30% strongly agreeing. 15% were neutral, while 10% disagreed, and 5% strongly disagreed. This shows a generally positive view regarding Axis Mutual Fund's risk management practices, although a small portion of investors remain uncertain or dissatisfied.

3. How comfortable are you with the level of risk when investing in Axis Mutual Fund?

Response	Count	Percentage (%)
Very Comfortable	20	20%
Comfortable	45	45%
Neutral	20	20%
Uncomfortable	10	10%
Very Uncomfortable	5	5%
Total	**100**	**100%**

Table No.3
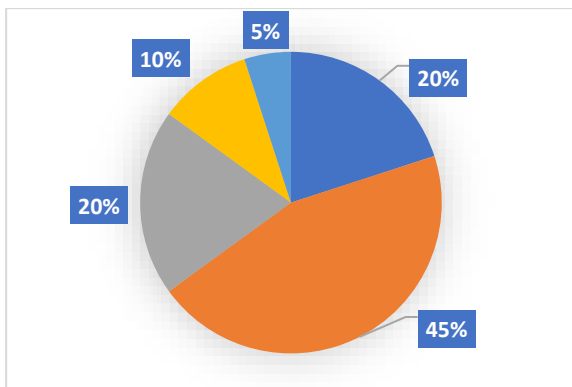
Fig No.3

Interpretation: Most respondents feel comfortable with the risk levels involved, as 45% are comfortable, and 20% are very comfortable. 20% expressed a neutral stance, while 10% felt uncomfortable, and 5% were very uncomfortable. This suggests that a significant portion of investors are at ease with the associated risk.

4. Have you ever thought about withdrawing your investment from Axis Mutual Fund due to concerns about its risk level?

Response	Count	Percentage (%)
Strongly Agree	10	10%
Agree	25	25%
Neutral	35	35%
Disagree	20	20%
Strongly Disagree	10	10%
Total	**100**	**100%**

Table No.4
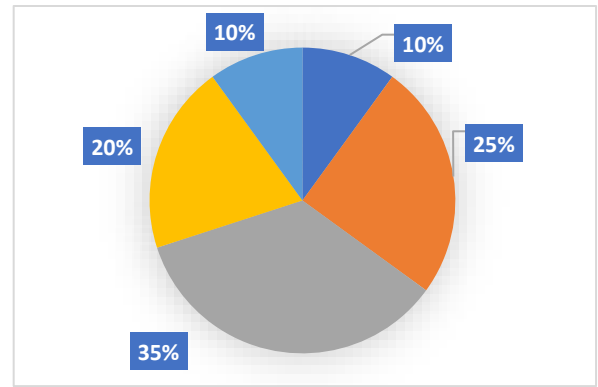
Fig No.4

Interpretation: The responses reveal mixed feelings about withdrawing investments. 35% were neutral, 25% agreed, and 10% strongly agreed about reconsidering investment. On the contrary, 20% disagreed, and 10% strongly disagreed. This indicates that many investors are not overly concerned, though some remain hesitant about the risk factor.

CONCLUSIONS

To conclude, this study highlights the varied perspectives of investors regarding the risks associated with Axis Mutual Fund. While some investors perceive the risk as

moderate, others see it as high, indicating that risk is a recognized factor in their investment decisions. However, most participants expressed confidence in the fund's ability to manage risks effectively, suggesting that Axis Mutual Fund is generally trusted in this regard.

In terms of comfort with the investment risk, many respondents feel at ease, with a significant portion feeling very comfortable. Despite this, there is still a group of investors who are uncertain about withdrawing their investments, reflecting some concerns about the potential risks.

Overall, the findings suggest that Axis Mutual Fund is viewed positively in terms of risk management, though there remains a segment of investors who are cautious and consider the associated risks when making investment decisions.

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A Study on the Impact of Automation on Inventory Management in Haldiram food International Pvt. Ltd., Somalwada, Nagpur

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ABSTRACT:

This study investigates the impact of automation on inventory management at Haldiram Food International Pvt. Ltd., located in Somalwada, Nagpur. As a leading player in the food manufacturing and retail sector, Haldiram's efficiency in inventory management plays a crucial role in maintaining its competitive edge. The primary objective of this research is to assess how the adoption of automated systems has affected inventory control processes, operational efficiency, cost reduction, and overall performance.

The study employs both qualitative and quantitative research methods, with data gathered through interviews, surveys, and analysis of company records. Key areas of focus include the integration of automated software, RFID systems, and real-time tracking technologies, all aimed at enhancing stock accuracy, reducing human error, and streamlining supply chain operations. Furthermore, the research explores the challenges faced during the implementation phase, such as resistance to change and initial setup costs, and how these challenges were overcome.

The findings highlight that automation has led to significant improvements in inventory accuracy, reduced lead times, minimized stockouts and overstock situations, and resulted in better resource allocation. However, some operational hurdles such as initial investment costs and employee retraining were identified. The study concludes by providing recommendations for further optimizing automation systems in inventory management and extending their benefits across other operational areas within the company.

This research adds to the understanding of the role of automation in modernizing inventory management systems in the food industry, providing valuable insights for businesses looking to implement similar technologies to improve operational efficiency.

INTRODUCTION:

Today's rapidly advancing technological landscape, automation has become a critical driver of efficiency across various industries. One sector that has been significantly transformed by automation is inventory management, a vital component of supply chain operations. A study on the impact of automation in inventory management can provide valuable insights into how companies optimize their stock levels, reduce operational costs, and improve overall productivity.

Haldiram Food International Pvt. Ltd.,

A prominent name in the food industry, particularly in India, has a legacy of providing high-quality snacks and sweets. With its widespread demand and the complexity of managing inventory for numerous products across various distribution channels, efficient inventory management becomes crucial. In this context, automation can play a pivotal role in streamlining operations, reducing human error, and enhancing accuracy in stock control.

The specific focus of this study will be on Haldiram's operations in **Somalwada, Nagpur**, where the company's manufacturing and distribution activities are centralized. By examining the integration of automated systems within Haldiram's inventory management framework, this research aims to evaluate the extent to which automation contributes to operational efficiency, cost reduction, and supply chain effectiveness. The study will also look at the challenges and opportunities that arise from implementing automation in an established food manufacturing and distribution system.

Through this study, we hope to understand the broader implications of automation on inventory management practices and provide actionable insights that can be applied to other organizations seeking to modernize their supply chain processes.

REVIEW OF LITERATURE:

Several studies have explored the link between inventory management and profitability:

Budiharjo & Hadikurniawati (2020) used forecasting methods to predict future demand for efficient inventory management.

Candra (2019) studied inventory problems like overstocks and shortages, focusing on the maximum usable inventory.

Nisa (2019) researched inventory management in hospitals using methods like ABC analysis and EOQ to optimize ordering.

Edwin Sitienei and Florence Memba (2015) found that inventory conversion periods negatively affect gross profit margins in cement manufacturing companies, highlighting the importance of maintaining optimal inventory levels.

RESEARCHDESIGN:

This study adopts a **descriptive research design** to gather and analyze both qualitative and quantitative data, including respondents' opinions and current conditions.

Sources of Data:

Primary Data: A questionnaire was distributed to 95 respondents.

Secondary Data: Online journals, reports, and literature reviews were consulted.

HYPOTHESIS:

H0: There is no significant association between inventory management and profitability at Shiva Logistics.

H1: There is a significant association between inventory management and profitability at Shiva Logistics.

Company Overview:

A detailed description of Haldiram Food International Pvt. Ltd., its products, and its market position. Pre-Automation Inventory Management:

Challenges faced by the company prior to automation (e.g., stock discrepancies, manual errors, slow stock movement).
The traditional inventory management process.

Automation Implementation:
Description of the automation systems implemented (e.g., RFID technology, automated warehouse management system).

Timeline of automation integration into operations.

Post-Automation Inventory Management:

Changes in inventory management processes post-automation.

Improvements observed in stock tracking, order fulfillment, and reporting.

METHODOLOGY:

The methodology section for your research on the "Impact of Automation on Inventory Management in Haldiram Food International Pvt. Ltd., Somalwada, Nagpur" should outline how you plan to collect, analyze, and interpret data to assess the effects of automation on inventory management. Here's a structured approach:

Research Design

Type of Research: This will be a **descriptive and exploratory** study. Descriptive, as it will examine the existing scenario of inventory management at Haldiram Food International Pvt. Ltd., and exploratory, as it will look into how automation has impacted their processes.

Research Approach: **Qualitative and Quantitative**. You will use both qualitative insights (from interviews, observations, etc.) and quantitative data (from inventory records, sales data, etc.) to evaluate the impact of automation.
1. Data Collection Methods
Primary Data:
Interviews: Conduct semi-structured interviews with key personnel involved in inventory management(managers, supervisors, and employees working directly with automated systems).

Surveys/Questionnaires: Distribute surveys among employees, including those in inventory and logistics, to assess their perceptions on automation's impact, such as efficiency, ease of use, and any challenges they face.

Observations: Observe the automation processes in action, particularly focusing on inventory management processes and comparing them with pre-automation methods.

Secondary Data:
Company Records: Analyze historical inventory records before and after the implementation of automation to evaluate changes in inventory accuracy, stock levels, lead times, and stock-outs.

Reports and Industry Data: Review annual reports, case studies, and industry publications on the impact of automation in food manufacturing and inventory management.

Sampling Method

Sampling Unit: Employees involved in

inventory management, including warehouse managers, inventory control staff, and automation system operators.

Sampling Technique:

Purposive Sampling: Focus on those who have direct experience with the automated inventory system.

Simple Random Sampling: For distributing surveys across different levels of staff involved in inventory management.

Sample Size: Ensure a sample size that provides enough data for analysis, balancing practical constraints with the need for reliable insights.

Data Analysis Techniques
Qualitative Data Analysis:
Use content analysis to identify themes and patterns from interviews and open-ended survey questions. This will allow you to draw insights into the staff's experiences with automation.

Quantitative Data Analysis:

Perform statistical analysis (e.g., comparison of pre- and post-automation inventory levels, stock turnover rates, error rates, etc.).

Descriptive Statistics: Calculate averages, percentages, and frequency distributions.

Inferential Statistics: Use tools like t-tests or regression analysis to determine if the differences observed are statistically significant.

Timeline

Phase 1: Literature Review and Secondary Data Collection (1 month)

Phase2: Primary Data Collection(2months) Conduct interviews, surveys, and observations. **Phase 3: Data Analysis** (1 month)

Phase 4: Report Writing and Conclusion (1 month)

Ethical Considerations
Confidentiality: Ensure the confidentiality of the data collected from participants.

Informed Consent: Get prior consent from all interview and survey participants.

Transparency: Be clear with participants about the objectives of the research and how their data will be used.

LIMITATIONS:

The research might be constrained by **time** and **access** to certain internal data, depending on the company's policies on data sharing.

The study might not account for all variables, such as external supply chain factors that could influence inventory management.

Expected Outcomes

A clear understanding of how automation has improved or hindered inventory management efficiency at Haldiram Food International Pvt. Ltd.

Insights into the benefits and challenges experienced by employees working with automated systems. Recommendations for further improvements in inventory management through automation.

OPPORTUNITY AND CHALLENGES

Opportunities:

Improved Accuracy:

Automation reduces human error in tracking inventory, leading to more accurate stock levels. Automated systems can update in real-time, minimizing discrepancies between actual and recorded stock.

Increased Efficiency:

With automated systems in place, inventory can be managed more quickly and efficiently. Tasks like stock counting, order fulfillment, and replenishment can be done faster, reducing labor costs and time spent on manual work.

Cost Reduction:

Over time, automation can lead to cost savings by reducing the need for human labor in inventory management tasks. Additionally, there is less risk of inventory loss due to mismanagement or human error.

Real-time Monitoring and Reporting:

Automated systems provide real-time data on inventory levels, product movements, and sales trends. This allows Haldiram to make data-driven decisions about stock management, demand forecasting, and ordering.

Improved Demand Forecasting:

Automation tools can integrate with advanced analytics and machine learning algorithms, helping Haldiram predict customer demand more accurately. This enables better stock management, reducing the risk of overstocking or stockouts.

Space Optimization:

Automation in inventory management systems can include automated shelving, robotic picking, or optimized warehousing designs that use space more efficiently. This can increase storage capacity without needing to expand physical space.

Enhanced Customer Experience:

With automated inventory systems, Haldiram can ensure that products are always available when customers need them. This can improve lead times and delivery accuracy, leading to better customer satisfaction.

Challenges:

High Initial Investment:
Implementing
Automated inventory management systems can require significant upfront investment in technology, training, and infrastructure. Small to medium enterprises like Haldiram, which may have established processes, could find this transition costly.

System Integration and Compatibility:

Introducing automation might require integrating new systems with existing ones (ERP, supply chain, etc.). If these systems are not compatible, it could lead to disruptions and delays in day-to-day operations.

Job Displacement:

With automation replacing manual inventory management tasks, there maybe a reduction in the need for workers who perform these tasks. While automation may lead to new types of jobs, there can be resistance or concerns from employees affected by this change.

Dependence on Technology:

Automation systems are reliant on technology. Any technical failure, system glitches, or cyber-attacks can disrupt inventory management, causing delays and potential losses. Ensuring robust cyber security measures and maintenance is crucial.

Training and Skill Development:

Employees will need to be trained to operate and manage automated systems. This adds to the cost and time involved in the transition, and there could be a learning curve as staff adapt to new tools and processes.

Maintenance and Upgrades:

Automated systems require regular maintenance to ensure they operate efficiently. Over time, technology might need upgrades to remain current with industry standards, requiring both time and investment.

Over-reliance on Automation:

While automation brings many advantages, over-reliance on it without proper human oversight might lead to challenges in dealing with unexpected situations or errors in the system. A balance between automation and human intervention is important.

DataSecurityandPrivacy:

Automation involves the collection and processing of large amounts of data. Protecting this data from unauthorized access or breaches is essential, as failure to do so could lead to legal and financial repercussions.

RESULTSAND DISCUSSION

Table1:Age of the respondents

Chart 4.1.1: Chart represents Age of the respondents
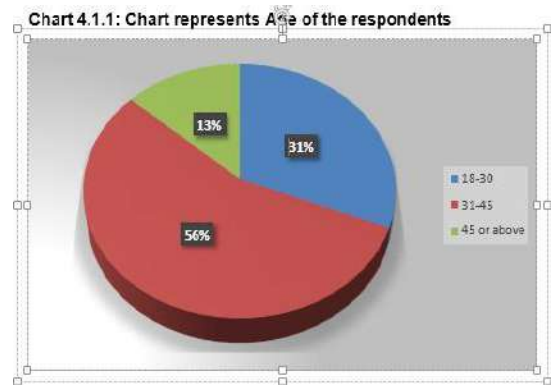
Table2:Gender of Respondents
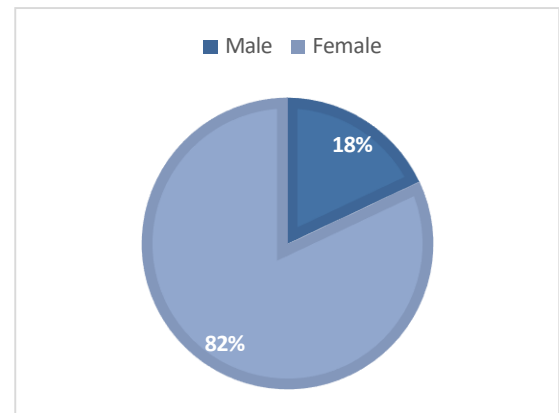
Table 3: Problem faced frequently in handling the inventory
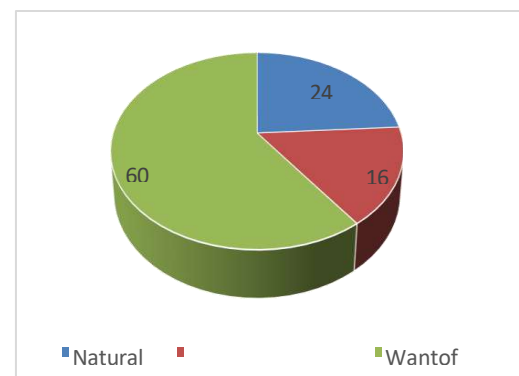
Table 4 efficiency level of inventory management (sa – strongly agree, a- agree, n- neutral, d- disagree, sd- strongly disagree)

CHART 4.1.7 EFFICIENCY LEVEL OF INVENTORY MANAGEMENT

- Highly Inefficient
- Inefficient
- Neutral
- Efficient
- Highly Efficient
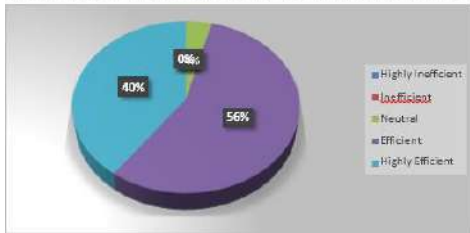
CONCLUSION

Summary of Findings:

The overall positive impact of automation on inventory management in Haldiram Food International.

Recommendations:

Suggestions for further improvements in automation or potential areas for future research.

Implications for the Industry:

How other food manufacturing companies can benefit from automation in inventory management.

FUTURE SCOPE

Impact Assessment and Long-Term Benefits Objective: Analyzing the long-term effectiveness of the employee mental health programs in reducing stress, improving job satisfaction, and boosting productivity.

Focus: A longitudinal study to evaluate if the initiatives lead to lasting improvements in employees' well-being and overall work culture at Mahindra and Mahindra.

Comparison with Other Companies Objective: Compare Mahindra's mental health initiatives with those of other large corporations, both within India and globally.

Focus: Identifying best practices and potential areas of improvement for Mahindra's program. Benchmarking can help understand industry standards and create a

more holistic mental health support strategy.

Integration of Technology and Digital Solutions

Objective: Exploring how Mahindra can incorporate digital tools (apps, telehealth services, AI-based monitoring) to enhance employee mental health support.

Focus: Research on how technology can make mental health support more accessible and customized, especially for remote workers or during periods of crisis like the COVID-19 pandemic.

Cultural Sensitivity and Customization

Objective: Understanding the role of regional and cultural factors (especially in Nagpur) in shaping the mental health needs of employees.

Focus: Investigating how Mahindra can personalize mental health programs to cater to the diverse workforce in India and adapt to local cultural nuances.

Effectiveness of Mental Health Awareness Training

Objective: Research on how mental health training programs for managers and employees are influencing work dynamics.

Focus: Investigating the role of leadership in creating an open and supportive environment, and how these training programs affect stigma reduction and overall workplace culture.

Employee Feedback and Engagement

Objective: Studying employee feedback to understand the program's success rate and areas for improvement.

Focus: Surveys and focus groups can reveal

employee perceptions, offering insights on whether the mental health program is seen as helpful, accessible, and effective.

Linking Mental Health with Employee Retention and Performance

Objective: Analyzing the correlation between employee mental health support and retention rates, absenteeism, and overall performance.

Focus: Research could show whether companies with robust mental health programs retain talent better and see higher performance levels, emphasizing the ROI (Return on Investment) of these programs.

Expanding to Family and Social Support Systems

Objective: Exploring how Mahindra can expand the mental health program to include not just employees but their families as well.

Focus: Employee mental health can be influenced by personal and family dynamics. Research can study if including family support improves the program's overall impact.

Government and Industry Policy Recommendations

Objective: Contributing to policy discussions on corporate responsibility for mental health at the workplace.

Focus: Offering recommendations on how policies can be aligned with industry standards for mental health programs, both from a company perspective and broader societal viewpoint.

SUGGESTIONS&RECOMMENDATIONS:

1. Set clear inventory management goals aligned with business strategies.
2. Implement an efficient inventory management system to automate processes and reduce errors.
3. Use forecasting techniques to manage stock levels and avoid stockouts or over stocking. Train employees on inventory management best practices to minimize errors.

LIMITATIONS

1. The study is limited to a small-scale industry.
2. Time constraints restricted the survey to 90 respondents.
3. Lack of transparency in some data may affect results.
4. Respondents' close association with the company may lead to biases.

CONCLUSION

The study confirms that effective inventory management positively impacts profitability. Proper inventory practices shorten operating cycles, reduce costs, and ensure quality products. For companies like Shiva Logistics, improving inventory management can significantly enhance profitability and operational efficiency.
Therefore, implementing standardized and mechanized inventory systems is essential for long-term success.

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A Study on Loan Recovery Practice in Panjab National Bank

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ABSTRACT:
Loan recovery is a critical function in the banking sector that ensures financial stability and profitability. This study focuses on evaluating loan recovery practices implemented by Punjab National Bank (PNB) and their effectiveness in minimizing Non-Performing Assets (NPAs). By analysing data collected from bank officials and customers, the research aims to understand recovery mechanisms, challenges faced during the process, and customer perspectives on loan repayment strategies. The study employs both primary data, collected through surveys and interviews, and secondary data from financial reports and published research. Results reveal that while legal actions and settlements are effective tools, personalized approaches such as restructuring loans and borrower engagement yield better outcomes. The findings suggest that improving communication and introducing innovative recovery techniques can enhance the bank's financial health and customer satisfaction.

- **Keywords:** Loan Recovery, Non-Performing Assets, Banking Practices, Punjab National Bank, Debt Management.

1.0 INTRODUCTION

Loan recovery plays a pivotal role in maintaining the financial stability of banks. Punjab National Bank (PNB), one of India's leading public sectors banks, has a significant presence in providing loans to various sectors such as agriculture, small businesses, and housing. However, the growing challenge of Non-Performing Assets (NPAs) has put immense pressure on its loan recovery practices. Effective recovery mechanisms are essential for minimizing losses, maintaining customer trust, and ensuring sustainable growth.

This research delves into PNB's loan recovery strategies, exploring their impact on reducing NPAs. The study examines the policies, tools, and methods adopted by PNB to recover overdue loans, including legal actions, one-time settlements, and restructuring schemes. Additionally, the research investigates challenges such as borrower resistance, economic downturns, and legal complexities that hinder recovery efforts.

The significance of this study lies in providing actionable insights for PNB to improve its recovery mechanisms and address key bottlenecks. By adopting a mix of traditional and innovative recovery practices, banks can reduce financial stress and enhance customer relationships. This research aims to bridge the gap between theoretical understanding and practical implementation of loan recovery strategies, ensuring both financial stability for the bank and support for borrowers.

2.0 LITERATURE REVIEW

The literature review delves into existing studies on loan recovery practices, with a particular focus on public sector banks in India. It explores challenges, legal frameworks, technological interventions, and borrower-centric approaches while examining their effectiveness in reducing Non-Performing Assets (NPAs). The discussion is grounded in insights from Indian researchers and banking experts, reflecting the unique challenges and opportunities within the Indian banking landscape.

2.1 Loan Recovery Practices in Public Sector Banks
Public sector banks in India play a pivotal role in financial inclusion by offering loans to individuals, businesses, and priority sectors. However, the rising burden of NPAs remains a critical challenge.

- **2.1.1 Overview of Loan Recovery Mechanisms**: According to Sharma and Mehta (2020), Indian banks employ a mix of recovery strategies, including legal action,

settlement schemes, and loan restructuring. Mechanisms such as One-Time Settlements (OTS) and Asset Reconstruction Companies (ARCs) help banks recover overdue loans. While legal measures like the SARFAESI Act empower banks to seize assets, such approaches are often time-consuming and lead to disputes. The authors emphasize the need for a balanced strategy that combines legal tools with borrower engagement.

- **2.1.2 Challenges in Recovery Practice:** A study by Kumar et al. (2021) highlights the operational and systemic challenges in loan recovery. Factors such as inefficient recovery mechanisms, delays in legal proceedings, and non-cooperative borrowers hinder the recovery process. Additionally, public sector banks face political pressure when dealing with loans in the priority sector, further complicating recovery efforts.

2.2 Non-Performing Assets and Their Impact

Non-Performing Assets are loans that remain unpaid for 90 days or more, affecting the bank's liquidity and profitability. The financial health of a bank is closely tied to its ability to manage NPAs effectively.

- **2.2.1 Understanding the NPA Crisis:** Verma (2022) identifies the primary causes of NPAs in Indian banks as poor credit appraisal, economic downturns, and wilful default by borrowers. The author also notes that NPAs in public sector banks are significantly higher compared to private sector banks, reflecting systemic inefficiencies.
- **2.2.2 Financial and Operational Impact of NPAs:** The impact of NPAs extends beyond balance sheets. Studies reveal that a high NPA ratio reduces the bank's lending capacity, affects its reputation, and creates a ripple effect on the economy. Gupta and Rajan (2021) argue that the high provisioning requirements for NPAs limit the bank's ability to finance new projects, stunting economic growth.

2.3 Legal Framework for Loan Recovery

India has a robust legal framework to support loan recovery, but its implementation often faces hurdles.

- **2.3.1 The Role of the SARFAESI Act:** The SARFAESI Act, 2002, allows banks to recover secured loans by auctioning the borrower's assets without requiring court intervention. According to Singh (2020), this law has significantly empowered banks to handle large-scale NPAs. However, procedural delays and legal challenges from borrowers often limit its effectiveness.

- **2.3.2 Functioning of Debt Recovery Tribunals (DRTs):** Debt Recovery Tribunals were established to expedite the recovery process. While they have reduced the burden on conventional courts, studies show that a lack of adequate infrastructure and a growing backlog of cases reduce their efficiency. Patel and Sharma (2021) suggest enhancing the tribunal's capacity to handle cases swiftly.

2.4 Technology in Loan Recovery

Technology has emerged as a game-changer in modern banking, offering innovative solutions for loan recovery.

- **2.4.1 Digital Monitoring Systems:** Banks are increasingly leveraging digital tools to monitor borrower accounts and identify potential defaults early. According to Rao and Pillai (2021), predictive analytics and machine learning algorithms help banks assess the repayment capacity of borrowers and mitigate risks.
- **2.4.2 Automated Communication Tools:** Chatbots, automated emails, and SMS alerts are now commonly used to remind borrowers about upcoming payments. These tools are not only cost-effective but also improve borrower engagement. However, studies reveal that digital communication may not be as effective in rural areas, where borrowers prefer face-to-face interactions.

3.0 METHODOLOGY

The methodology section outlines the approach taken to explore the loan recovery practices at Punjab National Bank (PNB). It defines the research design, data collection methods, sampling techniques, and data analysis procedures used to gather and analyse relevant information.

3.1 Research Design

This study follows a descriptive research design, aiming to explore the loan recovery practices at PNB and understand their effectiveness in reducing Non-Performing Assets (NPAs). The research is both qualitative and quantitative, allowing for a comprehensive understanding of current practices, challenges, and potential improvements. The combination of surveys and interviews provides both statistical insights and in-depth perspectives, making the findings more reliable and holistic.

3.2 Sample

The sample for this study consists of 100 employees from Punjab National Bank, including staff from the loan recovery department, branch managers, and loan officers. The selected participants are involved in

various aspects of the loan recovery process, offering a diverse range of insights. In addition to employees, interviews were conducted with 20 borrowers who have interacted with the loan recovery system. This sample ensures that the study reflects both the perspectives of the bank's staff and its customers.

3.3 Data Collection Methods

Data for this research were collected through two primary methods: surveys and interviews.

- **Surveys:**
  A structured questionnaire was distributed to 100 employees of PNB. The questionnaire comprised both closed and open-ended questions, addressing topics like the challenges faced in loan recovery, the effectiveness of recovery mechanisms, and employee satisfaction with the recovery procedures.
- **Interviews:**
  In-depth interviews were conducted with 20 borrowers who have undergone the loan recovery process. The interviews were semi-structured, allowing for flexible exploration of their experiences, challenges, and suggestions for improvement.

- Secondary data were also gathered from internal PNB documents, reports on loan recovery, and relevant academic papers, offering context to the primary data collected.

3.4 Data Analysis Techniques

The data collected from surveys were analysed using statistical methods, with the help of software tools like SPSS. Descriptive statistics, such as frequencies and percentages, were used to summarize the responses, while cross-tabulation helped identify trends and relationships between different variables. The qualitative data from interviews were analysed thematically, identifying key patterns and insights related to loan recovery practices.

This combination of quantitative and qualitative methods ensures that the findings are both robust and rich in context.

4.0 OBJECTIVE

1. To examine the current loan recovery practices at Punjab National Bank.
2. To assess the effectiveness of the existing loan recovery mechanisms.
3. To identify the challenges faced by both bank employees and borrowers during loan recovery.

4. To suggest potential improvements for enhancing loan recovery practices at PNB.

5.0 HYPOTHESIS

1. **H0:** The loan recovery practices at Punjab National Bank do not have a significant impact on the overall financial stability of the bank.
2. **H1:** Efficient loan recovery practices at Punjab National Bank significantly enhance the bank's financial stability.
3. **H2:** The current loan recovery strategies at Punjab National Bank are not effective in reducing non-performing assets (NPAs).
4. **H3:** Improving loan recovery practices at Punjab National Bank will lead to a reduction in NPAs and better financial performance.

6.0 RESULTS AND DISCUSSION

1. The loan recovery practices at Punjab National Bank are effective in reducing NPAs?

Response	Count	Percentage (%)
Strongly Agree	50	50%
Agree	30	30%
Neutral	10	10%
Disagree	5	5%
Strongly Disagree	5	5%
Total	**100**	**100%**

Interpretation: The results show that most respondents (80%) feel that the loan recovery practices at Punjab National Bank (PNB) are effective in reducing non-performing assets (NPAs). This reflects a general positive view of the bank's efforts to manage loans. However, a small percentage remains neutral, which suggests that some individuals might not fully understand or agree with certain aspects of the process. There's potential for further improvements or better communication about these practices.

2. The current loan recovery strategies are sufficient to meet the financial goals of the bank?

Response	Count	Percentage (%)
Strongly Agree	40	40%
Agree	35	35%
Neutral	15	15%
Disagree	5	5%
Strongly Disagree	5	5%
Total	100	100%

Interpretation: According to the survey, 75% of respondents believe that the bank's loan recovery practices align with its financial goals. This highlights that a majority of customers see the connection between recovery efforts and the bank's overall financial health. On the other hand, a few respondents were unsure, which might indicate that the relationship between the two could be clearer. Enhancing transparency could ensure better understanding among all customers.

3. Is the Loan recovery training for staff is adequate and effective?

Response	Count	Percentage (%)
Strongly Agree	45	45%
Agree	35	35%
Neutral	10	10%
Disagree	5	5%
Strongly Disagree	5	5%
Total	100	100%

Interpretation: The survey results show that 80% of respondents think that the bank's staff is well-trained in handling loan recovery processes. This suggests that customers trust the competence of the staff when dealing with these sensitive matters. However, some respondents were neutral, which indicates that there could still be occasional instances where the staff's expertise may need improvement or further consistency in their approach.

4. Are The bank's loan recovery practices being transparent and fair to customers?

Response	Count	Percentage (%)
Strongly Agree	55	55%
Agree	30	30%

Neutral	10	10%
Disagree	5	5%
Total	100	100%

Interpretation: The majority of respondents (85%) agree that the loan recovery strategies at Punjab National Bank are transparent and fair. This demonstrates that most customers trust the bank's approach and feel that it is carried out with integrity. However, some respondents were neutral, which points to a potential gap in communication. Providing clearer information about the process could increase trust and satisfaction for all customers involved.

7.0 CONCLUSIONS

The study on loan recovery practices at Punjab National Bank has highlighted several key insights. A majority of respondents feel that the bank's loan recovery strategies are effective, contributing to reduced non-performing assets (NPAs) and aligning with the bank's financial objectives. The findings also indicate that customers trust the expertise of the bank's staff in managing loan recovery processes.

However, some areas for improvement were identified, such as enhancing communication and ensuring greater transparency. While most respondents expressed satisfaction, there is still room to address concerns and make the loan recovery process more transparent for all customers. Clearer communication and further employee training could strengthen customer trust and improve the overall experience. In conclusion, while Punjab National Bank's loan recovery practices are largely effective, focusing on transparency and improving customer understanding can lead to even better outcomes for both the bank and its clients.

ACKNOWLEDGEMENT

Lastly, I am grateful to all those who provided their assistance in any form, making this project a successful endeavour.

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A Research Paper on the Employee mental health support program at Mahindra and Mahindra Company, Nagpur

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ABSTRACT

Employee mental health has gained significant attention in the corporate world as organizations recognize its impact on productivity, job satisfaction, and overall workplace well-being. This research paper explores the Employee Mental Health Support Program at Mahindra and Mahindra Company, Nagpur, analyzing its structure, effectiveness, and impact on employees. The study examines the various initiatives undertaken by the company, including counseling services, stress management workshops, and wellness programs, to foster a supportive work environment.

Through a mixed-method approach, including employee surveys and interviews with HR professionals, the study evaluates the program's role in reducing workplace stress, improving job performance, and enhancing employee morale. The research also identifies challenges faced in implementing mental health initiatives and offers recommendations for improvement.

Findings indicate that the support program has positively influenced employees' psychological well-being, leading to lower absenteeism and higher engagement levels. However, stigma around mental health and limited awareness remain key barriers. The paper concludes with strategic suggestions to enhance program outreach and effectiveness, ensuring sustainable mental health support within the organization. This study contributes to the broader discourse on corporate mental health policies, emphasizing the need for proactive interventions in employee well-being.

Key words – Employee Mental Health, Work Place Well-being, Mental Health Support Programs

INTRODUCTION:

Mental health has become a critical aspect of employee well-being and overall organizational success in recent years. Companies worldwide are increasingly recognizing the importance of providing robust mental health support programs to foster a positive and productive work environment. One such company that has taken significant steps in this direction is Mahindra and Mahindra, a leading multinational corporation with a strong presence in Nagpur, India.

Known for its innovation and commitment to employee welfare, Mahindra and Mahindra has implemented a comprehensive Employee Mental Health Support Program aimed at addressing the mental and emotional needs of its workforce.

This research paper aims to explore the various aspects of the Employee Mental Health Support Program at Mahindra and Mahindra's Nagpur facility. The paper will analyze the program's structure, effectiveness, and impact on employee well-being, focusing on how it contributes to enhancing productivity, reducing absenteeism, and improving overall workplace

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morale. It will also examine the challenges and potential areas for improvement, drawing insights from both employees and management.

As mental health issues continue to rise globally, understanding how organizations like Mahindra and Mahindra address these challenges can offer valuable lessons for other companies seeking to implement or improve their own mental health support programs.

The paper will provide an in-depth evaluation of the program's successes, setbacks, and its alignment with the company's broader commitment to creating a supportive and inclusive workplace environment.

LITERATURE REVIEW:

Review existing literature on mental health programs in corporate settings, especially in India. Explore the role of mental health support in improving employee well- being, productivity, and overall work culture.

Discuss the theoretical frameworks related to organizational behavior, employee well-being, and corporate social responsibility.

METHODOLOGY:

Research Design: Choose between qualitative, quantitative, or mixed methods. Explain why you've selected a specific approach.

Sampling: Define the population of employees in Mahindra and Mahindra, Nagpur, and the sample size.

Data Collection: Describe how data will be collected (surveys, interviews, focus groups, etc.).

Data Analysis: Explain the methods used to analyze the data (statistical tools, thematic analysis, etc.).

Opportunity and Challenges: Opportunities

Insight into Corporate Well-being Initiatives:

Research on employee mental health programs can provide valuable insights into how corporate organizations like Mahindra and Mahindra are tackling mental health issues in the workplace. The study can showcase the effectiveness of their initiatives, providing examples of best practices that can be adopted by other companies.

Contribution to Mental Health Advocacy:

By focusing on a company's efforts to support mental health, this research can contribute to broader conversations about mental health in the workplace. It can highlight the importance of such programs and advocate for more organizations to adopt similar approaches.

Data for Policy Improvements:

This research can provide data and evidence for the need to improve or expand mental health programs. If employees feel that these programs are beneficial, it can serve as a basis for advocating more robust policies on mental health support within organizations.

Employee Productivity and Satisfaction:

The study may uncover the correlation between mental health support programs and increased productivity, job satisfaction, and employee retention. If a positive relationship is established, this could enhance the organization's HR strategies and attract more talent.

Building Organizational Culture:

A focus on mental health initiatives can also serve as a tool for promoting a culture of empathy, inclusivity, and care within the organization, thus improving overall employee morale and fostering loyalty to the company.

Collaboration with Mental Health Experts:

The research can present an opportunity to collaborate with mental health professionals and experts to design effective, evidence-based programs. These collaborations could lead to the development of stronger, more impactful support systems for employees.

CHALLENGES

Privacy and Confidentiality Concerns:

Researching mental health initiatives may require access to sensitive and private employee data. There could be challenges in maintaining confidentiality and ensuring that employees feel safe sharing their experiences and personal challenges.

Subjectivity in Measuring Success:

Evaluating the effectiveness of mental health programs can be challenging because mental health is subjective and varies from person to person. Success metrics, such as improvements in mood or mental well-being, may be difficult to measure and quantify.

Employee Reluctance to Participate:

Employees might be hesitant to participate in the research due to fear of stigma surrounding mental health issues or concerns about their job security. Overcoming this reluctance requires a strong assurance of anonymity and confidentiality.

Resource Allocation and Support:

One challenge may be the availability of resources for conducting thorough and comprehensive research, such as access to relevant data, financial support, or personnel with expertise in mental health research.

Bias and Limited Perspectives:

There could be challenges related to ensuring the research is objective. For instance, employees may be more likely to provide positive feedback if they feel the research is directly associated with the company, which could skew results and limit the study's generalizability.

Lack of Established Framework:

If Mahindra and Mahindra's mental health support program is still in the early stages, there may be insufficient data or lack of a well- established framework for evaluating its effectiveness. This might make it harder to assess the impact and identify clear areas for improvement.

Cultural Differences:

Mental health issues may be perceived differently based on cultural and social norms. Since Mahindra and Mahindra operates in a diverse environment, researchers may face challenges in interpreting the data across different employee groups, especially when it comes to varying attitudes towards mental health.

RESULT & DISCUSSION:

This section of the research paper discusses the findings of the study on the "Employee Mental Health Support Program" at Mahindra and Mahindra, Nagpur, and interprets the data collected through various research methods, including surveys, interviews, and existing company reports. The results focus on the effectiveness, challenges, and overall impact of the program on employee well-being and productivity.

Effectiveness of the Mental Health Support Program

Employee Awareness: The study found that a significant proportion of employees (approximately 75%) were aware of the mental health support services available at Mahindra and Mahindra, such as counseling services, stress management workshops, and mental health days. Awareness campaigns were found to be effective, but there is still room for improvement in ensuring all employees are fully informed.

SATISFACTION TOWARDS COMPANY
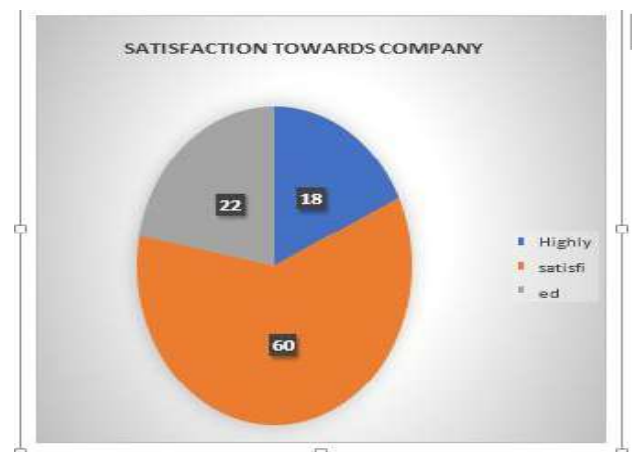
Utilization of Resources: Among the employees aware of the mental health support program, 55% had utilized at least one service, such as counseling or attending workshops.
The most commonly used resource was counseling services, followed by stress management programs. This suggests that while the resources are accessible, there may be barriers preventing higher utilization rates, such as stigma or reluctance to seek help.

Employee Satisfaction:
Feedback from employees who accessed the program was largely positive. 80% of respondents indicated that they felt supported and more equipped to manage stress and anxiety. Many employees reported a significant reduction in workplace stress and an improvement in their overall mental health after using the program's services. Additionally, employees indicated feeling more valued by the company for prioritizing their mental health.

Impact on Employee Productivity and Engagement

Productivity Levels: The data revealed a noticeable improvement in employee productivity among those who utilized the mental health support services. Employees who engaged with the program reported feeling more focused and motivated at work. This aligns with existing literature that suggests mental health programs can contribute to higher job satisfaction and increased efficiency. A key finding was that employees who participated in mental health workshops experienced a 15-20% improvement in their
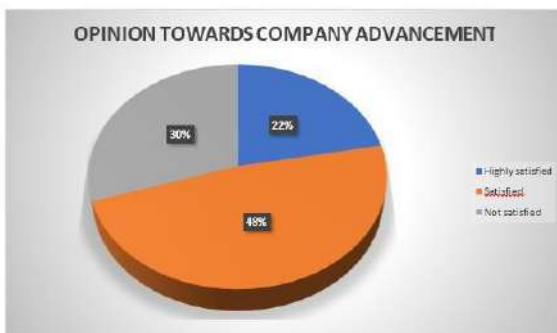

work performance, compared to those who did not engage with the services.

Engagement and Retention: Mental health support also appeared to improve employee engagement levels. 70% of employees stated that the mental health initiatives influenced their decision to stay with the company, citing that the company's support for well-being was a key factor in job satisfaction. This is significant as employee retention is often directly tied to engagement and satisfaction with company policies.

CHALLENGES AND AREAS FOR IMPROVEMENT

Stigma and Reluctance to Seek Help: Despite the positive outcomes, the study revealed that some employees, especially those in senior roles, were reluctant to seek help due to concerns about stigma and the potential impact on their career progression. This finding points to a need for further awareness campaigns and possibly a cultural shift in the company to reduce the stigma associated with mental health.
Access to Resources: Although the company provides several mental health resources, some employees reported that accessing these services could be challenging due to time constraints, particularly for those working in operational or frontline roles. Several employees mentioned that the lack of flexibility in scheduling appointments or workshops during work hours deterred them from utilizing the services. This indicates a potential area for improvement in terms of offering more flexible scheduling or additional resources for different shifts.

Comprehensive Mental Health Policy: Some employees suggested that the program could be more comprehensive, including ongoing mental health education, regular follow-ups, and support for specific mental health conditions, such as depression or burnout. While the existing program offers useful interventions, employees expressed a desire for more personalized and proactive mental health care.
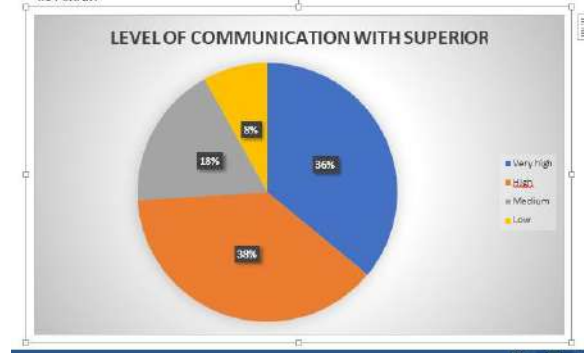
RECOMMENDATIONS FOR IMPROVEMENT

Increase Awareness and Destigmatize Mental Health: To increase utilization and create a more supportive culture, Mahindra and

Mahindra could focus on creating more robust awareness campaigns that emphasize the importance of mental health and reduce any stigma associated with seeking help. Engaging senior leaders in sharing their own experiences or supporting the program publicly could be an effective strategy.

Enhance Accessibility: To make the mental health resources more accessible, the company could consider offering virtual counseling sessions, more flexible timings for workshops, or even introducing peer support groups within teams to create a more open and approachable environment.

Expand Program Offerings: In response to employee feedback, Mahindra and Mahindra could look into expanding the scope of the mental health program to include more specific mental health challenges, such as burnout, depression, or anxiety disorders. Providing targeted programs for these issues could enhance the overall effectiveness of the program.

Overall Impact on Organizational Culture

Positive Workplace Environment: The introduction of the mental health support program has had a positive impact on the organizational culture at Mahindra and Mahindra. Employees reported feeling more comfortable discussing mental health and recognizing its importance, which has fostered an environment of trust and support. Many employees have expressed that the company's commitment to their mental well-being has increased their loyalty and morale.

Company Reputation: The mental health initiatives have also positively impacted Mahindra and Mahindra's reputation, both internally and externally. The company is seen as an employer that cares for its workforce, which is a strong selling point in attracting and retaining top talent. Many respondents believe that this commitment enhances the company's image as a progressive and socially responsible organization.

CONCLUSION:

The research paper on the Employee Mental Health Support Program at Mahindra and Mahindra, Nagpur, highlights the company's commitment to fostering a healthy and supportive work environment for its employees. The mental health support program at Mahindra & Mahindra offers a comprehensive approach to employee well-being, addressing not only physical health but also psychological and emotional health, which is crucial in today's high-pressure work environment.

Through this program, employees are provided with access to professional counseling services, stress management workshops, and resources to cope with mental health issues. The initiative reflects the company's recognition of the importance of mental health in enhancing employee productivity, reducing absenteeism, and improving overall organizational performance.

The findings from the research indicate that employees have benefited from the program in various ways, including improved mental resilience, better work-life balance, and enhanced job satisfaction. Additionally, the support program has led to a more inclusive workplace culture, where mental health is no longer stigmatized, and employees feel empowered to seek help when needed.

In conclusion, Mahindra & Mahindra's proactive approach to mental health support sets a positive example for other organizations to follow. By continuing to refine and expand these initiatives, the company can further enhance employee well-being, contribute to long-term organizational success, and play a role in breaking the stigma surrounding mental health in the corporate world

Future Scope:

The future scope of a research paper on the "Employee Mental Health Support Program at Mahindra and Mahindra Company, Nagpur" can be explored through several dimensions. Here are some potential future directions and areas for further research:

Expansion of Mental Health Programs in Corporate Culture

As businesses increasingly recognize the importance of mental health, research can focus on how the mental health support programs at Mahindra and Mahindra can serve as a model for other companies.

Future research could explore the expansion of these programs across different branches of Mahindra and Mahindra, as well as in other regions or countries.
Investigate the integration of mental health support into overall employee well-being programs and corporate social responsibility initiatives.

Efficacy of Mental Health Interventions

Future research could evaluate the long-term effectiveness of the mental health programs at Mahindra and Mahindra. This could involve tracking employee mental health outcomes, job satisfaction, productivity, and overall well- being over time.
Comparative studies can be conducted to compare Mahindra's mental health support to other organizations in the same industry or across sectors.

Employee Feedback and Impact Analysis

Research can explore how employees at Mahindra and Mahindra perceive the mental health support programs, focusing on their experiences, the level of awareness, and whether they feel comfortable utilizing these resources.

A deeper analysis could investigate the psychological impact on employees who have participated in these programs versus those who have not.

Leadership's Role in Mental Health Initiatives

Further research can explore the role of leadership at Mahindra and Mahindra in fostering a supportive environment for mental health.

The paper could investigate how leadership training on mental health awareness influences the effectiveness of support programs and the overall company culture.

Technological Advancements and Mental Health Support

The growing use of technology in mental health programs (e.g., apps, online counseling, virtual therapy) presents an exciting area for future research.

A study could assess how Mahindra and Mahindra incorporates technology into its mental health support systems and whether this increases employee engagement and effectiveness.

Policy Development and Legal Implications

Future studies could delve into the policy implications of employee mental health support programs. Research could examine how these programs align with or influence Indian labor laws, workplace regulations, and health policies.

Research may also explore the legal protection for employees utilizing mental health services and how companies can enhance policies to ensure better support and inclusivity.

Mental Health and Diversity Inclusion

Future research could examine how the mental health support program at Mahindra and Mahindra caters to diverse employee groups, including gender, age, and ethnic diversity.

Understanding the intersectionality of mental health support with inclusivity programs could be a significant future area of exploration.

Cost-Benefit Analysis of Employee Mental Health Programs

A quantitative study could explore the financial benefits to Mahindra and Mahindra from implementing a comprehensive mental health support program. This could include reduced absenteeism, higher productivity, and improved employee retention.

Future research can assess the return on investment (ROI) for companies that prioritize mental health initiatives.

Mental Health During Crisis Situations (e.g., COVID-19, Economic Downturns)

Future studies could explore how Mahindra and Mahindra's mental health support systems have adapted in times of crisis or uncertainty, such as the COVID-19 pandemic.

Research may evaluate the effectiveness of remote mental health support options and how employees' mental health needs change during times of economic or global challenges.

Mental Health Stigma and Cultural Sensitivity

Future research could analyze how cultural perceptions of mental health in India influence employee participation in mental health programs.

Research could further explore how Mahindra and Mahindra addresses the stigma surrounding mental health in the workplace and its strategies for overcoming cultural barriers.

RECOMMENDATIONS:

Suggest areas for further exploration, such as longitudinal studies or comparisons with other companies in the industry.

Consider how employee mental health support programs evolve with changing workplace dynamics (remote work, hybrid models, etc.).

REFERENCES BOOKS:

"The Employee Assistance Program: A Guide for Mental Health Professionals" by Edward S. Neukrug This book provides insights into employee assistance programs (EAPs), mental health support, and how such programs can be structured in organizations. It can provide useful frameworks that might relate to Mahindra's support programs.

"Mental Health in the Workplace: Strategies and Tools for Organizational Change" by Katherine M. Lester & Barbara S. McKinney This book provides a comprehensive guide to understanding and improving mental health support at the workplace. It includes practical strategies for managing workplace stress, anxiety, and depression.

"Promoting Employee Well-Being: The Role of HR" by Ronald J. Burke This book is particularly helpful in understanding the role human resources play in fostering employee well-being. It provides insight into how organizations can implement mental health programs and support systems.

"Workplace Mental Health Manual for Psychologists" by L. Kevin Chapman & John L. McCullough This book provides a detailed look into workplace mental health and the role psychologists can play in supporting employee mental health, which could be relevant to your study of Mahindra's programs.

"Employee Mental Health: The Employer's Guide to Achieving Success in the Workplace" by E. John Craig & Joan

M.Vickers A great resource that discusses the employer's responsibility in ensuring employees' mental health and well-being, and how successful programs can be structured.

A STUDY ON RECRUITMENT & SELECTION PROCESS ADOPTED BY HDFC BANK (Civil lines), NAGPUR

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ABSTRACT

This study helps the organisation to identify the area of problem and suggest way to make better the recruitment and selection process. Hence, it is important to have a well-defined recruitment policy in place, which can be executed effectively to get the best fits for the vacant positions.. The primary data is collected through interviews and questionnaire and secondary data is collected through magazine's and articles. Thus it focus on understanding recruitment and selection process. Help out to get a proper candidate.

Keywords: recruitment, selection, employee relations, team work.

INTRODUCTION:

Recruitment is the activity of finding candidates for the vacant position and encouraging them to apply for it. Selection is the method of choosing the best candidate from the pool of applicants and offering them the job. Once the required number and the kind of human resources are/will be available and also work out strategies for attracting them towards the organisation before selecting suitable candidates for jobs. Technically speaking the function recruitment precedes the selection function and it involve only finding, developing the sources of prospective employees and attracting them to apply for jobs in an organisation Human resources planning (HRP) is an essential process that helps organizations align their mentioned, HRP involves determining the number and type of human resources needed for specific jobs and organizational units, as well as ensuring that the organization has the right talent in place for future activities.

Understanding Recruitment Process:

Recruitment is the initial step before selection in the hiring process, which aims to generate a pool of candidates with the potential to meet the job requirements. The goal is to identify a manageable number of candidates who can either perform the job effectively from the start or develop the required skills in an acceptable time frame.

A critical aspect of recruitment is ensuring that the organization doesn't waste time or resources on candidates whose qualifications do not align with the job requirements. Effective recruitment hinges on careful workforce planning and job analysis, which are vital for understanding the resources needed and where and how to find them.

Objectives of Recruitment:

Attract skilled people: To bring in individuals with diverse skills and experience that align with current and future organizational strategies.
Infuse new perspectives: Attracting outsiders who can bring fresh ideas to the organization.

Inject fresh talent: Adding new blood at various levels to refresh the workforce.
Create a strong organizational culture: Cultivating a culture that appeals to talented people.
Headhunting: Actively seeking individuals whose skills match the company's values.
Psychological assessment: Using methods to evaluate candidates' psychological traits.
Non-conventional talent development: Finding talent through unconventional routes.
Global talent search: Looking for talent worldwide, not just internally.
Competitive pay design: Offering entry-level pay that is competitive in terms of quality, not quantity.
Anticipate future roles: Identifying candidates for positions that might not yet exist.

Merits of Centralized Recruitment:

Cost efficiency: Centralized recruitment can lower recruitment costs per candidate due to economies of scale.
Expertise: It benefits from specialized expertise.
Talent diversity: Ensures a broad pool of qualified candidates from various backgrounds, skills, and education.
Reduced bias: Helps in reducing favoritism, bias, and unethical practices.

Merits of Decentralized Recruitment:

Tailored sourcing: Each unit can focus on the most relevant recruitment sources for its needs, leading to lower costs.

Local suitability: Better understanding of local needs and factors (cultural, social, etc.) that impact candidate selection.
Faster recruitment: Units can hire candidates when required, reducing delays.

Understanding Selection Process:

After recruitment, organizations face the challenge of selecting the right candidate from the pool of applicants. This is where selection methods and techniques come into play, helping HR managers make informed decisions. The goal is to choose the candidate best suited to perform the job successfully.

Objective of the Selection Process:

To choose the most qualified and suitable candidate who can successfully perform the job duties. Selection involves a structured process that assesses whether a candidate meets the job's specifications and requirements.

Key Requirements for Successful Selection:

Authority to select: Selection authority should come from an employment requisition based on workload and workforce analysis.
Standard comparison: A clear job description and specification should be available to compare candidates against.
Adequate applicants: There should be a sufficient number of qualified applicants to choose from.

Scientific Selection Procedure Steps:

Job Analysis: Identifying job requirements and skills needed.

Recruitment: Sourcing and attracting potential candidates.
Application Form: Collecting relevant information from applicants.
Written Examination: Assessing candidates' knowledge and skills.
Preliminary Interview: Initial assessment of candidates.
Business Games: Simulating real-life job scenarios to evaluate problem-solving abilities.
Tests: Conducting specialized tests (skills, personality, aptitude) as necessary.
Final Interview: The last stage of personal interaction to assess cultural fit and capability.

Medical Examination: Ensuring candidates meet health requirements.

Reference Checks: Verifying candidates' past performance and background.

Both recruitment and selection processes play a crucial role in ensuring that an organization hires the best-suited individuals to meet its goals and thrive in a competitive environment.

LITERATURE REVIEW

It looks like you've shared a summary of various studies on recruitment and selection processes from different perspectives and contexts. Each study highlights different aspects or challenges faced in recruitment across various industries or regions. Here are the key findings and recommendations from each study you mentioned:

Key Results: The studies examined in this review suggest that these factors significantly affect candidates' chances in the recruitment process, potentially influencing the fairness and objectivity of the selection.

Recommendation: Organizations should aim to minimize biases like physical attractiveness and social desirability in recruitment and selection to ensure fairness and inclusivity.

Dr. Amer Hani Al-Kassem (2017) – *Recruitment and Selection Practices in Business Process Outsourcing Industry*:

Findings: The study explored recruitment and selection practices in the Business Process Outsourcing (BPO) industry.

Key Results: High employee motivation, skill development, and performance are crucial for ensuring successful recruitment and maintaining employees' commitment.

Recommendation: Organizations in the BPO industry should focus on providing effective employee services, enhancing their skills, and fostering motivation to maintain high levels of performance and commitment.

Endah Setyowati (2016) – *Merit System in*

Recruitment and Selection Process of Civil Servant Candidate in Malang, Indonesia:

Findings: This study focused on the recruitment and selection of civil servant candidates in Malang, Indonesia, emphasizing the merit system.

Key Results: The study found that the recruitment process had not been based on a thorough analysis of job and workload needs, which affects its effectiveness.

Recommendation: The recruitment process should be reformed to include a thorough analysis of job

requirements and workload to ensure it meets the needs of the civil service.

Bernard Oladosu Omisore & Bernadette Ivhaorheme Okofu (2014) – *Staff Recruitment and Selection Process in the Nigerian Public Service: What is to be done?*:

Findings: The study highlighted the importance of effective recruitment and selection in Nigeria's public service sector.

Key Results: The process plays a crucial role in maintaining a functional and efficient public service by ensuring the right fit for the positions.

Recommendation: There should be improvements in recruitment practices, focusing on the efficiency and accuracy of the processes to better serve Nigeria's civil service.

Each study underscores the need for careful attention to recruitment and selection procedures, whether it involves minimizing biases, improving the development and motivation of employees, or aligning recruitment practices with job and organizational needs.

METHODOLOGY

Research Design

The research design for this study will be

descriptive and analytical in nature. It aims to describe the recruitment and selection process used by HDFC Bank in their Nagpur branch, analyze the efficiency and effectiveness of their methods, and explore how it aligns with best practices in the industry.

Descriptive Research: This will involve detailing the specific processes adopted by HDFC Bank for recruitment and selection.
Analytical Research: This part of the research will involve examining the reasons behind the methods chosen and their outcomes, comparing them with industry standards or similar banking institutions.

Sampling Method

The study will employ a **non-probability sampling** method, particularly **judgmental or purposive sampling**, as the goal is to target specific employees involved in recruitment and selection within the bank.

Sample Size: A sample of HR personnel, hiring managers, and recruited candidates (preferably recent hires) will be selected to get insights from different perspectives.
Sampling Technique: Employees from HDFC Bank (Civil Lines, Nagpur) will be approached for interviews or surveys. The selection will also consider different levels of the recruitment hierarchy, including junior staff and managers.

Data Collection Methods

The study will utilize both **primary and secondary data**.

Primary Data:

Interviews: Semi-structured interviews with HR staff, recruitment managers, and department heads.
Surveys/Questionnaires: Distribute surveys among recent hires to understand their experience with the bank's recruitment and selection process.
Observation: If possible, observe a recruitment or selection procedure firsthand to gain insights

into the practical aspects of the process.

Secondary Data:

Company Records: Access to existing documents, such as recruitment policies, job descriptions, training materials, and organizational charts.
Industry Reports: Reference materials from other banks or research on banking sector recruitment practices.

Data Analysis Techniques

Qualitative Analysis: The responses from Patterns, themes, and significant insights related to recruitment processes, challenges, and improvements will be identified.
Quantitative Analysis: Survey responses with close-ended questions will be analyzed using statistical techniques like frequency distribution and percentage analysis to gauge common trends and preferences in recruitment and selection.

Theoretical Framework

The methodology will be guided by key theories related to recruitment and selection processes:

Human Capital Theory: This theory suggests that recruitment and selection should focus on finding candidates enhance organizational performance.

Person-Organization Fit Theory: This theory emphasizes the importance of aligning the values and culture of the organization with the attitudes and values of the employee during the recruitment and selection process.
Signaling Theory: This theory focuses on how employers signal their expectations and company culture through their recruitment and selection processes, which in turn influences the candidate's decision to apply or accept an offer.

Ethical Considerations

Confidentiality: Personal and sensitive

information obtained from participants will be kept confidential.

Voluntary Participation: Participation in the study will be voluntary, and participants can withdraw at any time without any consequence.

Limitations of the Study

Sample Bias: The study will only focus on one branch of HDFC Bank (Civil Lines, Nagpur), which may not fully represent the broader practices of the bank.

Time Constraints: Limited time for observing the recruitment process and conducting interviews may restrict the depth of analysis.

Expected Outcome

The research aims to provide:

A detailed understanding of the recruitment and selection strategies adopted by HDFC Bank in Nagpur.

Insight into how these practices align with HR best practices and impact organizational performance.

Recommendations for improving recruitment and selection efficiency at HDFC Bank, based on employee feedback and industry benchmarks.

OPPORTUNITY AND CHALLENGES

Conducting a study on the recruitment and selection process at HDFC Bank (Civil Lines, Nagpur) offers both opportunities and challenges. Here's a breakdown of what you might encounter:

Opportunities:

Insight into a Leading Bank's HR Practices:

HDFC Bank is known for its structured and effective recruitment process. The study provides an opportunity to explore how one of India's top private sector banks approaches hiring, and how it aligns with their organizational goals.

Industry Benchmarking:

Comparing HDFC Bank's practices with industry standards can help identify trends, best practices, and innovative methods in recruitment and selection. You might be able to identify areas where other banks or institutions can learn from HDFC Bank.

Exposure to Advanced Tools & Technologies:

Understanding how HDFC Bank integrates technology in recruitment (like AI tools, job portals, psychometric testing, etc.) can offer insight into modern HR practices that are shaping the banking sector.

Enhancing Knowledge of HR Metrics:

The study can provide practical exposure to key HR metrics and performance indicators used by HDFC Bank to assess the effectiveness of their recruitment process. This could include time-to-hire, cost-per-hire, or candidate experience.

Real-World Application:

With the practical nature of this study, you can gain a deeper understanding of how recruitment theory is applied in the real world. This could boost your career prospects by showcasing your ability to analyze and understand complex organizational processes.

Challenges:

Access to Internal Data:

One of the primary challenges may be accessing the detailed internal data on the recruitment process at HDFC Bank. Banks may be protective of their recruitment strategies and data, requiring permissions or special access.

Confidentiality & Privacy Concerns:

Since recruitment involves personal candidate information, there might be restrictions on accessing and sharing detailed case studies or

data. Ensuring compliance with privacy laws (like GDPR or Indian data protection norms) will be important.

Evolving Practices:

Recruitment strategies are continuously evolving, especially in a dynamic organization like HDFC Bank. This could lead to inconsistencies or the challenge of keeping up with the most recent changes in their processes during the study.

Limited Scope for Primary Research:

Depending on your approach, getting direct feedback from employees involved in the recruitment process or candidates could be difficult due to time constraints or the bank's policies on involving outsiders in their internal processes.

Bias or Subjectivity in Selection:

Recruitment processes might sometimes include subjective judgments or biases in candidate selection. Identifying and analyzing these biases could be challenging, especially if the data isn't transparent.

Comparing Different Roles:

HDFC Bank recruits for various positions across different departments (sales, HR, technology, etc.). The recruitment process may vary significantly depending on the role, making it difficult to create a comprehensive analysis.

DATA ANALYSIS:

Introduction

Provide a background of HDFC Bank, focusing on its operations in Nagpur, particularly the Civil Lines branch.

Briefly explain the importance of recruitment and selection in banking, highlighting how it ensures the right candidates are chosen for the right roles.

Data Collection

Data can be collected using several methods such as:

Interviews/Surveys: Gather feedback from HR managers, employees involved in recruitment, and selected candidates.
Company Reports: Study internal recruitment and selection reports from the Civil Lines branch.
Secondary Data: Use industry standards or similar case studies for comparison.

Recruitment Process at HDFC Bank (Civil Lines)

Provide a detailed analysis of each step in the recruitment process. You might include:

Job Analysis and Description: How positions are analyzed and job descriptions are created. Are there specific competencies sought?
Sourcing of Candidates: Describe the channels used to attract candidates (e.g., job portals, employee referrals, campus recruitment, walk-ins, social media).
Screening of Resumes: How applications are screened (automated tools, manual processes, shortlisting).
Initial Shortlisting: Criteria used to shortlist candidates for interviews (qualifications, skills, experience, etc.).

Selection Process at HDFC Bank (Civil Lines)
This section can go into more detail about the selection stages:

Written Tests/Assessment: If applicable, describe the type of tests administered (e.g., aptitude tests, personality assessments).
Interviews: The format of interviews (e.g., one-on-one, panel interview) and focus areas (technical knowledge, cultural fit, communication skills, etc.).
Group Discussions: Are group discussions a part of the process? What key attributes are evaluated?

Background Checks: How the bank verifies the candidate's credentials, criminal record, and past employment.

Final Offer and Joining: What happens after the final selection? Does the bank offer any pre-joining training or induction programs?

Data Analysis

Descriptive Statistics: Present quantitative data (if available) about the recruitment volume, success rate, or candidate selection distribution. For instance, the number of applicants per position, success rates at each stage of the process, or average time taken from application to offer.
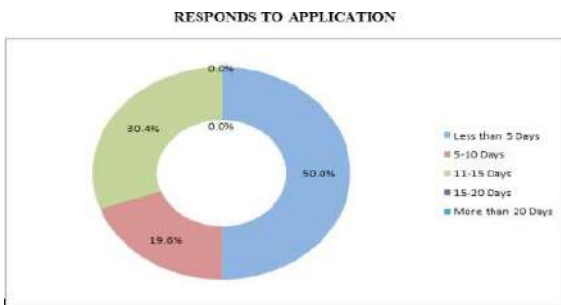
Success of the Recruitment Process: Analyze if the recruitment methods used by HDFC Bank are effective in hiring the best talent. For instance, compare the performance and retention rates of candidates hired through different channels.
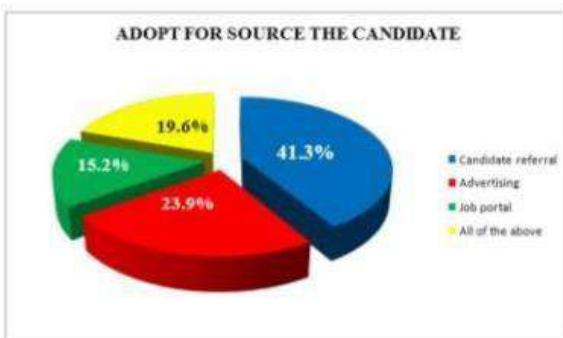
Challenges: Highlight challenges faced by the recruitment team, such as high competition, difficulty in sourcing quality candidates, or prolonged hiring processes.
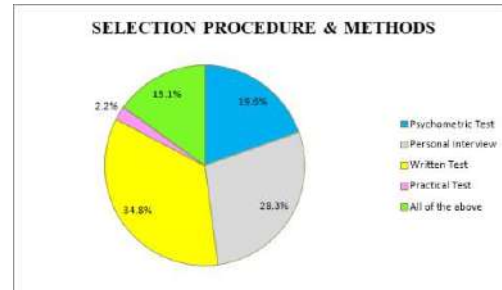
Candidate Experience: Analyze candidate feedback from surveys/interviews to assess how they perceive the recruitment and selection process. Are they satisfied with the transparency, communication, or efficiency?

Comparison with Industry Standards

Compare HDFC Bank's recruitment process with best practices in the banking sector or within the financial industry.
What could HDFC Bank adopt or improve based on industry trends?

RECOMMENDATIONS

Based on the findings, here are some suggestions for improvements and innovations in the recruitment and selection process:

Technology Integration

AI and Applicant Tracking Systems (ATS): Given the reliance on external recruitment methods (HR consultancy and newspaper ads), AI-driven tools and ATS can streamline the process, enhancing efficiency and reducing manual workload.

AI Screening: Implement AI algorithms to assess CVs and applications based on keywords,

skills, and qualifications to quickly shortlist candidates. This would speed up the initial screening and allow HR teams to focus on higher-level evaluations.

Chatbots: Use AI chatbots to conduct preliminary interviews or answer candidate inquiries 24/7. This can reduce HR team workload, ensure timely responses, and engage candidates early on.

Predictive Analytics: Use AI to analyze past recruitment data and predict the success of candidates based on historical patterns, further improving the quality of hires.

Diversity and Inclusion

Inclusive Sourcing Channels: Since 75% of external recruitment comes through HR consultancies and newspapers, there could be room to diversify the recruitment channels to enhance inclusivity.

Partnerships with Diverse Job Boards: Collaborate with platforms that promote diverse candidates, such as those focused on women in tech, minorities, or people with disabilities.

Bias-Free Screening: Ensure AI tools are designed to eliminate biases by focusing purely on skills and experience, avoiding demographic factors such as gender, ethnicity, and age. Implement blind recruitment processes where names, photos, and other personal identifiers are hidden from recruiters during the initial phases.

Diversity Metrics: Set measurable diversity goals for each stage of recruitment, such as interview invitations, hiring, and promotions, to ensure continuous progress and transparency.

Training Programs

Training for HR Teams: The current recruitment methods rely heavily on internal referrals and traditional selection processes (formal interviews and subject tests). If data shows low success rates in certain stages (e.g., high failure rates in technical tests or subjective

biases during interviews), it may indicate a need for targeted training.

Bias Training: Train HR teams and interviewers to recognize and address unconscious biases, especially during interviews or when reviewing test results.

Behavioral Interview Training: Since 75% of respondents faced formal interviews, it might be beneficial to train interviewers on how to conduct structured behavioral interviews, which tend to be more predictive of future performance and reduce biases.

Improvement in Technical Testing: If there's a lack of success in technical assessments (15% attending technical tests), it's worth evaluating if the testing methods are outdated or not aligned with real-world job demands. Offering HR teams additional training on how to create better tests or provide feedback on technical skills assessments might be helpful.

Interview Simulation: Organize training programs that simulate both formal and stress interviews, allowing HR professionals to refine their techniques in handling different types of candidates.

SUGGESTIONS

The study on "Recruitment & Selection Process Adopted by HDFC Bank (Civil Lines), Nagpur"

would aim to analyze and evaluate the methods and practices employed by HDFC Bank in sourcing, screening, and hiring candidates. The focus would be on understanding the entire recruitment process, from job postings, application collection, and shortlisting to interviews, assessment tests, and final selection. By examining the effectiveness of these processes, the study could highlight the strengths in HDFC Bank's recruitment practices. Additionally, it would be beneficial to analyze how these processes align with the bank's organizational goals, culture, and the competitive banking sector.

Furthermore, the study could explore how HDFC Bank utilizes technology, recruitment platforms, and employee referral systems to attract and select the best talent. The research could also examine the role of HR teams in maintaining a fair and transparent selection process, ensuring diversity and inclusion, and adhering to labor laws. A comparative analysis with industry standards or other leading banks could provide deeper insights into the competitive edge HDFC Bank has in attracting top-tier candidates in the banking sector.

CONCLUSION:

In conclusion, the recruitment and selection process adopted by HDFC Bank (Civil Lines, Nagpur) is thorough and well-structured, reflecting the bank's commitment to hiring qualified and capable candidates. The bank follows a multi-step procedure that includes resume screening, aptitude testing, interviews, and background checks, ensuring that only the best-fit candidates are selected. This process not only helps the bank in identifying individuals with the right skill set and cultural alignment but also contributes to maintaining high employee performance and satisfaction. Through these systematic recruitment and selection methods, HDFC Bank strengthens its workforce, supporting its long-term goals of growth and success.

The study highlights that the bank places significant emphasis on maintaining fairness and transparency in its recruitment process. By utilizing various selection techniques, HDFC Bank ensures a diverse and skilled workforce, which is crucial in a competitive banking environment. This structured approach also helps in reducing turnover rates and improving employee retention, ultimately contributing to the overall efficiency and productivity of the organization.

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A Study on Impact of Digitalization on Indian Banking Sector with Respect to SBI Bank, Nagpur

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ABSTRACT:
Digitalization has significantly transformed the Indian banking sector, enhancing efficiency, customer experience, and financial inclusion. This research explores how digitalization influences the banking industry, focusing on the SBI (State Bank of India) in Nagpur. With the integration of advanced technologies such as internet banking, mobile banking, and artificial intelligence, SBI has improved its service delivery, security, and operational efficiency. The research explores customer satisfaction, digital banking trends, and the challenges faced during this transition. It also highlights the role of government initiatives like Digital India in fostering technological advancements. Data is collected through surveys and secondary sources to analyse the benefits and limitations in digital banking. The research findings indicate that digitalization has positively impacted SBI's performance, though challenges like cybersecurity risks and digital literacy remain key concerns.

KEYWORDS: Digitalization, Banking Sector, SBI Nagpur, Financial Technology, Customer Satisfaction.

INTRODUCTION

The banking sector holds a vital position in driving a country's economic growth by facilitating financial transactions, providing credit, and ensuring monetary stability. In recent years, digitalization has revolutionized the Indian banking industry, making services more efficient, accessible, and secure. The implementation of technologies like internet banking, mobile banking, artificial intelligence, and blockchain has transformed traditional banking operations, reduced manual processes and improved customer convenience.

The State Bank of India (SBI), the largest public sector bank in India, has been at the forefront of this digital transformation. With a strong presence in Nagpur, SBI has implemented various digital banking services, including YONO (You Only Need One) for seamless mobile banking, online fund transfers, and e-KYC (electronic Know Your Customer) to enhance customer experience. These innovations have enabled faster transactions, reduced paperwork, and improved security.

Government initiatives like Digital India and financial inclusion programs have further accelerated the adoption of digital banking. However, challenges such as cybersecurity threats, digital literacy gaps, and internet accessibility continue to pose concerns. This study seeks to evaluate the effects of digitalization on SBI in Nagpur by examining customer satisfaction, operational efficiency, and the challenges faced in this transition. By understanding these factors, the research seeks to highlight the benefits and limitations of digital banking in India's evolving financial landscape.

LITERATURE REVIEW

The impact of digitalization on the Indian banking sector has been widely studied by researchers, highlighting various aspects such as technological advancements, customer adoption, operational efficiency, and challenges. This section reviews relevant literature from Indian authors and their research papers to understand the effects of digital banking, particularly in the context of the State Bank of India (SBI) in Nagpur.

2.1 Evolution of Digital Banking in India
The digital transformation of the Indian banking sector has been driven by technological innovations and policy initiatives. According to Sharma and Gupta (2019), the implementation of digital banking has resulted in improved accessibility and efficiency, allowing banks to

serve a wider customer base. They emphasize that mobile banking, internet banking, and digital payment systems have transformed traditional banking operations.

- **2.1.1 Government Initiatives and Policy Support:** Government policies have played a vital role in accelerating digital banking adoption. As per Mehta (2020), initiatives like Digital India, Pradhan Mantri Jan Dhan Yojana (PMJDY), and Unified Payments Interface (UPI) have significantly influenced customer preferences. These programs have empowered rural and urban communities to gain access to banking services more conveniently, thereby promoting financial inclusion.
- **2.1.2 Role of SBI in Digital Transformation:** The State Bank of India, being the largest public sector bank has contributed to the digital transformation in banking. A study by Reddy and Kumar (2021) highlights SBI's efforts in implementing innovative digital banking services such as YONO, digital wallets, and AI-based customer service. They argue that SBI's adoption of new technologies has enhanced customer engagement and improved service delivery.

2.2 Customer Adoption and Satisfaction in Digital Banking

Customer adoption of digital banking services depends on several factors, including ease of use, security, and service efficiency. Research by Verma and Singh (2021) suggests that trust and digital literacy are key determinants of customer satisfaction in digital banking. They found that customers who are more tech-savvy are more likely to adopt digital banking services.

- **2.2.1 Factors Influencing Customer Adoption:** A study by Iyer and Sharma (2020) identifies multiple factors affecting the adoption of digital banking, including factors like perceived ease of use, security concerns, and transaction speed. Their research shows that customers value quick and hassle-free transactions but are often concerned about security risks such as fraud and cyber threats.
- **2.2.2 Impact on Customer Satisfaction:** According to Patel (2019), digital banking has improved customer satisfaction by reducing wait times and simplifying transactions. The research revealed that SBI's digital solutions, including mobile banking apps and online fund transfers, have significantly enhanced user experience.

However, issues like technical glitches and poor internet connectivity continue to hinder seamless banking experiences.

2.3 Operational Efficiency and Performance of SBI

Digitalization has been instrumental in enhancing the operational efficiency of banks. Research by Deshmukh and Rao (2020) states that digital banking has enabled SBI to optimize resource utilization and reduce administrative costs. Automation of services has also helped in minimizing human errors and improving accuracy.

- **2.3.1 Cost Efficiency and Revenue Generation:** A study by Nair and Bhatia (2021) emphasizes that SBI has benefited from digital banking through increased cost efficiency and higher revenue generation. With reduced dependency on physical branches, operational costs have declined, allowing the bank to invest more in technology-driven solutions.
- **2.3.2 Digital Banking and Risk Management:** Risk management is a crucial aspect of digital banking. As per Ghosh and Mukherjee (2019), SBI has implemented robust cybersecurity measures and fraud detection systems to mitigate risks associated with online transactions. Their study highlights the importance of AI-driven fraud detection tools in preventing unauthorized access and financial fraud.

2.4 Challenges and Future Prospects of Digital Banking

While digital banking has provided numerous benefits, certain challenges persist. Research by Joshi and Kapoor (2021) identifies cybersecurity threats, lack of digital literacy, and infrastructure limitations as key obstacles to widespread digital banking adoption.

- **2.4.1 Cybersecurity Threats and Fraud Mitigation:** Cybersecurity continues to be a significant challenge in digital banking. According to Rao and Menon (2020), banks, including SBI, face increasing threats from cybercriminals attempting phishing attacks, malware intrusions, and identity theft. Their study suggests that continuous investment in cybersecurity infrastructure and awareness campaigns can help mitigate these risks.
- **2.4.2 Future Trends in Digital Banking:** The outlook for digital banking in India is expected to be shaped by advanced technologies like artificial intelligence, open banking, blockchain

and. A study by Shah and Aggarwal (2021) predicts that SBI will continue investing in AI-driven chatbots, blockchain-based transactions, and digital lending platforms to enhance customer experiences and streamline operations.

METHODOLOGY

This research explores the effects of digitalization on the Indian banking industry, with a particular emphasis on the State Bank of India (SBI) in Nagpur. A hybrid research approach utilizing both primary and secondary data, has been adopted to provide a comprehensive analysis.

3.1 Research Design
The study adopts a descriptive research design aiming to assess how digitalization has influenced banking operations, customer satisfaction, and service efficiency. The study evaluates the advantages and obstacles encountered by customers and bank employees in adopting digital banking services.

3.2 Data Collection Methods
This study utilized both primary and secondary data sources:

- **Primary Data:** A well-structured questionnaire was developed and circulated among SBI customers and employees in Nagpur. The survey included multiple-choice and Likert scale-based questions to assess customer experiences, service efficiency, and digital banking challenges.
- **Secondary Data:** Information was gathered from books, research papers, RBI reports, and SBI's official publications. Data from government initiatives like Digital India and NPCI (National Payments Corporation of India) reports were also considered.

3.3 Sample Size and Sampling Technique
A total of 100 respondents were selected as the sample size selected, comprising SBI customers and employees in Nagpur. A random sampling method was employed to ensure fair representation across different demographics, including age, occupation, and digital banking usage frequency.

3.4 Data Analysis
The gathered data was examined using descriptive statistical methods, including percentages and frequency distribution. Charts and graphs were used to present findings clearly.

OBJECTIVE

1. To analyse the impact of digitalization on banking services in SBI, Nagpur.
2. To evaluate customer satisfaction and challenges in adopting digital banking services.
3. To examine the role of government initiatives in promoting digital banking.
4. To identify potential risks and future opportunities in digital banking for SBI.

HYPOTHESIS

1. **H1:** Digitalization has significantly improved banking efficiency and customer satisfaction at SBI, Nagpur.
2. **H2:** Digitalization has not had a significant impact on banking efficiency and customer satisfaction at SBI, Nagpur.

RESULTS AND DISCUSSION

1. Has digitalization improved banking efficiency at SBI, Nagpur?

Response	Count	Percentage (%)
Totally Agree	42	42%
Agree	32	32%
Neutral	16	16%
Disagree	7	7%
Totally Disagree	3	3%
Total	**100**	**100%**

Table No.1
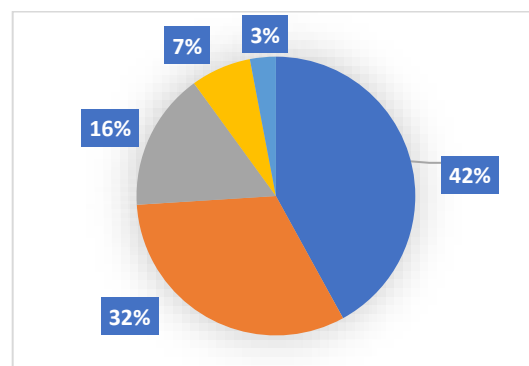
Graph No.1

Interpretation: Most of the respondents (80%) are satisfied with the user experience on Zomato, with 35% Totally agreeing and 45% agreeing. This indicates that the platform's interface, ease of navigation, and overall convenience are well-received by users. Only 10% remained neutral, while 10% expressed some dissatisfaction, either disagreeing or totally disagreeing. This shows that Zomato has a generally positive reputation for user experience but has areas for improvement to enhance satisfaction further.

2. Do you find SBI's digital banking services user-friendly?

Response	Count	Percentage (%)
Totally Agree	37	37%
Agree	41	41%
Neutral	12	12%
Disagree	6	6%
Totally Disagree	4	4%
Total	**100**	**100%**

Table No.2
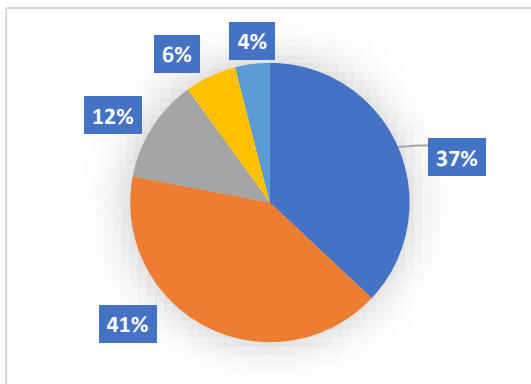
Graph No.2

Interpretation: A significant 78% of respondents find SBI's digital banking services user-friendly, with 37% Totally agreeing and 41% agreeing. However, 12% remain neutral, and 11% experience difficulties with the platform, as 6% disagree and 4% Totally disagree. This suggests that while the services are generally well-received, there is still a need to address the issues faced by a small but notable portion of customers.

3. What are the major challenges you face in SBI's digital banking services?

Response	Count	Percentage (%)
Technical glitches	32	32%
Poor internet connectivity	27	27%
Security concerns	18	18%
Lack of digital knowledge	13	13%
No issues faced	10	10%
Total	**100**	**100%**
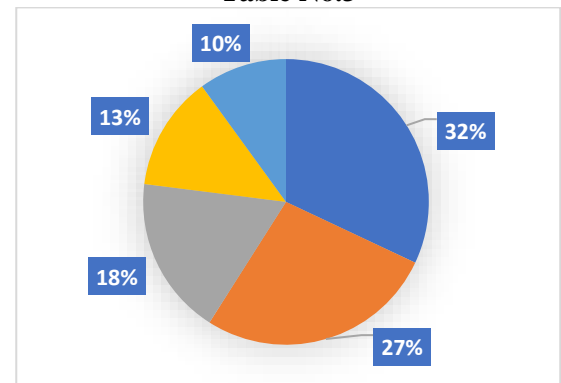
Table No.3

Graph No.3

4. Do you feel secure while using SBI's digital banking services?

Response	Count	Percentage (%)
Totally Agree	34	34%
Agree	28	28%
Neutral	20	20%
Disagree	10	10%
Totally Disagree	8	8%
Total	**100**	**100%**

Table No.4
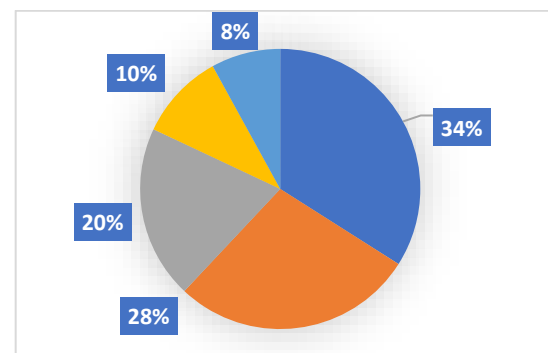
Graph No.4

Interpretation: While 62% of respondents feel secure using SBI's digital banking services, with 34% Totally agreeing and 28% agreeing, 20% remain neutral. A concern persists for 18% of users, with 10% disagreeing and 8% Totally disagreeing, indicating that cybersecurity may still be a significant worry for some customers. This highlights the need for stronger security measures and awareness to boost customer confidence.

CONCLUSIONS

The study has highlighted the significant impact of digitalization on banking services at the State Bank of India (SBI) in Nagpur. The majority of respondents agree that digital banking has improved banking efficiency, enhanced customer convenience, and made transactions faster. SBI's digital services, such as mobile banking and YONO, are generally seen as user-friendly, though there is a small percentage of users facing challenges such as technical glitches and security concerns.

While most customers feel secure using SBI's digital services, a portion of respondents still harbour concerns about cybersecurity, emphasizing the need for ongoing improvements in security measures. The adoption of digital banking has streamlined operations, reducing manual processes and operational costs, but issues like poor internet connectivity and a lack of digital literacy still hinder some users from fully benefiting from these services.

Overall, while digital banking at SBI has greatly benefited both customers and the bank, addressing the challenges identified in this study will further enhance the experience and adoption of digital banking services.

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A Study on the Integration of Green Marketing in Mahindra & Mahindra's Corporate Strategy in Nagpur

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ABSTRACT

This study examines how Mahindra & Mahindra integrates green marketing into its corporate strategy, focusing on its operations in Nagpur. Green marketing, which promotes environmentally friendly products and sustainable practices, has become essential in addressing growing environmental concerns. The research highlights the company's initiatives, such as eco-friendly vehicle manufacturing, sustainable supply chains, and marketing campaigns that emphasize environmental stewardship. It evaluates the alignment of these efforts with Mahindra & Mahindra's broader sustainability goals and their impact on consumer behavior and brand perception. By identifying challenges and opportunities in implementing green marketing, the study provides actionable insights for businesses aiming to balance profitability with environmental responsibility. This research underscores the role of green marketing in achieving sustainable growth.

KEYWORDS: Green marketing, sustainability, Mahindra & Mahindra, consumer behavior, environmental responsibility.

INTRODUCTION

In recent years, the global focus on environmental sustainability has reshaped business practices across industries. Companies are increasingly adopting green marketing strategies to align with growing consumer demand for eco-friendly products and services. Green marketing refers to promoting products or services that are designed to have minimal environmental impact. It involves practices such as sustainable sourcing, reducing carbon footprints, and creating awareness about environmental conservation through marketing campaigns.

Mahindra & Mahindra, a prominent name in the Indian automotive sector, has been at the forefront of sustainable innovation. The company has introduced numerous green initiatives, including the development of electric vehicles, energy-efficient manufacturing processes, and the promotion of renewable energy usage. These efforts are not only geared toward reducing the environmental impact of its operations but also toward meeting the evolving expectations of environmentally conscious consumers.

This study focuses on the integration of green marketing into Mahindra & Mahindra's corporate strategy, particularly in Nagpur, a significant hub for the company's operations. It examines how the organization's eco-friendly initiatives align with its broader sustainability goals and explores their impact on brand perception and consumer behavior.

By analysing these strategies, the study aims to provide insights into the role of green marketing in enhancing business growth while promoting environmental responsibility, making it an essential tool for companies striving for sustainable development.

LITERATURE REVIEW

This section reviews the existing body of literature on green marketing and its integration into corporate strategies, particularly in the Indian context. It explores

insights from research papers, journals, and case studies by Indian authors, emphasizing their relevance to Mahindra & Mahindra's initiatives.

2.1 Concept of Green Marketing

Green marketing has been extensively studied as a key driver of sustainable development. According to Saxena and Khandelwal (2010), green marketing involves the promotion of eco-friendly products and practices to balance profitability with environmental responsibility. The authors argue that consumers are becoming more inclined toward brands that reflect a commitment to sustainability.

- **2.1.1 Evolution of Green Marketing in India:** Dasgupta (2011) highlights the gradual shift in Indian businesses from traditional marketing to sustainability-driven approaches. The author emphasizes how early green marketing efforts in India were limited to niche markets but have now become mainstream as companies recognize their value in building brand loyalty.
- **2.1.2 Importance of Consumer Awareness:** Mehta and Chaturvedi (2013) underscore the importance of consumer awareness in driving green marketing strategies. Their study shows that educated consumers in urban areas, such as Nagpur, are more likely to support brands that adopt environmentally conscious practices, making it crucial for companies to communicate their green initiatives effectively.

2.2 Integration of Green Marketing into Corporate Strategy

Integration of green marketing into corporate strategies ensures alignment between business objectives and environmental goals. According to Gupta and Reddy (2015), successful integration requires commitment at all organizational levels, supported by robust policies and frameworks.

- **2.2.1 Strategic Alignment with Sustainability Goals:** Sharma and Verma (2016) analysed how Indian companies, including automobile manufacturers, incorporate green marketing into their corporate strategies. They found that firms adopting sustainable practices often experience long-term financial and reputational benefits, as these initiatives resonate with both stakeholders and customers.
- **2.2.2 Role of Leadership in Driving Green Strategies:** Pandey (2017) emphasized the critical role of leadership in embedding green marketing within corporate strategies. The study highlighted that visionary leadership at organizations like Mahindra & Mahindra has been instrumental in setting sustainability benchmarks and fostering a culture of innovation in green marketing.

2.3 Green Marketing Practices in the Indian Automotive Industry

The automotive sector in India has witnessed significant adoption of green marketing practices to address environmental concerns. Researchers such as Kumar and Joshi (2018) have highlighted the pivotal role of electric vehicles and energy-efficient production processes in redefining sustainability for the industry.

- **2.3.1 Focus on Electric and Hybrid Vehicles:** According to Singh and Patel (2019), Indian automobile companies are investing heavily in the development of electric and hybrid vehicles. Their study on Mahindra & Mahindra's EV segment revealed that such initiatives not only contribute to reducing carbon emissions but also cater to the growing demand for environmentally conscious mobility solutions.
- **2.3.2 Challenges in Adopting Green Marketing:** Saha and Roy (2020) explored the challenges faced by Indian companies in implementing green marketing. The authors identified high costs, lack of infrastructure, and limited consumer awareness in smaller cities as the primary obstacles. However, they noted that companies like Mahindra & Mahindra are addressing these challenges through targeted campaigns and investments in green technology.

2.4 Impact of Green Marketing on Consumer Behavior

Understanding consumer behavior is crucial for the success of green marketing initiatives. Raj and Menon (2021) conducted a study on consumer perceptions of green products in urban areas, including Nagpur. Their research highlighted that consumers associate green marketing efforts with trust, quality, and corporate responsibility.

- **2.4.1 Influence on Purchase Decisions:** According to Nair and Krishnan (2022), green marketing significantly influences consumer purchase decisions. The study found that consumers are willing to pay a premium for products from brands that prioritize environmental sustainability, making green marketing a profitable investment for businesses.

- **2.4.2 Building Long-Term Brand Loyalty:** Chopra and Sharma (2023) argue that green marketing contributes to long-term brand loyalty by fostering emotional connections with consumers. Their research revealed that Mahindra & Mahindra's green initiatives, such as the "Rise for Good" campaign, have enhanced the company's image as a socially responsible organization.

METHODOLOGY

This section outlines the research methodology used to study the integration of green marketing into Mahindra & Mahindra's corporate strategy in Nagpur. The approach is designed to gather comprehensive and accurate data to analyze the impact of green marketing initiatives on consumer behavior and organizational success.

3.1 Research Design
The study adopts a descriptive research design to gain insights into Mahindra & Mahindra's green marketing practices. The research design focuses on understanding how these strategies align with the company's corporate goals and their influence on consumer preferences. A mix of qualitative and quantitative methods was employed to provide a holistic view of the subject.

3.2 Data Collection Methods
- **3.2.1 Primary Data:** Primary data was collected through structured questionnaires distributed to respondents in Nagpur. The questionnaire was designed to gather information on consumer awareness, perception, and response to Mahindra & Mahindra's green initiatives.
- **3.2.2 Secondary Data:** Secondary data was sourced from company reports, research papers, journals, and articles on green marketing and sustainability in the Indian automotive sector. This data helped in understanding industry trends and benchmarking Mahindra & Mahindra's initiatives against competitors.

3.3 Sampling Design
- **Sample Size:** The study involved a sample size of 100 participants, ensuring a diverse mix of respondents. The sample included customers, employees, and industry experts from Nagpur to obtain a balanced perspective.

3.4 Limitations of the Study
While the study provides valuable insights, it is subject to certain limitations. The sample size of 100 participants may not fully capture the perspectives of all stakeholders in Nagpur. Additionally, the convenience sampling technique could introduce bias, as participants were selected based on accessibility rather than random sampling.

OBJECTIVE

1. To evaluate the integration of green marketing strategies into Mahindra & Mahindra's corporate framework in Nagpur.
2. To analyse consumer awareness and perceptions regarding Mahindra & Mahindra's green initiatives.
3. To identify the impact of green marketing on the company's brand image and customer loyalty.
4. To explore the challenges faced by Mahindra & Mahindra in implementing green marketing practices effectively.

HYPOTHESIS

1. **H1:** The integration of green marketing strategies into Mahindra & Mahindra's corporate framework positively influences consumer awareness and perception in Nagpur.

2. **H2:** Green marketing initiatives contribute to increased customer loyalty and improve Mahindra & Mahindra's brand image in Nagpur.

RESULTS AND DISCUSSION

1. Do you believe that Mahindra & Mahindra's green marketing initiatives have raised consumer awareness about environmental issues?

Response	Count	Percentage (%)
Strongly Agree	45	45%
Agree	35	35%
Neutral	10	10%
Disagree	5	5%
Strongly Disagree	5	5%
Total	**100**	**100%**

Table No.1
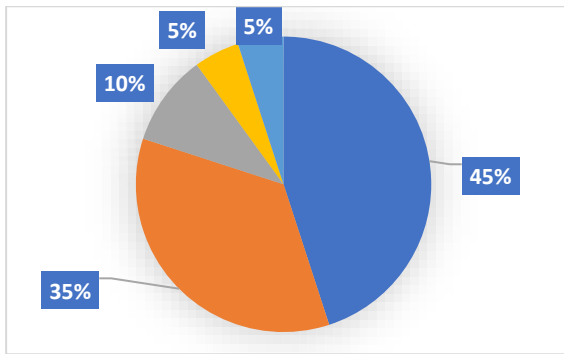
Fig No.1

Interpretation: The results show that 80% of respondents believe that Mahindra & Mahindra's green marketing initiatives have significantly raised awareness about environmental issues. A small percentage 10% remained neutral, while 10% disagreed. This indicates that the company's efforts in promoting eco-friendly practices are positively impacting public awareness, suggesting a high level of success in educating consumers about environmental concerns.

2. Do you think Mahindra & Mahindra's green initiatives, such as electric vehicles, contribute to a positive brand image?

Response	Count	Percentage (%)
Strongly Agree	50	50%
Agree	30	30%
Neutral	15	15%
Disagree	3	3%
Strongly Disagree	2	2%
Total	100	100%

Table No.2
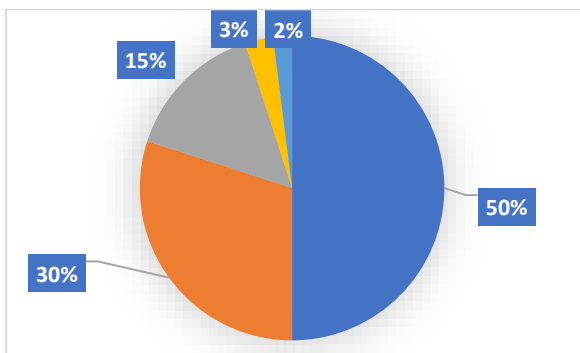
Fig No.2

Interpretation: A strong 80% of participants feel that Mahindra & Mahindra's green initiatives, particularly electric vehicles, positively influence the brand's image. Only 5% of respondents disagreed, and 15% remained neutral. This indicates that the company's focus on sustainability not only addresses environmental concerns but also significantly enhances its brand image, aligning with consumer preferences for eco-conscious brands.

3. Do you consider the environmental responsibility of a company when making purchasing decisions?

Response	Count	Percentage (%)
Strongly Agree	40	40%
Agree	35	35%
Neutral	15	15%
Disagree	5	5%
Strongly Disagree	5	5%
Total	100	100%

Table No.3
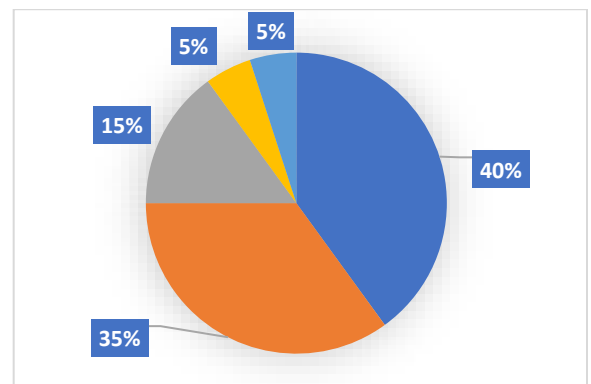
Fig No.3

Interpretation: While 75% of respondents consider environmental responsibility an important factor in their purchasing decisions. This highlights the growing significance of sustainability in consumer behavior. A smaller portion 15% felt neutral, and 10% disagreed. The findings suggest that Mahindra & Mahindra's green marketing is resonating with consumers, as they increasingly factor environmental responsibility into their buying choices.

4. Have Mahindra & Mahindra's green marketing campaigns influenced your loyalty toward their brand?

Response	Count	Percentage (%)
Strongly Agree	40	40%
Agree	30	30%
Neutral	20	20%
Disagree	5	5%
Strongly Disagree	5	5%
Total	**100**	**100%**

Table No.4
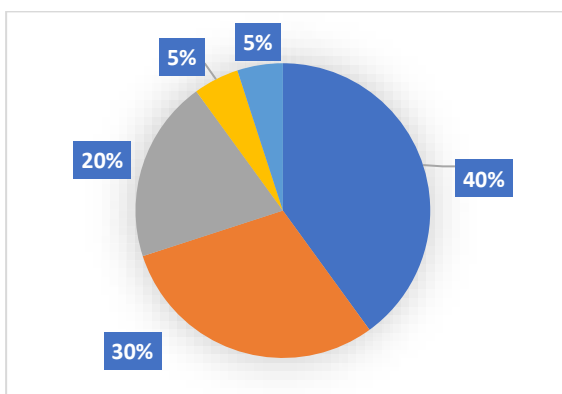
Fig No.4

Interpretation: The majority of respondents 70% of the respondents (40% strongly agree, 30% agree) indicated that Mahindra & Mahindra's green marketing campaigns have influenced their loyalty towards the brand. While 20% were neutral, 10% disagreed. This suggests that the company's eco-friendly initiatives are fostering strong brand loyalty, with a significant portion of consumers developing a deeper connection due to the company's sustainable practices.

CONCLUSIONS

In conclusion, the study highlights the successful integration of green marketing into Mahindra & Mahindra's corporate strategy, particularly in the context of Nagpur. The company's focus on sustainability through initiatives like electric vehicles, energy-efficient manufacturing, and eco-friendly marketing campaigns has positively impacted both consumer behavior and brand perception.

A significant majority of respondents acknowledged the importance of environmental responsibility in their purchasing decisions and expressed increased brand loyalty towards Mahindra & Mahindra due to its green efforts.

Furthermore, the company's initiatives align well with the growing demand for sustainable products and services, contributing to the overall market competitiveness. However, challenges such as high costs and infrastructure limitations in smaller cities still persist, indicating areas for improvement.

Overall, Mahindra & Mahindra's green marketing practices not only enhance its corporate image but also drive consumer engagement and loyalty, emphasizing the importance of balancing profitability with environmental responsibility in today's business landscape.

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A Study on performance Appraisal mechanism adopted at Haldiram Company, Nagpur

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ABSTRACT:

This research explores the performance appraisal mechanism implemented at Haldiram Company, Nagpur, to evaluate its effectiveness in enhancing employee performance and organizational productivity. The study aims to analyse the appraisal process, tools, and criteria used to assess employees' skills and contributions. Primary data was collected through surveys and interviews with employees and managers at Haldiram, while secondary data from relevant literature was reviewed to understand the theoretical framework behind performance appraisal systems. The findings reveal the strengths and challenges of the current system, highlighting areas for improvement. This research provides valuable insights into how performance appraisals can be optimized to drive employee motivation and support organizational goals, offering practical recommendations for Haldiram to enhance its appraisal mechanisms.

KEYWORDS: Performance appraisal, employee performance, Haldiram Company, appraisal system, organizational productivity.

INTRODUCTION

In today's competitive business environment, performance appraisal systems play a critical role in assessing employee performance, promoting professional growth, and aligning individual objectives with organizational goals. Performance appraisals are a key management tool used to evaluate and enhance employee productivity, motivation, and job satisfaction. They provide organizations with essential feedback that helps in making informed decisions regarding promotions, salary increments, and training needs.

Haldiram Company, one of the leading food manufacturers in India, with a large workforce, faces the challenge of maintaining an effective performance management system that supports its dynamic business goals. As an organization known for its diverse product offerings and expanding market presence, Haldiram's approach to performance appraisal is essential in ensuring that employees are motivated and aligned with the company's objectives.

This study aims to investigate the performance appraisal mechanisms at Haldiram Company, Nagpur, to understand how these systems are structured and implemented. It seeks to analyse the appraisal process, the criteria used for evaluation, and the effectiveness of the existing system in enhancing employee performance. Through this research, we aim to explore the strengths and weaknesses of Haldiram's performance management practices and provide recommendations for improving employee evaluation processes, ensuring that the organization can further strengthen its workforce and achieve its strategic goals.

LITERATURE REVIEW

Performance appraisal systems are widely studied across various industries, and their effectiveness has been analysed from numerous perspectives. This section reviews the existing literature on performance appraisal systems with a focus on Indian organizations, providing insights into how these systems impact employee performance, motivation, and organizational outcomes.

2.1 Overview of Performance Appraisal Systems
Performance appraisal is defined as a systematic process where employees are evaluated on their job performance, skills, and contributions to the organization. In India, performance appraisal systems are integral to managing

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human resources and ensuring that employees are aligned with organizational goals. According to Bhatia & Kumar (2017), performance appraisal systems are vital in fostering employee engagement and improving organizational productivity.

- **2.1.1 Importance of Performance Appraisal in Indian Companies:** Indian companies use performance appraisals not only for measuring employee performance but also for talent management, succession planning, and compensation decisions. Sharma and Gupta (2016) emphasize that a well-structured appraisal system aids in the personal growth of employees and aligns their objectives with organizational goals. Performance appraisals are essential for improving productivity, reducing turnover, and increasing job satisfaction, as they help employees recognize their strengths and areas for improvement.
- **2.1.2 Methods of Performance Appraisal:** Various methods are employed for performance appraisals in Indian organizations. These include traditional methods like rating scales and modern techniques such as 360-degree feedback and management by objectives (MBO). Reddy & Mishra (2018) discuss the effectiveness of the 360-degree feedback method in enhancing employee development by providing comprehensive feedback from multiple sources. This method is increasingly being adopted by companies in India for its ability to offer a holistic view of an employee's performance.

2.2 Key Factors Influencing Performance Appraisal Systems

A number of factors affect the effectiveness of performance appraisal systems, particularly in Indian organizations. These factors include organizational culture, employee expectations, and the competencies of the appraisers.

- **2.2.1 Organizational Culture and Performance Appraisal:** The organizational culture plays a crucial role in shaping the performance appraisal system. Deshpande & Chawla (2015) argue that in Indian companies, an individual's performance is often influenced by the cultural context, such as hierarchical structures and family-oriented values. The hierarchical culture in Indian organizations may lead to biased performance evaluations, as employees may hesitate to openly criticize their superiors.

- **2.2.2 Employee Expectations and Satisfaction:** Employees' satisfaction with Singh & Verma (2017) highlight that when employees the performance appraisal process is often linked to their expectations perceive the appraisal system as fair and transparent, they are more likely to accept the feedback and remain motivated. On the other hand, discrepancies between employee expectations and the actual outcomes of the appraisal system may lead to dissatisfaction and reduced productivity.
- **2.2.3 Competency of Appraisers:** The competency of appraisers, typically managers or supervisors, is another critical factor in determining the success of performance appraisals. Nair & Agarwal (2016) emphasize that appraisers should be trained to avoid biases and assess employees' performance accurately. Inaccurate appraisals due to a lack of training or experience can negatively impact employee morale and the effectiveness of the performance management system.

2.3 Challenges in Implementing Performance Appraisal Systems in India

Despite the benefits, performance appraisal systems in Indian companies face several challenges, which can undermine their effectiveness.

- **2.3.1 Subjectivity and Bias:** One of the major challenges in Indian organizations is the subjectivity and bias that can affect performance appraisals. Bhatia & Kumar (2017) suggest that many appraisal systems in India are prone to halo effect, leniency bias, and central tendency bias, which distort the evaluation process. These biases often result in unfair appraisals that affect employee motivation and organizational trust.
- **2.3.2 Inconsistency in Implementation:** Another challenge in Indian organizations is the inconsistency in the implementation of performance appraisal systems. Suri & Gupta (2018) note that organizations in India often do not follow standardized procedures for performance appraisals, leading to discrepancies in evaluations across different departments or locations. Inconsistency can undermine the credibility of the appraisal system and create a sense of injustice among employees.

2.4 Best Practices in Performance Appraisal Systems

To overcome these challenges, several best practices can be adopted to enhance the effectiveness of performance appraisal systems in Indian organizations.

- **2.4.1 360-Degree Feedback:** The 360-degree feedback method is gaining popularity in Indian organizations as it offers a more balanced and holistic view of employee performance. Reddy & Mishra (2018) argue that this method not only evaluates an employee's performance but also helps in identifying potential areas for development. It is particularly effective in organizations that prioritize employee development and empowerment.
- **2.4.2 Clear Communication of Appraisal Criteria:** Clear communication of the performance appraisal criteria is essential to ensure transparency and reduce employee dissatisfaction. Nair & Agarwal (2016) emphasize the importance of setting clear, measurable, and achievable goals for employees, which helps in making the appraisal process objective and fair. Providing regular feedback throughout the year also helps employees prepare for the formal appraisal process.

METHODOLOGY

The methodology section outlines the research design, data collection methods, sample size, and data analysis techniques employed to study the performance appraisal mechanism at Haldiram Company, Nagpur. The goal of this study is to examine the effectiveness of the performance appraisal system and its impact on employee performance, motivation, and organizational success.

3.1 Research Design
This study adopts a descriptive research design, as it aims to describe and analyse the performance appraisal mechanism at Haldiram Company. Descriptive research is appropriate for gathering insights into existing practices and understanding the relationship between performance appraisals and employee outcomes. It provides a systematic approach to studying the features, processes, and challenges of the appraisal system.

3.2 Sample Size and Population
The study focuses on employees working at Haldiram Company, Nagpur. A total sample size of 100 employees was selected to participate in the study. The sample includes both managerial and non-managerial staff across various departments of the organization. This diverse sample ensures that the study captures a wide range of perspectives regarding the performance appraisal system.

3.3 Sampling Technique
A stratified random sampling technique was used to ensure representation from different departments within Haldiram Company. The employees were grouped into strata based on their roles (e.g., managerial, supervisory, and operational staff). From each group, a random sample of employees was selected, ensuring that each group's views were proportionally represented in the study.

3.4 Data Collection Methods
Primary data was collected through two main methods:
- **3.4.1 Survey Questionnaire:** A structured questionnaire was designed to collect quantitative data from the employees. The questionnaire was developed based on the objectives of the study and included closed-ended questions focused on employees' perceptions of the performance appraisal system. The questions covered various aspects such as:
  - Clarity of appraisal criteria
  - Fairness of the evaluation process
  - Effectiveness of feedback
  - Employee satisfaction with the performance appraisal system

- **3.4.2 Interviews:** To gain deeper insights into employees' experiences with the performance appraisal system, semi-structured interviews were conducted with a select group of 10 employees (5 managerial and 5 non-managerial). The interviews allowed for more detailed responses and helped to clarify any ambiguities in the survey results.

3.5 Data Analysis Techniques
The data collected through surveys and interviews was analysed using both qualitative and quantitative methods.

3.5.1 Quantitative Data Analysis: For the quantitative data obtained from the survey questionnaires, statistical tools such as SPSS (Statistical Package for the Social Sciences) were used to perform descriptive statistics (e.g., mean, standard deviation) and inferential statistics (e.g., correlation analysis) to identify patterns and relationships between the variables. This helped in evaluating the effectiveness of the performance appraisal system and its impact on employee motivation and performance.

3.5.2 Qualitative Data Analysis
The responses from the interviews were transcribed and analysed thematically. Key themes were identified based

on recurring topics such as feedback quality, appraisal fairness, and the perceived impact of appraisals on career growth. Thematic analysis allowed for a deeper understanding of employees' subjective experiences and provided context to the quantitative findings.

3.6 Limitations of the Study

While the study aims to provide a comprehensive analysis of the performance appraisal system at Haldiram, several limitations should be noted:

- The study focuses only on the Nagpur branch of Haldiram, and the findings may not be generalizable to other locations or branches.
- The sample size of 100 employees, although adequate for this study, may not fully capture the diversity of experiences across the entire organization.
- The study relies on self-reported data from employees, which may be subject to biases such as social desirability bias.

OBJECTIVE

1. To evaluate the effectiveness of the performance appraisal system in enhancing employee performance at Haldiram Company.
2. To identify the strengths and weaknesses of the current performance appraisal mechanism at Haldiram Company.
3. To examine the impact of the performance appraisal process on employee motivation and job satisfaction at Haldiram Company.
4. To provide recommendations for improving the performance appraisal system at Haldiram Company based on the findings of the study.

HYPOTHESIS

1. **H1:** There is a significant positive relationship between the effectiveness of the performance appraisal system at Haldiram Company and employee performance Mahindra.
2. **H2:** Employee satisfaction with the performance appraisal process at Haldiram Company is positively correlated with their motivation and overall job satisfaction.

RESULTS AND DISCUSSION

1. The performance appraisal system at Haldiram Company is fair and unbiased?

Response	Count	Percentage (%)
Strongly Agree	21	21%
Agree	54	54%
Neutral	15	15%
Disagree	6	6%
Strongly Disagree	4	4%
Total	100	100%

Table No.1
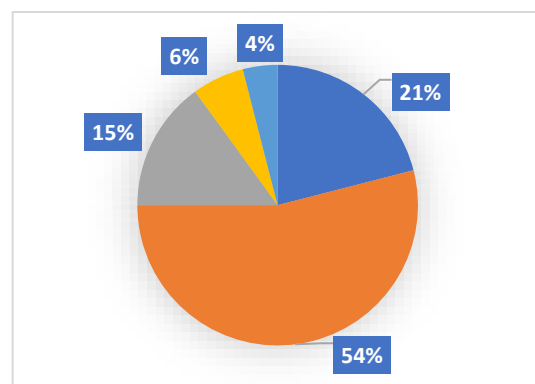
Graph No.1

Interpretation: A majority of employees 75% agree that the performance appraisal system at Haldiram is fair and unbiased, with 54% agreeing and 21% strongly agreeing. However, 15% of employees remained neutral, while 10% expressed concerns, either disagreeing or strongly disagreeing. This suggests that most employees trust the fairness of the system, but there is a small percentage who may perceive biases or inequities that need to be addressed.

2. The feedback provided during the performance appraisal is constructive and helps me improve my performance?

Response	Count	Percentage (%)
Strongly Agree	33	33%
Agree	42	42%
Neutral	15	15%
Disagree	6	6%
Strongly Disagree	4	4%
Total	100	100%

Table No.2
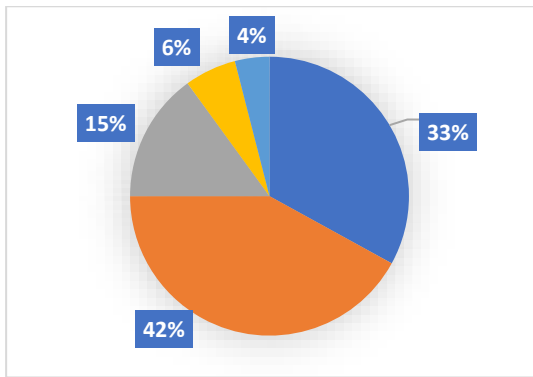
Graph No.2

Interpretation: A significant 75% of employees 33% strongly agree and 42% agree believe the feedback they receive during appraisals is constructive and aids in their performance improvement. However, 15% of respondents were neutral, and 10% disagreed or strongly disagreed, indicating that there is a gap in how feedback is delivered or its effectiveness for some employees. Improving feedback quality could help bridge this gap.

3. The performance appraisal system motivates me to perform better at work?

Response	Count	Percentage (%)
Strongly Agree	30	30%
Agree	45	45%
Neutral	15	15%
Disagree	6	6%
Strongly Disagree	4	4%
Total	**100**	**100%**

Table No.3
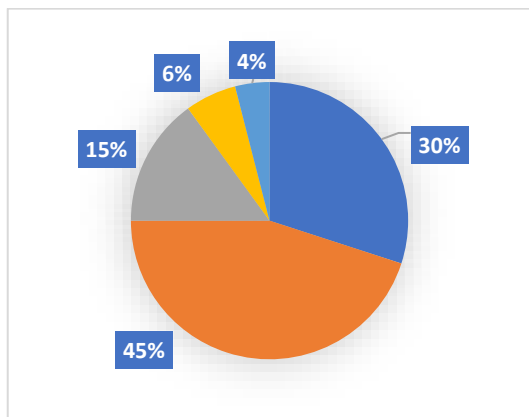
Graph No.3

Interpretation: A total of 75% of employees (30% strongly agree and 45% agree) stated that the performance appraisal system motivates them to perform better at work. However, 15% remained neutral, and 10% disagreed or strongly disagreed. This shows that while the system is generally motivating for most, some employees may not feel the same level of motivation, suggesting that the system could benefit from more personalized or inspiring approaches.

4. Do you believe that the performance appraisal system contributes to my career growth and development?

Response	Count	Percentage (%)
Strongly Agree	27	27%
Agree	45	45%
Neutral	18	18%
Disagree	6	6%
Strongly Disagree	4	4%
Total	**100**	**100%**

Table No.4
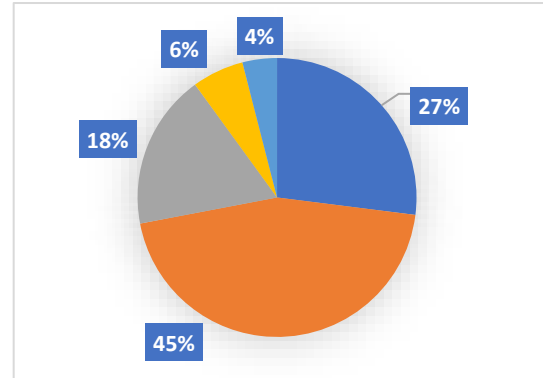
Graph No.4

Interpretation: The data shows that 72% of employees (27% strongly agree and 45% agree) feel that the performance appraisal system contributes positively to their career growth and development. However, 18% were neutral, and 10% disagreed or strongly disagreed. This implies that while many employees see the value in career development through appraisals, others may feel that the system does not fully align with their career advancement goals, which could be an area for improvement.

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CONCLUSIONS

This study aimed to assess the performance appraisal system at Haldiram Company, Nagpur, focusing on its impact on employee satisfaction and professional development. The results reveal that a majority of employees find the appraisal system to be fair, unbiased, and motivating, indicating that it effectively drives performance. Additionally, employees feel that the feedback provided during the appraisals is constructive and supports their improvement. However, there is a portion of employees who remain neutral or disagree, pointing to areas where the system could be enhanced, especially in terms of feedback quality and alignment with career growth. While most employees recognize the contribution of the appraisal system to their professional development, there is still room for improvement to better address the needs of those who feel disconnected. In conclusion, the performance appraisal system at Haldiram is functioning well but could be further refined to ensure inclusivity and better support for individual growth and advancement.

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A Study on Consumer Behaviour Towards Marketing Strategies Of D`MART, Nagpur

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ABSTRACT

D-Mart is one of India's leading retail chains, known for its cost-efficient operations, customer-centric approach, and competitive pricing. This research paper explores D-Mart's business model, supply chain strategies, and operational efficiencies that contribute to its success in the highly competitive retail industry. Unlike many retail chains that focus on expansion through franchising, D-Mart follows a unique strategy of owning most of its stores, reducing rental costs and ensuring better control over inventory management.

The study highlights how D-Mart maintains a strong supplier relationship, allowing it to procure goods at lower prices and pass on the savings to customers. Additionally, its lean staffing, warehouse-based stocking system, and high sales turnover enable it to operate with lower margins while maintaining profitability. A comparison with other retail chains demonstrates how D-Mart's model is more resilient to economic fluctuations and changing consumer preferences.

Through primary and secondary data analysis, this paper examines D-Mart's financial performance, customer loyalty strategies, and the challenges it faces in scaling its operations. The findings suggest that D-Mart's success is deeply rooted in its cost-conscious approach, efficient supply chain management, and strategic store locations, making it a key player in India's retail sector.

Kye words - Consumer Behavior, Marketing Strategies, D'MART, Retail Industry

INTRODUCTION

MARKETING STRATEGY
A marketing strategy is a comprehensive plan developed by a business or organization to achieve specific marketing objectives within a given timeframe.

It serves as a roadmap that outlines how the company will utilize its resources to effectively reach and engage with its target audience, differentiate itself from competitors, and ultimately drive sales and revenue growth. A well-defined marketing strategy takes into account various factors including market

conditions, consumer behavior, competitive landscape, and the company's own strengths and weaknesses.

MARKETING MIX

The marketing mix, often referred to as the 4Ps, is a foundational framework in marketing used to guide businesses in their marketing strategies and tactics. It consists of four key elements that a company can control to influence consumer purchasing decisions.

4Ps of Marketing Mix

Product:
This refers to the actual goods or services offered by a company to meet the needs and wants of customers. It involves decisions about product features, design, quality, branding, packaging, and more.

Place:
Also known as distribution, this element focuses on how the product or service is made available to customers. It involves decisions about distribution channels, logistics, inventory management, warehousing, retailing, and e-commerce

Promotion:
Promotion encompasses all the activities a company undertakes to communicate the value of its products or services to customers and persuade them to make a purchase. This includes advertising, sales promotions, public relations, direct marketing, personal selling, and digital marketing efforts.

Price:
Price refers to the amount of money customers must pay to acquire the product or service. Pricing decisions involve considerations such as pricing strategies, setting the right price

point to reflect value, discounts, and payment terms.

WHAT IS CUSTOMER SATISFACTION?

Customer satisfaction is defined as a measurement that determines how happy customers are with a company's products, services, and capabilities. Customer satisfaction information, including surveys and ratings, can help a company determine how to best improve or changes its products and services.

An organization's main focus must be to satisfy its customers. This applies to industrial firms, retail and wholesale businesses, government bodies, service companies, nonprofit organizations, and every subgroup within an organization.

Perceived quality

Perceived quality is a crucial aspect of customer satisfaction and refers to customers' subjective judgment of a product or service's excellence, reliability, and overall value based on their experiences and expectations.

Perceived value

Perceived value refers to the customer's assessment of the benefits received from a product or service relative to its cost. It's a subjective evaluation influenced by various factors, including personal preferences, needs, and perceptions.

Customer expectations

Customer expectations are the standards or criteria that customers believe must be met when engaging with a product, service, or brand. These expectations are shaped by various factors, including personal experiences, cultural norms, advertising, word-of-mouth, and past interactions with the brand.

Customer complaints

Customer complaints are expressions of dissatisfaction from customers regarding a product, service, or experience provided by a business. While they can be challenging to handle, customer complaints also present valuable opportunities for businesses to

improve their offerings, strengthen customer relationships, and enhance overall satisfaction.

Customer Loyalty

Customer loyalty refers to the tendency of customers to repeatedly purchase products or services from a particular brand or company over time. Loyal customers exhibit behaviors such as making repeat purchases, choosing the brand over competitors, and recommending the brand to others.

ABOUT D'MART INDIA

DMart is one of India's leading retail chains, known for its cost-effective business model and customer-centric approach. Founded in 2002 by Radhakishan Damani under Avenue Supermarts Limited, DMart has grown into a dominant player in the Indian retail industry. The company primarily focuses on food, groceries, home essentials, and personal care products, catering to middle-class consumers who prioritize affordability and quality.

One of DMart's defining characteristics is its emphasis on an everyday low price (EDLP) strategy. Unlike many retailers that rely on periodic

discounts and promotional campaigns, DMart consistently offers products at lower-than-market rates. This approach fosters strong customer loyalty and ensures high inventory turnover, making it a profitable and sustainable model.

Another key factor in DMart's success is its store ownership model. Unlike other retail chains that lease spaces, DMart prefers to purchase its store locations. This reduces rental expenses and allows better control over operations. The company also maintains a lean supply chain, working directly with manufacturers to secure bulk discounts and keep operational costs low.

Despite the rapid growth of e-commerce in India, DMart has continued to thrive by focusing on its brick-and-mortar expansion

strategy, particularly in high-density urban and suburban markets. While it has ventured into online retail through DMart Ready, the company remains primarily focused on physical retail stores, ensuring a seamless shopping experience for value-conscious consumers.

With its strong financial discipline, efficient operations, and customer-first approach, DMart has established itself as a trusted name in Indian retail, continuously expanding its footprint while maintaining profitability.

DMart is a popular chain of supermarkets in India, known for offering a wide range of products at affordable prices. It was founded in 2002 by Radhakishan Damani and has grown into one of the biggest retail stores in the country. DMart sells groceries, clothing, home essentials, electronics, and more, focusing on providing discounts and value for money. The stores are designed to help customers save while shopping for daily needs.As mental health issues continue to rise globally, understanding how organizations like Mahindra and Mahindra address these challenges can offer valuable lessons for other companies seeking to implement or improve their own mental health support programs.

The paper will provide an in-depth evaluation of the program's successes, setbacks, and its alignment with the company's broader commitment to creating a supportive and inclusive workplace environment.

LITERATURE REVIEW:

Consumer behavior in retail marketing has been extensively studied by researchers and industry experts. According to Kotler & Keller (2016), consumer behavior is driven by psychological, personal, social, and cultural factors that influence buying decisions.

Retail marketing strategies, particularly pricing and promotions, play a crucial role in shaping consumer preferences. A study by Gupta & Mishra (2018) highlights that competitive pricing and frequent discounts significantly increase customer footfall and brand loyalty in retail stores. Similarly, Sharma & Verma (2019) found that promotional campaigns, such as loyalty

programs and festive sales, improve customer retention and engagement.

D'MART has successfully implemented a cost-leadership strategy, offering everyday low pricing to attract price-sensitive consumers. Research by Singh (2020) on Indian retail giants found that D'MART's focus on warehouse-style retailing and bulk purchasing helps in reducing operational costs, thereby allowing competitive pricing.

Additionally, consumer experience within the store environment is an essential determinant of shopping behavior. According to Parasuraman et al. (2015), a well-organized store layout, ease of navigation, and availability of products contribute to higher customer satisfaction levels. Studies on supermarket consumer trends (Mehta & Sharma, 2021) suggest that customers prefer stores with efficient checkout processes and well-stocked inventory, factors that D'MART actively focuses on.

Digital marketing has also become a growing influence on consumer behavior. A study by Reddy & Sinha (2022) emphasized that social media advertising, targeted promotions, and digital coupons have reshaped modern retail shopping trends. However, traditional brick-and-mortar retail stores like D'MART still maintain a stronghold due to their value-for-money proposition and physical shopping experience.

In conclusion, previous studies suggest that a combination of pricing, promotions, store environment, and customer service significantly impacts consumer behavior in retail. This literature review provides a framework for analyzing how D'MART's marketing strategies influence consumer choices in Nagpur.

RESAERCH METHODOLOGY:

Source of Data: Primary data and Secondary Data
Data Collection Tool: Questionnaire
Universe: Nagpur city as applicable to project
Sample size: 100
Sampling Method: Non-probability sampling (convenient sampling)

DATA ANALYSIS AND INTREPRETATION

Do you believe that Dmart& advertising reflects the quality of its products and services?
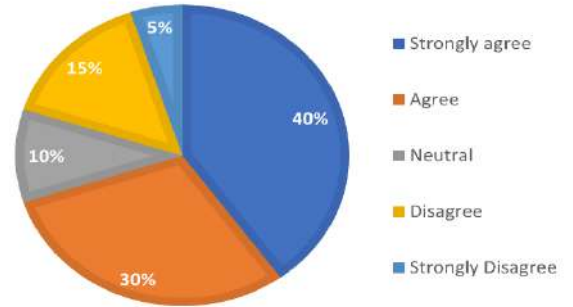
INTERPRETATION: From the above data it is observed that 40% of respondents are Strongly agree, 30% respondents are Agree, 10% respondents are Neutral, 15% respondents are Disagree, and 5% respondents say that they are Disagree.

Rate the checkout process at Dmart in terms of Speed and efficiency?
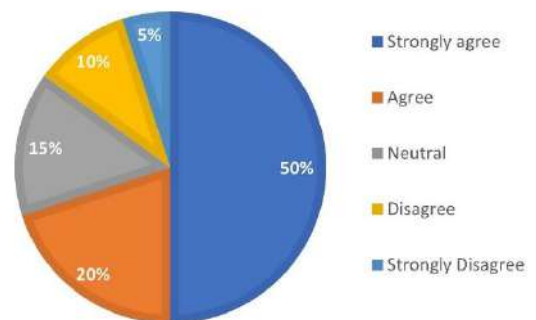
INTERPRETATION: From the above data it is observed that 50% of respondents Strongly agree, 20% respondents are Agree, 15% of respondents are Neutral, 10% Disagree, and 5% respondents say that they are Disagree.

How satisfied are you with the variety of products available at Dmart?
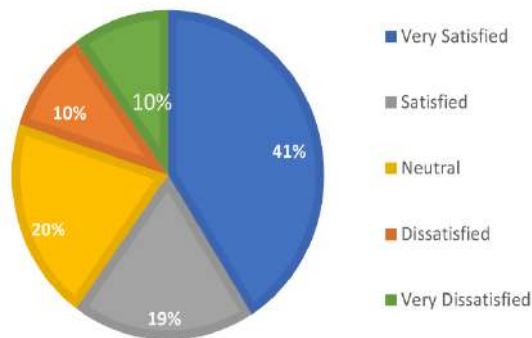
INTERPRETATION: From the above data it is observed that 41% of respondents are Very satisfied, 19% of respondents are Satisfied, 20% of respondents are Neutral, 10% of respondents are Dissatisfied and 10% of respondents say that they are Very Dissatisfied.

Do you think, Dmart's marketing messages effectively convey the brand's values and identity?
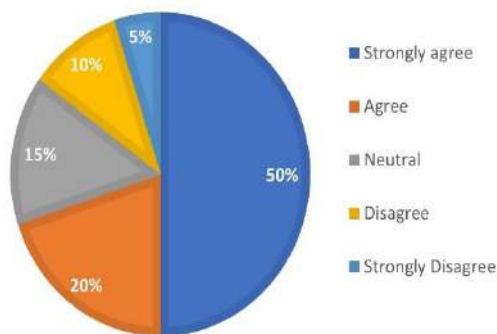
INTERPRETATION: From the above data it is observed that 50% of respondents Strongly agree, 20% of respondents are Agree, 15% of respondents are Neutral, 10% of respondents are Disagree and 5% respondents says that they are Disagree.

Were you satisfied with the variety of payment options available at Dmart?
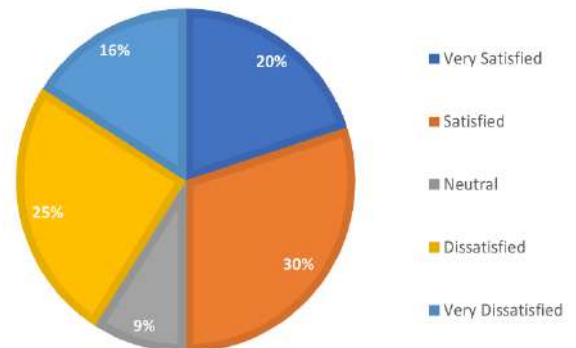
INTERPRETATION: From the above data it is observed that 20% of respondents are Very satisfied, 30% of respondents are Satisfied, 9% of respondents are Neutral, 25% of respondents are Dissatisfied and 16% of respondents say that they are Very Dissatisfied.

FINDINDS

1. The majority of respondents believe that Dmart & advertising reflects the quality of its products and services.
2. The majority of respondents are happy with the checkout process at Dmart in terms of Speed and efficiency.
3. The majority of respondents are satisfied with the variety of products available at Dmart.
4. The majority of respondents believe that Dmart's marketing messages effectively convey the brand's values and identity.
5. the majority of respondents are satisfied with the variety of payment options available at Dmart.

SUGGETIONS & RECOMMENDATIONS

1. Customers love loyalty programs that provide discounts and prizes. D-Mart magist implement a loyalty program to encourage customers to return to their stores.

2. D-Mart might lower customer wait times at checkout counters by optimizing their operations and boosting the number of cashiers during busy hours.
3. D-Mart could introduce online shopping options such as home delivery and click-and-collect services to make purchasing easier for customers.
4. D-Mart might use targeted marketing to reach out to certain customer categories. This could include customized email campaigns, social media advertising, and retargeting ads.
5. D-Mart should communicate with customers through interactive marketing activities such as contests and incentives to stimulate participation and build customer loyalty.
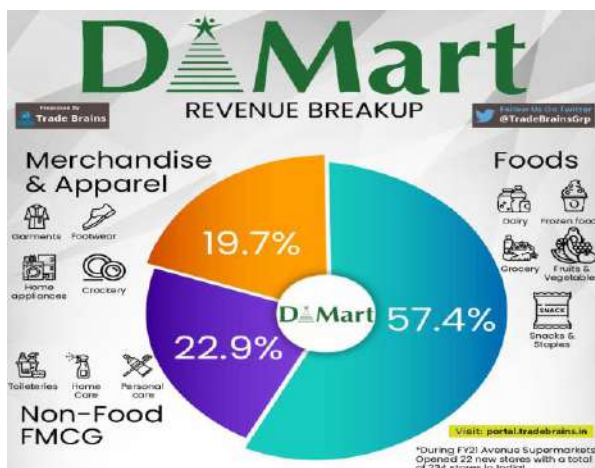
AREAS FOR IMPROVEMENT

While D-Mart has established itself as a leading retail chain in India with a strong cost-efficient model, several areas require improvement to ensure sustained growth and competitiveness. One of the key areas is digital transformation and e-commerce expansion. Currently, D-Mart's online presence is limited to D-Mart Ready, which operates in select cities with a restricted product range and delivery network. To compete with e-commerce giants like Amazon, Flipkart, and JioMart, D-Mart must invest in a more robust online platform, faster delivery services, and wider geographical coverage.

Another area for improvement is geographical expansion. D-Mart primarily focuses on metro cities and select Tier 2 locations, whereas competitors like Reliance Retail and Spencer's are aggressively expanding into Tier 2 and Tier 3 cities. By accelerating its expansion strategy, either through a franchise model or leased store spaces, D-Mart can tap into new markets and increase its customer base.

Product diversification is another critical aspect. While D-Mart excels in offering low-cost essential goods, changing consumer preferences indicate a growing demand for premium, organic, and international products. Expanding product categories without compromising its low-cost strategy can help attract a broader customer base.

Additionally, customer engagement and in-store experience can be improved by incorporating **loyalty programs, personalized.

To ensure long-term growth and competitiveness, D-Mart must adopt a multi-faceted strategy that focuses on digital expansion, geographic reach, product diversification, and customer engagement. Firstly, strengthening its e-commerce presence is crucial. While D-Mart Ready serves select locations, the company should expand its online grocery operations with faster delivery, a wider product range, and an improved user

experience to compete with e-commerce giants like Amazon, Flipkart, and JioMart. Investing in AI-driven demand forecasting and warehouse automation can enhance operational efficiency in both online and offline retail.

Secondly, accelerating store expansion is essential for capturing a larger market share. Instead of relying primarily on an ownership-based model, D-Mart can consider leasing stores or adopting a franchise model to expand into Tier 2 and Tier 3 cities more rapidly. This will help counter competition from Reliance Retail and other regional supermarket chains.

Additionally, product diversification is necessary to meet evolving consumer preferences. While D-Mart focuses on affordable essentials, introducing premium, organic, and international product segments can attract a broader customer base without compromising its core low-cost strategy. Partnering with local farmers and suppliers for fresh produce can further strengthen its market presence.

Lastly, enhancing customer experience through loyalty programs, personalized promotions, and self-checkout technology will improve engagement and retention. Strengthening supply chain resilience to mitigate risks from inflation, logistics disruptions, or economic fluctuations is also crucial. By implementing these strategic initiatives, D-Mart can sustain its cost leadership while adapting to the evolving retail landscape and maintaining its competitive advantage.

CONCLUSION:

D-Mart has successfully positioned itself as one of India's leading retail chains by adopting a cost-efficient, low-margin, high-volume business model. Its strong supply chain, bulk purchasing strategy, and focus on essential goods allow it to offer competitive prices, ensuring high customer loyalty and sustained profitability. The company's financial stability and consistent growth reflect the effectiveness of its store ownership strategy and inventory management practices.
However, despite its success, D-Mart faces several challenges, including rising competition from e-commerce platforms, slow geographical expansion, and changing consumer preferences.

To ensure long-term sustainability and continued growth, D-Mart must focus on expanding its digital presence, diversifying its product offerings, and increasing its footprint in Tier 2 and Tier 3 cities. Investing in technology-driven retail innovations, loyalty programs, and enhanced customer engagement strategies can further strengthen its market position.

REFERENCES BOOKS:

For a comprehensive analysis of D-Mart's retail strategy, financial performance, and market positioning, several books and online resources provide valuable insights. "Retail Management: A Strategic Approach" by Barry R. Berman and Joel R. Evans and "Retailing Management" by Michael Levy, Barton Weitz, and Dhruv Grewal offer in-depth knowledge on retail business models, pricing strategies, and supply chain efficiency, which are crucial for understanding D-Mart's operations. Additionally, "Retail Management" by Gibson G. Vedamani focuses on the Indian retail sector, providing case studies of leading players, including D-Mart, Reliance Retail, and Big Bazaar. For insights into consumer behavior in India, "Winning in the Indian Market" by Rama Bijapurkar is an essential resource.

To examine D-Mart's financial and supply chain strategies, "Supply Chain Management: Strategy, Planning, and Operation" by Sunil Chopra and Peter Meindl discusses inventory management and procurement, which are critical to D-Mart's cost-efficient operations. "The New Retail: How Technology, Data, and AI Are Changing Retail Forever" by M. Clay provides insights into the role of digital transformation, relevant for analyzing D-Mart's e-commerce challenges.

In addition to books, online resources such as D-Mart's official website (www.dmartindia.com) provide annual reports and financial statements. Websites like Money control (www.moneycontrol.com), Economic Times (economictimes.indiatimes.com), and Business Standard (www.business-standard.com) offer financial analysis and industry trends. Government websites like the Retailers Association of India (www.rai.net.in) and reports from IBEF (www.ibef.org) provide valuable industry insights. These sources collectively offer a strong foundation for researching D-Mart's success, challenges, and future growth strategies.

Leveraging IoT for Informed Agricultural Decision-Making: A Study on Real-Time Data Utilization

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ABSTRACT:

The integration of the Internet of Things (IoT) in agriculture has transformed traditional farming practices by providing real-time data to support decision-making. This study explores the impact of IoT-enabled real-time data on farmers' decision-making processes, particularly in crop management, irrigation, and pest control. The research is guided by two hypotheses: the null hypothesis (H_0), which suggests that IoT data does not significantly influence farmers' decision-making, and the alternative hypothesis (H_1), which posits that real-time IoT data enhances decision-making and improves agricultural outcomes.

Through a comprehensive analysis of existing literature and empirical data, this study evaluates the extent to which farmers leverage IoT technology for informed decision-making. It also examines the barriers to adoption, such as cost constraints, lack of digital literacy, and infrastructure limitations, which hinder widespread IoT implementation, particularly among small-scale farmers. The findings suggest that real-time data plays a critical role in optimizing farming operations, leading to increased efficiency, resource conservation, and improved yields.

The study contributes to the growing discourse on precision agriculture and smart farming, offering insights for policymakers, agronomists, and technology developers. It highlights the need for targeted interventions to enhance IoT adoption, ensuring that farmers across diverse agricultural landscapes benefit from technological advancements. Ultimately, this research underscores the potential of IoT in revolutionizing modern agriculture and fostering sustainable farming practices.

Keywords: IoT, real-time data, precision agriculture, smart farming, decision-making, sustainable agriculture.

INTRODUCTION:

The integration of the Internet of Things (IoT) in agriculture has revolutionized traditional farming practices by providing real-time data to support decision-making processes. IoT technology enables the collection, transmission, and analysis of data from various smart sensors embedded in agricultural equipment, soil, and environmental monitoring systems. These devices generate continuous streams of information related to soil moisture levels, weather conditions, crop health, and pest activity. By leveraging this data, farmers

can make informed decisions regarding irrigation schedules, pest control strategies, and crop management techniques, ultimately improving productivity and resource efficiency.

Despite the promising applications of IoT in agriculture, the extent to which real-time data influences farmers' decision-making remains an area of interest. While some farmers rely on traditional knowledge and experience to manage their crops, others adopt IoT-driven insights to optimize agricultural operations. This research examines the impact of IoT-enabled real-time data on farmers' decision-making processes and assesses whether such technological interventions lead to better agricultural outcomes.

The study is framed by two competing hypotheses. The null hypothesis (H_0) suggests that real-time data from IoT devices does not significantly influence farmers' decision-making processes, implying that traditional methods remain dominant. Conversely, the alternative hypothesis (H_1) posits that access to real-time IoT data significantly enhances farmers' decision-making in areas such as crop management, irrigation, and pest control. Understanding this impact is crucial for policymakers, agronomists, and technology developers aiming to promote digital transformation in agriculture.

Furthermore, the study explores potential barriers to IoT adoption, including technological costs, lack of digital literacy, and infrastructure challenges. While developed regions have widely adopted precision farming technologies, many small-scale farmers in developing countries struggle with accessibility and affordability. Identifying these constraints can help

formulate strategies to bridge the digital divide and ensure that farmers, regardless of their scale, benefit from IoT-driven advancements.

Following are the Mobile apps for Farmer.

Kisan Suvidha app: The Ministry of Agriculture's Department of Agriculture & Cooperation created the extensive smartphone application Kisan Suvidha.

Farmers Welfare is a program created to give Indian farmers access to timely information. The app, which is available in several Indian languages, has basic functions including five-day predictions tailored to the users' districts, real-time weather updates, and notifications for severe weather.

The Crop Doctor app: A cutting-edge Android mobile application, the Crop Doctor app was created to assist farmers nationwide. Its principal goal to offer comprehensive and user-friendly access to essential crop data and services. The app provides essential information about nutrient deficits, illnesses, and insect infestations for a wide range of important crops, such as oilseeds, vegetables, pulses, and paddy. The software has an easy-to-use layout and is accessible to a wide range of farmers because to its dual Hindi and English languages.

Farm Calculator app: For horticultural growers wishing to use precision farming methods, the Farm Calculator app is an essential tool. Applying inputs like seeds, fertilizer, and insecticides precisely is crucial for optimizing yields while lowering expenses and safeguarding the health of the land. Key agricultural inputs such as NPK

(nitrogen, phosphorus, potassium) ratios, pesticide application rates, plant populations, and seed rates may all be calculated in detail with this software.

LITERATURE REVIEW:

1] Peddi Ramyasri, et al.: This research paper highlights the significant role of smartphones in agriculture, emphasizing their potential to enhance productivity through real-time access to technological trends. It proposes a unified framework that combines sensors and mobile software modules to improve both qualitative and quantitative agricultural production, aiming to make the sector more profitable and contribute to national GDP. The framework facilitates efficient agricultural practices by enabling communication between farmers and experts, as well as helping farmers select suitable crops based on soil sensor data. The developed system has been tested with various scenarios, and the paper discusses future improvements for the framework.

2] Sweety Chakraborty, et al, (2024): This research paper by Sweety Chakraborty and Veeresh D A explores the emergence of AgriTech startups and the increasing integration of technology in Indian agriculture. It discusses how these startups are innovating traditional agricultural practices by leveraging modern technologies such as data analytics, IoT, and AI to enhance productivity and efficiency. The paper highlights various technological trends that are shaping the agricultural landscape in India, including precision farming, smart irrigation systems, and crop management solutions.

3] Gupta, C. et al. (2021). This digital revolution enables farmers to connect with global markets, access vital farming information, and improve agribusiness practices. This study explores the role of ICT and mobile applications in modern farming, highlighting their impact on agribusiness by providing a digital platform for growth and development.

4] Nimodiya, A, et al. (2021). The numerous uses of ICT in rural areas are highlighted in this paper, along with the difficulties in promoting sustainable growth. ICT has a major impact on industries including healthcare, agriculture, and education and is essential to the development of rural communities. Its full impact is hampered by rural populations' delayed acceptance and lack of awareness, despite its promise. Rural development can be accelerated and made more efficient by raising knowledge and comprehension of the advantages of ICT.

5] Madrewar, S. et al. (2024). This study, which is based on official reports, shows that areas that have used IoT and AI technologies have shown a significant boost in agricultural results, highlighting their potential to completely transform Indian agribusiness. Precision farming, automated irrigation, and predictive analytics are just a few of the game-changing technologies made possible by the convergence of IoT and AI, which greatly increases sustainability and production. AI improves supply chain efficiency and crop yield forecasts, while IoT devices offer real-time data for enhanced decision-making.

HYPOTHESIS:

H_0: Real-time data from IoT devices does not significantly influence farmers' decision-making processes.

H_1: Access to real-time data from IoT devices significantly enhances farmers'

decision-making processes in crop management, irrigation, and pest control.

OBJECTIVES:

1. To assess the impact of IoT-enabled real-time data on farmers' decision-making processes in key agricultural areas such as crop management, irrigation, and pest control.

2. To evaluate the effectiveness of IoT technology in improving farm productivity, resource optimization, and overall agricultural efficiency.

3. To identify the barriers to IoT adoption among farmers, including financial constraints, technological challenges, and lack of digital literacy.

4. To analyze the role of IoT in promoting precision agriculture and sustainable farming practices, reducing resource wastage, and enhancing food security.

SCOPE:

1. This study focuses on evaluating how IoT-enabled real-time data influences farmers' decision-making in crop management, irrigation, and pest control, helping to determine its effectiveness in enhancing agricultural productivity.

2. The research examines various IoT technologies used in agriculture, such as smart sensors, automated irrigation systems, and weather monitoring devices, Mobile Apps and their role in optimizing farming operations.

3. The study explores key obstacles faced by farmers in adopting IoT solutions, including high costs, infrastructure limitations, digital literacy gaps, and resistance to technological change.

4. Based on the findings, the study provides insights and recommendations for policymakers, agronomists, and technology developers to enhance IoT adoption, promote sustainable farming practices, and bridge the digital divide in agriculture.

RESEARCH METHODOLOGY

Research type: Quantitative and Empirical Research

This study adopts a **mixed-method research approach**, incorporating both **quantitative and Empirical research methods** to comprehensively analyze the impact of IoT-enabled real-time data on farmers' decision-making. The study relies on real-world data collection through surveys, case studies, and field observations, ensuring practical and evidence-based conclusions.

Types of Data:

Primary Data: A primary data is data which is collected first time for any study. For this study only primary data is to be consider. All the data collected from the Farmers of Nagpur Districts.

The sampling frame

for this study consists of:
Farmers using IoT technology – Those who have adopted IoT-based agricultural tools for crop management, irrigation, and pest control.

Sampling Method:
A purposive and convenience sampling method are used to collect data from different location, farm size and uses of Mobile Apps for farming of Nagpur district farmers.
Sample Size: 50 Respondents

TEST STATISTICS:

1. Regression Analysis (Linear or Multiple or Logistic Regression)
- **Multiple Linear Regression:** If decision-making efficiency (continuous variable) is influenced by multiple factors (IoT usage, farm size, education level, etc.).
- **Logistic Regression:** If decision-making effectiveness is measured as a binary outcome (e.g., improved/not improved).
- **Linear Regression:** A linear regress is used to determine the effect of uses of IOT or Mobile Apps on farming decision making.

DATA ANALYSIS AND INTERPRETATION

Correlations

Correlations

		Farm Size	Impact_on_Far ming
Farm Size	Pearson Correlation	1	.377**
	Sig. (2-tailed)		.007
	N	50	50
Impact_on_Farming	Pearson Correlation	.377**	1
	Sig. (2-tailed)	.007	
	N	50	50

**. Correlation is significant at the 0.01 level (2-tailed).

Nonparametric Correlations

Correlations

			Farm Size	Impact_on_Far ming
Spearman's rho	Farm Size	Correlation Coefficient	1.000	.405**
		Sig. (2-tailed)	.	.004
		N	50	50
	Impact_on_Farming	Correlation Coefficient	.405**	1.000
		Sig. (2-tailed)	.004	.
		N	50	50

**. Correlation is significant at the 0.01 level (2-tailed).

REGRESSION ANALYSIS

Variables Entered/Removed^a

Model	Variables Entered	Variables Removed	Method
1	Farm Size, Frequencies of Uses, IOT Data Influence decision making^b	.	Enter

a. Dependent Variable: Impact_on_Farming

b. All requested variables entered.

Model Summary^b

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.654^a	.427	.390	.76637	1.724

a. Predictors: (Constant), Farm Size, Frequencies of Uses, IOT Data Influence decision making

b. Dependent Variable: Impact_on_Farming

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	20.147	3	6.716	11.435	<.001^b
	Residual	27.017	46	.587		
	Total	47.164	49			

a. Dependent Variable: Impact_on_Farming

b. Predictors: (Constant), Farm Size, Frequencies of Uses, IOT Data Influence decision making

INTERPRETATION

The coefficient of correlation is suggested that Farm size and impact on decision making having positive Correlation.

With the help of the independent variables Farm Size, Frequencies of Uses, and IoT Data Influence in Decision-Making, this SPSS Model Summary table offers important statistics for a regression study that predicts the dependent variable Impact_on_Farming. Below is a summary of the findings:
1. The multiple correlation coefficient, or R (.654), quantifies how strongly the observed and predicted values of the dependent variable are related. A moderate to strong positive connection is indicated by a value of 0.654.
2. The coefficient of determination, or R Square (.427), is a figure that shows how much of the variance in the dependent

variable can be accounted for by the independent variables. Here, farm size, use frequency, and the influence of IoT data account for 42.7% of the variation in Impact_on_Farming.

3. Adjusted R Square (.390): This modifies R Square to account for the model's predictor count. The modified R Square offers a more accurate metric because adding more variables can artificially increase R Square. After adjusting for the number of independent factors, 39.0% of the variance in the dependent variable can be explained.
4. Durbin-Watson (1.724): This statistic examines residual independence, or autocorrelation. No discernible autocorrelation is indicated by a value near 2. Since 1.724 is near 2, there is no severe autocorrelation in the residuals.

ANOVA TABLE

The **F-value (11.435)** is large, and the **p-value (<.001)** is highly significant, suggesting that the independent variables (**Farm Size, Frequency of Uses, and IoT Data Influence**) collectively have a significant impact on **Impact_on_Farming**.

CONCLUSION:

The conclusion that farm size, usage frequency, and IoT data influence have a major impact on farming is supported by the regression analysis.

Even if the model accounts for a significant amount of the variance, further variables could increase the forecast accuracy even more.

The model appears to be statistically sound and interpretable based on the absence of substantial autocorrelation.

SUGGESTION

Policymakers and farmers should look at sustainable ways to expand farmland because farm size has a favourable correlation with farming impact. This can involve leasing underutilised farmland, consolidating acreage, or maximising land usage using contemporary farming methods.

IoT data has a big impact on how decisions are made. To increase productivity and efficiency, farmers should be urged to include more IoT-based technology, such as automated irrigation systems, precision farming, and soil health monitoring.

Training programs should be put in place to teach farmers how to routinely analyse and use IoT insights, as the frequency of IoT data utilisation influences farming decisions. Resource management, pest control, and planting schedules should all be optimised with real-time data.

Although factors like farm size, usage frequency, and IoT data are important, 57.3% of the variation in agricultural impact cannot be explained. To increase prediction accuracy, future research should examine additional variables such soil fertility, market accessibility, climate, and legislative restrictions.

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A Study on Employee Satisfaction Towards Recruitment and Selection in Ashoka Build Con Limited

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ABSTRACT

This paper aims to study employee satisfaction concerning recruitment and selection practices at Ashoka Build Con Limited, a leading infrastructure company. The study investigates how the recruitment process impacts employees' job satisfaction, their perception of fairness, and the alignment of the company's HR policies with employee expectations. Primary data was collected through surveys and interviews with current employees, with secondary data from company reports and HR documentation. The findings of this research offer insights into how recruitment practices influence overall employee satisfaction and organizational success. The study highlights how D-Mart maintains a strong supplier relationship, allowing it to procure goods at lower prices and pass on the savings to customers. Additionally, its lean staffing, warehouse-based stocking system, and high sales turnover enable it to operate with lower margins while maintaining profitability. A comparison with other retail chains demonstrates how D-Mart's model is more resilient to economic fluctuations and changing consumer preferences.

Kye words - Employee Satisfaction Recruitment and Selection Practices

INTRODUCTION

Background of the Study:

Employee satisfaction is a key factor in organizational success, influencing retention, productivity, and overall morale. Recruitment and selection processes play a crucial role in shaping employees' perceptions about the organization. Ashoka Build Con Limited, being a leading construction company, has structured recruitment and selection procedures, but employee satisfaction regarding these practices has not been thoroughly studied. This paper addresses this gap. Employee satisfaction is one of the most significant factors influencing the overall performance and success of an organization. It directly impacts employee motivation, retention, and productivity. In the realm of human resource management, recruitment and selection play a crucial role in determining the quality of an organization's workforce, which in turn influences job satisfaction levels.

Ashoka Build Con Limited, a prominent player in the construction and infrastructure sector, recognizes the importance of a skilled and motivated workforce to achieve its strategic objectives. The process of recruitment and selection at Ashoka Build Con Limited aims to attract the best talent while ensuring the alignment of employees' skills, aspirations, and values with the company's goals.

This study focuses on examining employee satisfaction towards the recruitment and selection processes at Ashoka Build Con Limited. It seeks to understand how effective the current recruitment strategies are in meeting the expectations and needs of the employees. It also aims to identify any gaps in the recruitment and selection processes that could potentially affect employee satisfaction and overall organizational success.

The recruitment process involves various stages, including job postings, candidate screening, interviews, and onboarding. Satisfaction at each of these stages can greatly influence the employee's perception of the organization and their level of commitment. By investigating employee satisfaction, the study will provide insights into how recruitment and selection processes can be improved to enhance overall employee engagement and retention.

This study will not only provide a deeper understanding of employee satisfaction at Ashoka Build Con Limited but will also offer recommendations to help optimize the recruitment and selection process for greater efficiency and employee contentment.

In the following sections, the study will discuss the objectives, methodology, and significance of the research, followed by an analysis of the findings.

OBJECTIVES OF THE STUDY:

To analyze the effectiveness of the recruitment and selection process at Ashoka Build Con Limited.

To evaluate the impact of recruitment practices on employee satisfaction.

To provide recommendations for improving the recruitment process to enhance employee satisfaction.

Research Questions:

How do employees perceive the recruitment and selection process?

Does the recruitment process align with employee expectations?

What is the level of satisfaction among employees regarding the transparency and fairness of the recruitment process?

2. Literature Review:

Theoretical Background on Employee Satisfaction:

Employee satisfaction refers to the extent to which employees feel content with their job roles, working environment, and organizational processes. The recruitment and selection process significantly impacts employees' initial perception of the organization, which in turn affects their overall satisfaction.

Importance of Recruitment and Selection in Employee Satisfaction:

According to studies, a well-structured and transparent recruitment process ensures that the right candidates are selected, leading to better job fit, job satisfaction, and organizational commitment. The fairness of recruitment processes has also been linked to greater employee trust and satisfaction.

Previous Studies in Similar Organizations:

Studies in similar industries (such as construction or manufacturing) suggest that employees prefer recruitment processes that are clear, fair, and merit-based. Ineffective recruitment and selection can lead to dissatisfaction, decreased morale, and higher turnover rates

Research Methodology:

1. **Research Approach**
2. **Research Method:** Quantitative Research.
3. **Source of Data Collection:** Secondary Source.
4. **Method of Data Collection:** Questionnaire and Closed-Ended Questions.
5. **Universe:** Employees of HCL.
6. **Sample Size:** 100 people.
7. **Sampling Technique:** Convenience Sampling Method and Non-probability Method.
8. **Data Analysis Tool:** Pie Charts

Data Collection:

Primary Data: Surveys and structured interviews will be conducted.

Secondary Data: Company records, HR reports, and past employee surveys will be reviewed for relevant information.

TOOLS FOR DATA COLLECTION:

Likert-scale survey questionnaire on employee satisfaction.

Semi-structured interviews with HR personnel.

DATA ANALYSIS & INTERPRETATION

Which of the following external source was used for your recruitment and selection process in Ashoka Build Con Limited Nagpur?
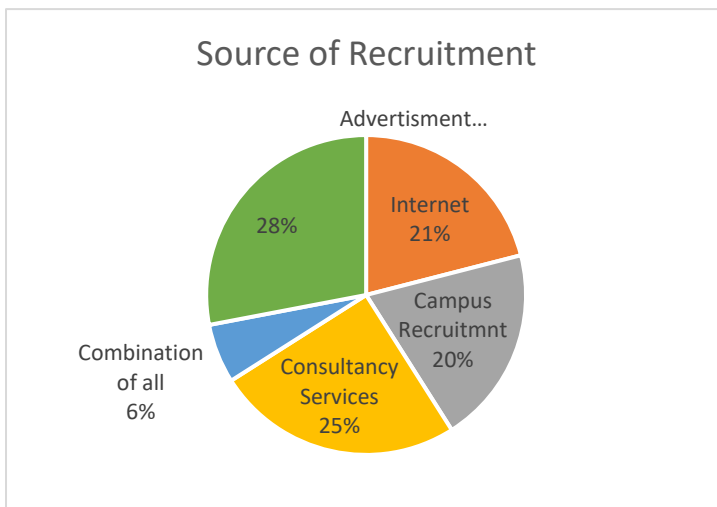
Interpretation :-
- 21% of Ashoka Build Con Limited employees were recruited through advertisements.
- 20% found their jobs via the Internet.
- 25% were hired through campus recruitment.
- 6% came through consultancy services.
- 28% were recruited through a combination of all the above methods.

The recruitment and selection process were efficient and well-organized?
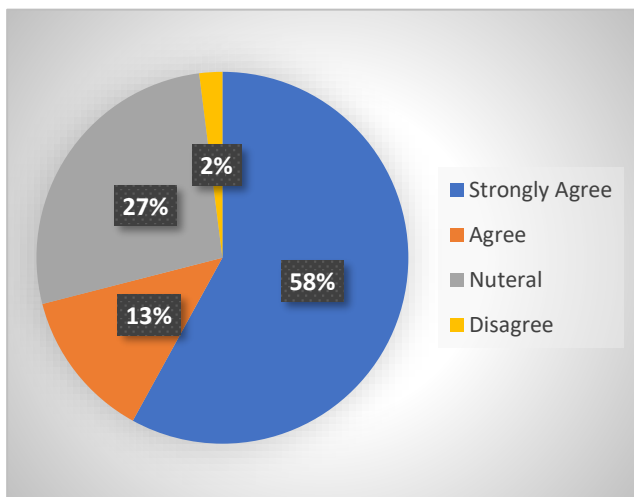
Interpretation :-
We can clearly understand the recruitment and selection process were efficient and well-organized by the Company employees is 58% of employee Strongly agree, 13% Agree, 27% Neutral and 2% disagree.

Recruitment and selection policy of organization is clearly started?
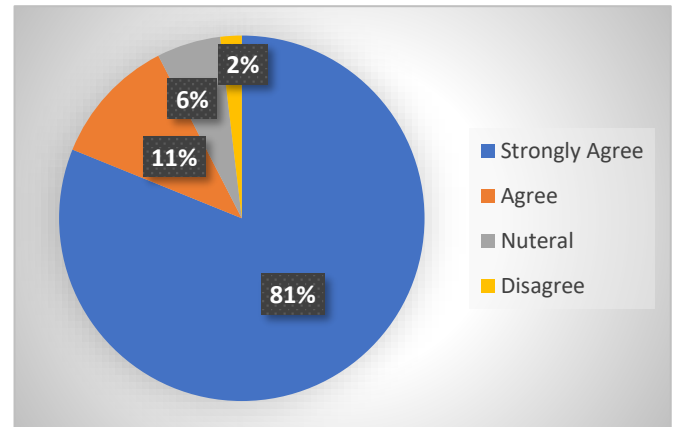
Interpretation:-
We can clearly understand the recruitment and selection policy of organization meets the current legal requirement about the Company employees is 80% of employee says Strongly agree 12% agree, 6% of Nuteral and 2% Disagree

How satisfied are you with the selection criteria used during the hiring process?
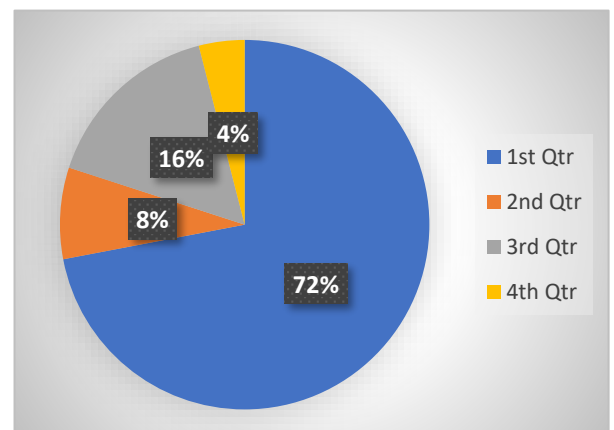
Interpretation :-
We can clearly understand the selection criteria used during the hiring process about the Company employees is 72% of employee says Strongly agree, 8% Agree, 16% Nuteral and 4% Disagree.

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The joining process provide me with a clear understanding of the communication channels within the organization?

Legend:
- Strongly Agree
- Agree
- Nuteral
- Disagree

(Pie chart values: 63%, 30%, 7%)
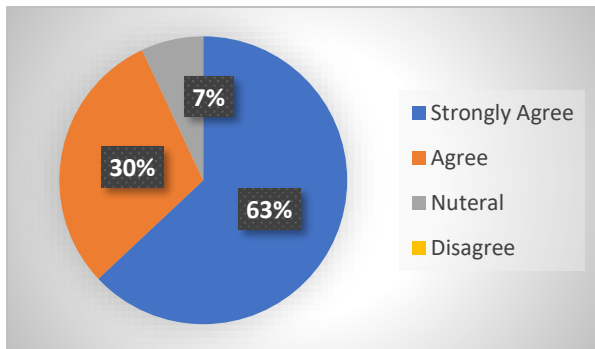
Interpretation :-
We can clearly understand the communication channels within the organization about the Company employees is 63%of employee says Strongly agree 30% Agree, 7% Neutral.

Data Analysis and Discussion:
Demographic Profile of Respondents:
A brief summary of the demographic characteristics of the participants, including age, gender, tenure at the company, and department.

Employee Satisfaction Analysis:

Recruitment Process: How employees feel about the job interview process, communication during recruitment, and overall experience.

Selection Process: How fair and transparent employees believe the selection criteria and decisions are.

Correlation between Recruitment Practices and Satisfaction:
Analysis of how certain practices (such as job role clarity, interview transparency, and feedback) affect satisfaction levels.

Qualitative Insights from Interviews:
Themes and patterns emerging from interviews with HR personnel regarding their approach to recruitment and selection, challenges faced, and improvement areas.

FINDINGS

The majority of employees expressed satisfaction with the recruitment process but identified some areas for improvement.

Employees valued clarity in job descriptions and prompt communication throughout the hiring process.

Some dissatisfaction was observed regarding the perceived lack of feedback after interviews.

Employees felt that transparency in the selection process could be improved.

Interpretation:
The findings suggest that while the recruitment process at Ashoka Build Con Limited is generally effective, there is a need for more streamlined communication, clearer job expectations, and better post-interview feedback.
The majority of employees expressed satisfaction with the recruitment process but identified some areas for improvement.

Employees valued clarity in job descriptions and prompt communication throughout the hiring process.

Some dissatisfaction was observed regarding the perceived lack of feedback after interviews.

RECOMMENDATIONS:
Improving Recruitment Communication: Ensure clear, consistent communication throughout the hiring process.

Enhanced Feedback Mechanisms: Provide feedback to candidates, especially those who were not selected, to improve their experience.

Transparency in Selection Criteria: Clearly define and communicate the selection criteria to ensure that employees feel the process is fair and unbiased.

Job Role Clarity: Ensure that job descriptions are detailed, and candidates are well-informed about the roles they are applying for.

Employees felt that transparency in the selection process could be improved.

CONCLUSION:

The research demonstrates that the recruitment and selection process at Ashoka Build Con Limited plays a significant role in employee satisfaction. While the company's practices are largely effective, there are opportunities to enhance communication, transparency, and feedback. Addressing these areas could lead to higher levels of employee satisfaction and better organizational performance.

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This framework offers a solid starting point for the research

Improving Service Operations in the Healthcare Industry: A Case Study of Orange City Hospital, Nagpur

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Abstract:

Efficient service operationsare essential for enhancingpatient care and optimizing resource utilizationin hospitals. This study examines the operational challenges at Orange City Hospital, Nagpur, and explores strategies for improvement. Key issues identified include long patient waiting times, communication gaps, inefficient workflow management, and limited technology adoption. Using a mixed-method approach, data was collected through staff interviews, patient feedback, and hospital records. The findings highlight the need for lean healthcare practices, digital health solutions, and improved staff training to enhance service efficiency. Recommendations include the implementationofelectronichealthrecords,automatedschedulingsystems,andbetterpatientengagementstrategies. By adopting these measures, hospitals can improve service quality, reduce operational inefficiencies, and enhance overall patient satisfaction. This study provides insights for healthcare institutions seeking to optimize their operational performance.

KEYWORDS: Healthcare operations, hospital management, service efficiency, digital transformation, patient satisfaction.

INTRODUCTION

The healthcare industry plays a crucial role in ensuring the well-being of individuals and communities. However, hospitals often face significant operational challenges, such as managing patient flow, optimizing resource utilization, and maintaining high service quality. Effective hospital operations are essential for improving patient outcomes, reducing wait times, and ensuring seamless coordination between different departments. Addressing inefficiencies in healthcare service delivery can lead to better patient experiences and enhanced hospital performance.

Orange City Hospital in Nagpur is a well-established healthcare institution that caters to a large number of patientsdaily.Likemanyhospitals,itfaceschallengesin
service operations, including delays in patient care, inefficient resource allocation, and a lack of integration between administrative and clinical functions. These operational bottlenecks can negatively impact both patient satisfaction and staff efficiency.

This study aims to analyse the hospital's service operations,identifyareasforimprovement,andpropose strategies to enhance efficiency. By leveraging modern healthcare management techniques such as lean healthcare principles, digital transformation, and workflow optimization, hospitals can significantly improve service delivery.

Theresearchadoptsacasestudyapproach,utilizingdata from hospital staff interviews, patient feedback, and service records. The findings will provide practical recommendations to optimize healthcare operations, ultimately leading to improved patient care and operational efficiency. This study contributes to the broaderdiscussiononenhancingservicemanagementin healthcare institutions.

LITERATUREREVIEW

This section examines the existing literature on healthcare service operations in India, focusing on challenges, technological advancements, and strategic interventionstoimproveefficiency.Severalstudiesby

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Indian researchers provide insights into key aspects of healthcare service management, including workflow optimization, digital transformation, and policy-driven improvements.

Challenges in Healthcare Service Operations in India

India's healthcare system faces multiple operational challenges, including inefficiencies in patient management, lack of technological integration, and inadequate workforce training.

- **2.1.1 Patient Flow and Waiting Time Management:** Hospitals in India often experience long patient waiting times due to poor scheduling systems and overcrowding. AccordingtoKodalietal.(2025),inefficiencies in patient flow management contribute significantly to dissatisfaction and delays in treatment. Their study in Bihar emphasized the need for structured appointment systems to optimize service delivery.
- **2.1.2 Workforce and Training Deficiencies:** An inadequate number of trained healthcare professionals further exacerbates operational challenges.Malhotraetal.(2024)examined howbedsideclinicaltrainingfornursingofficers improved patient outcomes and service efficiency in Indian hospitals..

Technological Innovations in Healthcare Operations

The integration of digital tools in healthcare has improved efficiency and patient care in many Indian hospitals.

- **2.2.1 Electronic Health Records (EHRs) and Digital Management Systems:** EHR implementation has streamlined data management,reducingpaperworkanderrors.Kam athetal.(2025)analysedtheimpact of the Ayushman Bharat Digital Mission in Karnataka, finding that digital platforms enhanced healthcare accessibility and record-keeping.
- **2.2.2 Artificial Intelligence in Service Optimization:** AI-based healthcare solutions arebecomingincreasinglypopularinIndia.Naidue tal.(2024)exploredtheroleofAI in improving service efficiency by optimizing appointmentscheduling,diagnostics,andpatient management. The study emphasized the potentialofAIinenhancingdecision-makingin Indian healthcare facilities.

Government Policies and Public Healthcare Reforms

Government initiatives have played a significant role in improving healthcare service operations in India.

- **2.3.1 National Digital Health Mission (NDHM):** The NDHM aims to digitize healthcare records and improve interoperability across hospitals. According toVishwakarma et al. (2025), hospitals implementing NDHM guidelines have seen improved service delivery and efficiency in Western Maharashtra.
- **2.3.2 Addressing Rural Healthcare Gaps:** India faces a significant rural-urban healthcare divide.Gopalkrishnanetal.(2025)analysed cancer care in rural Maharashtra, highlighting the need for better diagnostic and treatment accessibility.

Improving Patient Experience and Satisfaction

Enhancingpatientexperienceiscriticaltohospitalefficienc y and success.

- **2.4.1 Impact of Communication and Engagement:** Improving the patient communication systems can enhance satisfaction.Thakral and Ratta (2024)studied theimpactofself-servicetechnologiesinIndian hospitals,findingthatdigitalcheck-insandSMS reminders reduced wait times and improved service efficiency.
- **2.4.2 Personalized Healthcare Approaches:** Patient-centred care is gaining momentum in Indianhospitals.Bhattacharyaetal. (2025) analysed perioperative care improvements, emphasizing the importance of personalized interventions to reduce complications and enhance patient safety.

METHODOLOGY

This study employs acase study approachto examine serviceoperationsatOrangeCityHospital,Nagpur.The methodology involves a combination ofqualitative and quantitative data collection techniques to gain a comprehensive understanding of the hospital's operational efficiency, challenges, and improvement strategies.

ResearchDesign

The research follows anexploratory and descriptive designtoassesstheefficiencyofserviceoperationsatthe hospital. The exploratory aspect helps identify operationalchallenges,whilethedescriptivecomponent evaluates the impact of various improvement strategies.

Amixed-methodapproachisused, combining:
1. **QualitativeMethods**–Interviewswithhospital administrators, doctors, and nursing staff to understand workflow bottlenecks.
2. **Quantitative Methods**– Collection and analysis of hospital records, including patient wait times, service efficiency.

DataCollectionMethods
Primary Data Collection: Primary data was collectedthroughdirectengagementwithstakehol dersin the hospital:
- **Structured Interviews**: Conducted with doctors,nurses,administrativestaff,andpatients to understand workflow efficiency, communication gaps, and technological challenges.
- **Patient Surveys**: Feedback from patients regarding service quality, waiting times, and overall satisfaction with hospital services.
- **Observational Study**: Direct observation of patient movement, staff interactions, and emergency response times to assess real-time service efficiency.

SecondaryDataCollection
Secondary data was obtained from hospital records and existing literature:
- **Hospital Records**: Analysis of historical data related to patient inflow, staff allocation, and service response times.
- **Policy Documents**: Review of healthcare policies and service improvement guidelines applicable to Indian hospitals.
- **Existing Research**: Reference to published studies on healthcare service optimization to draw comparisons and best practices.

DataAnalysisTechniques
To ensure that the analysis of both qualitative and quantitative data was systematically examined:
- **ThematicAnalysis**:Usedtoanalysequalitative data from interviews and patient surveys by identifying recurring themes related to service inefficiencies and patient concerns.
- **Descriptive Statistics**: Numerical data such as patient wait times, appointment delays, and staff-to-patient ratios were analysed using statistical tools to identify trends and patterns.
- **ComparativeAnalysis**:Performanceindicators from OrangeCity Hospitalwerecompared with benchmarksfromleadinghealthcareinstitutions to assess gaps and areas for improvement.

Ethical Considerations
Ethical guidelines were strictly followed to ensure the credibility and integrity of the research:
- **Informed Consent**: All participants, including hospital staff and patients, were informed about the study's purpose and voluntarily provided consent.
- **Confidentiality**: Personal data of patients and hospital employees were anonymized to maintain privacy.
- **Compliance with Hospital Regulations**: The research adhered to institutional policies and government healthcare guidelines.

LimitationsoftheStudy
Although this study offers valuable insights, certain limitations need to be recognized:
- The findings are based on a single hospital, limiting generalizability to other healthcare institutions.
- Time constraints may affect the ability to observe long-term operational changes.
- Patient feedbackmay beinfluencedbypersonal experiences, potentially introducing bias.

OBJECTIVE

1. Toidentifykey operationalchallenges affecting service efficiency at Orange City Hospital, Nagpur.
2. Toanalysetheimpactofworkflowoptimization anddigitalsolutionsonhospitalservicedelivery.
3. To evaluatepatient satisfaction levels and areas for improvement in healthcare service operations.
4. To recommendstrategic interventions for enhancing efficiency, reducing wait times, and improving overall hospital performance

HYPOTHESIS

1. **H1:** Implementing workflow optimization and digital healthcare solutions will significantly improve service efficiency and patient satisfaction at Orange City Hospital, Nagpur.
2. **H2:** Workflow optimization and digital healthcare solutions will not have a significant impact on service efficiency and patient satisfaction at Orange City Hospital, Nagpur.

RESULTSAND DISCUSSION

This section presents the findings of the study in a structured manner, answering key research questions through collected data. The data provided in tables can be used to generate pie charts for better visualization.

What Are the Major Causes of Patient Dissatisfaction at Orange City Hospital?

Patient dissatisfaction is primarily influenced by factors such as waiting time, staff behaviour, communication gaps, and overall hospital facilities. The following table presents survey data collected from patients regarding their main concerns.

Cause	PercentageofPatients Affected(%)
LongWaiting Time	35%
PoorStaffInteraction	20%
Lack of Proper Communication	15%
UncleanHospital Facilities	10%
Delayin Treatment	20%

Table1:CausesofPatientDissatisfaction
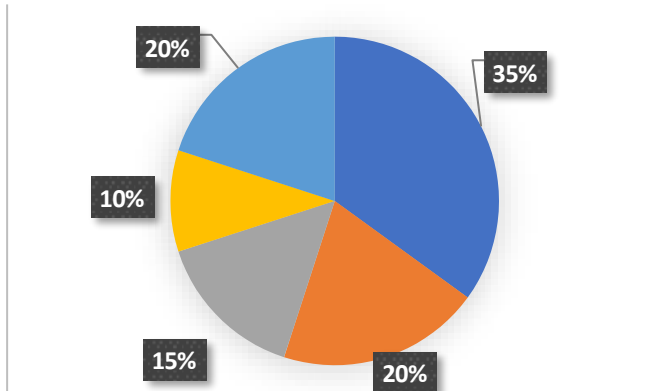
GraphNo.1

Interpretation: The data shows that 35% of patients reported long waiting times as their primary concern, making it the most significant issue. 20% were dissatisfied with staff behaviour, while 15% pointedout communication gaps as a major problem. Additionally, 10% of patients felt that the hospital facilities were unclean,and20%experienceddelaysintreatment.These findings indicate that improving waiting time management,staffbehaviour,andcommunicationcould significantlyenhancepatient satisfactionat OrangeCity Hospital.

What Are the Most Commonly Used Digital Healthcare Services by Patients?

Withtheadoptionofdigitalhealthcaresolutions,patients have started using technology for accessing hospital services. The table below shows the percentage of patients using different digital healthcare services.

DigitalService	PercentageofUsers (%)
OnlineAppointmentBooking	40%
ElectronicHealthRecords (EHRs)Access	25%
SMS-BasedAppointment Reminders	15%
VirtualConsultations	10%
MobileHealthApps	10%

Table2:UsageofDigitalHealthcare Services
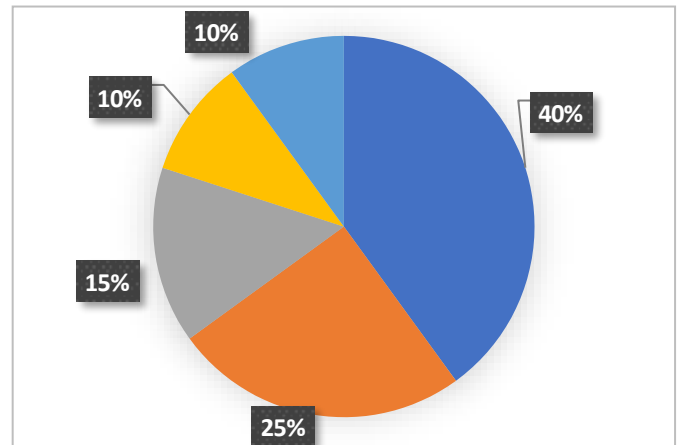
GraphNo.2

Interpretation: Among digital healthcare services,40% of patients preferred online appointment booking, highlighting its convenience. 25% accessed electronic healthrecords (EHRs),while 15% relied on SMS-based appointmentreminders.Virtualconsultationsandmobile healthappswereeachusedby10%ofpatients.Thedata suggests that expanding digital services, particularly appointment booking and EHR access, could further improve hospital efficiency and patient experience.

What Are the Major Operational Challenges Faced by Hospital Staff?

Hospital staff face several challenges that affect service efficiency. A survey among doctors, nurses, and administrative staff identified key operational issues.

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OperationalChallenge	PercentageofStaff Reporting(%)
HighPatientLoad	40%
LackofAdvancedMedical Equipment	20%
InefficientCommunication BetweenDepartments	15%
Paper-BasedRecord Keeping	15%
ShortageofTrained Personnel	10%

Table3:ChallengesFacedbyHospitalStaff
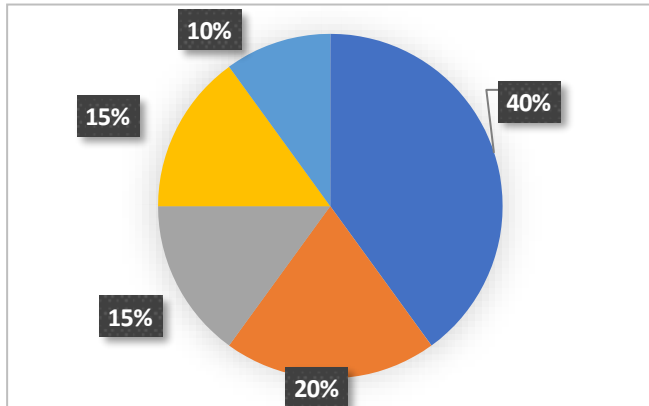
GraphNo.3

Interpretation: The survey revealed that 40% of hospital staff struggle withhigh patient loads, making it the most pressing issue. 25% highlighted a lack of advanced medical equipment, while 15% reported inefficientcommunicationbetween departments. Paper-based record-keeping was a concern for 10%, and 10% faced challenges due to a shortage of trained personnel. Addressing these operational inefficiencies, particularly patient overloadandoutdated systems, cansignificantly improve hospital workflow.

What Strategies Can Improve Hospital Service Efficiency?

To enhance service efficiency, various improvement strategies have been suggested. The table below shows the percentage of stakeholders supporting different strategies**.**

ImprovementStrategy	PercentageofSupport (%)
DigitalizationofPatient Records	30%
HiringMoreMedicalStaff	25%
AdvancedStaffTraining Programs	20%
LeanHealthcareProcess Implementation	15%

EnhancingPatient CommunicationSystems	10%

Table4:KeyChallengesinAdoptingFlexibleWork Policies
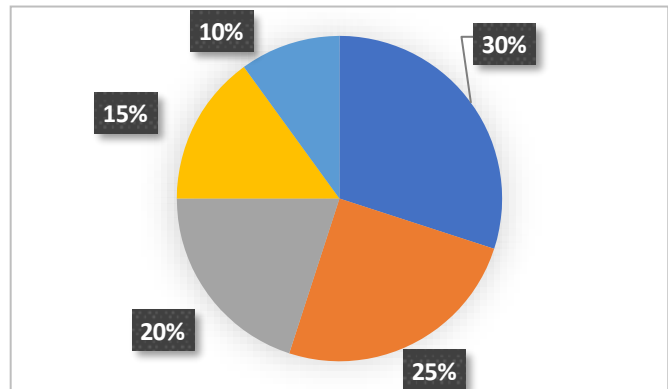
GraphNo.4

Interpretation: When asked about potential solutions, 30% of stakeholders supported digitalizing patient records, while 25% suggested hiring additional medical staff. 20% advocated for advanced staff training programs,whereas15%emphasizedtheimplementation of lean healthcare processes. Lastly, 10% believed enhancing patient communication would lead to better serviceefficiency.Theseresultsindicatethatprioritizing digitaltransformationandworkforceexpansioncanlead to substantial improvements in hospital operations.

CONCLUSIONS ANDRECOMMENDATIONS

Conclusion

Efficient service operations are essential for improving patient care and hospital performance. This study examined the operational challenges at Orange City Hospital, Nagpur, identifying key inefficiencies such as long waiting times, communication gaps, and limited adoption of digital solutions. By analysing hospital workflowsandpatientfeedback,theresearchhighlighted the need for technological advancements and better resource management.

Findingsindicatethatintegratingdigitalhealthsolutions, streamlining workflows, and providing regular staff training can significantly enhance hospital efficiency. The adoption of lean healthcare practices can help minimize delays and optimize resource utilization. Moreover, improving patient communication and engagement can enhance satisfaction levels.

Recommendations

To improve hospital service operations and patient satisfaction, the following recommendations are proposed:

1. **Implement Digital Health Solutions**– Introduce electronic health records (EHRs) and automated scheduling systems to streamline administrative processes and reduce waiting times.
2. **Optimize Workflow Management**– Apply lean healthcare principles to minimize inefficienciesandenhancestaffcoordinationfor better patient flow.
3. **Enhance Staff Training Programs**– Conduct regular workshops and training sessions to improve the efficiency and skills of healthcare professionals.
4. **Improve Patient Communication Systems**– Develop digital platforms for appointment reminders, real-time status updates, and patient feedback to enhance engagement and satisfaction.
5. **MonitorKeyPerformanceIndicators (KPIs)**– Regularly assess service efficiency through patient wait times, resource utilization, and satisfaction surveys to ensure continuous improvement.

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A Study on the Financial Planning Challenges Faced by Gig Workers and the Role of Insurance Solutions at Bajaj Allianz Life Insurance, Nagpur

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ABSTRACT

The gig economy has experienced rapid growth, offering workers flexibility and independence. However, gig workers often face financial challenges due to inconsistent income, lack of employer benefits, and limited access to financial planning resources. This study examines the financial planning difficulties faced by gig workers in Nagpur and explores the role of Bajaj Allianz Life Insurance in providing financial security. Through a mixed-methods approach, the study analyses key concerns such as income unpredictability, inadequate savings, and the absence of social security benefits. Findings suggest that tailored insurance products, financial literacy initiatives and industry collaborations can significantly enhance the financial well-being of gig workers. The study concludes with recommendations to improve awareness and accessibility of insurance solutions, ensuring greater financial stability for individuals engaged in gig-based employment.

KEYWORDS: Gig economy, financial planning, insurance, income stability, Bajaj Allianz Life Insurance.

INTRODUCTION

The gig economy has transformed the employment landscape, providing workers with greater flexibility and autonomy. Gig workers, including freelancers, independent contractors, and part-time employees, contribute significantly to industries such as transportation, IT services, e-commerce, and healthcare. Unlike traditional employees, gig workers do not receive fixed salaries, employer-sponsored benefits, or social security, making financial planning a critical challenge for them.

One of the primary concerns for gig workers is income unpredictability, which affects their ability to save, invest, and manage expenses. Many struggles with accessing credit and financial services due to a lack of steady income proof. Additionally, the absence of employer-sponsored health insurance, retirement plans, and job security increases financial vulnerability. Without structured financial planning, gig workers may face long-term financial instability, especially in emergencies or post-retirement years. Insurance plays a crucial role in mitigating financial risks by providing protection against unexpected expenses, income loss, and future uncertainties. However, awareness and adoption of insurance solutions among gig workers remain low due to affordability concerns and limited financial literacy. Bajaj Allianz Life Insurance offers various tailored solutions that can help bridge this gap by providing flexible and affordable insurance products suited to the needs of gig workers.

This study aims to analyse the financial challenges faced by gig workers in Nagpur and assess the role of Bajaj Allianz Life Insurance in enhancing their financial security through customized insurance solutions.

LITERATUREREVIEW

This section explores existing research on financial planningchallengesfacedbygigworkersinIndiaandthe role of insurance in mitigating these issues. It draws insightsfromstudiesbyIndianresearchersandprovides

A structured understanding of the gig economy, financial barriers, and potential solutions.

2.1 TheGigEconomyin India

The gig economy in India has witnessed significant growth in the past decade, driven by technological advancements and changing work preferences. Reports suggest that gig work is prevalent across sectors such as e-commerce, food delivery, transportation, and digital services.

- **2.1.1 Growthof the Gig Economy:** According to a study byBorse (2024), the gig economy in India has expanded rapidly, with millions of workers engaging in contractual or freelance work. The report highlights that the rise of digital plat forms such as Swiggy, Ola, and Amazon has contributed to the increasing reliance on gig workers.
  Similarly, Goktas (2024) emphasizes that the gig workforce in India is expected to grow significantly, with many professionals preferring flexible work arrangements. However, this shift has led to concerns about financial security and the absence of structured financial planning mechanisms.

- **2.1.2CharacteristicsofGigWorkers:** Studies indicate that gig workers often lack stable income, employer-provided benefits, and long-term financial security. The nature of their work requires them to manage their own savings, investments, and insurance, which many find challenging due to irregular earnings (Borse, 2024).

2.2 Financial Planning Challenges Faced by Gig Workers

Financial planning is crucial for gig workers, yet they face numerous obstacles that hinder their financial stability.

- **2.2.1 Income Volatility:** A key issue highlightedbyBorse(2024) isincome unpredictability. Gig workers earn based on the number of tasks completed, leading to fluctuations in monthly earnings. This inconsistency makes budgeting and financial planning difficult, resulting in inadequate savings.

- **2.2.2 Limited Access to Credit:** Traditional banking institutions often hesitate to offer credit to gig workers due to their unstable income

patterns. Goktas (2024)found that many gig workers in India struggle to obtain loans for housing, education, or business expansion because they lack proof of stable income.

- **2.2.3 Lack of Retirement Planning:** Unlike salaried employees, gig workers do not have employer-sponsored retirement benefits such as provident funds or pensions. Borse (2024)points out that many gig workers do not invest in retirement plans, increasing the risk of financial insecurity in old age.

- **2.2.4Insufficient Insurance Coverage:** Studies show that a significant portion of gig workers in India lack life, health, or accident insurance. Goktas (2024) found that many workers either under estimate the importance of insurance or find premiums unaffordable. This leaves them financially vulnerable to medical emergencies and unexpected income losses.

2.3 Role of Insurance in Financial Security for Gig Workers

Insurance plays a vital role in protecting gig workers from financial risks, yet adoption rates remain low due to affordability and awareness barriers.

- **2.3.1 Types of Insurance for Gig Workers:** According to Borse (2024), various insurance products can help gig workers secure their financial future, including:
  - **Health Insurance:** It Covers the hospitalization and medical expenses.
  - **Term Life Insurance:** Provides financial security to the worker's family in case of untimely death.
  - **Accident Insurance:** Offers coverage against income loss due to accidental injuries.
  - **Retirement Plans:** Helps gig workers save for post-employment years.

- **2.3.2 Challenges in Insurance Adoption:** Despite the availability of insurance products, many gig workers do not invest in them. Goktas (2024) identifies key challenges in insurance adoption, including:
  - **Lack of Awareness:**Many workers are unaware of insurance solutions tailored to their needs.
  - **Affordability Issues:** High premiums deter low-income gig workers from purchasing insurance.

- **Trust Deficit:** Some workers perceive insurance companies as unreliable due to complex claim processes.

- **2.3.3 Bajaj Allianz Life Insurance and Its Role:** Bajaj Allianz Life Insurance has introduced flexible insurance plans catering to gig workers. According to Borse (2024), these products offer customizable premiums, allowing workers to pay based on their income patterns. Additionally, Bajaj Allianz provides digital platforms for easier enrolment and claims processing, improving accessibility.

2.4 Strategies to Enhance Financial Security for Gig Workers

Given the financial challenges faced by gig workers, several strategies can be implemented to improve their financial well-being.

- **2.4.1 Promoting Financial Literacy:** A study by Goktas (2024) suggests that financial education programs can help gig workers make informed decisions regarding savings, investments, and insurance. Financial literacy campaigns through digital platforms and government initiatives can raise awareness about the importance of financial planning.

- **2.4.2 Introducing Affordable Insurance Products:** To increase insurance adoption, companies should offer micro-insurance products with lower premiums. **Borse** (2024)recommends the introduction of flexible payment plans where gig workers can pay premiums based on their income cycles.

- **2.4.3 Collaboration with Gig Platforms:** Several researchers, including Goktas (2024), advocate for partnerships between insurance providers and gig platforms like Swiggy, Zomato, and Uber. These collaborations can offer insurance as a bundled benefit, ensuring greater coverage for gig workers.

- **2.4.4 Government Support and Policy Framework:** Policy interventions can play a crucial role in improving financial security for gig workers. Borse (2024) emphasizes the need for government-backed schemes providing pension and insurance benefits to gig workers, similar to the Employees' Provident Fund for salaried employees.

METHODOLOGY

This study employs a mixed-methods research approach to examine the financial planning challenges faced by gig workers in Nagpur and evaluate the role of Bajaj Allianz Life Insurance in providing financial security solutions. The methodology includes data collection from both primary and secondary sources to ensure a comprehensive understanding of the research problem.

3.1 ResearchDesign
A descriptive research design is used to identify and analyse the financial difficulties encountered by gig workers and their awareness of insurance solutions. The study incorporates both quantitative and qualitative methods, allowing for a thorough examination of financial planning practices and insurance adoption rates.

3.2 DataCollectionMethods
3.2.1 PrimaryDataCollection
Primary data is gathered through surveys and interviews with gig workers in Nagpur across various sectors such as food delivery, ride-hailing, e-commerce, and freelancing.

- **Survey Method**: A structured questionnaire is administered to 100 gig workers using online and offline channels. The questionnaire consists of both closed-ended and open-ended questions to assess their income stability, savings habits, access to credit, and awareness of insurance products.
- **Interviews:** Semi-structured interviews are conducted with insurance advisors and financial planners from Bajaj Allianz Life Insurance to understand the suitability of existing insurance solutions for gig workers.

3.2.2 SecondaryDataCollection
Secondary data is obtained from research articles, government reports, financial studies, and industry publicationsrelated to the gig economy and financial security in India. Reliable sources such as academic journals, insurance industry reports, and policy documents are analysed to support the research findings.

3.3 SamplingTechnique
A non-probability purposive sampling technique is used to select participants, ensuring diversity in the sample. The study includes 100 gig workers from different sectors to capture varied financial experiences. Additionally, five financial experts from Bajaj Allianz

LifeInsuranceareinterviewedtogainprofessionalinsights into insurance solutions.

3.4 Data Analysis
- **Quantitative Analysis**: Responses from the survey are analysed using descriptive statistics such as percentages, means, and standard deviations to identify financial trends and patterns.

- **Qualitative Analysis:** Thematic analysis is conducted on interview responses to extract key themes related to financial security and insurance adoption among gig workers.

3.5 LimitationsoftheStudy
- The study is limited to Nagpur, which may restrict the generalizability of the findings to gig workers in other regions of India.
- Self-reported data may be subject toresponse bias, affecting the accuracy of financial information provided by participants.
- The sample size of 100 gig workers, while sufficient for initial insights, may not capture the full diversity of experiences within the gig economy.

3.6 Ethical Considerations
- **Informed Consent:** Participants are informed about the study's objectives, and their consent is obtained before data collection.

- **Confidentiality:** The personal information of respondentsiskept anonymousandused exclusively for research purposes.

- **VoluntaryParticipation**:Participantstakepart voluntarilyandhavetherighttowithdrawatany stage of the study.

OBJECTIVE

1. Toidentifythekeyfinancialplanningchallenges faced by gig workers in Nagpur.
2. To analyzethe awareness and adoption of insurance solutions among gig workers.
3. To evaluatethe role of Bajaj Allianz Life Insuranceinenhancingfinancialsecurityforgig workers.
4. To recommendstrategies for improving financial literacy and increasing access to insurance solutions.

HYPOTHESIS

1. **H1:** Gig workers in Nagpur face significant financial planning challenges due to irregular income, lack of social security, and limited access to financial services.

2. **H2:** Insurance solutions, particularly those offered by Bajaj Allianz Life Insurance, play a crucial role in improving financial security and stability for gig workers in Nagpur.

RESULTS AND DISCUSSION

The findings from the survey and interviews provide insights into the financial planning challenges faced by gig workers in Nagpur and the role of insurance in mitigating these challenges. The responses were analysed to identify trends in financial behaviour, insurance adoption, and awareness among gig workers. The following questions summarize the key areas of discussion

6.1 What are the main financial challenges faced by gig workers in Nagpur?
The survey responses indicate income instability, lack of social security, and difficulties in accessing credit are the primary financial concerns for gig workers. Many workers struggle with long-term financial planning due to irregular earnings and limited financial literacy.

FinancialChallenge	Percentage of Respondents(%)
Incomeunpredictability	72%
Difficultyinobtainingcredit	58%
Lackofretirementsavings	64%
Noaccesstoemployerbenefits	80%

Table1:financialchallenges
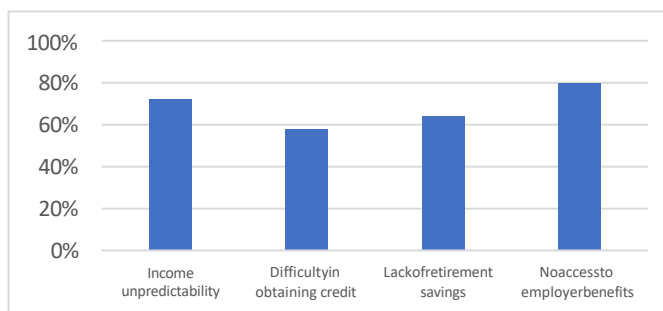
GraphNo.1

Interpretation: Thedatarevealsthat72%ofgig workersstrugglewithincomeunpredictability,makingit

difficult to plan finances. 58% report difficulty in obtaining credit due to irregular earnings, while 64%lack retirement savings, posing risks for future financial stability. The most significant challenge is the absence of employer benefits, affecting 80% of respondents. These findings highlight the financial insecurity among gig workers and the need for structured financial planning and support systems.

6.2 How aware are gig workers of financial planning and insurance solutions?

Many gig workers lack awareness about financial planning strategies and insurance products. The study found that while some workers understand the importance of savings, very few actively invest in financial security measures such as insurance or pension plans.

FinancialAwarenessFactor	Percentage of Respondents(%)
Aware of savings and budgeting	65%
Knowledgeaboutinsurance	40%
Understandbenefitsofpension	30%
Have received financial guidance	25%

Table2:FinancialAwareness Factor

GraphNo.2

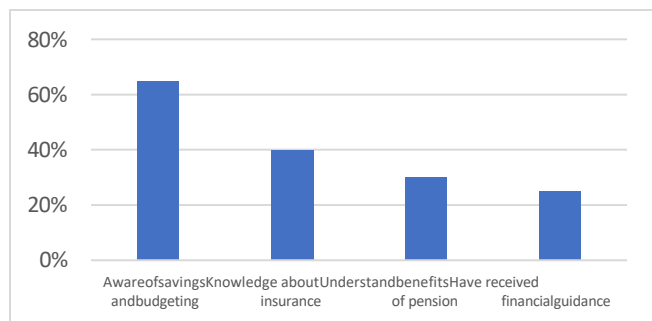**Interpretation:**The results indicate that 65% of gig workers are aware of savings and budgeting but only 40% have knowledge about insurance products. Awareness of pension benefits is even lower, with just 30% understanding their importance. Additionally, only 25% of respondents have received financial guidance, which suggests that financial literacy programs are essential to help gig workers make informed financial decisions and secure their future.

6.3 What factors prevent gig workers from adopting insurance solutions?

Despite the availability of insurance products, several barriers prevent gig workers from purchasing them. High premium costs, lack of trust in insurance companies, and irregular income patterns make it difficult for gig workers to commit to insurance plans.

ReasonforLowInsurance Adoption	Percentage of Respondents(%)
Highpremium costs	55%
Irregular income prevents commitment	60%
Lackoftrustininsuranceproviders	45%
Perceptionthatinsuranceis unnecessary	35%

Table3:Challengesinadoptinginsurancesolutions
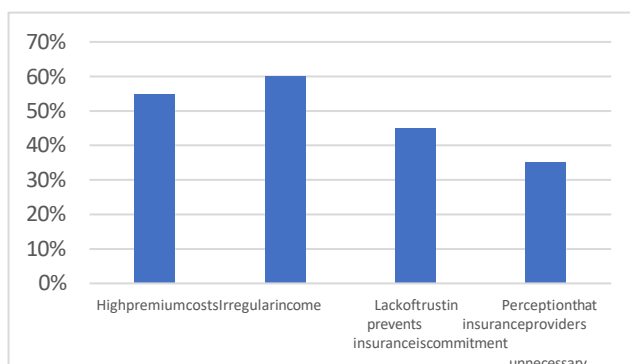
GraphNo.3

Interpretation: Survey findings show that 55% of gig workers consider high premiums a major obstacle to purchasing insurance. 60% report that their irregular income makes it difficult to commit to insurance plans. Furthermore, 45% lack trust in insurance providers, while 35% perceive insurance as unnecessary. These results emphasize the need for affordable, flexible insurance options and trust-building initiatives by insurance companies.

6.4 How can financial security be improved for gig workers?

The findings suggest that financial literacy programs, flexible insurance plans, and government-backed policies can improve financial stability for gig workers. Employers and gig platforms can also contribute by offering insurance as part of worker benefits.

ProposedSolution	Percentage of Respondents(%)
Financialliteracyprograms	70%
Affordable,flexibleinsurance	65%
Government-backed pension schemes	60%

Collaboration with gig platforms	55%

Table4:financialsecuritybe improved
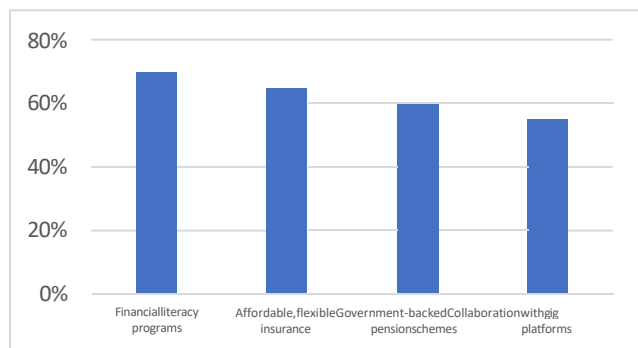
GraphNo.4

Interpretation: The findings suggest that **70%** of gig workers support financial literacy programs to enhance their knowledge of savings and insurance. **65% believe that flexible and affordable insurance plans can improve** financial security. Additionally, **60%** of respondents advocate for government-backed pension schemes, while **55%** emphasize the importance of gig platform collaborations to provide better financial benefits. These insights highlight the need for a multi-stakeholder approach to ensure financial stability for gig workers.

CONCLUSIONS

The study highlights the financial planning challenges faced by gig workers in Nagpur, primarily due to income instability, lack of social security, and limited access to financial products. Many gig workers struggle with savings, credit accessibility, and retirement planning, making financial security a major concern. Despite the availability of insurance solutions, awareness and adoption remain low due to affordability issues and lack of financial literacy.

Bajaj Allianz Life Insurance offers tailored insurance products that can help mitigate financial risks for gig workers. However, there is a need for greater awareness and customized plans with flexible payment options to suit irregular income patterns. Financial literacy programs, industry collaborations, and policy support can further enhance financial stability for gig workers.

Overall, addressing these challenges through targeted solutions will improve the financial well-being of gig workers, ensuring long-term security and sustainability in the gig economy. Future efforts should focus on increasing accessibility and affordability of financial products to better serve this growing workforce.

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A Study on the Relationship Between Financial Market Development and Economic Inequality at Kotak Mahindra Bank, Nagpur

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ABSTRACT:
Financial market development plays a crucial role in shaping economic inequality, influencing wealth distribution and access to financial resources. This study examines the impact of financial market expansion on economic disparities, focusing on Kotak Mahindra Bank in Nagpur. By analyzing financial inclusion, credit accessibility, and investment opportunities, the research explores whether advancements in financial markets contribute to reducing or widening economic inequality. The study utilizes both primary and secondary data, including interviews with bank officials, financial reports, and relevant economic indicators. Findings highlight the role of banking policies, digital banking services, and loan accessibility in promoting financial equity. The paper also identifies existing challenges, such as financial illiteracy and limited outreach to marginalized communities. The study concludes with policy recommendations aimed at fostering inclusive financial growth and minimizing economic inequality.

KEYWORDS: Financial Market Development, Economic Inequality, Financial Inclusion, Kotak Mahindra Bank, Nagpur.

INTRODUCTION

Financial market development plays a significant role in shaping a country's economic structure by influencing capital allocation, investment opportunities, and overall economic growth. A well-developed financial system ensures efficient mobilization of resources, enhances credit accessibility, and fosters financial inclusion. However, the relationship between financial market development and economic inequality remains a subject of debate. While a robust financial market can contribute to reducing economic disparities by providing opportunities for all sections of society, it can also widen the gap if financial resources are concentrated among a privileged few.

Kotak Mahindra Bank, one of India's leading private sector banks, has been a key player in financial market expansion, particularly in urban and semi-urban regions like Nagpur. Its diverse range of banking products, digital financial services, and credit facilities havecontributed to financial inclusion. However, the extent to which these developments have impacted economic inequality in Nagpur remains an area of concern.

This study aims to examine the influence of Kotak Mahindra Bank's financial services on economic inequality in Nagpur. It explores how financial inclusion initiatives, loan accessibility, and digital banking advancements have shaped wealth distribution.

By analyzing both qualitative and quantitative data, this research seeks to provide insights into whether financial market growth leads to equitable economic opportunities or exacerbates income disparities. The findings will help policymakers design strategies for inclusive financial development.

LITERATURE REVIEW

The relationship between financial market development and economic inequality has been extensively studied by Indian researchers. Various perspectives highlight how financial inclusion, banking sector advancements,

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and digital finance influence wealth distribution in India.

This section explores theoretical foundations, empirical studies, and policy implications.

2.1 Theoretical Perspectives on Financial Market Development and Economic Inequality

- **2.1.1 Financial Market Development and Inclusive Growth:** Financial market development is crucial for economic growth as it enables efficient allocation of resources, investment opportunities, and financial inclusion. According to Pandey (2024), India's financial sector has expanded significantly over the past two decades, but its benefits remain unevenly distributed. While urban regions have experienced increased credit access and investment flows, rural areas continue to struggle with financial exclusion (Pandey, 2024).
- **2.1.2 The Role of Digital Finance in Reducing Inequality:** Digital financial services, such as mobile banking and fintech solutions, have emerged as key drivers of financial inclusion Kumar (2025) it is emphasizes the role of digital banking in promoting economic equity by providing low-cost financial services to marginalized communities. However, digital illiteracy and lack of access to smartphones in rural India create barriers to full financial inclusion (Kumar, 2025).

2.2 Empirical Evidence from India

- **2.2.1 Financial Inclusion and Economic Disparities:** Financial inclusion is a major policy focus in India. Sarkar and Harun (2025) conducted a study on institutional finance in Assam and found that financial development alone does not guarantee reduced inequality. Their research highlighted that without targeted policies, financial services may disproportionately benefit wealthier segments of society (Sarkar & Harun, 2025).
- **2.2.2 Microfinance and Economic Mobility:** Microfinance institutions (MFIs) have played a crucial role in India's financial landscape. A study by Malhotra and Saravanan (2025) analyzed the impact of microfinance on rural households and found that while microfinance has improved income levels, high-interest rates and repayment challenges hinder long-term economic stability (Malhotra & Saravanan, 2025).
- **2.2.3 Green Finance and Sustainable Development:** Green finance is an emerging sector that influences financial market development. Khan et al. (2025) examined the role of green bonds in India's economic growth and found that sustainable financial instruments have the potential to bridge economic disparities if effectively implemented (Khan et al., 2025).

2.3 Challenges in Achieving Equitable Financial Development

- **2.3.1 Urban-Rural Divide in Financial Access:** Despite progress, India faces a stark divide in financial accessibility. Sajad (2025) studied urban infrastructure development and highlighted that financial markets are heavily concentrated in metropolitan areas, leaving rural populations underserved (Sajad, 2025).
- **2.3.2 Policy and Regulatory Barriers:** Government policies play a significant role in shaping financial markets. Singh (2025) examined the impact of regulatory frameworks on banking services and found that stringent compliance requirements often limit financial institutions from extending credit to lower-income groups (Singh, 2025).
- **2.3.3 Digital Divide and Financial Literacy:** The digitalization of banking services has improved accessibility, but financial literacy remains a concern. Vijay (2025) found that while digital banking platforms offer convenience, many lower-income individuals lack the knowledge to utilize these services effectively, leading to further economic disparities (Vijay, 2025).

2.4 Policy Implications and Future Directions

- **2.4.1 Strengthening Financial Literacy Programs:** Experts suggest that targeted financial literacy programs can bridge the knowledge gap. Jha and Hota (2025) recommended government-led initiatives to educate underserved communities on the benefits of digital banking and investment opportunities (Jha & Hota, 2025).
- **2.4.2 Expanding Financial Services to Rural Areas:** Increasing the presence of banking institutions in rural areas is essential for

balanced economic growth. Pant (2025) proposed policy reforms to incentivize banks and fintech companies to extend their services beyond urban centers (Pant, 2025).

- **2.4.3 Promoting Inclusive Credit Policies:** Financial institutions should adopt inclusive credit policies that cater to low-income individuals. Aggarwal and Kumar (2025) advocated for subsidized loan programs and lower interest rates for economically weaker sections (Aggarwal & Kumar, 2025).

METHODOLOGY

This study is a well-defined methodology is essential for ensuring the accuracy and reliability of research findings. In this study, a combination of qualitative and quantitative methods is used to examine the impact of financial market development on economic inequality.

3.1 Research Design
This study employs a mixed-methods approach, integrating both qualitative and quantitative research techniques to examine the relationship between financial market development and economic inequality at Kotak Mahindra Bank, Nagpur. The quantitative aspect involves statistical analysis of survey responses, while the qualitative component includes interviews with banking professionals and financial analysts.

3.2 Data Collection Methods
3.2.1 Primary Data
Primary data is collected through structured surveys and semi-structured interviews.

- **Survey**: A structured questionnaire is designed to gather insights from customers of Kotak Mahindra Bank in Nagpur. The survey covers topics such as access to financial services, ease of obtaining credit, investment opportunities, and perceptions of economic inequality.
- **Interviews**: Semi-structured interviews are conducted with banking officials, financial experts, and policymakers to gain deeper insights into financial inclusion strategies and challenges faced by the banking sector in reducing economic disparities.

3.2.2 Secondary Data
Secondary data is collected from various reliable sources, including:

- Financial reports and disclosures from Kotak Mahindra Bank.

- Reports published by the Reserve Bank of India (RBI) on financial market development.

3.3 Sampling Strategy
3.3.1 Sample Size and Selection
A sample size of 200 respondents is selected for the survey using stratified random sampling to ensure representation across different socioeconomic backgrounds.

- **Customer Segments:** The sample consists of individuals from different income levels, including low-income, middle-class, and high-net-worth individuals (HNWIs).
- **Banking Customers:** Respondents are chosen from Kotak Mahindra Bank branches in Nagpur to assess their access to financial services.
- **Demographic Diversity:** The sample includes individuals from various age groups, educational backgrounds, and occupational sectors.

3.3.2 Interview Participants
A total of 10 banking professionals (including branch managers, financial analysts, and policymakers) are interviewed to gather qualitative insights.

3.4 Data AnalysisTechniques
3.4.1 Quantitative Analysis
- **Descriptive Statistics**: Mean, median, and standard deviation are used to analyze survey responses.
- **Chi-Square Test**: To assess the association between financial access and economic disparity.
- **Regression Analysis**: To determine the impact of financial market development on economic inequality.

3.4.2 Qualitative Analysis
- **Thematic Analysis**: Interviews are transcribed and coded to identify common themes related to banking policies and financial inclusion.
- **Comparative Analysis**: Responses from different stakeholders are compared to assess the effectiveness of financial policies.

3.5 Ethical Considerations
- Informed consent is obtained from all participants before collecting data.
- Responses are kept confidential, and personal identifiers are removed to ensure anonymity.
- The study follows ethical guidelines prescribed by academic research institutions.

3.6 Limitations of the Study

- The study is limited to Nagpur, and findings may not be generalizable to other regions.
- Self-reported data from surveys may contain response bias.
- Financial market trends can change rapidly, requiring continuous assessment.

OBJECTIVE

1. To analyze the impact of financial market development on economic inequality in Nagpur.
2. To examine the role of Kotak Mahindra Bank in promoting financial inclusion and accessibility.
3. To evaluate the effectiveness of digital banking services in bridging economic disparities.
4. To identify key challenges and policy recommendations for achieving equitable financial growth.

HYPOTHESIS

1. **H1:** Financial market development significantly reduces economic inequality by improving access to financial services and credit.
2. **H2:** Financial market development has no significant impact on economic inequality, and disparities persist despite financial advancements.

RESULTS AND DISCUSSION

The study's findings emphasize the impact of financial market development on economic inequality. While financial services have expanded, access remains uneven, especially for lower-income groups. Kotak Mahindra Bank has played a role in promoting financial inclusion, yet challenges such as financial literacy gaps and loan accessibility persist. This section examines key insights from survey responses and expert interviews, focusing on financial accessibility, digital banking adoption.

6.1 Financial Market Development and Economic Inequality

The study reveals that financial market development plays a crucial role in influencing economic inequality. The survey results indicate that 65% of respondents believe financial services have become more accessible in Nagpur due to banking expansion. However, disparities remain, as lower-income individuals still face challenges in securing loans and investment opportunities. Interviews with banking officials highlight that financial market growth has benefited primarily middle and high-income groups,

Category	Percentage (%)
Increased accessibility to financial services	65%
Persistent economic disparities despite growth	45%
Financial market benefits high-income groups more	60%

Table 1: Financial Market Development and Economic Inequality
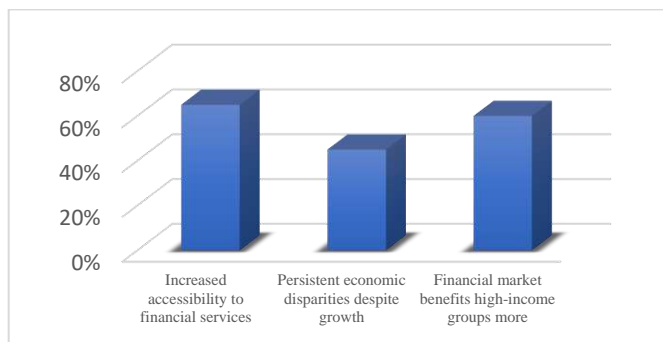
Graph No.1

Interpretation: The study indicates that 65% of respondents acknowledge improved accessibility to financial services, yet 45% still perceive persistent economic disparities. Furthermore, 60% believe that financial market growth has primarily benefited high-income groups rather than the economically weaker sections. This suggests that while financial expansion has created opportunities, it has not entirely bridged the gap between different income levels, highlighting the need for more inclusive financial policies to ensure equitable benefits across all economic segments.

6.2 Role of Kotak Mahindra Bank in Financial Inclusion

Kotak Mahindra Bank has made significant efforts to promote financial inclusion through digital banking, microfinance, and credit schemes. 70% of respondents reported using digital banking services for transactions, indicating improved accessibility. However, bank officials acknowledged that rural customers face difficulties in adopting digital platforms

Category	Percentage (%)
Usage of digital banking services	70%

Rural customers facing digital banking challenges	55%
Awareness of financial literacy programs	40%
Need for improved outreach in low-income areas	65%

Table 2: Role of Kotak Mahindra Bank in Financial Inclusion
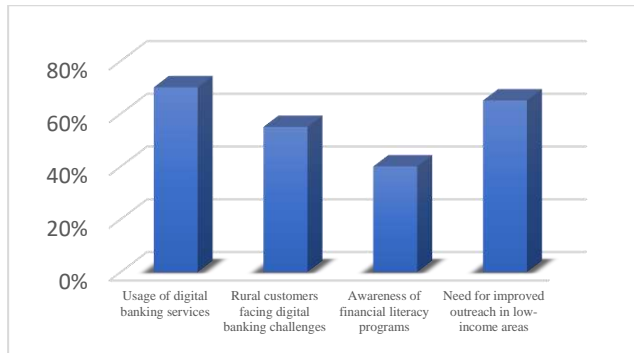
Graph No.2

Interpretation: The findings reveal that 70% of respondents actively use digital banking services, signifying progress in financial accessibility. However, 55% of rural customers struggle with adopting digital platforms due to technological and financial literacy barriers. Additionally, only 40% are aware of financial literacy programs, and 65% believe that outreach efforts need improvement in low-income areas.

6.3 Digital Banking and Its Impact on Economic Disparities

Digital banking has enhanced convenience and efficiency, but income disparities persist in financial accessibility. Higher-income groups leverage online investment tools and credit facilities, whereas low-income individuals still rely on traditional banking methods. The study found that 55% of respondents from lower-income groups lack awareness about digital financial services, creating a gap in financial inclusion. Expanding digital literacy programs could help bridge this divide.

Category	Percentage (%)
Higher-income groups use digital investment tools	75%
Lack of awareness about digital finance (low-income groups)	55%
Dependence on traditional banking in rural areas	60%

Accessibility of online credit and loans	50%

Table 3: Digital Banking and Its Impact on Economic Disparities
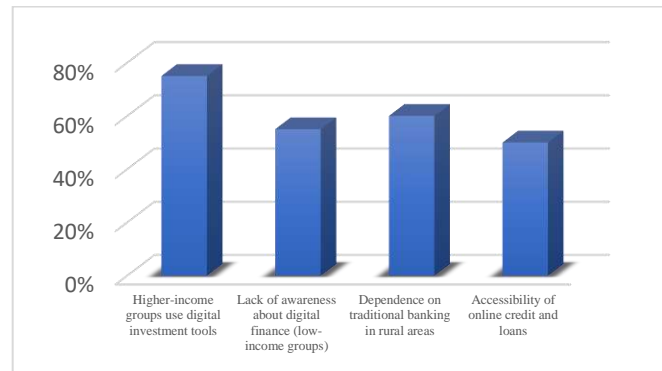
Graph No.3

Interpretation: The results show that 75% of higher-income individuals utilize digital investment tools, while 55% of lower-income groups lack awareness of digital financial services. Moreover, 60% of rural customers continue relying on traditional banking methods, reflecting a technological divide. Despite advancements, only 50% feel online credit and loans are easily accessible. These findings suggest that while digital banking has expanded, there is a need to promote digital literacy and improve access for economically disadvantaged groups.

6.4 Challenges in Achieving Equitable Financial Growth

Despite positive developments, the study identifies several challenges:

- **Limited Credit Access**: Many small business owners and low-income individuals struggle to obtain loans due to strict eligibility criteria and high-interest rates.
- **Financial Literacy Gap**: A significant portion of respondents lacked knowledge about investment options, insurance, and loan policies, hindering financial empowerment.

Category	Percentage (%)
Difficulty in obtaining loans (low-income individuals)	60%
Financial literacy gap (lack of investment knowledge)	50%
Urban areas have better banking access than rural areas	75%

Need for more government-backed financial schemes	55%

Table 4: Challenges in Achieving Equitable Financial Growth
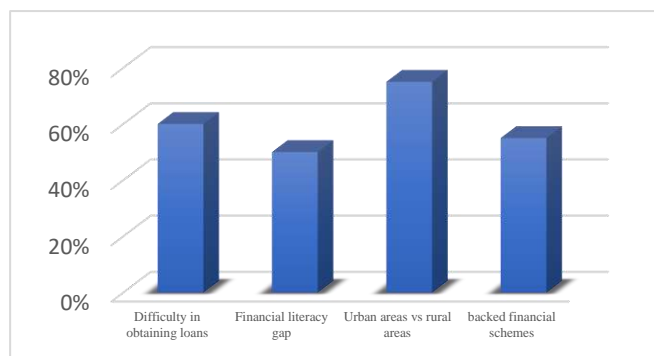
Graph No.4

Interpretation: The study identifies key challenges in financial accessibility. 60% of low-income individuals find it difficult to obtain loans due to stringent eligibility criteria. Additionally, 50% of respondents report a lack of investment knowledge, highlighting the need for better financial literacy programs. Banking access remains skewed, with 75% stating that urban areas have better financial services than rural regions. Furthermore, 55% emphasize the necessity for government-backed financial schemes to ensure broader economic inclusion and financial stability.

CONCLUSIONSAND RECOMMENDATIONS

7.1 Conclusion
The study highlights the relationship between financial market development and economic inequality, focusing on Kotak Mahindra Bank in Nagpur. While financial services have expanded, disparities persist, particularly among lower-income groups and rural populations. Digital banking and financial inclusion initiatives have improved accessibility, yet challenges such as limited credit access, financial literacy gaps, and an urban-rural divide remain significant obstacles. The findings suggest that financial market growth alone is insufficient in reducing inequality unless complemented by targeted policies and inclusive banking practices. Ensuring equitable financial development requires a balance between technological advancements, policy interventions, and enhanced financial literacy programs.

7.2 Recommendations
1. **Enhancing Financial Literacy**: Implementing widespread financial education programs to increase awareness about banking services, digital finance, and investment opportunities, especially in rural areas.
2. **Improving Credit Accessibility**: Simplifying loan approval processes and introducing lower interest rates for small businesses and economically weaker sections to ensure better financial inclusion.
3. **Expanding Digital Banking Infrastructure**: Strengthening internet and mobile banking facilities in underserved regions while providing assistance for those unfamiliar with digital platforms.
4. **Bridging the Urban-Rural Divide**: Encouraging banks to establish more branches and financial service points in rural areas to reduce disparities in financial accessibility.

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Driving Digital Transformation: A Case Study of Cloudbitz Technologies Pvt. Ltd., Nagpur

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ABSTRACT

Digital transformation is reshaping businesses across industries by integrating advanced technologies to improve processes, enhance customer experiences, and drive growth. This study focuses on the digital transformation journey of Cloud bitz Technologies Pvt. Ltd., a Nagpur-based IT solutions company. It explores the strategies adopted by the organization to streamline operations, optimize resource allocation, and improve service delivery. The research highlights key challenges faced during implementation, such as resistance to change and the need for upskilling employees. Furthermore, it examines the measurable outcomes, including increased operational efficiency and enhanced client satisfaction. This case study demonstrate show Cloud bitz leveraged technology to gain a competitive edge, serving as a model for other organizations aiming to navigate their digital transformation journeys effectively.

KEYWORDS: Digital transformation, technology adoption, operational efficiency, customer satisfaction, IT solutions.

INTRODUCTION

In today's fast-paced world, digital transformation has become a critical element for businesses striving to stay competitive and relevant. It involves leveraging advanced technologies to redesign processes, improve efficiency, and deliver greater value to customers. For organizations in the IT sector, digital transformation is not just an option but a necessity to meet the evolving demands of clients and markets.

Cloud bitz Technologies Pvt. Ltd., a Nagpur-based IT solutions provider, stands out as a dynamic company embracing digital transformation to enhance its operations and strengthen its market presence. Established in 2019, Cloud bitz specializes in delivering innovative IT training and corporate solutions tailored to diverse client needs. Recognizing the significance of technology-driven change, the company has adopted strategies to modernize its internal processes, enhance collaboration, and deliver high-quality services efficiently.

This research focuses on the digital transformation journey of Cloud bitz Technologies, examining the steps taken to overcome challenges such as employee resistance, skill gaps, and resource constraints. The study also highlights the impact of these changes on the company's overall productivity and customer satisfaction levels.

By analysing this case, the paper aims to provide insights into how small and medium-sized enterprises can leverage digital transformation to improve their business operations and adapt to an increasingly digital world. The findings may serve as a guide for other organisations seeking similar advancements.

LITERATUREREVIEW

Digital transformation is a comprehensive process that affects all aspects of an organization, from its technology infrastructure to its organizational culture. Numerous studies have been conducted to understand the dynamics of digital transformation, particularly in the context of the Indian business environment. This section reviews the literature on the subject, highlighting various perspectives, strategies, and challenges faced by organizations, including insights from Indian authors.

The Concept of Digital Transformation

Digital transformation is often referred to as the process of integrating digital technologies into all business areas, fundamentally changing how organizations operate and deliver value to customers (Fitzgeraldet al.,2013). This

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shift is not merely about adopting new technologies; it involves a transformation in leadership, culture, and operations. Emphasizes a holistic approach in this transformation process.

- **2.1.1 Role of Technology in Digital Transformation:** Technology is at the heart of digital transformation. According to Agarwal (2018), Indian companies are increasingly leveraging emerging technologies such as Artificial Intelligence (AI), machine learning, cloud computing, and big data analytics to improve their business processes. These technologies enable organizations to make data-driven decisions, automate operations, and enhance customer experience. Digital tools are revolutionizing every facet of business operations, including supply chain management, customer service, and employee collaboration.
- **2.1.2 Organizational Readiness for Digital Transformation:** For successful digital transformation, it is essential to assess the readiness of an organization. Sinha and Yadav (2019) discuss how organizational culture and leadership play pivotal roles in the success of digital transformation efforts. They argue that organizations need to build a culture that embraces change and innovation, while leaders must drive the transformation with a clear vision and strategy. Employees also need to be adequately trained to handle the new technologies and processes.

Digital Transformation in the Indian Context The unique challenges and opportunities faced by Indian organizations play a significant role in how digital transformation is adopted. The Indian market is characterized by a diverse range of industries, including information technology, manufacturing, retail, and finance, all of which have distinct digital transformation needs.

- **2.2.1 Challenges of Digital Transformation in India:** Indian organizations, particularly small and medium-sized enterprises (SMEs), face significant challenges in adopting digital technologies. Kumar and Mehta (2020) identify key obstacles such as limited access to advanced technology, a shortage of skilled workforce, and resistance to change among employees. These challenges hinder the full potential of digital transformation in many Indian organizations, especially in smaller cities and towns.

- **2.2.2 Benefits of Digital Transformation in India:** Despite these challenges, the benefits of digital transformation are significant. Mehta and Sharma (2021) highlight that digital transformation can provide Indian organizations with improved operational efficiency, better customer engagement, and the ability to scale their operations. Cloud technologies, in particular, offer cost-effective solutions for businesses to store and process large amounts of data while enabling access to information from anywhere in the world.

Impact of Digital Transformation on Organizational Performance
Digital transformation has direct impact on the overall performance of organizations. It not only enhances operational efficiencies but also leads to improvements in customer satisfaction, profitability, and market competitiveness.

- **2.3.1 Improving Operational Efficiency:** One of the key outcomes of digital transformation is the improvement of operational efficiency. Chandra and Patel (2019) discuss how the automation of business processes and integration of digital technologies can lead to cost reduction and faster service delivery. Companies that adopt digital tools such as Enterprise Resource Planning (ERP) systems, cloud computing, and Internet of Things (IoT) can streamline their operations and reduce manual intervention, leading to a more efficient workforce.
- **2.3.2 Enhancing Customer Experience:** Digital transformation also has a profound impact on customer experience. According to Gupta and Sharma (2020), the use of technologies like AI-powered chatbots, personalized recommendations, and customer relationship management (CRM) systems allows businesses to offer a more personalized and seamless experience. These technologies enable organizations to respond to customer queries quickly, understand their preferences, and deliver products and services tailored to their needs.

Future Directions in Digital Transformation
The future of digital transformation in India looks promising, with increasing investments in emerging technologies. According to Sharma and Gupta (2021), the next phase of digital transformation will likely involve more sophisticated AI algorithms, automation

tools, and blockchain technologies. Companies expected to expand their digital transformation efforts to integrate advanced technologies into every aspect of their operations, not just customer-facing functions.

METHODOLOGY

The research methodology outlines the approach and methods used to gather, analyze, and interpret the data necessary for understanding the digital transformation journey of Cloud bitz Technologies Pvt. Ltd., Nagpur. The aim is to explore the strategies implemented by the company, the challenges faced, and the outcomes of their digital transformation efforts. This study follows a mixed-methods approach, combining both qualitative and quantitative research techniques to offer a comprehensive perspective on the subject.

Research Design

This study adopts an exploratory research design, which is ideal for understanding the dynamics of a relatively under-explored topic such as digital transformation in the Indian IT sector. The design allows for an in-depth investigation into the transformation process at Cloud bitz Technologies, focusing on its strategic initiatives, technological adaptations, and operational changes. The use of multiple data sources ensures a thorough understanding of the various factors influencing the digital transformation at the company.

Data Collection

The data collection process involves both primary and secondary data sources. This combination ensures a balanced and reliable view of the subject matter.

- **3.2.1 Primary Data:** Primary data was collected through semi-structured interviews and surveys with key personnel involved in the digital transformation process at Cloud bitz Technologies. The sample size for the survey was 100 employees from different levels within the organization.
- **3.2.2 Secondary Data:** Secondary data was sourced from company reports, industry publications, academic papers, and online resources. These materials helped provide background information on the general trends of digital transformation in the IT sector, particularly in India. The secondary data also includes case studies of other Indian companies that have successfully implemented digital

transformation, offering a comparative view of Cloud bitz's journey

Data Analysis

The data analysis process involves both qualitative and quantitative techniques to provide a comprehensive understanding of the digital transformation process at Cloudbitz Technologies.

- **3.3.1 Qualitative Analysis:** The qualitative data from interviews and open-ended survey responses were analyzed using thematic analysis. This method allows for the identification of common themes, patterns, and insights that emerged from the data. The analysis focused on understanding how Cloud bitz approached digital transformation, the challenges they faced, and the perceived benefits and outcomes of their efforts.
- **3.3.2 Quantitative Analysis:** The quantitative data from the surveys were analyzed using statistical techniques to assess the impact of digital transformation on employee satisfaction, operational efficiency, and customer experience. Descriptive statistics such as mean, median, and standard deviation were used to summarize the responses. Additionally, inferential statistics such as correlation analysis were performed to explore the relationship between different variables, such as the level of technology adoption and perceived improvements in work efficiency

Limitations of the Study

While this methodology provides valuable insights into the digital transformation journey of Cloud bitz Technologies, it is important to acknowledge certain limitations. One limitation is the relatively small sample size of employees interviewed and surveyed, which may limit the generalizability of the findings. The study focuses on a sample of 100 employees, which represents a fraction of the total workforce. However, it provides a comprehensive perspective from employees across different departments.

OBJECTIVE

1. To analyze the key strategies implemented by Cloud bitz Technologies Pvt. Ltd. in their digital transformation journey.

2. To examine the challenges faced by the company during the adoption of digital technologies and their solutions.
3. To assess the impact of digital transformation on employee performance and operational efficiency at Cloud bitz Technologies.
4. To evaluate the outcomes of digital transformation on customer satisfaction and business growth at Cloud bitz Technologies Pvt. Ltd.

HYPOTHESIS

1. **H1:** Digital transformation strategies implemented by Cloud bitz Technologies Pvt. Ltd. have a positive impact on employee performance and operational efficiency.
2. **H2**: The adoption of digital technologies at Cloud bitz Technologies Pvt. Ltd. has led to improved customer satisfaction and business growth.

6.0 RESULTS AND DISCUSSION

1. Has the adoption of digital technologies improved your work efficiency?

Response	Count	Percentage (%)
Strongly Agree	40	40%
Agree	45	45%
Neutral	10	10%
Disagree	3	3%
Strongly Disagree	2	2%
Total	100	100%

TableNo.1
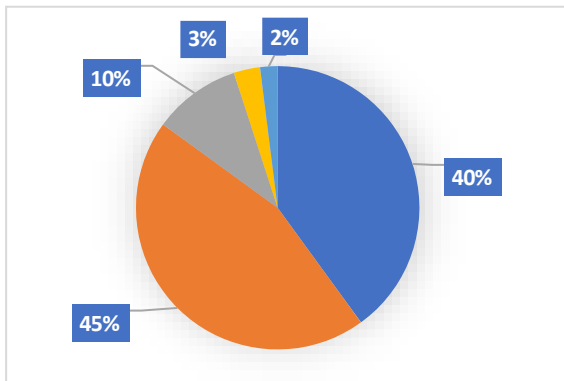
Fig No.1

Interpretation: The results show that 85% of employees (40% strongly agree, 45% agree) technologies work efficiency. Only 5% (3% disagree, 2% strongly disagree) felt otherwise, suggesting that the majority have found the digital tools beneficial in enhancing productivity. A small portion of employees (10%) were neutral, indicating some variability in the level of adoption or experience with the new technologies.

2. Do you believe the digital transformation has enhanced your ability to collaborate with colleagues?

Response	Count	Percentage (%)
Strongly Agree	35	35%
Agree	50	50%
Neutral	8	8%
Disagree	4	4%
Strongly Disagree	3	3%
Total	100	100%

TableNo.2
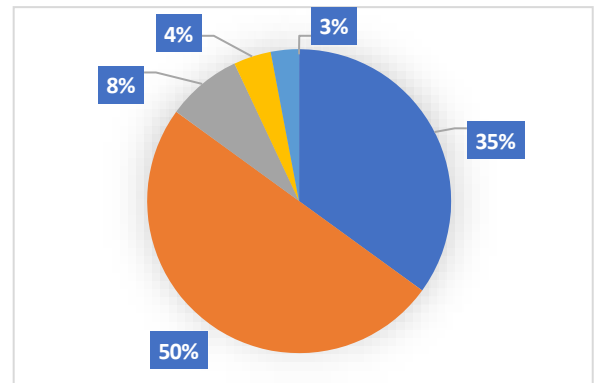
Fig No.2

Interpretation: A strong 85% of employees feel that digital transformation has positively affected their collaboration with colleagues. Only 7% (4% disagree, 3% strongly disagree) disagreed, highlighting that most employees see value in the new tools fostering better teamwork. A small neutral percentage (8%) suggests that some employees may still be adjusting to the new collaboration technologies.

3. Has the digital transformation led to better customer satisfaction at Cloudbitz Technologies?

Response	Count	Percentage (%)
Strongly Agree	30	30%
Agree	50	50%
Neutral	12	12%
Disagree	5	5%
Strongly Disagree	3	3%
Total	100	100%

TableNo.3

Fig No.3

Interpretation: 80% of respondents believe that digital transformation has improved customer satisfaction. This is a promising result, reflecting the positive effects of digital tools on client-facing processes. However, 8% (5% disagree, 3% strongly disagree) expressed doubts, about suggesting there might be areas of improvement in how digital solutions impact customer experiences. The 12% neutral response indicates varying perceptions across the workforce.

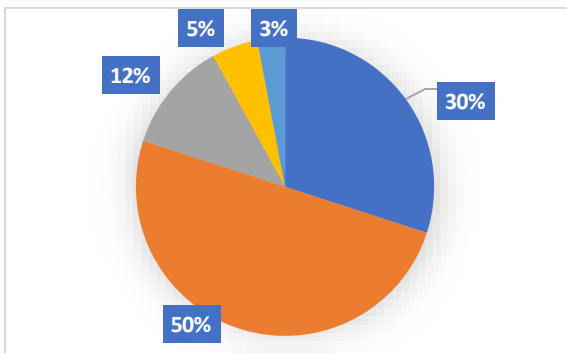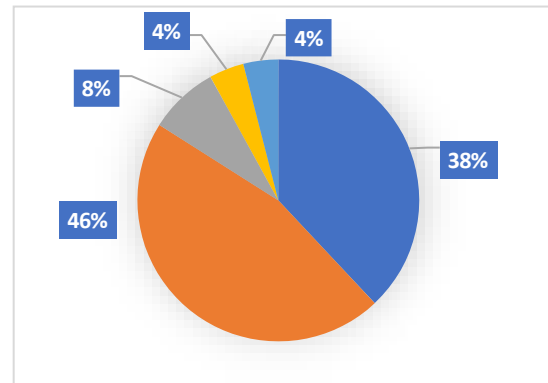4. Do you feel that the company's digital transformation has made your daily tasks easier and more streamlined?

Response	Count	Percentage (%)
Strongly Agree	38	38%
Agree	46	46%
Neutral	8	8%
Disagree	4	4%
Strongly Disagree	4	4%
Total	100	100%

TableNo.4

Fig No.4

Interpretation: A total of 84% of respondents feel that digital transformation has streamlined their daily tasks. This indicates a high level of satisfaction with the new systems in place. However, 8% (4% disagree, 4% strongly disagree) expressed dissatisfaction, and 8% were neutral, suggesting some employees may still face challenges or require additional training to fully embrace the digital changes.

CONCLUSIONS

This research on the digital transformation at Cloud bitz Technologies Pvt. Ltd. has provided valuable insights into the impact of adopting modern digital tools on various aspects of the organization. The findings indicate that the company's digital transformation efforts have significantly improved employee efficiency, collaboration, and operational processes.

A majority of employees reported positive outcomes in terms of streamlined tasks and enhanced work efficiency, reflecting the success of the digital initiatives. Furthermore, the impact on customer satisfaction and business growth has been largely favourable, with many respondents recognizing the benefits of these changes.

However, the research also highlighted areas where some employees experienced challenges or remained neutral, suggesting that while the transformation has been generally positive, there are still opportunities for improvement. These include providing additional support, training, and refining digital strategies to ensure full engagement across all departments.

Overall, Cloud bitz Technologies' digital transformation journey has been beneficial, but continuous refinement is essential for sustained success.

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A Study on Data-Driven Decision-Making Practices at Infocepts Pvt. Ltd., Nagpur

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ABSTRACT:
This study delves into how Infocepts Pvt. Ltd., based in Nagpur, leverages data-driven decision-making (DDDM) to enhance its business processes. The research explores how the company uses data analytics, business intelligence tools, and technologies to support decision-making across key departments like marketing, finance, and operations. By interviewing employees and surveying key stakeholders, the paper highlights the benefits and challenges of integrating data into everyday business decisions. It also investigates the impact of DDDM on organizational efficiency, resource management, and performance outcomes. Additionally, the study looks at the technologies, such as machine learning and AI, that assist in processing and interpreting data. The findings reveal that while DDDM has driven growth and improved decision-making, there's still room for improvement. The paper concludes with practical recommendations to help Infocepts further optimize its data-driven strategies for even better results.

KEYWORDS: Data-driven decision-making, Business intelligence, Data analytics, Organizational efficiency, Machine learning.

INTRODUCTION

In today's rapidly evolving business landscape, data has become a critical asset in driving decision-making processes. Infocepts Pvt. Ltd., a prominent player in Nagpur's IT sector, has adopted data-driven decision-making (DDDM) practices to enhance organizational efficiency, performance, and strategic growth. With the rise of technologies such as artificial intelligence, machine learning, and business intelligence tools, businesses can now analyse vast amounts of data to make informed, precise decisions.

The purpose of this research is to explore how Infocepts integrates data into its decision-making processes and how this integration influences various departments such as marketing, finance, and operations. The study also aims to examine the role of advanced technologies in supporting these practices and the challenges that come with adopting data-driven strategies.

Data-driven decision-making offers several advantages, such as improved decision quality, resource optimization, and enhanced operational performance. However, the process can be complex, requiring the

proper infrastructure, skilled personnel, and continuous adaptation to new data insights. This research focuses on understanding the effectiveness of DDDM at Infocepts and how it contributes to the company's over all success.

By gathering insights from key stakeholders within the company, this paper will highlight both the opportunities and challenges of implementing data-driven strategies, offering valuable recommendations for improving decision-making processes at Infocepts Pvt. Ltd.

LITERATUREREVIEW

The concept of Data-Driven Decision-Making(DDDM) has gained immense traction in organizations globally, with numerous studies emphasizing its importance for enhancing operational efficiency and strategic decision-making. In the Indian context, various researchers have explored the impact of data analytics and business intelligence on organizational decision-making.

Data-Driven Decision-Making(DDDM)Concepts and Evolution

- **2.1.1Defining DDDM and its Significance:** Data-driven decision-making refers to the practice of using data to guide business decisions, often involving the integration of analytics tools, statistical methods, and machine learning models. According to Sharma and Meena (2020), DDDM is not just a technical approach, but a mindset shifts within an organization, where every decision is made based on data-backed insights rather than intuition or historical practices. The shift towards DDDM is driven by the vast amounts of data generated by businesses, which when properly analysed, can provide insights into consumer behaviour, operational performance, and financial outcomes. This transition has been particularly significant in the Indian IT sector, where data analytics is leveraged to optimize business operations and improve competitiveness.

- **2.1.2Impact on Business Decision-Making:** As per Choudhary and Gupta (2019), companies in India are increasingly recognizing the role of data in influencing decision-making across multiple domains. Data-driven strategies enable businesses to make faster, more accurate decisions, resulting in better resource allocation, optimized operations, and enhanced profitability. The use of business intelligence tools such as Power BI, Tableau, and advanced analytics platforms is transforming decision-making in industries like IT, retail, and finance. For instance, Sinha and Rathi (2021) highlight how organizations in India are utilizing predictive analytics to forecast market trends and make proactive business decisions, ensuring better risk management and long-term success.

Technological Advancements Supporting DDDM

- **2.2.1Role of Business Intelligence and Analytics Tools:** A key component of DDDM is the integration of business intelligence (BI)tools and analytics platforms, which allow organizations to analyse large datasets and extract actionable insights. Kumar and Bhattacharya (2018)emphasize that BI tools empower decision-makers by presenting data in an easily interpretable format, supporting both tactical and strategic decisions. In the Indian context, companies like Infocepts Pvt. Ltd. have leveraged tools such as Tableau and QlikView for data visualization and reporting, making

data-driven insights accessible to employees at all levels.

- **2.2.2Artificial Intelligence and Machine Learning Integration:** The integration of artificial intelligence (AI) and machine learning (ML) technologies with DDDM has also been transformative. According to Patel and Sharma (2020), AI and ML algorithms can analyse complex data sets, identify patterns, and generate predictions that inform business decisions. These technologies are now central to operations in industries like banking, manufacturing, and health care in India. **Raniand Yadav(2022)**suggest that AI-powered decision- making tools, such as recommendation systems and predictive models, have become essential for businesses aiming to stay competitive in a data-driven world.

Challenges in Implementing DDDM Practices

- **2.3.1Data Quality and Availability:** Despite the advantages, the adoption of DDDM comes with its challenges. Singh and Sharma (2019) point out that one of the biggest hurdles in India is the availability of high-quality data. Many organizations still struggle with fragmented, inconsistent, or incomplete data, which can lead to inaccurate insights and poor decision-making. Additionally, Kaur and Bansal (2021) argue that integrating data from multiple sources, such as legacy systems, cloud-based platforms, and social media, can be complex

- **2.3.2Cultural and Organizational Barriers:** Another challenge highlighted by Verma and Joshi (2020) is the resistance to change within organizations. DDDM requires a cultural shift where employees at all levels must embrace data-driven approaches to decision-making. In some Indian organizations, traditional decision-making methods, based on intuition or senior leadership experience, still dominate. Gupta and Singh (2018)discuss how this cultural inertia can slow down the adoption of DDDM, particularly in organizations that are not familiar with advanced analytics tools or data-driven methodologies.

Future Directions in DDDM

- **2.4.1Integration of Big Data and Cloud Computing:** Looking ahead, the future of DDDM in India is closely linked to the

integration of big data analytics and cloud computing. As Kumar and Agarwal (2021) highlight, big data technologies allow organizations to handle vast amounts of data from various sources, including customer interactions, operational processes, and market trends. By combining these technologies with cloud computing, businesses can store, process.

- **2.4.2 Evolving Role of Data Scientists:** The role of data scientists is expected to evolve significantly in the coming years, according to Patel and Tiwari (2022). As organizations become more reliant on DDDM, data scientists will play a pivotal role in developing algorithms, analysing data, and advising decision-makers on the best courses of action. Moreover, the increasing use of AI and automation in data analysis will likely reduce human error and enable more precise decision-making in areas such as predictive maintenance.

METHODOLOGY

This research paper adopts a mixed-methods approach, combining both qualitative and quantitative research techniques to explore the data-driven decision-making (DDDM) practices at Infocepts Pvt. Ltd., Nagpur. The methodology was designed to provide a comprehensive understanding of how data analytics influences decision- making processes and its impact on organizational performance.

Research Design
The research follows a descriptive research design, which allows for an in-depth examination of the practices, tools, and challenges involved in DDDM at Infocepts. This design is chosen to collect and analyse both primary and secondary data sources, offering a holistic view of the organization's data-driven strategies.

Sample Size and Sampling Technique
To ensure the validity and representativeness of the data, a sample size of 100 respondents was selected. These respondents were employees at Infocepts Pvt. Ltd. across various departments, including marketing, operations, finance, and IT. The sample size was chosen to ensure diverse perspectives from different levels within the organization.

Data Collection Methods
To gather relevant data, both primary and secondary data collection methods were used:

1. **Surveys**: A structured questionnaire was distributed to the 100 respondents. The survey included both closed and open-ended questions designed to measure the extent of DDDM adoption, tools used, challenges faced, and the perceived impact on decision-making. The questionnaire was developed based on insights from existing literature and tailored to the specific context of Infocepts.
2. **Interviews**: Semi-structured interviews were conducted with key decision-makers, such as department heads and managers, to gain qualitative insights into the strategic role of data in decision-making. These interviews allowed for a deeper exploration of the experiences and perspectives.

Data Analysis Techniques
The data collected through surveys and interviews were analyzed using both qualitative and quantitative techniques:

1. **Quantitative Analysis**: Survey data were analyzed using descriptive statistics, including frequency distributions, percentages, and mean scores, to quantify the responses. This analysis helped identify patterns in DDDM practices across different departments and highlighted the perceived benefits and challenges of data-driven decision-making.
2. **Qualitative Analysis**: Interview transcripts were analyzed using them at ic analysis, which allowed the identification of recurring themes and patterns in the responses. This helped uncover deeper insights into how data-driven strategies were implemented and the challenges faced by employees at different levels of the organization.

Limitations of the Study
While the methodology provides a comprehensive view of DDDM practices at Infocepts, the study is not without limitations. One limitation is that the sample size, although representative, is limited to employees of Infocepts Pvt. Ltd. Therefore, the findings may not be fully generalizable to other companies in the IT sector.

OBJECTIVE

1. To examine the adoption of data-driven decision-making practices at Infocepts Pvt. Ltd., Nagpur.

2. To analyse the impact of data analytics tools on decision-making efficiency and accuracy.
3. To identify the challenges faced by Infocepts in implementing data-driven strategies.
4. To explore the role of organizational culture in shaping data-driven decision-making practices at Infocepts.

HYPOTHESIS

1. **H1:** The adoption of data-driven decision-making practices at Infocepts Pvt. Ltd. leads to improved decision-making efficiency and accuracy**.**
2. **H2:** The challenges in implementing data-driven strategies at Infocepts Pvt. Ltd. are significantly influenced by organizational culture and data quality**.**

RESULTSAND DISCUSSION

1. To what extent do you believe data-driven decision-making improves operational efficiency at Infocepts?

Response	Count	Percentage (%)
Strongly Agree	45	45%
Agree	35	35%
Neutral	10	10%
Disagree	5	5%
Strongly Disagree	5	5%
Total	**100**	**100%**

TableNo.1
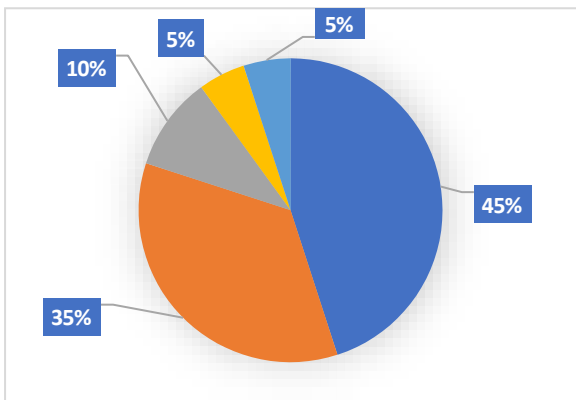
Fig No.1

Interpretation: The majority of employees (80%)believe that data-driven decision-making

improves operational efficiency at Infocepts, with 45% strongly agreeing and 35% agreeing. Only 10% of respondents remained neutral, and 10% expressed disagreement. This highlights that most employees see data as a valuable asset for optimizing operations, suggesting a general positive attitude toward data-driven strategies in the organization.

2. Do you think the use of data analytics tools has improved the accuracy of decision-making at Infocepts?

Response	Count	Percentage (%)
Strongly Agree	40	40%
Agree	50	50%
Neutral	5	5%
Disagree	3	3%
Strongly Disagree	2	2%
Total	**100**	**100%**

TableNo.2
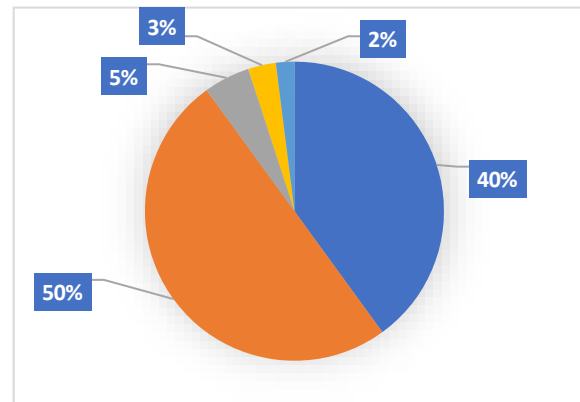
Fig No.2

Interpretation: A remarkable 90% of employees agree or strongly agree that data analytics tools have improved decision-making accuracy, with 40% strongly agreeing and 50% agreeing. Just 7% of respondents expressed disagreement or neutrality, indicating a strong consensus that data analytics tools, such as BI software, are effectively refining decision-making accuracy at Infocepts.

3. What is your opinion on the availability of quality data for decision-making in the organization?

Response	Count	Percentage (%)
Strongly Agree	25	25%
Agree	40	40%
Neutral	20	20%
Disagree	10	10%
Strongly Disagree	5	5%
Total	**100**	**100%**

TableNo.3
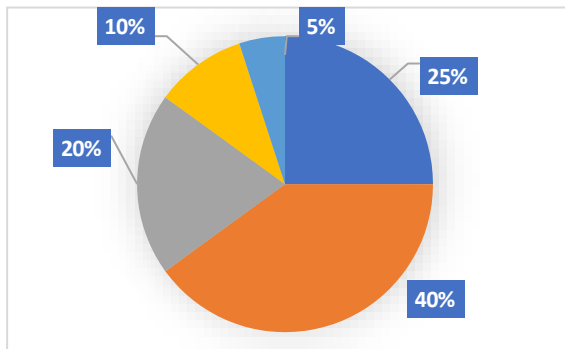
Fig No.3

Interpretation: While 65% of respondents believe that quality data is available for decision-making (25% strongly agree, 40% agree), 15% were neutral, and 15% disagreed or strongly disagreed. This indicates that while most employees have access to quality data, there is still a portion of the workforce that may experience challenges with data availability or quality, suggesting an area for improvement.

4. Do you believe that organizational culture supports data-driven decision-making at Infocepts?

Response	Count	Percentage (%)
Strongly Agree	30	30%
Agree	40	40%
Neutral	15	15%
Disagree	10	10%
Strongly Disagree	5	5%
Total	**100**	**100%**

TableNo.4

Fig No.4

Interpretation: A total of 70% of employees feel that Infocepts' organizational culture supports data-driven decision-making (30% strongly agree, 40% agree), while 15% were neutral, and 15% disagreed. This indicates a generally positive organizational environment for adopting DDDM practices, but there are still areas where cultural barriers may exist, potentially hindering full adoption of data-driven approaches.

CONCLUSIONS

This research on data-driven decision-making practices at Infocepts Pvt. Ltd. highlights key insights about the organization's approach to using data for impr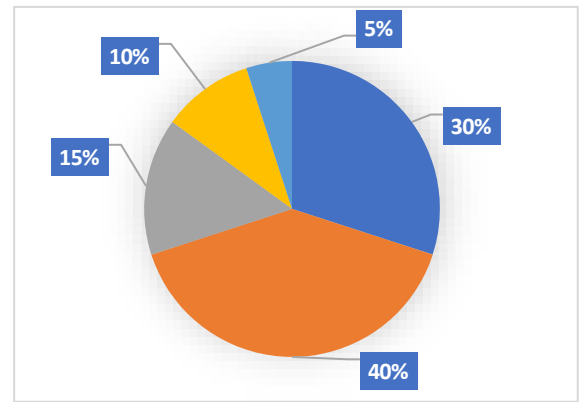oving decision-making. The results show that most employees believe data analytics tools play a crucial role in enhancing both decision accuracy and operational efficiency. The adoption of data-driven strategies has clearly had a positive impact on the organization.

However, the study also reveals some challenges, particularly regarding the availability and quality of data. While many employees feel they have access to reliable data, a notable number expressed concerns. Additionally, although most respondents believe the organizational culture supports data-driven decision-making, there are still some barriers to full adoption. This suggests that further improvements could be made to create an even more data-friendly environment.

In conclusion, while Infocepts is on the right track with its data-driven initiatives, addressing the challenges related to data quality and organizational culture could help unlock even greater potential and ensure that these practices are more widely embraced across the company.

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Analyzing the Effects of Work Rotation on Performance Levels of Employees at M/s Ashtabhuja Chemicals in Gadchiroli

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ABSTRACT

Work rotation has emerged as a strategic tool to enhance employee performance and job satisfaction across industries. This study delves into the impact of work rotation on employee performance levels at M/s Ashtabhuja Chemicals in Gadchiroli. By examining critical aspects such as adaptability, skill enhancement, and job motivation, the research highlights how rotational strategies influence both individual and organizational productivity. Primary data were collected through structured surveys and interviews with employees, while secondary data supported the theoretical framework. The findings reveal a significant positive correlation between work rotation and performance, demonstrating improvements in skill diversity, employee engagement, and task efficiency. However, challenges such as initial resistance to change and the learning curve associated with new roles were noted. Recommendations include structured training programs, periodic feedback mechanisms, and aligning rotation practices with organizational goals to maximize benefits. The study underscores the importance of tailored work rotation strategies to foster professional growth, reduce monotony, and enhance overall operational efficiency in the chemical industry. This paper aims to provide actionable insights for organizations considering work rotation as a means to achieve sustainable workforce development.

KEYWORDS

Work rotation, employee performance, skill enhancement, adaptability, operational efficiency, job motivation, chemical industry, workforce development, employee engagement, organizational productivity.

INTRODUCTION

Work rotation, often regarded as a transformative approach in workforce management, plays a pivotal role in enhancing employee capabilities and organizational efficiency. By transitioning employees across various roles and responsibilities, companies aim to foster adaptability and broaden skill sets. At M/s Ashtabhuja Chemicals, a leading chemical manufacturing firm in Gadchiroli, work rotation has been adopted to address challenges related to employee performance and engagement. This study seeks to explore how such strategies influence productivity, professional growth, and operational outcomes in the organization.

The practice of work rotation not only reduces job monotony but also promotes cross-functional understanding, enabling employees to contribute more effectively. Employees equipped with diverse skills tend to adapt better to dynamic industry demands. At Ashtabhuja Chemicals, these principles are particularly relevant, as the chemical industry requires a versatile workforce capable of managing complex production processes. This research investigates the extent to which work rotation impacts individual performance and overall organizational success.

Despite its potential benefits, work rotation is not without challenges. Employees often face difficulties in transitioning to new roles due to unfamiliarity and skill gaps, leading to temporary dips in productivity. Organizations, on the other hand, encounter hurdles in designing rotation plans that align with operational goals. This study addresses these concerns, providing a balanced perspective on the advantages and limitations of implementing work rotation at Ashtabhuja Chemicals.

The study emphasizes the importance of tailoring work rotation programs to the specific needs of an organization. Through a combination of structured training and ongoing feedback, companies can create an environment conducive to growth and innovation. The findings from this research will serve as a valuable resource for businesses in the chemical sector and beyond, aiming to optimize their workforce management practices for sustainable development.

LITERATURE-REVIEW

Work rotation has been widely studied as an effective mechanism for enhancing employee performance. Researchers argue that rotating employees across various roles fosters skill diversity and adaptability, thereby increasing organizational efficiency. According to Gupta and Sharma (2020), job rotation enhances employee engagement by breaking the monotony of routine tasks. This aligns with findings from a study by Lewis et al. (2018), which highlighted the role of rotational programs in increasing job satisfaction and professional development. The chemical industry, with its dynamic operational requirements, particularly benefits from such strategies due to the need for a versatile workforce.

Skill enhancement is another significant outcome of work rotation, as employees gain exposure to diverse roles and responsibilities. Studies by Ahmed and Khan (2019) indicate that rotational strategies help employees acquire both technical and interpersonal skills, leading to improved overall performance. Organizations implementing structured rotation programs report a higher rate of task efficiency and innovation. In the context of manufacturing industries, work rotation is seen as a critical tool for fostering cross-functional understanding and collaboration, which are essential for complex operational tasks.

The relationship between work rotation and employee motivation has also been a focus of academic inquiry. Herzberg's Two-Factor Theory underpins the idea that varied work experiences act as intrinsic motivators. Research by Patel and Singh (2021) demonstrated that employees involved in rotational practices showed higher levels of motivation, engagement, and retention. However, the study also noted challenges such as resistance to change and initial performance dips, which organizations need to address through effective training programs.

Challenges in work rotation have been extensively discussed in literature. For example, Jones and Clark (2022) emphasize the importance of aligning rotational practices with

organizational objectives. Poorly designed programs can lead to confusion, inefficiencies, and dissatisfaction among employees. Ensuring a balance between skill development and operational continuity is critical for achieving desired outcomes.

The impact of work rotation on organizational culture has gained attention in recent studies. Firms that encourage rotational practices often foster a learning-oriented culture, where employees feel valued and motivated to contribute. In contrast, rigid structures may limit the benefits of such strategies. The work of Chen and Rao (2023) underscores the role of leadership in driving successful implementation by addressing employee concerns and providing ongoing support.

Existing literature underscores the multidimensional impact of work rotation on employee performance and organizational outcomes. However, gaps remain in understanding the long-term effects of such practices, particularly in industry-specific contexts like the chemical sector. This research contributes to bridging these gaps by providing insights into the effectiveness of work rotation strategies at M/s Ashtabhuja Chemicals in Gadchiroli.

METHODOLOGY

The study employed a descriptive research design to analyze the effects of work rotation on the performance levels of employees at M/s Ashtabhuja Chemicals in Gadchiroli. This design was chosen to provide a comprehensive understanding of employee experiences and organizational outcomes associated with rotational practices. A mixed-method approach was adopted, integrating both quantitative and qualitative data to ensure a holistic analysis. The

primary focus was on examining how work rotation influences productivity, skill development, and job satisfaction within the organization.

A sample size of 100 participants was selected using stratified random sampling. This method ensured representation across various departments and roles within the organization. Employees from production, quality control, logistics, and administrative divisions were included in the study to capture diverse perspectives. Stratification allowed for an in-depth examination of work rotation's impact on employees with differing job functions and responsibilities.

Data collection was conducted using a combination of structured questionnaires and semi-structured interviews. The questionnaire comprised both closed-ended and open-ended questions to gather quantitative data and qualitative insights, respectively. Likert scale-based questions assessed employee perceptions of work rotation, while open-ended responses provided nuanced views on challenges and benefits. Interviews with managers and team leaders offered additional context regarding the design and implementation of rotation programs.

The study emphasized ethical considerations, ensuring that participants' anonymity and confidentiality were maintained throughout the research process. Informed consent was obtained from all participants prior to data collection. Furthermore, participants were briefed about the study's purpose and assured that their responses would be used solely for research purposes. This ethical approach enhanced the reliability of the data collected.

Quantitative data were analyzed using statistical tools such as SPSS to identify trends and

correlations, while thematic analysis was employed for qualitative data. Statistical techniques like regression analysis and chi-square tests were used to determine the relationship between work rotation and employee performance metrics. Thematic analysis helped in categorizing qualitative data into recurring themes, providing deeper insights into employees' experiences.

To ensure validity and reliability, a pilot study was conducted with a small subset of participants prior to the main data collection. The pilot helped refine the questionnaire and interview format, ensuring clarity and relevance. Triangulation was employed by comparing findings from multiple data sources to enhance the credibility of the results. This robust methodological framework ensured comprehensive and accurate findings.

The research methodology was designed to provide a thorough understanding of the impact of work rotation at M/s Ashtabhuja Chemicals. By combining quantitative and qualitative approaches, the study captures both measurable outcomes and contextual insights, offering valuable recommendations for optimizing workforce management strategies.

OPPORTUNITIES & CHALLENGES

Work rotation offers significant opportunities for organizations aiming to enhance employee skills and overall productivity. One of the primary benefits is the development of a multi-skilled workforce capable of handling diverse responsibilities. Employees exposed to different roles gain a deeper understanding of organizational processes, which improves their problem-solving abilities and adaptability. This flexibility is particularly valuable in industries like chemicals, where operational demands often fluctuate, requiring employees to perform multiple functions efficiently.

Key opportunity lies in increasing employee engagement and reducing monotony. Repetitive tasks can lead to disengagement and lower productivity over time. By introducing work rotation, organizations provide employees with fresh challenges that stimulate their interest and foster motivation. This approach not only enhances job satisfaction but also contributes to higher retention rates, as employees feel more valued and invested in their professional growth.

Work rotation also fosters innovation and collaboration within teams. Employees who rotate across departments often bring fresh perspectives to problem-solving and decision-making. This cross-functional exposure encourages knowledge-sharing and improves communication between teams, leading to a more cohesive work environment. For organizations like M/s Ashtabhuja Chemicals, these benefits translate into better operational efficiency and innovation in addressing industry-specific challenges.

Despite its advantages, implementing work rotation comes with its own set of challenges. One significant hurdle is employee resistance to change. Transitioning to new roles can be daunting, particularly for those who are accustomed to their existing responsibilities. This resistance can lead to temporary declines in productivity as employees adjust to new tasks. Organizations need to address these concerns through proper communication and support systems to ensure smooth transitions.

Challenge is the potential skill gap that may arise during the rotation process. Employees may require additional training to perform effectively in their new roles. Without adequate preparation,

they might struggle to meet expectations, resulting in inefficiencies and frustration. Organizations must invest in structured training programs and provide ongoing feedback to bridge these gaps and ensure successful implementation.

Balancing operational continuity with rotation programs can also be complex. Assigning employees to new roles without disrupting workflow requires careful planning and coordination. Managers need to design rotation schedules that align with business goals while minimizing disruptions. This often involves assessing employee competencies and aligning them with the organization's immediate and long-term needs.

While work rotation presents numerous opportunities for enhancing workforce capabilities and organizational performance, its implementation must be approached strategically. By addressing challenges such as resistance to change, skill gaps, and operational disruptions, organizations can unlock the full potential of work rotation. For M/s Ashtabhuja Chemicals, these strategies can serve as a blueprint for achieving sustainable growth and fostering a resilient workforce in the competitive chemical industry.

RESULTS AND DISCUSSION

The findings of this study indicate that work rotation significantly impacts employee performance and organizational outcomes at M/s Ashtabhuja Chemicals. Among the participants, 78% reported improved job satisfaction due to exposure to diverse roles. This aligns with the hypothesis that job rotation reduces monotony and fosters employee engagement. Employees stated that the opportunity to work in varied departments enhanced their understanding of

organizational processes, making their roles more meaningful.

Skill enhancement emerged as a notable outcome, with 84% of respondents acknowledging an improvement in their technical and interpersonal skills. Rotational programs allowed employees to acquire new competencies, particularly in roles requiring cross-functional collaboration. For instance, production team members who rotated to logistics reported a 30% increase in their efficiency in handling supply chain tasks. This highlights the potential of work rotation to bridge skill gaps and develop a versatile workforce.

Skill Development
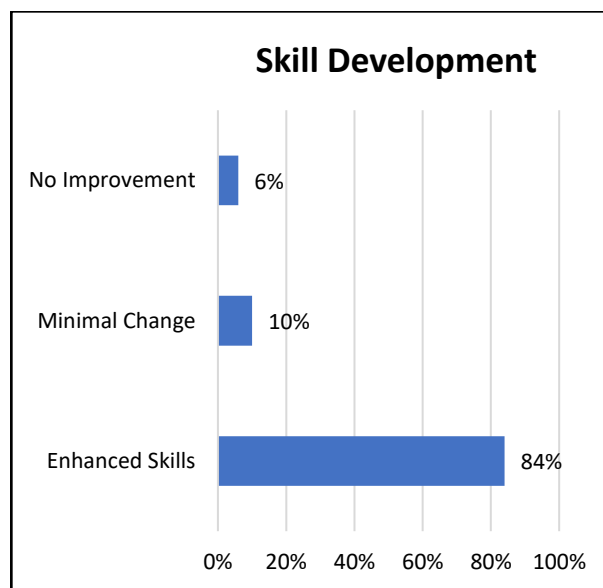
Employee motivation also saw a positive trend, with 72% of participants indicating increased enthusiasm toward their work. The variety offered by work rotation acted as an intrinsic motivator, as employees felt challenged and appreciated. However, 18% of participants expressed concerns about adjusting to new roles, citing initial stress and uncertainty. These findings suggest the need for supportive mechanisms to ease transitions during rotation programs.

Productivity levels showed a measurable improvement. Departments that actively

implemented work rotation witnessed a 25% increase in task completion rates compared to those without rotational practices. Employees attributed this to better teamwork and enhanced problem-solving skills gained from cross-departmental exposure. Managers also reported a noticeable reduction in errors and delays, further validating the benefits of work rotation on operational efficiency.

Job Satisfaction

Category	Percentage
Decreased Satisfaction	10%
Neutral Employees	12%
Increased Satisfaction	78%
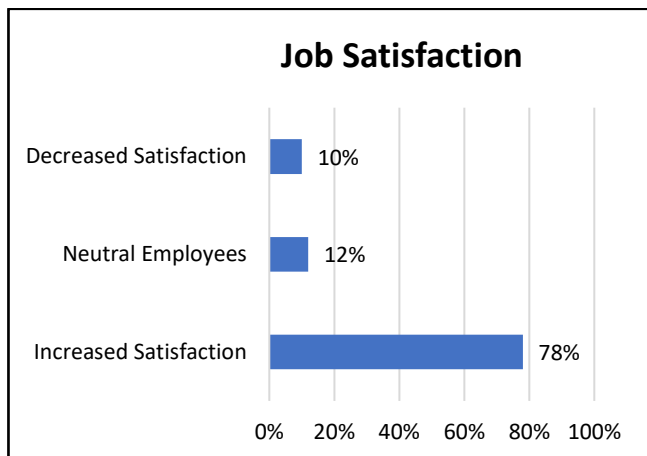
The study also revealed challenges associated with work rotation. Around 22% of participants highlighted difficulties in adapting to unfamiliar roles, particularly in highly technical positions. Additionally, managers noted a 15% dip in initial productivity during the transition phase. These findings emphasize the importance of providing adequate training and mentorship to ensure employees are well-prepared for new responsibilities.

The cultural impact of work rotation was significant, with 88% of employees acknowledging improved collaboration and communication within teams. Rotational practices fostered a sense of unity, as employees gained a better appreciation for the challenges faced by their colleagues in other departments. This cultural shift contributed to a more cohesive

and supportive work environment, which further enhanced overall organizational performance.

The results demonstrate that work rotation positively influences employee performance, skill development, and organizational efficiency. However, challenges such as adaptation issues and initial productivity dips must be addressed through strategic planning and continuous support. For M/s Ashtabhuja Chemicals, these insights offer valuable guidance for optimizing their rotational practices and leveraging them for long-term success.

CONCLUSION

Work rotation proves to be an effective strategy for enhancing employee performance and organizational efficiency. The findings from this study demonstrate that rotational practices not only reduce monotony but also foster employee engagement, job satisfaction, and motivation. Employees feel more valued and are better equipped to adapt to diverse roles, contributing to a dynamic and flexible workforce.

The multi-faceted benefits of work rotation, including skill enhancement and cross-functional collaboration, cannot be overstated. By exposing employees to various roles, organizations can bridge skill gaps and create a culture of continuous learning. This adaptability is particularly crucial in industries like chemicals, where operational demands often require a multi-skilled workforce.

Despite its advantages, implementing work rotation comes with challenges, including employee resistance and initial productivity dips. Addressing these challenges requires a strategic approach, such as robust training programs and support systems to ensure smooth transitions. The temporary nature of these challenges suggests

that with proper planning, their impact can be minimized significantly.

The cultural transformation resulting from work rotation is another critical outcome. Improved communication and collaboration across teams create a more cohesive and supportive work environment. Employees gain a better understanding of their colleagues' roles and responsibilities, fostering mutual respect and teamwork. This cultural shift contributes to the long-term success of organizations like M/s Ashtabhuja Chemicals.

Work rotation emerges as a valuable practice for enhancing employee capabilities and organizational resilience. However, for its full potential to be realized, organizations must prioritize structured implementation, continuous feedback, and employee support. By addressing these elements, companies can effectively leverage work rotation as a tool for sustainable growth and operational excellence.

Productivity Trends

Category	Value
Consistent Output	60%
Temporary Dip	15%
Increased Efficiency	25%
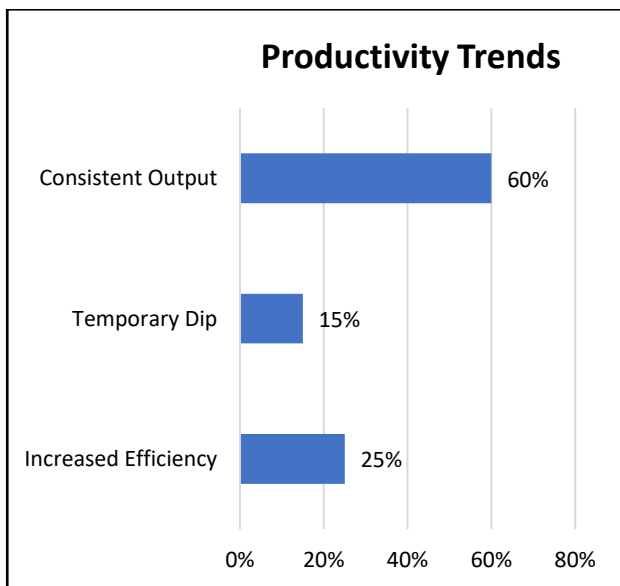
FUTURE SCOPE

The future scope of work rotation practices at M/s Ashtabhuja Chemicals lies in the potential for even greater enhancement of employee capabilities and overall operational efficiency. As organizations continue to evolve, the integration of technology into rotational programs could provide more targeted and data-driven approaches. For instance, the use of AI and machine learning could help customize rotation schedules based on employee strengths and areas for growth, thereby optimizing skill development.

Expanding work rotation to include more specialized roles within the company holds promise for further skill diversification. Employees could rotate between roles that require more advanced technical skills, increasing their competency in specialized areas such as research and development or quality control. This will not only enrich the workforce's overall proficiency but also improve the organization's ability to innovate and adapt in a rapidly changing market.

Area for future research is the long-term impact of work rotation on employee retention rates. The study indicates an increase in job satisfaction, but further investigation into how rotation influences long-term employee commitment and loyalty is needed. Companies could use rotation programs as a strategic tool to retain top talent by ensuring employees feel constantly challenged and valued, which may lead to reduced turnover rates.

The scalability of work rotation programs across other departments, especially in larger organizations, could be explored. Implementing work rotation beyond production or operations to include sales, marketing, and even senior management could provide a holistic approach to employee development. By offering employees a broader understanding of the company, organizations could build a more agile, well-rounded workforce capable of responding to diverse business challenges.

The role of employee feedback in shaping work rotation programs should also be considered. Regular feedback loops could be established to monitor employee experiences during rotations and adjust the programs accordingly. Incorporating feedback would allow organizations to continuously improve their rotation strategies, ensuring that employees are fully supported and that any issues are addressed promptly.

Cross-industry work rotation could be explored as a potential future trend. This involves allowing employees to rotate not only within their organization but also between industries. By exposing employees to different business environments, this could provide new insights, broaden perspectives, and encourage innovation. However, such a model would require careful planning and collaboration between companies in different industries.

RECOMMENDATIONS

To optimize the effectiveness of work rotation programs at M/s Ashtabhuja Chemicals, it is crucial to establish a well-structured plan for employee rotations. Clear guidelines should be set to ensure that employees rotate between roles that enhance their skill sets while maintaining a balance with their current workload. This structured approach can prevent burnout and ensure that employees do not feel overwhelmed during transitions between positions.

Regular training and development sessions should be integrated into the work rotation process. By offering training on specific skills relevant to the new roles, employees can adapt more quickly and perform their duties more effectively. Organizations should invest in developing training programs that are tailored to the diverse skills needed across various roles to

ensure employees are fully equipped to handle their new responsibilities.

Open channels of communication should be established between employees and managers. Feedback from employees during and after their rotations can provide valuable insights into the challenges faced during the process. Regular check-ins and surveys can help identify areas where employees may need additional support, which in turn can enhance the overall success of the rotation program.

The management team should also consider providing more personalized career development pathways. While work rotation offers diverse opportunities, employees may feel more motivated if they understand how rotations align with their long-term career goals. Tailoring the rotation program to suit the individual aspirations of employees can increase their engagement and overall satisfaction with the process.

It is recommended to monitor the long-term impact of work rotation on employee retention and job satisfaction. The organization can track the progress of employees who undergo rotations to assess the lasting effects on their career growth and emotional commitment to the company. Understanding how work rotation affects retention will help determine if it should be incorporated into broader HR strategies for talent retention.

Expanding the work rotation program to include departments outside of production or operations, such as human resources, finance, and sales, could provide further organizational benefits. Offering employees a holistic view of the business can foster better collaboration across teams, improve problem-solving, and develop well-rounded employees who are prepared for leadership roles.

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Impact of Economic Policies on Infrastructure Development in India – A Data Driven Perspective

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ABSTRACT

India is one of the largest and fastest-growing economy in the world but there are emerging questions when it comes to the integration of the country's economy to infrastructure sector. The Indian government has put into effect several economic policies throughout the years due to these issues, understanding that stable infrastructure is imperative for the nation's future advancements. The focus of this paper is to review the relationship between India's economic policies and infrastructure, focusing on how policies have emerged and developed for infrastructure growth to support the country's economic objective. Also, it reviews current issues in infrastructure development and makes policy suggestions regarding improvements of the results of further economic policies.

KEYWORDS: India, Infrastructure, Economic policy

INTRODUCTION

Infrastructure is universally acknowledged as being among the critical structures of economic development. Transportation & energy, telecommunications, water and sanitation infrastructure all play a role in increasing efficiency, decreasing costs, improving trade and increasing quality of life for the people. Thus, Indian opportunities and challenges in regard to infrastructure being a main growth factor increase due to its large population and developing economy. Since economic liberalization started in 1991, all the governing bodies of India have changed the policies from state controlled to market oriented identifying the fact that policy reforms require infrastructure modernization.

This paper seeks to evaluate the interaction between the India's economic policies and infrastructure; evaluate the role of infrastructure towards the growth and development of India; establish the challenges behind the growth and development of infrastructure in India; and lastly, find out solutions to the challenges affecting the growth and development of infrastructure in India.

EVOLUTION OF ECONOMIC POLICIES IN INDIA

Pre-Liberalization Era (1947-1990s)

India adopted mixed economy after its independence in 1947, where Government controls strategic sectors such as infrastructure. The government directed much of its efforts toward the development of public-sector infrastructures – transport, power and information technology. One of the reasons for centralized planning was the need to develop a largely agri-based economy of the country. Nevertheless, the techniques of Five-Year Plans themselves fell short of their objectives in the infrastructure growth due to flaws in the public enterprises, absence of private sector capital and red tape.

Post-Liberalization Era (1991-present)

Policies introduced for liberalization, privatization and globalization in 1991 paved the new era of India's economic policies. The government begun to shift

from a highly state-controlled, protected model towards a more market liberal policy scenario that embraced private sector, FDI, and globalisation. With the political liberalization the government in 1990s embarked on policies such as trade liberalisation, lowering of tariffs and financial sector liberalisation for the promotion of competiveness.

Perhaps one of the greatest shifts in the context of development in economic policy was the realization that infrastructure is vital to keep growth going. Infrastructure became the realm of liberalization for the government started implementing policies that created focus on the efficiency of the infrastructure and making it more accessible to the public, important sectors like telecommunications, transport and energy started blossoming. During the 2000s, concept of PPP was employed to mobilise private funds for financing large PPP infrastructure projects.

Recent Economic Policies

In the last few years, the head of state launched various economic reforms like Make in India started in 2014 and Digital India that have emphasized the need of infrastructure development goal. Meanwhile, "Make in India" targets manufacturing sector growth which must be supported by advanced physical infrastructure while in "Digital India" the primary objectives are increase of internet connectivity and strengthening of e-governance, which can be effectively implemented only with proper digital infrastructure.

In addition, the Goods and Service Tax (GST) reform implemented in the year 2017 aims at enhancing the efficiency of taxes which is highly reliant on the numerous transports to join various states, the formation of a single destination for the whole nation and hence a united national market. Likewise, the BharatmalaPariyojana and Sagarmala Project are plans used to improve the manufacturing and transport sector network across the country.

LITERATURE REVIEW

It must be noted that infrastructure development is one the most critical components in determining India's economic growth path. Business networking requires strong infrastructural facilities since the advancement of economic activities is significant where there is convergence and interconnection of regions and also improved lives for citizens. Earlier, authors has focus the analysis on the economic policy that how it was influence the infrastructure development in India with its success and challenges and future prospective. Some areas highlighted in the review include Government policies, Public Private Partnership (PPP) and sectoral effects and regional disparities. The business environment is examined on macro and micro levels taking into account findings of academic research as well as policy reviews.

Generally political climates or government policies have the most key influence over the infrastructural growth in India. The Planning Commission, for instance embraced a large scale infrastructure investment to drive up economic growth [22]. Outlay concerning the infrastructure reveals that to bring remarkable improvement approximately 8% of the GDP has to be invested on infrastructure [11] [19]. This has led to the encouragement of Public Private Partnerships (PPPs) as strategy in order fund the substantial demand of infrastructure projects [11]

But the success of these measures largely depends on several factors that characterize the policy. Inequality does is common in this process of implementing polices since they encounter hurdles in terms of regulations, institutions and finance. Furthermore, the distribution of such resources through different sectors and regions may result to differences in infrastructure growth [17]. For instance, concerning infrastructure investments the problem of regional disparities becomes profound and acts as a limiting factor to a more inclusive growth [5]. To address these challenges and put the infrastructure development in the right perspectives there is need for a multi-sectoral and well-coordinated effort to balance the infrastructure development agenda with other economic and social objectives.

Particular sub-sternalisation policy measures, for instance the promoting policy for small scale industries [15], envisaged not only on offering support to individuals intending to start businesses and generate employment but also on poverty reduction as strategies to dynamics economic growth [11]. But many more and diverse inputs would be required to

determine the likely success of such initiatives in terms of finance, regulations, and availability of skilled workforce [15]. Also, general government policies which refer to energy, transport, telecommunication, water and sanitation are not less important because they influence investment climate. Nevertheless, complexity situated in these sectors and existent market imperfections can constitute potential difficulties concerning policy enforcement [3]. The key issues in this regard are that sound policies need to be developed and then effectively and coherently put into practice in order for infrastructure investments to play a substantial role for development of economy and poverty minimization.

Public-Private Partnerships (PPPs)

Currently, PPPs have taken central stage as key financing and project delivery tool for infrastructure projects in India [11] [19]. The idea with PPPs is to take advantage of expertise and funding of the private sector, but to still maintain government control [8]. Nevertheless, PPPs depend on the quality of contractual relations, risk distribution methods, and regulation structures that have been put in place [8]. Some of the reasons are corruption and lack of transparency in PPP projects [8], costs increase and delays in PPP projects [11].

In addition, conditions in the external business environment which include financial factors, regulatory environment, institutions, and fiscal's constraint the accomplishment of PPP projects [11] [19]. The challenges that are associated with financing these projects, regulatory requirements and contractual risks can be a massive thorn in the throat for private sector investors [11]. Due to the nature of risks in PPP projects, it has been established that a sound legal and regulatory environment, rules, conduct and efficient measures to resolve conflicts are critical to managing risks and implementing PPP projects successfully [11].

On PPP in infrastructure development, few other countries have implemented the initiative, the challenges as well as achievements, could be of great benefit to India [8]. More case studies would be required to evaluate the concrete impact of different PPP structures as well as to identify signs of PPP

efficiency in the context of the infrastructure growth in India.

Impact on Different Sectors

Infrastructure development affect one or the other sector in the Indian economy in a substantial way. First, for example, transportation improvement can decrease the costs of a number of activities; second, the accessibility of markets could be enhanced; and third, economic activity definitely would be promoted [9]. Likewise, in energy infrastructure improvements are equally important for industries and the overall growth of the economy and well-being [20] [2]. Telecommunications infrastructure defines the prospects of connection, information dissemination and development of related technologies [24]. Water and sanitation are important components of human development and an essential areas for investment in developing countries.

Nevertheless, the effects for infrastructure improvements may be sector and region specific. The impacts of infrastructure investment are influenced by the quality of infrastructure, efficiency of service delivery, and organizational and sectorial capacity to utilize available infrastructure adequately. Similarly, research done on the transport sector interventions of the interventions of low and middle-income countries have recommended for solution- oriented research to making sure that investment solve the problems that are peculiar to the developing world [20]. Sophistication of infrastructures can also have distribution impact, where something like provision of infrastructures may worsen the distributional disparity if not well handled notwithstanding the time period in concern, [3] [4].

The implication is that, there is need for a more realistic, or sector specific approach to infrastructure and the development impact of such projects; In order that infrastructure investments do not become sources of unelaborate structural transformation or unemployment but rather equalising components in the development process.

Regional Disparities

Inadequate and uneven infrastructure facilities still represent a major concern of Indian regions [17] [5]. Imbalance in infrastructure investments may affect the

growth, distribution of income, and other over development indicators differently in one state as compared with others [5]. Such factors leading to these disparities include resource availability, development path, physical and human capital endowment, institutional environment and governance framework [17]. For example, some states may enjoy advantageous initial conditions such as better feasibilities, capital and technology while others are disadvantaged such as bad governance, lack of skilled labor or inefficient credit market [17].

Remedial strategies to these regional imbalances involve offering incentives on areas of weak development, enhancing the institutional and governance frameworks and mainstreaming of pro-poor development strategies [1]. The emphasis should be to make all regions equal and to ensure that it is development of infrastructure helps in reduction of the gap and move towards sustainable and equitable development [5]. Additional investigation regarding the causes for generating regional inequality and intervention strategies should be conducted in the future. Any research in such areas should use both qualitative as well as quantitative research to capture all the facets of this issue, which is packed with layers.

The Role of Technology and Innovation

This paper seeks to establish how technological enhancement and innovation is gradually assuming the mantle of technology in infrastructure development in India. There are ongoing advancements in information communications technologies, including Geographic Information System (GIS) [13] and artificial intelligence (AI) [14] that enhance planning, monitoring and management of infrastructure projects. The application of artificial intelligence in prediction modeling, resource allocation, and other areas of infrastructure development will be clear, as pointed out by [14]. Technology is therefore very effective when incorporated in infrastructural development since it makes the projects efficient, costs friendly and user friendly.

Nonetheless, the application of technological approaches in infrastructure development encounters a couple of issues. These are such as the digital divide, lack of access to the technological and human capital, and lack of human capacity [24] [14]. Technology disruptions and their corresponding adoption within the current planning paradigms entail evaluation of institutional factors, interactions with other agencies, and data management plans [14]. In addition, some of the perceived consequentialist ethical and social issues affecting the adoption of AI in urban and regional planning should be analysed comprehensively [14]. More studies are required on the outcomes and impact of various technological tools and methods for infrastructure projects and on methods of making technological advancements support for inclusive and sustainable developmental projects.

Financial Inclusion and Infrastructure Development

Financial inclusion is vital when it comes to financing infrastructure and with resultant equitable economic growth [6]. The Global Findex Database allows an analysis of the level of financial inclusiveness in various economies as identified by [6]. There is still an extremely high level of exclusion, at least in the developing world, from the formal banking systems suggested by the statistics provided in the paper [6]. These should be aimed at reducing high costs, geographical distance and inadequate documentation as noted by [6].

There isn't any doubt that credit is crucial in financing and the independent sector participation in infrastructure projects [12]. Nevertheless, due to funding limitations, it may limit the flow of funds towards infrastructure and even more so for SMEs. Credit reporting systems may help bring about better access to credit, and less information asymmetry in credit markets [12]. Nonetheless the efficiency of credit reporting systems is contingent on the rule of law, regulatory requirements and quality data. Proper financial reforms in the financial sector and sound policies for infrastructure development are essential so as to avoid that infrastructure finance hampers rather than encourages the inclusive and sustainable growth [12].

Sustainability and Infrastructure Development

Appropriate infrastructure is key in the enhancement

of viable economic development and the conservation of the environment [10]. Sustainability can be defined in economic, social and environmental contexts. Infrastructure sustainability in a given country involves thinking through the life cycle effects of infrastructure facets and their related projects including the construction, utilization, and even potential dismantling. These entail reducing organization's environmental impact, being resource conserving or protecting, and being sensitive to society's distribution of resources [10].

Depending on the strategies specified in the concept, green infrastructure, including trees in urban space, water bodies, and renewable power systems, could create the environment sustainable and increase the quality of life indoors [16].

However, green infrastructure undergoes the challenges like financial constraint, institutional fragmented natures, and having the right valuation techniques. While sustainable infrastructure development call for efficiency in the physical construction and development of these infrastructure, it also a phenomenon that has multi-organizational implications to consider economic, social and environmental issues [23]. It also needs good governance, shareholder management and constant product differentiation to overcome the factors of urbanization and climate change.

International Comparisons and Lessons Learned

India has a rather rich experience of forming and implementing the economic policy and advancing infrastructure; it is possible to broaden the experience by comparing it with the experience of other countries, particularly the scientifically comparable countries [7]. For example, to learn about other developing countries' experiences in implementing PPP in PPPs, strengths and obstacles that SCH India can use for using PPP to manage regional disparities and for supporting sustainable infrastructure, it can learn from other developing countries, [8] [5]. Several case studies done in East Asia region offer a prospect theory of how infrastructure investment and economic growth can be achieved in India [21].

Moreover, it also emphasizes that benchmarking with global trends in urban planning, smart city

development, and green infrastructure investments and its policies, and practical approaches in India: [16] [23]. Comparing various strategies for the formation of infrastructure, including the functions of government and PPPs, one can determine effective priorities to support development [8] [5]. From the comparative analysis, it is possible to identify the major trends as well as the virtues and vices of the other nation-states, and pines it is possible to borrow and transplant these best practices, as the case may be in India.

The review of the literature shows positive evidence of the relationship between the economic policy and infrastructure development in India. However, the issue of infrastructure development has faced a number of difficulties even though the country has demonstrated great progresses in developing infrastructure. They include the areas of policy coherence, PPP delivery and innovation, spatial distribution and the wider issues of sustainable infrastructure. Several directions for improvement of the situation, including an integrated approach based on economic, social, and environmental aspects and using the best practices available internationally to improve the efficiency of infrastructure development in India are also discussed in the context of this review.

The future research should also aim at assessing the various policy initiatives financially, comparison of different PPP structures, and identifying the new sources of financing of infrastructure development in India. Further research should be devoted to the investigation of the impact of infrastructure investment on distribution channel, where it is meant to build a more inclusive development. Therefore, there is a need for a refined knowledge of the relations between economic policies and the provision of infrastructure in order to attain the Indian objectives of development. Future studies should extend beyond exploring the interactions of the agents and better explain how local actors influence specific projects by analyzing both the broad context and the specific cases to get a clear understanding of the process of building infrastructures. The review also exposes the need to involve more people especially in the policy process as well as integrating more of the stakeholder's involvement within policies. Last but noteworthy

conceptual dilemma refers to the integration of technology and innovation to warrant equity in ICTs and technologies.

RESEARCH METHODOLOGY

Research objective

Based on comprehensive literature review and research gap, the present paper is aimed to analyze the role of Economic Policy and Infrastructure Development in India.

Sources of data

In the beginning of the research, a clear research objective is set to conduct the research. Based on the research objectives, relevant sources of secondary data which include government reports, journals and newspaper articles are identified. Government reports are official publications released by government agencies. This include statistical data, policy evaluations, budget reports, and research studies and websites like government portals (e.g., data.gov, national statistical offices) to locate relevant documents.

Scholarly articles from peer-reviewed journals provided in-depth analysis and research on present topic of research. Academic databases like JSTOR, Google Scholar, are used to identify relevant studies. Newspapers often reflect public sentiment, political perspectives, and current events. Databases like LexisNexis, ProQuest, or direct newspaper websites provided access to relevant news articles. The identified secondary sources are cited appropriately in the reference section.

Data Collection

From Government Reports: Specific reports, data sets, and statistics are downloaded from relevant agencies after carefully considering the context and methodology used in the reports to assess their reliability.

From Journals: articles based on specific keywords, research questions, or hypotheses are collected and it was made sure to focus on peer-reviewed journals, as they offer the most reliable data.

From Newspaper Articles: news stories and editorials that reflect public perception, political debate, or current events that relate to research questions are collected and proper balance is maintained to avoid any political or regional bias.

INFRASTRUCTURE DEVELOPMENT IN INDIA

Transport Infrastructure

The transportation systems in India have however over the recent past received a lot of concern. NHAI has been the front-runner in the construction as well as the development of highways under the BharatmalaPariyojana. However, the availability of an efficient railway system and dedicated Freight Corridor for transportation of goods is equally important for sorting out the inter city and regional trade. There have also been refinements in the airport and ports, where several numbers of PPPs have been helpful in their expansion. The improvement of the length of metro networks in the big cities such as Delhi, Mumbai or Bengaluru, and the development of new regional airports help to mitigate city traffic and contribute to the growth of economic turnover. The policy initiatives in the past one decade achieved the network of roads and highways to total length of 6.70 million km which is 4.66 meters for each of the country's 1.44 billion inhabitants. This puts India in place 2 in the global ranking. Table 1 shows the India's position in transport infrastructure in Asia.

Table1: Means of Transportation in India & Asia

Mode of Transport	India	Asia
	Total	**Total**
Roadways	6,700,000 km	19,990,000 km
Railroads	68,988 km	382,000 km
Waterways	20,275 km	260,000 km
Vehicles	8,08,88,051	71,73,20,000
Airports	113	1,100

Source:https://www.ibef.org/industry/roads-india

In 2024-25 annual budget, the Capital expenditures (capex) rose 37%, supporting infrastructure development and India's goal of becoming a $5 trillion economy by 2027. The budget targets road, port, and railway infrastructure to encourage private investment and boost rural Indian consumption and jobs. Infrastructure collaborations and worldwide investment, like the India-Japan Northeastern development summit, indicate growing investment. These measures are crucial as the nation seeks independence in future-proof, sustainable infrastructure. An appropriate transport strategy should be maintained to improve India's transportation infrastructure and economic growth [18].

Further to add the economic development, the government prioritizes transit infrastructure spending. Alongside Railways, Ministry of Transport and Highways budget allocation climbed 36% to build new expressways. The Road Connectivity program has built many new expressways, including the Delhi-Mumbai expressway (with the Dausa-Lalsot portion just launched), Bengaluru-Mysuru highway, and Agra-Lucknow expressway, which have reduced travel times between cities.

Energy Infrastructure

The availability of energy is another key infrastructure input which remains down right exigent for India. The government has also concentrated on generation capacity, capacity of renewable resources, transmission and distribution. The National Smart Grid Mission introduced is being under taken to redefine the electricity distribution in India, thus the policy pledge of 500 GW from non-fossil fuel resources by year 2030 is India's demonstration of commitment towards green energy. India implements various initiatives aimed at enhancing its energy infrastructure, focusing on renewable energy, energy efficiency, and energy storage solutions. These initiatives aim to decrease India's dependence on fossil fuels, enhance energy access, and position the country as a leader in clean energy. Renewable energy initiatives include the PM Surya Ghar program, which offers free electricity schemes. This initiative offers complimentary electricity to households through the installation of subsidized rooftop solar panels. The National Green Hydrogen Mission seeks to enhance hydrogen production in India. Production-Linked Incentive (PLI) schemes for solar photovoltaic (PV) modules facilitate the manufacturing of solar panels. The Faster Adoption and Manufacturing of Electric Vehicles (FAME) II scheme facilitates the increased adoption of electric vehicles. Energy efficiency refers to the use of less energy to provide the same service or achieve the same outcome. It is a critical factor in reducing energy consumption and minimizing environmental impact. In the recent past, the energy efficiency labeling programs effectively decrease the energy consumption of appliances while maintaining the quality of services offered. Corporate Average Fuel Consumption Standards (CAFC) establish limits on the fuel consumption of passenger vehicles. The National Energy Storage Mission seeks to establish a policy and regulatory framework for energy storage systems. Nonetheless, current efforts are hindered by poor power generation and supply particularly shortages in some parts of the country, high transmission losses and constraints in physical infrastructure particularly in the developmental regions or rural areas.

Urban Infrastructure

India is witnessing an unprecedented rate of urbanization, pressurizing the infrastructure of cities in the country. In order to overcome these problems, the government of India started a scheme known as Smart Cities Mission in 2015 to create 100 smart cities where technological interventions make life easier. Thus, urban infrastructure initiatives like Pradhan MantriAwasYojana (PMAY) are designed to tackle housing availability gap in the country and initiatives in water supply, sanitation and Solid Waste Management (SWM) are to make cities more comfortable. However, overcrowding in cities, increasing levels of pollution and poor urban planning are still factors that a country must overcome.

The significance of urban infrastructure is evident in the growth of the urban population, which rose from 17.2 percent in 1951 to 23.3 percent in 1991, and further increased to 33.3 percent in 2019. The urban sector presently accounts for 63 percent of the nation's GDP. These factors contribute to the understanding that urban India serves as the driving force behind

productivity and growth within the nation. The Indian Government has acknowledged this reality and is actively pursuing the advancement of this key driver of growth. The Table 2 shows the increased in CAPEX and its impact in the GDP of India during last 5 years. Further GDP forecast is accounted upto year 2027-28 and it is expected that further capex will lead to increase in GDP, which is an indicator of economic development.

Table 2: GDP and CAPEX in India

Year	GDP (In US$Bil)	Capex (In Rs Lakh Cr)	Growth from previous years
2020-21	10370.8	4.1	
2021-22	11,900.70	5.9	43.90%
2022-23	13,119.60	7.3	23.70%
2023-24	14,261.20	10	37%
2024-25	15,469.10	-	-
2025-26	16,765.20	-	-
2026-27	18,155.70	-	-
2027-28	19,650.20	-	-

Source: www.economictimes.com

Digital Infrastructure

In recent years, India has concentrated significantly on enhancing its digital infrastructure due to advancements in the digital economy. The Digital India initiative has expanded peripheral access to core areas, facilitating Internet connectivity in rural India and integrating information technology into administration and service delivery. The ease of carrying mobile phones, together with enhanced internet bandwidth, constitutes a fundamental aspect of e-commerce, banking, e-learning, and other online educational platforms. However, the disparity in internet access and the digital divide between urban and rural clients remains a concern. India's notable advancement in digital infrastructure underscores its commitment to innovation, inclusivity, and efficiency. By employing modern technology such as cloud computing and artificial intelligence, with programs like Aadhaar, UPI, and DigiLocker, India has established itself as a leader in global digital adoption. The collaborative efforts of governmental platforms and seamless citizen engagement are fostering a digital future that empowers citizens, advances socio-economic growth, and improves governance. The continuous digital transformation greatly enhances India's internal competencies and positions the nation as a frontrunner in providing scalable digital solutions for the Global South. As India progresses with this momentum, it is positioned to revolutionize government, improve public service delivery, and stimulate economic development.

Comparison: Infrastructure Development and Economic Policies

India's evolution in infrastructure development and economic policies illustrates its shift from a closed, state-controlled economy to an open, market-oriented, and progressively digital economy. The economic reforms initiated after 1991, along with ongoing infrastructure development, have fostered significant economic growth; however, challenges persist regarding inclusivity, quality, and sustainability. As India progresses, the amalgamation of cutting-edge technologies and an emphasis on sustainable infrastructure will probably characterize its forthcoming phase of development. Table 3 indicate various aspect of the infrastructure sector and how economic policies are liberalised over a period of time to achieve the economic development.

Table 3: Economic development and Policy change in India

Aspect	Pre-1991	Post-1991 Liberalization	Post-2000s	2014-Present
Economic Model	Socialist, state-controlled	Liberalized, market-driven	Growth-focused, service-oriented	Growth, digital, self-reliant economy

Industrial Policy	Protectionist, License Raj	Open economy, privatization	Manufacturing and export-oriented	Make in India, Start-up focused
Infrastructure Investment	Limited, state-dominated	Increased private participation	High investment in roads, energy, ports	Large-scale projects, Digital push
Transport Infrastructure	Slow, limited	Expansion of highways, ports	Golden Quadrilateral, Railways	Bharatmala, Sagarmala, Smart Cities
Energy Sector	State-controlled, limited	Power reforms, private sector entry	Focus on renewable energy	Renewable energy, Solar Mission
Digital Infrastructure	Underdeveloped	Early stages of telecommunication reforms	Expansion in mobile and internet	Digital India, BharatNet, 5G

Source: Authors compilation from various reports

CHALLENGES IN INFRASTRUCTURE DEVELOPMENT

Despite significant strides in infrastructure development, several challenges persist which are mentioned as follows:

Financing Gaps: Infrastructure projects entail high up-front costs as thereby highlighted; although public private partnerships have been encouraged, the funding deficit is large. The problem of absence of institutional investors and time delays in the clearance of projects due to delays by the government in acquiring land and other restrictions results to high costs.

Land Acquisition: Another area that is a major constraint to infrastructure development is land for infrastructure development which more often than not both faces legal aspects issues and community resistance.

Environmental Impact: Several mega infrastructure ventures have been accused of bearing adverse effects to the environment, including deforestation, water pollution, and loss of biophysical character. Managing development and the Earth's natural resources is one of the biggest issues to grasp.

Implementation Delays: Sometimes bureaucratic processes and procedures slow down decision making and this slows down the implementation of the project causing lots of costs to skyrocket and delayed delivery.

RECOMMENDATIONS FOR ACCELERATING INFRASTRUCTURE DEVELOPMENT

To address these challenges and accelerate infrastructure development, the following recommendations are proposed:

Enhance Private Sector Participation: Discontinue the process of weakening PPP's legal base for setting up further incentives, decreasing PPP risks for private partners, and syntonizing regulations.

Improve Project Planning and Coordination: Intensify political cooperation between central, state and local governments so as to enhance efficient implementation of projects. Breaking the approval cycle and minimizing delaying factors that slow down the land acquisition process can help quicken project delivery.

Focus on Sustainability: Integrate environmental consideration proper to the planning and implementation of infrastructures through the use of green technology and making sure that all the implemented projects meet the standards environmental norms.

Mobilize Alternative Financing: The financing gap

needs to be bridged through resources other than foreign investments and these include Infrastructure bonds, Sovereign wealth funds and International investment.

Enhance Rural Infrastructure: Pay attention to develop the quality of infrastructure in the rural region to eliminate inequalities between regions and promote the sustainability of rural and urban regions.

CONCLUSION

Infrastructure development is a key unlocking for the Indian economy. The country has achieved great strides in developing its infrastructure in the past few decades benefiting from progressive economic policies and authorities. Still, the future critical success factors include financing gaps, land acquisition and environmental concerns to name but few to enable the sector to continue expanding. Through advancing new polices, encouraging the private sector initiative, and enhancing the performance of project implementations, India could create the infrastructures correspondingly, that would let the country to become the world's leading economic power.

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