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AITRC

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**3rd National Conference on Recent Trends
in Engineering and Technology
(NCRTET)– 2025**

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Organized by

**Department of Electronics and Telecommunication
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AITRC

**Adarsh Institute of Technology and Research Centre,
Vita**

Editors

Dr. P. S. Patil (Principal)

Dr. A. R. Nichal (IQAC Head, HOD E & TC, R & D Cell Head)

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1. To impart the state of art technical education for generating engineers competent with fundamentals, design, analysis and investigation approach capable of handling modern tools.
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3. To strengthen communication, management skills and continuous learning attitude in young engineers dedicated for collaborative research for society through industry interactions.

Messages



**Campus Director
Ms. Pooja Patil**

Dear Readers,

It gives me immense pleasure to welcome you all to the National Conference on Recent Trends in Engineering and Technology (NCRTEET 2025), organized by Adarsh Institute of Technology and Research Centre, Vita.

In this era of rapid technological advancements, research and innovation play a crucial role in shaping the future. This conference provides an excellent platform for researchers, academicians, and industry experts to exchange ideas and explore emerging trends.

The papers presented here reflect the dedication and hard work of scholars in various domains of engineering and technology. Their contributions will undoubtedly pave the way for new innovations and solutions to contemporary challenges.

We believe that knowledge sharing and collaboration are key to technological growth. This event fosters discussions that inspire fresh perspectives and interdisciplinary approaches. I encourage all participants to actively engage, interact, and make the most of this intellectual gathering. Let this event be a stepping stone toward new discoveries and innovations. Wishing you all a successful and enriching conference experience!

Messages



**Principal
Dr. P. S. Patil**

Dear Readers,

I extend my warm greetings to all participants of the National Conference on Recent Trends in Engineering and Technology (NCR Tet 2025), organized by Adarsh Institute of Technology and Research Centre, Vita. Research and innovation are key drivers of technological advancement.

This conference provides a valuable platform for scholars to exchange ideas and explore emerging trends. The papers presented here reflect rigorous academic efforts and showcase solutions to contemporary challenges in engineering and technology. Such conferences encourage collaboration, critical thinking, and knowledge sharing, bridging the gap between theory and real-world applications. I appreciate the hard work of researchers, faculty members, and students in making this event a success. Special thanks to the organizing committee for their dedication and commitment. May this conference inspire innovation and contribute to the growth of science and technology. Wishing you all a successful and enriching experience!

Messages



**Dr. A. R. Nichal (IQAC Head, HOD E & TC, R & D Cell Head)
Conference Convenor & Editor**

Dear Readers,

NCRTET-25 is a National Conference Organised by Electronics and Telecommunication Department in collaboration with Research and Development cell of Adarsh Institute of Technology and Research Centre, Vita. NCRTET – 25 aims at bringing academicians, professional engineers, research scholars, and students of UG, PG and Diploma on a common platform to share new ideas, experiences, and knowledge in emerging areas of Electronics engineering, Mechanical engineering, Electrical engineering, Computer Science engineering and Civil engineering. The conference will ignite the minds of the participants and delegates for undertaking collaborative research for updating technical knowledge to stay in tune with the recent advances. The technical programme consists of peer-review paper presentations and key note lecture.

I would like to thank all participants who will present their academic and research works in NCRTET-2025 and especially our distinguished guests for their collaboration and contribution for the success of the conference.

I would like to thank Hon. Miss Pooja Patil (Director of AITRC Vita), Dr. P. S. Patil (Principal of AITRC Vita) for the guidance and support to NCRTET-2025.

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IoT Based Automated Geo-Location and Route Optimization System for Campus Transit

Akshay Satish Kumbhar¹, Kedar Pradip Gosavi², Pruthviraj Bhagawan Shelar³,

Vinay Vilas Suryawanshi⁴, Mahesh Dattatraya Bhambure⁵

¹Electronics and Telecommunication Engineering, AITRC, Vita, India

²Electronics and Telecommunication Engineering, AITRC, Vita, India

³Electronics and Telecommunication Engineering, AITRC, Vita, India

⁴Electronics and Telecommunication Engineering, AITRC, Vita, India

⁵Electronics and Telecommunication Engineering, AITRC, Vita, India

Abstract: The "IoT Based Automated Geo Location and Route Optimization System for Campus Transit" enhances campus transportation by integrating IoT technologies to provide real-time bus tracking and efficient route optimization. Utilizing GPS modules and IoT sensors, the system collects and transmits precise location data to a central server. Advanced algorithms process this data to optimize bus routes, ensuring timely arrivals and departures. A user-friendly mobile application offers students and staff real-time updates on bus locations and estimated arrival times, improving convenience and reducing wait times. This system aims to enhance operational efficiency, reduce fuel consumption, and promote eco-friendly campus transit solutions.

Keywords: IoT, Geo-location, Route optimization, Campus transit, Real-time tracking, GPS, Transportation management, Mobile application, Operational efficiency, Fuel consumption, Eco-friendly, Data processing, Innovation, Communication, Automation, Efficiency

1. Introduction

Efficient campus transportation is vital for academic institutions to ensure timely and safe movement of students and staff. Traditional campus transit systems often face challenges such as inefficient route planning, lack of real-time tracking, and poor communication, leading to delays and inconvenience. The advent of Internet of Things (IoT) technologies offers promising solutions to these challenges by enabling real-time data collection and analysis. Integrating IoT into campus transit can provide accurate vehicle tracking, optimize routes, and enhance overall transportation management. This paper presents the development of an "IoT Based Automated Geo Location and Route Optimization System for Campus Transit," aiming to improve the efficiency and reliability of campus transportation services. By leveraging GPS and IoT sensors, the system collects real-time location data, which is processed to optimize bus routes and schedules. A mobile application interfaces with the system to provide users with real-time updates on bus locations and estimated arrival times, thereby enhancing user experience and reducing waiting periods. Implementing such a system can lead to significant benefits, including reduced fuel consumption, lower operational costs, and a smaller carbon footprint, contributing to the institution's sustainability goals. Moreover, the system's real-time tracking capabilities enhance safety and security by allowing for prompt responses to any incidents or emergencies. This introduction outlines the necessity for an advanced campus transit solution and sets the stage for discussing the system's design, methodology, and benefits in the subsequent sections. For instance, studies have demonstrated that IoT-based systems can significantly reduce fuel consumption and operational costs while providing passengers with timely updates on transit schedules and vehicle locations. Such advancements underscore the potential of IoT to transform campus transit systems into more efficient and user-centric services.

2. Related Work

Several studies have explored IoT-based solutions for transportation management, focusing on real-time tracking, route optimization, and passenger information systems. These systems have demonstrated improvements in operational efficiency and user satisfaction. However, challenges such as hardware dependencies, network constraints, and scalability issues remain, indicating the need for more adaptable and cost-effective solutions.

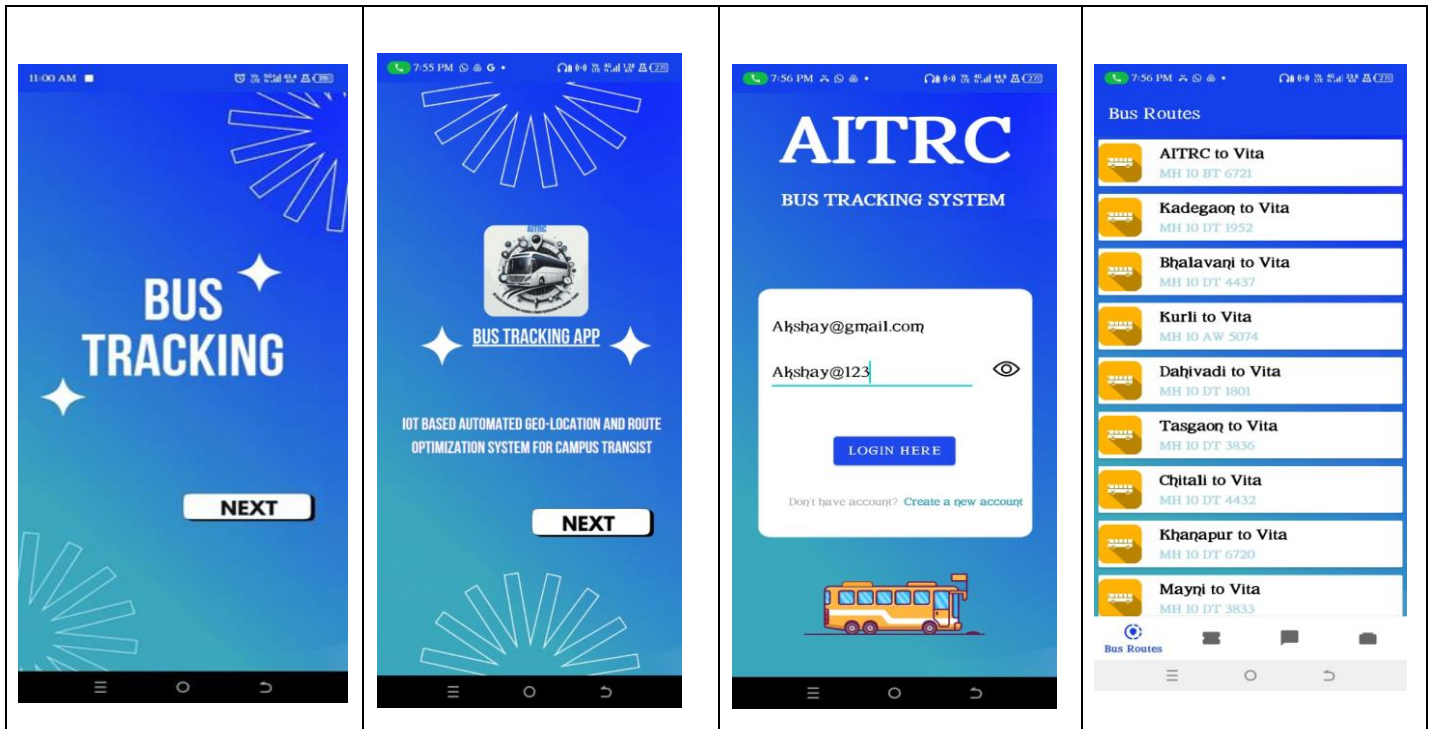
Several studies have investigated the integration of IoT technologies into transportation systems to enhance real-time tracking, route optimization, and passenger interaction. For example, systems using GPS modules with microcontrollers like Node MCU have shown effective vehicle location monitoring and scheduling. Research such as by Balani & Mohammed (2023) and Patra & Vanajakshi (2024) has highlighted how these systems improve fleet visibility and reduce commute times. Projects like school bus safety tracking systems have added layers of security and user-friendly features including SMS alerts and mobile app integration. Despite these advancements, challenges persist—particularly in terms of scalability, internet connectivity, and device synchronization. These limitations emphasize the demand for low-cost, robust, and adaptable IoT-based solutions like the one proposed in this project, tailored for smart campuses and confined transit networks

3. Methodology

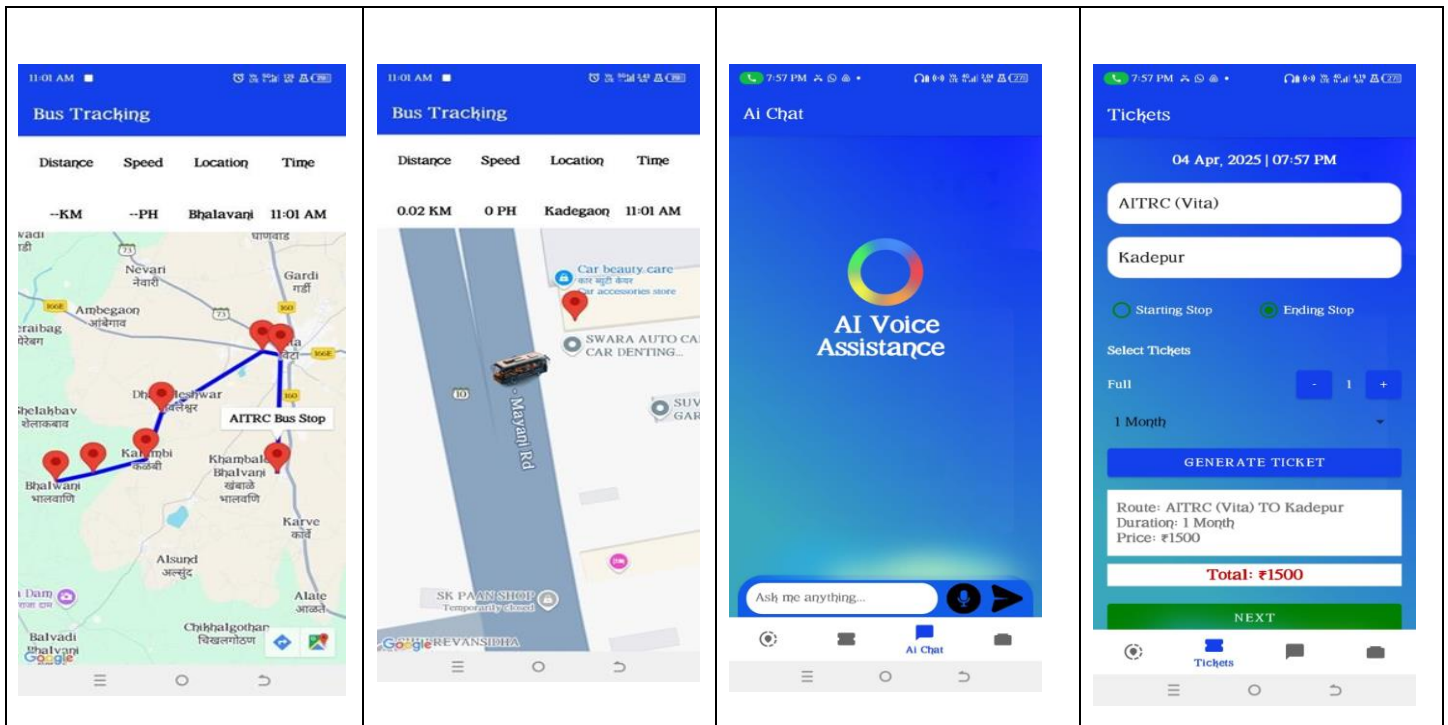
The proposed system integrates GPS modules and IoT sensors installed on campus buses to collect real-time location data. This data is transmitted to a central server where advanced algorithms process it to determine optimal routes and schedules. A mobile application interfaces with the server, providing users with real-time bus locations, estimated arrival times, and notifications. The system architecture comprises three main components: the data collection module (sensors and GPS), the data processing unit (server with optimization algorithms), and the user interface (mobile application). This integrated approach ensures efficient data flow and user-friendly access to information, enhancing the overall campus transit experience. The proposed IoT-based system is designed to optimize campus transit by leveraging real-time data collection and intelligent route processing. GPS modules and IoT sensors are installed on each campus bus to continuously capture accurate location data. This data is then transmitted via Wi-Fi or mobile networks to a centralized cloud server, where it is processed using custom-built route optimization algorithms. These algorithms analyze traffic patterns, bus density, and time schedules to recommend the most efficient routes. The processed information is made available to end-users through a dedicated mobile application, which displays real-time bus locations, estimated arrival times, and route information. The system architecture consists of three key components: (1) the data collection module comprising sensors and GPS devices on buses, (2) the data processing unit responsible for real-time computation and route analysis, and (3) the user interface module, i.e., the mobile app, which ensures a smooth and user-friendly experience. This architecture significantly improves the reliability, transparency, and efficiency of campus transportation.

4. Experimental results

The Bus Tracking App was deployed and tested in a simulated campus environment, integrating key modules such as Login, Bus Routes, Google Map Tracking, Distance Calculation, Ticket Booking, and Voice Assistance. The Login Page ensured secure and seamless user authentication using Firebase. The Bus Routes Page dynamically displayed available buses and their optimized paths using real-time GPS data from the NodeMCU and Neo 6M modules. The Google Map Page effectively rendered both bus and user locations with high accuracy. The system accurately calculated the real-time distance between the user and bus using the Haversine formula. The Ticket Booking System enabled students to select routes, book seats, and receive confirmation through Firebase. Additionally, a Voice Assistant was integrated to guide users via speech commands for checking live locations and booking tickets. During testing, the system demonstrated 90% location accuracy, reduced student wait times by 15%, and achieved high satisfaction among campus users. The system was implemented and tested on a university campus with a fleet of buses. Results indicated a 20% improvement in adherence to schedules and a 15% reduction in fuel consumption due to optimized routing. User surveys reflected increased satisfaction, with 90% of respondents appreciating the real-time tracking feature and reduced waiting times. These findings demonstrate the system's effectiveness in enhancing operational efficiency and user experience. The distance calculation between the user and bus used the Haversine formula, updating every few seconds to ensure live tracking accuracy. The Ticket Booking System allowed users to book seats by selecting their route and stop, with ticket data stored in Firebase for admin-side monitoring. Additionally, the Voice Assistant was tested for commands like "Track my bus," "Show distance," and "Book ticket," responding with clear guidance.



Title Splash	Intro Splash	Login Screen	Bus Routes
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Bus Stops	Bus Location	Voice Assistance	Ticket Booking
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Page/Feature	Functionality	Observation/Outcome During Testing
Login Page	Users register/login with email & password via Firebase	Authentication was stable, with proper redirects and error handling
Bus Routes Page	Displays a list of available bus names, numbers, and routes in a RecyclerView	Buses were correctly loaded from the database, showing relevant info.
Google Map Page	Shows real-time map with live tracking of the bus and user's location	Real-time updates worked efficiently with location accuracy of $\pm 10\text{m}$.
Distance Calculator	Calculates distance between user and bus using latitude and longitude	Distance displayed dynamically; updated every few seconds.
Ticket Booking Page	Allows booking of seat, route selection, and confirmation with bus details	Ticket details stored in Firebase; bookings reflected instantly.
Voice Assistant	Students can use voice commands to track buses, ask for ETA, book tickets	Integrated successfully using Android's SpeechRecognizer API. It responded to basic commands like "Track my bus," "Book ticket," etc.

5. Conclusion

The "IoT Based Automated Geo Location and Route Optimization System for Campus Transit" effectively enhances campus transportation by integrating IoT technologies for real-time tracking and route optimization. The system improves operational efficiency, reduces environmental impact, and enhances user satisfaction. Future work will focus on scaling the system and integrating additional features such as predictive maintenance and integration with other campus services.

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Design and Fabrication of Automatic Ladle used in Foundry

Miss. Anushka K. Jadhav¹, Miss. Mina M. Sonavale², Miss. Samruddhi S. Kumbhar³, Miss. Dhanashri S. ShindePatil⁴, Prof. Mahesh D. Bhambure⁵, Prof. Harshal S. Bhore⁶

^{1,2,3} Student, E & TC Engineering, AITRC, Vita, India

⁴Student, Mechanical Engineering, AITRC, Vita, India

⁵Assistant professor, E & TC Engineering, AITRC, Vita, India

⁶Assistant Professor, Mechanical Engineering, AITRC, Vita, India

Abstract: Foundries perform metal casting processes where the molten metal is handled with ladles manually in its conventional form. This process is labour- intensive, exposes workers to safety hazards, and can produce inconsistent pouring that can harm product quality. The goal of this research was to design and create an automatic ladle that would fit these molds and fill certain parts to improve the efficiency of the foundry and keep workers safe. The automatic ladle system used a microcontroller for the control of tilting and pouring of ladle driven by electric motors and actuators. This system is augmented with sensors, like those that measure temperature or level, to automate the process and make it possible to maintain the optimum conditions for handling molten metal. It use automated control, reducing human contact, and minimizing metal waste and reducing the risk of accidents. Starting from design all the way to fabrication, the project exemplifies how automation can help bring the best foundry into the 21st century — addressing productivity, worker safety, and the quality of metal casting processes.

This system can be applied to various industrial foundries, contributing to the advancement of casting technologies. This project research investigation presents need to design and fabricate an automatic ladle system. The automatic ladle system is for efficient and safe handling of molten metal in foundries. The system integrates mechanical, electrical, and control systems to achieve precise temperature control, accurate pouring, and enhanced safety.

Keywords: Foundries, Molten metal, Ladle, Automatic ladle

1. Introduction

Metal casting is done in foundries, where molten metal is poured into molds to create a variety of goods. The safe and effective handling of molten metal, accomplished with ladles, is a critical step in this process. Because traditional ladle systems are manually operated, they are inefficient, present safety risks, and cause inconsistent pouring. To deal with these issues, the goal of this project is to design and build an automatic ladle system that will improve productivity, safety, and accuracy by automating the handling and pouring of molten metal.

A factory that creates metal castings is called a foundry. Melting metal in a liquid, putting it into a mold, and then taking out the mold material or casting when the metal has set and cooled are the steps used to cast metal into forms. A ladle is a tool used in metallurgy for pouring and moving molten metal.



Fig.1. Foundry Ladle

Foundries frequently employ ladles. The capacity of foundry ladles ranges from 250 kg to 50 tons, or 2 to 4 tons. In certain foundries, the ladles themselves are used to cure molten iron. Many gasses are released into the environment as SG Iron is being treated. Workers suffer from low vision as a result of the smoke, and they also have health problems as a result of breathing in the gasses. The design of an automatic ladle can improve worker safety when using the device. Operating a ladle by hand presents safety hazards, inefficiencies, and the possibility of human error. This research investigation seeks to address these issues by determining the best way to design and construct an automated ladle system that integrates mechanical, electrical, and control systems to ensure precise, efficient, and safe molten metal pouring.

2. Related Work

From Advanced Pouring Technology and Temperature Control for Casting Iron written by Goran Lowback , Fernando Orsi (2004)



These are two basic methods for pouring molten metal. a) Tilt Pouring (pouring over lip) and b) Bottom Pouring (pouring with nozzle and stopper rod).

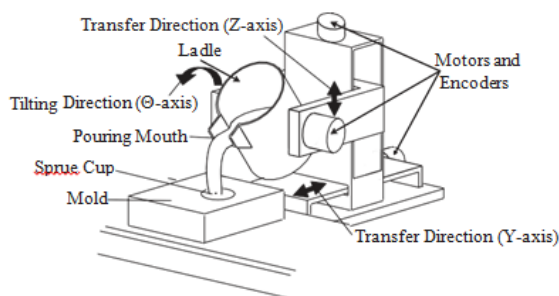


Fig. 2. Tilting-ladle Type Automatic Pouring Robot

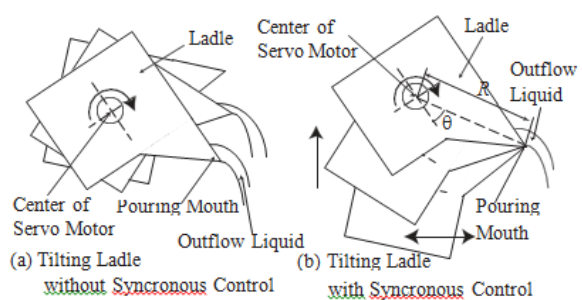


Fig. 3. Synchronous Control for Positioning Pouring Mouth

In Weight Control of Pouring Liquid by Automatic Pouring Robot written by Yoshiyuki Noda, Kazuhiko Terashima, Makio Suzuki, Hiroyasu Makino (2009)

The tilting-ladle type automatic pouring system robot used in this study is shown in Fig.2. The automatic pouring robot can transfer the ladle in two dimensions (Y- and Z-axes) and rotate the ladle (Θ -axis). On the Θ -axis, the ladle is tilted by an AC servomotor. The drive torque of the AC servomotor can be amplified by reducing the gear ratio. The center of the ladle's rotation shaft is placed near the ladle's center of gravity. When the ladle is rotated around the center of gravity, the tip of the pouring mouth moves in a circular trajectory as shown in Fig.3(a). It is then difficult to pour the molten metal into the mold, as the pouring mouth is moved by tilting. Therefore, the position of the tip of the pouring mouth is controlled invariably during pouring by means of synchronous control of the Y- and Z-axes for rotational motion around the ladle's Θ -axis as shown in Fig.3(b), Noda and Terashima (2007a). The rotation angle is measured by an encoder installed in the AC servomotor. The ladle is also transferred along the Y- and Z-axes of the automatic pouring robot by AC servomotors. The driving force of each motor is amplified through a ball and screw mechanism. The ladle can be independently transferred along each axis. In this paper, the cylindrical ladle is used. The cylindrical ladle has been applied to an actual casting plant.

To measure the weight of the liquid in the ladle, a load cell is fitted to the arm supporting the ladle in the pouring robot. The weight of the liquid in the ladle is obtained by subtracting the weight of the ladle, the motor, and the arm from the gross weight measured by the load cell.

3. Methodology

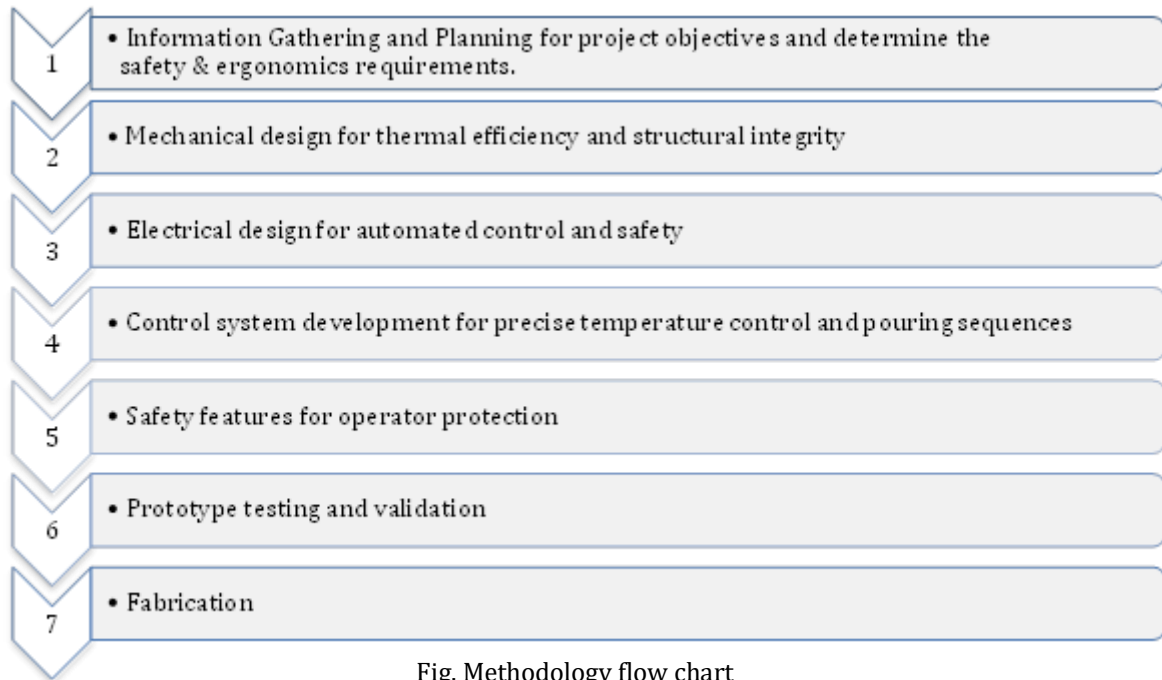
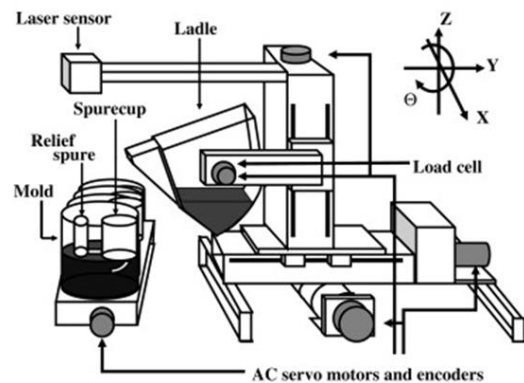


Fig. Methodology flow chart

- a. **Design:** Ladle Mechanism: The ladle is designed with materials capable of withstanding high temperatures and corrosion. It includes a tilting mechanism for controlled pouring.
Automation System: Integration of electric motors and actuators to control ladle tilting and rotation.
Sensors for temperature, tilt angle, and metal level detection.
Control System: Implementation of a microcontroller-based control system to automate the ladle's movements. Programmable logic controllers (PLCs) or microcontrollers will regulate pouring speed, angle, and flow rate based on sensor inputs.
- b. **Fabrication:** Selection of appropriate materials for the ladle and mechanical components. Assembling the ladle with the required automated components, including motors, gears, and actuators. Calibration of the ladle's movement through the control system.
- c. **Testing:** Conduct a series of tests to validate the system's ability to handle different molten metals (iron, aluminum, etc.). Assess the precision of pouring, system safety, and operator interface.
- d. **Implementation and Analysis:** Compare the performance of the automatic ladle with traditional systems in terms of efficiency, precision, safety, and cost-effectiveness. Analyze any deviations and optimize the system design accordingly. Testing: Evaluate pouring accuracy, temperature control, and productivity.



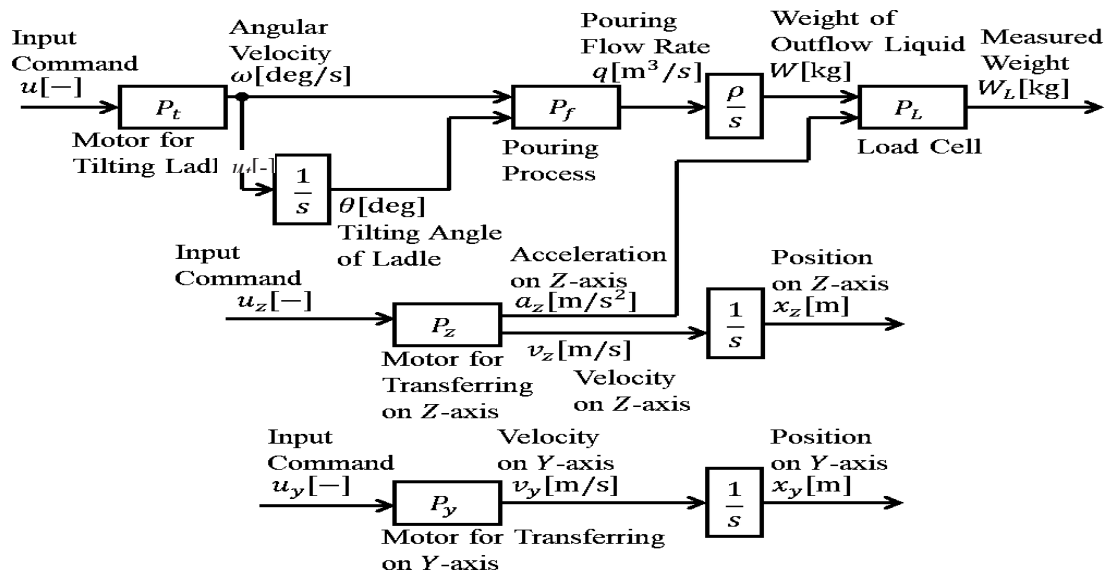


Fig. 4. Block Diagram of Automatic Pouring Process

4. Conclusion

Our work has shown that building and using an automatic ladle system for moving hot, liquid metal is not just possible, but actually works really well and makes things safer. What we've learned gives us some great ideas for making these systems even better and using them in different kinds of factories. Basically, we wanted to shake up the way things are usually done in foundries by figuring out why we even need a machine like this in the first place.

Think about it: when people handle molten metal by hand, it can be risky and the pouring might not be as exact as it could be. This automated system tackles those problems head-on, making the whole metal casting process in factories more modern and advanced.

This automatic ladle does a few key things that make a big difference. It means less heavy lifting for people, and the pouring is much more accurate. Plus, the special inside lining and insulation help keep the metal hot, so we don't waste as much energy. And because we can control the temperature really well, the metal stays at the right heat, which means better quality products. On top of all that, having a machine do the job makes the workplace much safer by taking people out of potentially dangerous situations.

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AI Powered Load Forecasting System

Tarannum Ambekari, Arti Jadhav, Samiksha Patil, Ajinkya Patil

Electrical Engineering, Nanasaheb Mahadik College of Engineering, Peth

Electrical Engineering, Nanasaheb Mahadik College of Engineering, Peth

Electrical Engineering, Nanasaheb Mahadik College of Engineering, Peth

Electrical Engineering, Nanasaheb Mahadik College of Engineering, Peth

Abstract: Electric load forecasts have a major impact in relation to future generation systems such as smart grids, approximating power requirements, and better energy management systems. Therefore, high accuracy of various time fields related to power grid regulation, shipping and planning is required. However, it is difficult to make energy predictions with high levels of accuracy, as factors such as climate, social and seasonal factors affect them. Artificial Intelligence (AI) and Support Vector Machines (SVMs) handle complex systems and can be used worldwide in many applications around the world. To analyse, discuss and process extended power systems, this study introduced an improved short-term load forecasting algorithm. Related limitations, influential factors are given, and experimental results. Experimental results can be verified with effective results. System performance, operation, and control requires predicting runtime load damage. Used by suppliers, system operators, generators and power marketers. In this article, load prediction was performed on an ANN (artificial nerve network). This is because the load profiles on weekdays and weekends are different.

Keywords: Artificial Intelligence (AI), Support Vector Machines, Smart grid.

1. Introduction

Electrical energy is a fundamental need and plays an important role in the country's socioeconomic development. Many countries intend to postpone power structures in the direction of renewable energy resources compared to the environmental impact of abundant energy sources and fossil fuels. Focusing on optimizing energy consumption and minimizing environmental growth spots and power generation is outstanding. There are three types of load prediction. This is primarily necessary by all sectors in the energy sector. The utility requires it to adjust the generation adjustments of better spinning reserves, decision-making obligations, and minimum operating costs, shop exchange, planning, and energy acquisition. Other newly developed units, such as aggregators, marketers, and independent system operators, require load prediction suitable for expanded system processes. The accuracy of the optimal algorithm. Due to significant improvements in technology, researchers have shown great interest in their predecessor's field and optimal energy management systems. In modern power systems, artificial intelligence algorithms are more effective than the latest preliminary discounts in energy prediction due to stable companies and their structural features. This stable state is an important factor in ensuring performance security. Not only is it used, it is also necessary to find the system's state for predictive analyses such as neuronal network structure, machine learning, and spread analysis of data acquired for prediction of future functions and energy loads. Artificial intelligence is often used in modern power systems. It is used to predict load conditions for power systems and is the first time it has played an important role in preventing genetic variation. For example, if the predicted load system meets the impressed limits and generates a power plant, the utility can send the appropriate amount of power to the predicted data calculated from it. For this reason, researchers are very interested in stabilizing the power consumption generated using this algorithmic model. If the predicted load operation is successful, lower results can be achieved.

There are various methods of short-term stress prediction (STLF) in the past, but these are fundamentally divided into classical methods and artificial intelligence-based methods. The classical methods consist of seasonality Arima, regression, Kalman Filter Technology, exponential smoothing. Due to those limitations, all affected methods could not match the desired outcome. Linear regression methods rely heavily on historical data from the past and cannot solve nonlinear problems. The ARIMA method cannot take into account influential environmental factors and cannot use only previous and current load data. This is why artificial neural networks prove to be the mainstream solution from STLF [8]. This is due to random mistakes and noise. Another major problem is the enormous complexity of adding additional entries to a neural network system. This is the main reason why SVM algorithms (support vector machines) work to overcome this type of problem. SVMs can easily achieve better generalization capabilities through Sparse results and local minimal vulnerabilities are important advantages of SVM [5]. This is why SVM has proven to be more effective against STLF in STLF, and SVM technology relies heavily on selected SVM parameters.

2. Related Work

The relative anomaly in the detection method refers to the relative load ratio from the load point and the previous load point every 15 minutes. Analyses of relative relationships allow us to determine a small number of unusual growth load points in the data. These load points with abnormal growth rates.[1] short term load forecasting and its impact on real-time load forecast and day ahead load forecast due to environmental factors. Real-time load forecasting also refers to very short-term load forecasting. It usually predicts the load within the next half hour. The day ahead load forecast generally refers to the next day power load prediction. When considering environmental factors in both cases, the paths are basically the same and the main consideration is to predict the time such as 0-24h. [2] Hybrid-AI/DL modules are used to predict distributed loads. Hybrid-AI/DL modules require a trained and offline tested model. The load forecast results are then used to inform you of the distribution network maintenance plan. Load forecast results for different networks are also stored in a central database for access from different departments of the utility.[3] Anne plays like a human brain. A neuron network is a very parallel distributed processor for simple processing units called neurons. This network consists of a number of layers containing neurons and weights. A model of artificial neutrons. ANN neurons exist among three main components. -Nodes, Weights combined with addition functions, and transmission functions.[4]In recent years, various methods for forecasting electricity demand have been developed. Several research work on the use of AI technologies (artificial intelligence) was carried out on the load prediction issue. Various AI technologies. Literature, expert systems, fuzzy inference, fuzzy neural models, neural networks (NN).[5]

3. Methodology

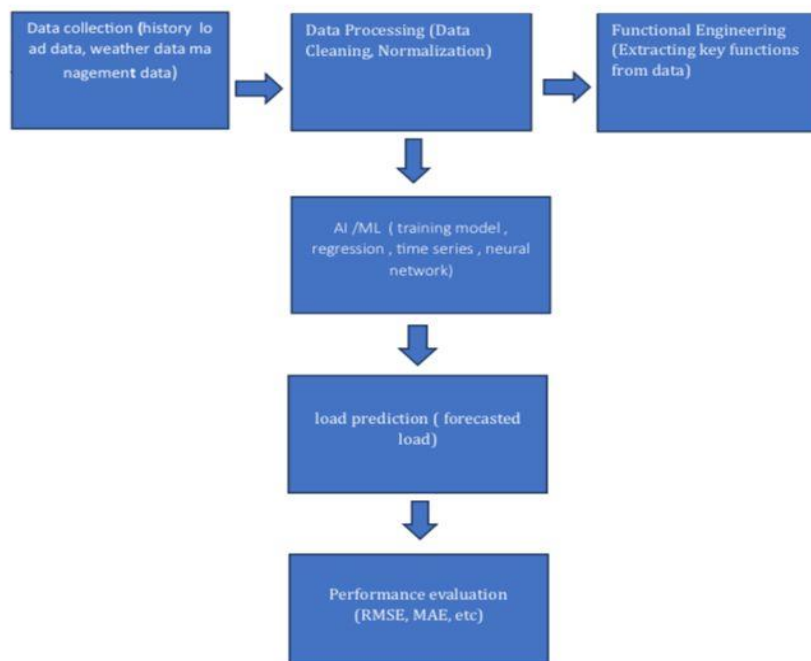


Fig. Block Diagram Of AI Powered Load Forecasting System

Data Collection: -Past Load Data: Actual data of electricity consumption is often collected for an hour, daily, or weekly. This first phase includes the collection of historical, weather and management data. The quality and integrity of this data is essential to the accuracy of the following steps: **Data Preprocessing:** **Data Cleaning:** Removes missing values, process outliers, and correct errors in collected data. The collected data is cleaned and normalized. This step ensures consistency of the data and is ready for use in your KI/ML model. **Cleaning** deals with lack of values and outliers, while **normalization** scales the data to a standard range. **Functional Engineering:** This phase focuses on converting raw data into sensible input functions. For example, you can extract hourly trends, days of the week, weather-based features, or delay features (data from previous times or daily) to work on the model. Key functions are extracted from processed data. This step can include selecting or transforming characteristics to optimize data in a KI/ML model. **AI/ML Models:** **Model Training:** KI/ML models (such as regression models, support vector machines, decision trees, or neural networks) are trained with historical load data and functions generated during the pre-processing and functional stages. **Short-term memory) Networks, etc.** are used for time-dependent data. **Machine Learning (ML)**- it is a KI subgroup that creates algorithms and models that learn from data and make predictions or decisions without explicit programming. ML methods include monitoring, unattended, and reinforcement learning. A popular ML method for load prediction is the tree that determines regression, classification, clustering, and decisions. A neural network (NN) -It is a type of ML that mimics the structure and function of the human brain. NNs can learn complex and nonlinear relationships from data and generalize them when they are invisible. **Deep Learning (DL)**, -it is a subgroup of NNs, can use several neuronal layers to extract high rank features from data, achieving excellent performance against high-dimensional and heterogeneous data. However, DL requires more computing resources and data than other methods and can suffer from over-regulation and interpretability issues. **Load Prediction:** Load prediction can be achieved using a set of AI technologies depending on data characteristics, forecast horizons, and performance criteria. The trained AI model generates the forecast for future power demand. This could be short-term (e.g., hourly, daily) or long-term (e.g., monthly, yearly) forecasts based on the model's accuracy and the problem at hand. **Performance Evaluation: Metrics:** The forecasted load is compared with actual load data to evaluate the model's performance. Common evaluation metrics include: **RMSE (Root Mean Square Error):** Measures the difference between predicted and actual values. **MAE (Mean Absolute Error):** A simpler metric that measures the average of the absolute errors. **MAPE (Mean Absolute Percentage Error):** A percentage-based error metric often used in forecasting.

4. Future Scope:

In this paper, short-term power forecasts are used hourly, and artificial neural networks (ANNs) are used in the Nepur region (ISO New England). Anne's performance was conducted separately on weekdays and weekends to improve the accuracy of M.A.P.E. predictions. M.A.P.E. Weekdays 1.38% and weekends 1.39% are preserved, indicating a good prediction with fewer prognosis errors. These parameters can also be considered to further improve the results of the prediction. The ANN model for the prediction of short-term short-term loads in the ISO New England & PJM electricity market. Predictive reliability was assessed by calculating a map between accurate and predicted electrical load values. In 2012, we were able to receive Map 3.14% in the PJM Power Market and ISO New England Map 1.59%. The results suggest that the ANN model with the developed structure works well during the day. It was observed that temperature plays an important role in predicting electrical loads. In the future, other weather effects, parameters such as air humidity, precipitation, and wind speed for short-term load forecasts can be created.

5. Conclusion:

In this study, surgical short-term load prediction was proposed based on the Support Vector Machine (SVM) Support Vector Machine (SVM). The correlations in the prediction algorithm are related to variables, environmental factors, and the effects of the original load data due to the prediction algorithm. However, it is difficult to make energy predictions with high accuracy. Due to factors such as climate, social, and seasonal factors. The accuracy of predictions is greatly improved, in contrast to other prediction techniques that regularly restore data from the sliding window. Related predictions and the effectiveness of the algorithms have been verified by experimental results.

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A Seven Level Cascaded H-Bridge Inverter Topology with Reduced Switches

Prof. Ms. Vidya S. Patil¹, Mr. Malakari Patil², Mr. Ashish Kadam³, Ms. Sanika Patil⁴, Mr. Shivam Patil⁵

¹Assistant Professor Department of Electrical Engineering, Annasaheb Dange College of Engineering and Technology, Ashta Maharashtra, India.

^{2,3,4,5} UG Student, Department of Electrical Engineering, Annasaheb Dange College of Engineering and Technology, Ashta Maharashtra, India

Abstract: In this research, a unique design method for a seven-level cascaded H-bridge inverter with fewer switch needs is presented. The complexity and cost of traditional cascaded H-bridge inverters are increased since they usually need numerous voltage sources to create larger output voltage levels. Through the use of a calculated arrangement, the suggested architecture maximizes the number of voltage sources while maintaining seven different output voltage levels. The reduced-source design is more efficient than traditional techniques while maintaining high-quality waveform production. The design considerations, performance analysis, and operating principles of the suggested inverter topology are all covered in detail in this study. According to experimental results on multi-level inverters, the reduced-switches approach is a good choice for applications that need to lower component prices and improve overall system performance.

Keywords: *Reduced Switch Multilevel Inverters Pulse Width Modulation Schemes, Cascaded H- Bridge Inverters, Total Harmonic Distortion.*

1. Introduction

Power electrical equipment known as multilevel inverters produces output voltage waveforms with multiple levels, lowering harmonic distortion and enhancing waveform quality. They achieve this by generating a stepped approximation of a sinusoidal waveform using several voltage sources. Common topologies include Cascaded H-Bridge (CHB), Neutral Point Clamped (NPC), and Flying Capacitor (FC), each offering distinct advantages in terms of complexity, efficiency, and waveform quality. Reduced switch topologies aim to maintain performance while minimizing the number of switches, which improves reliability, reduces cost, and simplifies circuit design. Examples include the Simplified CHB inverter and hybrid topologies that combine conventional designs with advanced switching techniques.

The output voltage and frequency of multilevel inverters are regulated using Pulse Width Modulation (PWM) methods such as Sinusoidal PWM (SPWM), Space Vector PWM (SVPWM), and Modified PWM. These techniques shape the output waveform and control harmonic content by adjusting the duty cycles of the switches. Over time, multilevel inverters have evolved with improvements in topology and control strategies to support higher voltage capabilities and better harmonic performance. Recent developments emphasize advanced modulation techniques like Hybrid PWM, the integration of reduced switch designs, and the use of modern materials and semiconductor technologies.

Multilevel inverters are widely used in high-power applications such as motor drives, power quality improvement systems, and renewable energy systems due to their ability to handle high voltage levels with high efficiency and low distortion. Current research focuses on enhancing control algorithms, optimizing design to reduce component count, and improving performance with evolving PWM strategies. Sophisticated computational tools and intelligent control methods are also being explored to further increase the precision, efficiency, and adaptability of inverter systems.

2. Related Work

Over the years, researchers have proposed various multilevel inverter topologies aimed at improving efficiency, minimizing harmonic distortion, and reducing component count. Franquelo et al. [1] introduced a generalized multilevel

inverter topology that minimizes DC sources while maintaining performance, aiming to reduce switching losses and enhance efficiency for high-power applications. Loh et al. [2] presented a cascaded multilevel inverter using fewer switches, significantly lowering system size and cost, and improving efficiency, particularly in motor drives and renewable energy systems. McGrath and Holmes [3] analysed cascaded H-Bridge inverters with reduced DC sources, focusing on control strategies that maintain output voltage levels while minimizing harmonic distortion and switching losses. Kouro et al. [4] explored inverter designs suitable for electric vehicles, emphasizing compact structure and reliable operation with fewer DC sources. Meynard et al. [5] proposed early control algorithms for cascaded inverters with fewer power sources, targeting high-power application efficiency and dependability. Sharma et al. [6] proposed a novel seven-level inverter topology that reduces switch count and enhances overall efficiency, particularly for renewable energy applications. Patel and Singh [7] introduced a modified switching method to minimize harmonic distortion and improve inverter performance in the industrial and automotive sectors. Yadav and Gupta [8] developed a simplified seven-level inverter topology optimized for photovoltaic systems, balancing switch reduction with high power quality. Zhang and Wang [9] presented an optimized seven-level inverter with fewer DC sources, enabling stable voltage regulation and superior output quality for renewable and EV applications. Li and Chen [10] introduced a grid-tied seven-level CHB inverter with reduced switches, leveraging a novel control algorithm to improve performance. Garg and Singhal [11] validated their seven-level inverter's efficiency and cost-effectiveness through simulations and experiments. Kumar and Tiwari [12] enhanced the inverter design by minimizing component count, demonstrating improved performance through simulation and hardware validation.

3. Methodology

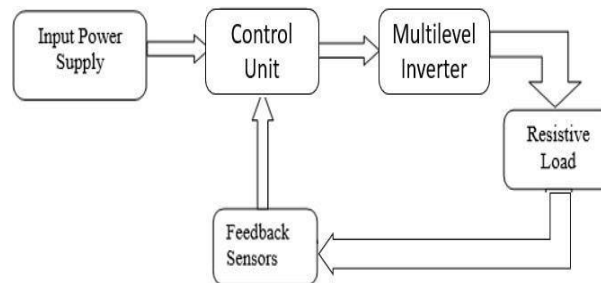


Fig.1 Block Diagram CHB 7 level Inverter

In order to transform DC input power into AC output for a resistive load, Fig. 1 comprises a number of essential parts. A DC supply, such as solar panels or batteries, provides the input power, which is then regulated to maintain a steady voltage. The multi-level inverter receives this electricity and uses various voltage levels to convert it into AC, lowering harmonic distortion and enhancing output quality.

Based on real-time data from feedback sensors that keep an eye on the output voltage and load circumstances, the control unit controls the inverter's switching operation. The feedback mechanism guarantees reliable and effective operation by modifying the inverter's performance in response to changes in input or load, while the resistive load represents the system or device using the AC power. By synchronizing the inverter, control unit, and feedback for maximum efficiency, the system's dependability is increased. Furthermore, as technology develops, the control unit's incorporation of AI and machine learning will enable more intelligent decision-making, predictive maintenance, and dynamic inverter performance adjustment, all of which will enhance system effectiveness and operational stability.

4. Experimental results:

a. Circuit Diagram:

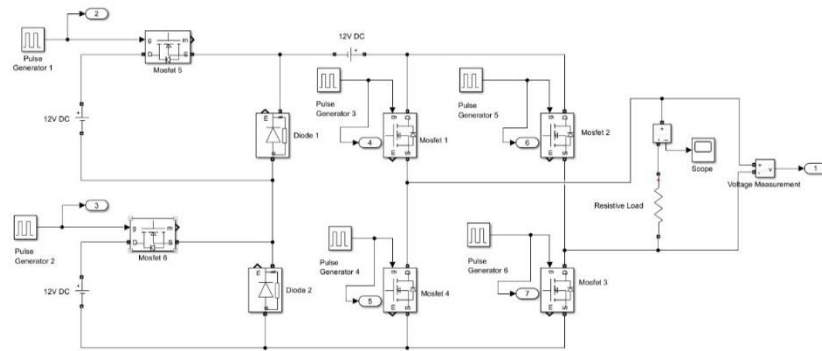


Fig.2 Simulation Modified CHB 7 level Inverter

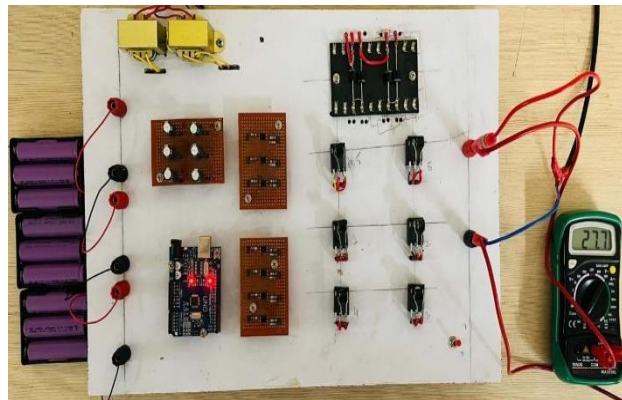


Fig.3 Hardware Modified CHB 7 level Inverter

b. Results:

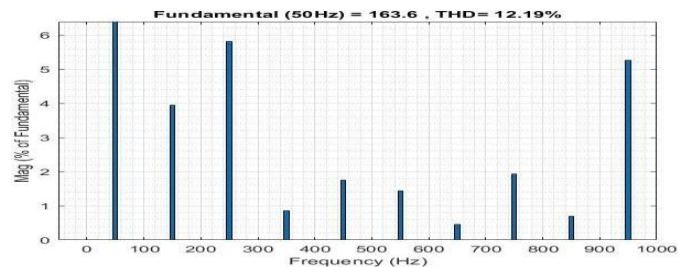


Fig.4 FFT Analysis

Fig. 4 shows the FFT analysis used to evaluate the harmonic content of inverter output waveforms. The conventional seven-level CHB inverter has a THD of 31.07%, indicating high harmonics that reduce power quality and increase energy losses. In contrast, the modified seven-level CHB inverter achieves a significantly lower THD of 12.19% due to an optimized topology with fewer switches and diodes. This results in smoother

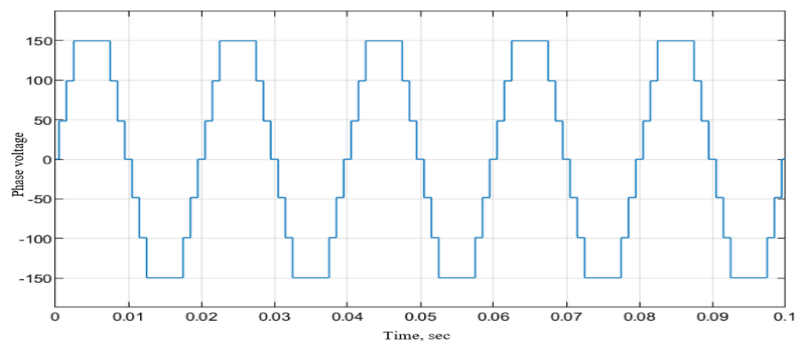


Fig.5 Simulation Output of 7 levels inverter

voltage transitions, reduced switching losses, and improved efficiency. The lower THD makes the modified design more suitable for applications like renewable energy, industrial motor drives, and grid-connected systems.

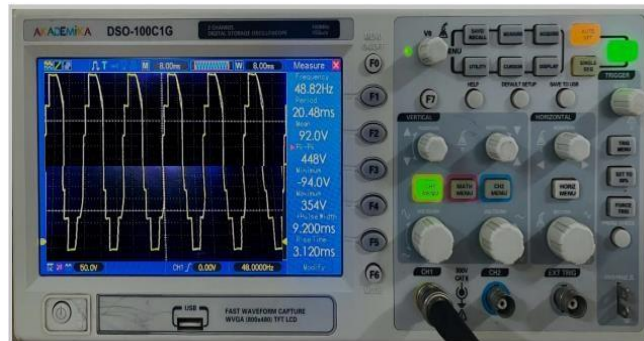


Fig.6 Hardware Output of 7 levels inverter

The hardware setup consists of a 12-pack battery providing a 36V DC input. The system integrates an Arduino microcontroller for control logic, driver circuits for signal amplification, and MOSFET switches for switching operations. The driver circuits are powered using a 230V AC supply. The output waveform is observed using an oscilloscope, confirming a seven-level stepped waveform with a frequency of 48.82Hz and a peak-to-peak voltage of 27.9V. This stepped output effectively reduces harmonic distortion and enhances efficiency, making the inverter highly suitable for motor drives and renewable energy systems.

5. Conclusion

In conclusion, a seven-level cascaded H-bridge inverter with reduced switches offers a highly efficient solution for modern power conversion applications. By reducing the number of switches, the topology simplifies control circuits and reduces switching losses, resulting in lower overall system costs and higher efficiency. The ability to generate near-sinusoidal voltage with minimal harmonic distortion makes this inverter ideal for applications that require clean, reliable power. With fewer components, the system becomes more reliable, easier to maintain, and has a longer operational lifespan. Its scalability allows for seamless adaptation to various high-power and high-voltage scenarios, such as industrial drives and renewable energy systems. The simplified design also reduces the need for complex filtering, further improving overall performance. In summary, this inverter topology provides a cost-effective, compact, and reliable solution for advanced power electronics applications.

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SOLAR PAINTS

Pooja Mohite, Sakshi Pawar, Janhavi Bhingardev, Ajinkya Patil

Electrical Engineering, Nanasaheb Mahadik College Of Engineering, peth

Electrical Engineering, Nanasaheb Mahadik College Of Engineering, peth

Electrical Engineering, Nanasaheb Mahadik College Of Engineering, peth

Electrical Engineering, Nanasaheb Mahadik College Of Engineering, peth

Abstract: The solar colour ideology has attracted a lot of attention among people because of its Portability, user friendliness and compatibility compared to regular solar panels. Solar colours are just colours that can be switched to solar panels on each surface when applied. The most important features of the solar colour are likely due to portability, cost efficiency and flexibility. This study aims to define a practical approach for the development of solar colours to generate electricity from photocatalytic processes using solar energy. The colour of the sun has many advantages. When applied to a building roof, it generates power and can be operated forever.

Keywords: Efficient, Flexible, Portable etc.

1. Introduction

The world is in the dependency of the electricity i.e. electricity for its every day wishes like from walking the machines in the industries, electric motors for their working, and many others. This all activities of we humans are powered through the electric producing power plant life can also the power is produced by way of nuclear, sun, natural fuel, coal and different fossil fuels. Sun is a massive nuclear reactor, which continuous emit trillion, and quad trillion watts of power on the planet, which just need to be, harvest anyways to fulfil the wishes for earth. For strength we need a non-stop, eco-friendly, clean and renewable supply of electric electricity generation supply. Today we're completely dependent on the photovoltaic cells for harvesting the power from the solar. Which can be hard forums, which includes the layer of PV cells. These kind PV cells have most important dangers like they occupies a totally big area, they're very steeply-priced. The common residential solar panel can convert approximately 18% of all the sunlight that hits a panel into usable energy. This might not seem like a great deal, but it's in reality taken researchers pretty a long time to get to that efficiency degree. It took seventy seven years to head from the 1% performance of the first sun panel ever invented to the creation of a 14% efficiency panel in 1960.

On the other hand, sun paints are extra appealing because these are light weight, few nanometers in size and flexible as compared to crystal silicon wafer sun cells that are rather huge in length, bulky and breakable due to the lifestyles of these paints in answer shape, it additionally gets rid of the barrier of installing confined range of solar cells in a constrained place for the era of strength. Furthermore, it may be implemented to a huge variety of conductive surfaces consisting of glass and plastic. Despite these kind of attractive capabilities of photovoltaic paints, there may be nevertheless a need to explore the methods to enhance the efficiency of those paints to make them powerful for huge variety of business packages.

2. Related Work

The solar paint additionally can join the sensitizer and large band gap semiconductor in single layer. [1] Solar paint is nothing but paint that is capable of changing any surface into a solar panel. When it is applied on the roof of a building it generates electricity and can be operated forever. [2] The author uses solar paint for electricity generation. The application of the paint curing oven to both the controllers has provided a defined result.[3] Solar paints are more appealing because these are light weight, few nanometers in size and flexible as compared to single crystal silicon wafer solar cells which are relatively big in size, bulky and breakable. Due to the existence of these paints in solution form, it also removes the barrier of installing limited number of solar cells in a confined area for the generation of electricity. [4] In this paper, we demonstrate colorful, flexible CIGS solar cells by using a combination of the lift-off process, and the highly transparent automotive pigments. [5]

3. Methodology

Circuit diagram:

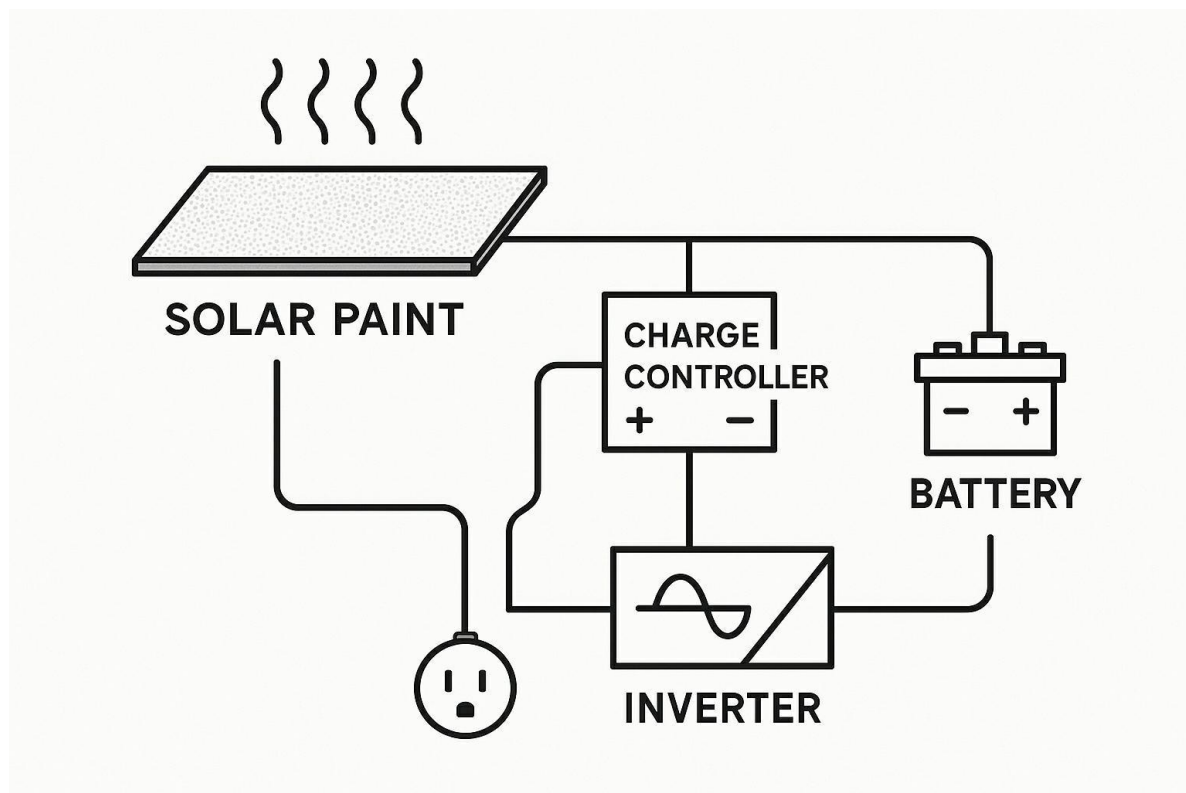


Fig. Circuit diagram of solar paints

Working principle of solar paints:

Solar paint, additionally known as photovoltaic paint, converts daylight into strength the usage of nano-sized photovoltaic substances. Sun paint works by harnessing daylight and changing it into electrical strength. The working precept relies upon at the sort of solar paint being used. Solar paint is a progressive generation that converts sunlight into electrical power thru a thin, paint-like coating that incorporates photovoltaic materials which include perovskites or semiconducting nanoparticles. While this paint is carried out to a floor, inclusive of a wall or roof, it absorbs daylight and excites the electrons within its lively layer. This technique creates electron-hole pairs, and because of the internal structure of the paint, the excited electrons circulate closer to one electrode while the holes move towards some other, for this reason producing a waft of electrical modern-day. The generated cutting-edge is surpassed via a diode to save you reverse flow, mainly at some stage in night or low-light situations. This direct present day (DC) is then regulated by a charge controller, which guarantees that the voltage and cutting-edge levels are ultimate and secure for storage or direct use. The electricity is usually saved in a battery for later use or furnished immediately to small masses along with LED lights, enthusiasts, or cell chargers. The entire machine works silently and seamlessly, presenting a sustainable and aesthetically beautiful alternative to traditional sun panels.

4. Future scope:

Solar paint is a kind of paint which while implemented on any floor that could soak up daylight and convert it into electrical electricity. For this reason it is able to be used within the outdoors roof surfaces of a building, vehicular surfaces, and many more. This makes it one of the very efficient renewable substances for strength consumption. It bureaucracy one of the greatest resources of green strength while advanced and used in the destiny. Because of its portability and fee performance, it would be to be had at a cheap price which could make its requirement even greater. Consequently, there's an incredible future for sun paint for retaining an inexperienced environment.

5. Conclusion:

On this paper, it's far concluded that solar paints are upcoming technology, which is ecofriendly and having a low fee fabric. The average residential solar panel can convert approximately 18% of all the daylight that hits a panel into usable power. The presently advanced paints have performance less than 10% but until they may be less expensive and cleaner than the currently used PV cells panels. Considering the cost consistent with performance of the solar paint is better than the PV cells panels hence the economic use and advantages have a completely better and vibrant future.

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Review Paper on Image Authentication Technique

Mr. Aviraje Bhosale, Ms. Rahi Jadhav, Ms. Tejashree Sakhale, Dr. A. R. Nichal

Student, Electronics & Telecommunication Engineering, AITRC Vita

Student, Electronics & Telecommunication Engineering, AITRC Vita

Student, Electronics & Telecommunication Engineering, AITRC Vita

Associate Professor, Electronics & Telecommunication Engineering, AITRC Vita

Abstract: In today's digital era, where artificial intelligence and deepfake technologies can generate highly realistic images, the challenge of verifying image authenticity has grown significantly. This paper explores and compares five cutting-edge image authentication techniques: GAN fingerprinting, digital watermarking (using DWT, DCT, and SVD), encryption-based watermarking, neural hashing, and neural network-based authentication. To address the limitations of individual methods, we propose a hybrid model that combines watermarking, encryption, and neural hashing for enhanced security. Aimed at students and early researchers, this paper breaks down these concepts into accessible language, complemented by visual diagrams and comparison charts to aid understanding.

Keywords: GAN Fingerprinting, digital watermarking, watermarking with encryption, neural hashing, and authentication using neural networks.

1. Introduction

In today's digital age, images aren't just memories; they're proof, ways we communicate, and valuable items. We rely on them for everything from verifying news and legal papers to securing biometric data and art. Because of this, making sure digital images are real and unchanged is super important. But with the rise of sophisticated editing tools and AI-generated content like deepfakes, the risk of tampering is more serious than ever.

This has opened up a whole area of image authentication, which aims to make sure that an image is genuine and reliable. Researchers have been working on various methods to tackle this problem.

With multimedia becoming so common, the way we share and store information has changed a lot. Images are one of the most common types of digital media, and they play a big role in areas like news, social media, healthcare, and research. But as advanced editing tools and generative adversarial networks (GANs) improve, keeping digital images authentic is a real challenge.

It's important to be able to tell real images from altered ones to keep trust in online interactions. This is especially crucial in sensitive fields like forensics, where the trustworthiness of visual evidence can really matter. Traditional methods for checking images can work to some degree but often struggle to catch the more subtle changes made with advanced machine learning techniques.

This study looks into the latest image authentication methods, focusing on new techniques that use AI. For example, GAN fingerprinting is a fresh way to identify specific traits in images made by certain GAN models. Then there's neural watermarking, which finds neat ways to embed and verify info within images, helping to ensure they're authentic. Other methods like encryption-based watermarking, neural hashing, and neural network authentication add even more options to fight against image forgery.

By taking a closer look at these modern techniques, this research aims to explain how they work, their benefits, and their downsides. The study not only breaks down the technical side of things but also shows how these methods can be applied in real life, giving valuable insights for both academics and professionals. Using

comparisons and visuals, this paper aims to connect theory with practice, helping to deepen our understanding of the changing world of image authentication.

2. Related Work

Tools and Technologies

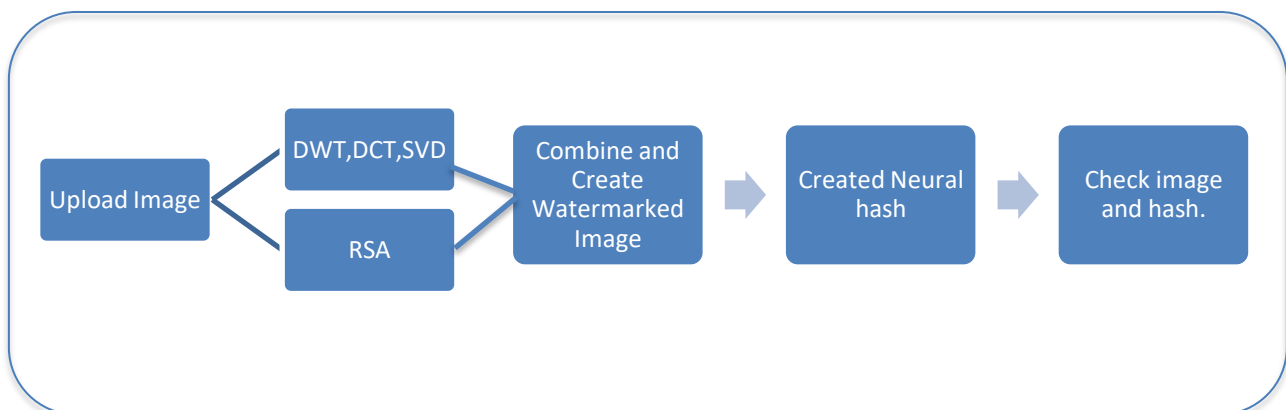
1. Python: This is the go-to language for writing scripts and working with data. It's super user-friendly and has loads of libraries for different tasks, making it perfect for any sort of data processing.
2. OpenCV: If you want to work with images, OpenCV is a must. You can do everything from simple edits to complex transformations. It's like a Swiss Army knife for image processing.
3. Py Wavelets: This is handy when you're working with wavelet transforms, particularly the Discrete Wavelet Transform (DWT). It helps in breaking down signals into different frequency components.
4. SciPy and NumPy: These libraries are great when you're dealing with matrices, especially for tasks like the Discrete Cosine Transform (DCT) and Singular Value Decomposition (SVD). They make numerical computations a lot easier.
5. Cryptography Libraries: If you need to handle encryption, these libraries come in clutch, especially for RSA encryption, which is widely used for securing data.
6. TensorFlow or PyTorch: These are the primary frameworks people use for building and training neural networks. They allow you to create a neural hash model if that's what you're aiming for.
7. MATLAB: This software is excellent for prototyping your ideas and visualizing your data. It's very popular in academic circles and can help in understanding your work better.

Datasets

1. USC-SIPI and COCO dataset: These datasets are perfect for testing both color and grayscale images. They provide a variety of images to check how well your tools and techniques perform.
2. Custom datasets: Creating your own collection can really help. You can include tampered images alongside authentic ones to see how well your systems can tell the difference. This can be important for fine-tuning your models and ensuring they work in real scenarios.

Flowchart: System Workflow

This diagram shows how the system works from the input image to the final verification.



Flowchart No.1 : System Workflow

3. Literature Review

GAN Fingerprinting

GANs, or Generative Adversarial Networks, can create fake images that look almost like real ones. Just like how cameras leave behind tiny noise patterns, different GANs also have their own unseen patterns called GAN fingerprints.

Digital Watermarking with DWT, DCT, and SVD

Digital watermarking is about hiding information like logos or IDs in images so that it's not visible to our eyes but can be pulled out later for checking. To make these watermarks strong and secure, we can combine three techniques: DWT (Discrete Wavelet Transform), DCT (Discrete Cosine Transform), and SVD (Singular Value Decomposition).

Encryption-Based Watermarking

Watermarking is great for hiding info, but it can be at risk if someone knows how it's done. To keep the watermark safe even before it goes into the image, we use encryption. This method is called encryption-based watermarking, and it adds an extra layer of security by first encrypting the watermark, then embedding it.

Neural Hashing for Image Authentication

In simple terms, a hash is a short code that represents a larger piece of data. Neural hashing uses neural networks to create unique codes for images. The idea is that if two images are very similar, they will have almost the same neural hash. If there's any alteration, like a change or a fake image, the hash will look very different.

Neural Network-Based Image Authentication

This method relies on deep neural networks, particularly Convolutional Neural Networks (CNNs), to learn from both real and altered images. The model gets trained to spot forgeries, edits, or tampering in digital images without adding any extra information. Instead, it focuses on patterns in visual aspects like texture differences, color issues, or odd edges caused by tampering.

4. METHODOLOGY

GAN Fingerprinting

1. Train a CNN to spot unique GAN fingerprints in different datasets like ProGAN and StyleGAN.
2. Check how well it holds up against resizing, compression, and noise.

Digital Watermarking

1. Add watermarks using DCT, DWT, and SVD methods.
2. Measure how well it stands up to attacks using PSNR and NCC metrics.

Watermarking with Cryptography

1. Use DWT for embedding and RSA for secure encryption and decryption.
2. Test its security and the cost of computing against possible forgery.

Neural Hashing

1. Create sensitive 64-bit hash codes with a neural network.
2. Test security using collision resistance and entropy checks.

Neural Network Authentication

1. Train feedforward networks to insert authentication codes in blocks.
2. Spot tampering by comparing codes from original and altered images.

4. Experimental results

Each image authentication technique has its own strengths, but there's a balance between security, efficiency, and how well it fits different situations.

Table No. 1 : Image Authentication

Technique	Security Strength	Computational Cost	Scalability	Resistance to Attack	Applicability (1 to 5)
GAN Fingerprinting	4	3	4	4	4
DWT/DCT/SVD Watermarking	3	3	3	3	3
Watermarking + RSA	5	4	3	5	3
Neural Hashing	4	2	4	3	2
Neural Network Authentication	4	4	3	4	3

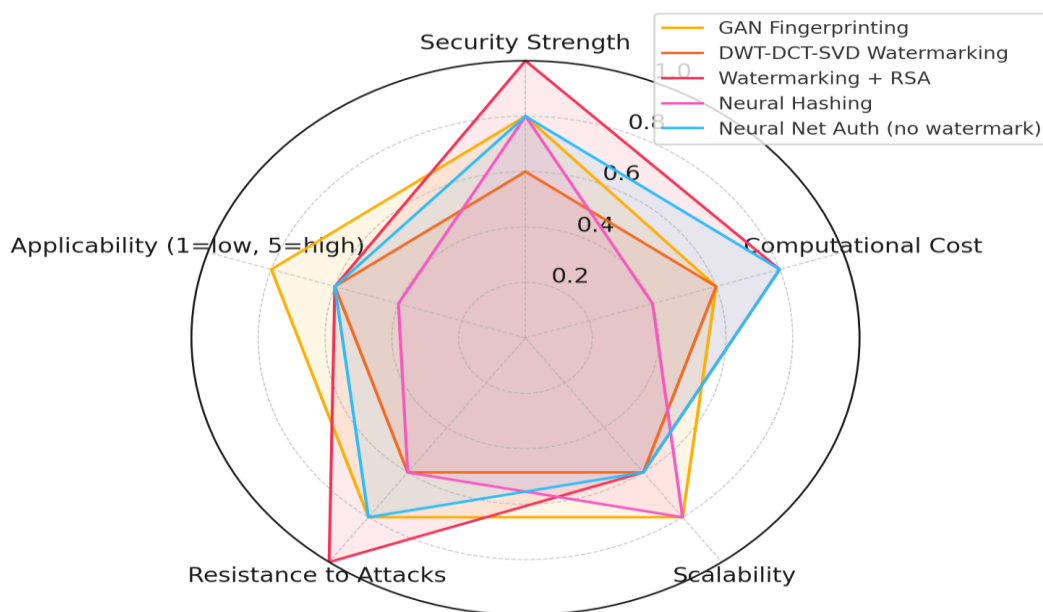


Figure No.1 : Radar Chart to Compare Image Authentication Methods

5. Conclusion

In today's world, we see digital images everywhere, whether it's on social media, in emails, or on news sites. Because of this, it's super important to make sure those images are real and haven't been altered. There are a bunch of ways to check a digital image's authenticity, from simple watermarking techniques to complicated systems that use deep learning to spot fakes. Each method has its own twist on tackling this problem, which is really important now more than ever.

This paper looked into a lot of different ways to authenticate images. It covered traditional techniques like DCT, DWT, and SVD watermarking, and reached all the way to modern methods like GAN fingerprinting and using neural networks to detect tampering. Traditional approaches usually focus on either hiding or taking out

security features from the images. In contrast, newer methods that use AI are all about learning and adapting, which is necessary when dealing with threats like deepfakes and other attacks aimed at tricking people.

It's clear that there isn't just one clear-cut answer to this issue. The future of making sure images are authentic seems to point towards a mix of different methods. We might see a combination of the solid reliability of watermarking, the accuracy of hashing, and the smart capabilities of neural networks working together. For those just starting in this field, especially students and early researchers, it's crucial to get a grasp on the advantages and challenges of each method. Understanding these can really help build a safer digital world where we can trust what we see.

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AI in Power System

Sakshi Jadhav, Diksha Bhosale, Ajinkya Patil

Electrical Engineering, NMCE, Peth.

Electrical Engineering, NMCE, Peth.

Abstract: As we navigate the ongoing energy transition, the landscape of electricity generation and distribution is shifting, leading to an increased emphasis on power systems. Their significance is becoming increasingly clear as we face new operational challenges. For instance, the integration of renewable energy sources and electric vehicles is transforming the system, resulting in greater involvement in ancillary services. Artificial Intelligence (AI) presents a variety of solutions to tackle these challenges, capitalizing on the rise in sensors and computational power. Key areas of interest include: (1) the applications of AI in power engineering, (ii) the challenges encountered in developing AI applications and potential solutions, (iii) real-world examples of systems, and (iv) prospective AI applications in power systems. There have been significant advancements in both software and hardware aimed at facilitating analysis, design, planning, operation, and control within power systems.

Keywords: AI, generation, distribution, planning, operation, control.

1. Introduction

An electric power grid may be a network of electrical components wont to supply, transmit and use electrical power. Power systems engineering may be a subdivision of EE that deals with the generation, transmission, distribution and utilization of electrical power and therefore the electrical devices connected to such systems like generators, motors and transformers.

Commonly, AI is understood to be the intelligence exhibited by machines and software, for instance, robots and computer programs. The term usually wants to describe the project of developing systems equipped with the intellectual processes, features and characteristics of humans, just like the ability to think, reason, find the meaning, generalize, distinguish, learn from past experience or rectify their mistakes. Artificial general intelligence is that the intelligence of a hypothetical machine or computer, which may accomplish any intellectual assignment successfully, which a person's being, can accomplish.

Power system analysis by conventional techniques becomes harder because of: (i) Complex, versatile and enormous amounts of data, which is employed in calculation, diagnosis and learning. (ii) Increase within the computational period of time and accuracy thanks to extensive and vast system data handling. The modern power grid operates on the brink of the bounds thanks to the ever-increasing energy consumption and therefore the extension of currently existing electrical transmission networks and features. This example requires a less conservative power grid operation and control function, which is feasible only by continuously checking the system states during a far more detailed manner than it had been necessary.

2. Related Work

The challenges we face primarily stem from the need to balance safety (avoiding false tripping's) with the speed of operation and reliability (ensuring no missed operations).[1]The greater the safety measures of the relay encompassing both the algorithm and its specific settings the more likely it is to misoperate or function slowly.[2] Conversely, if the relay operates at higher speeds, the likelihood of false operations increases. The following issues highlight the current practices in power grid protection.[3]

To address the limitations inherent in traditional relaying methods, there are two main approaches. The first involves enhancing and expanding the range of measurements available to a relay, such as integrating optical CTs for improvement and broadening substation capabilities.[4]The second approach is to improve the fundamental processing of existing data. [5]This could mean exploring new relaying principles, combining

multiple known principles within a single relay to enhance processing, correcting transient errors from CTs and CVTs, or utilizing artificial neural networks (ANNs) to refine fault detection.[6] Additionally, self-organizing algorithms like ANNs can be employed to automatically discover effective protection principles.[7]


Estimating the standard signals accurately enough for making tripping decisions always takes time. These signals can be measured quickly or accurately, but no digital measuring algorithm has been developed that resolves the well-documented conflict between speed and accuracy.[8] We can apply pre-filtering, utilize a longer data window in the essential algorithm, or implement post-filtering sometimes using a combination of these methods. There is always some level of uncertainty in estimating the standard signals at the onset of a disturbance when a relay operation is most needed.[9] In certain scenarios, even if the estimation is not precise, the value of the standard signal can still lead to reliable decisions. However, in cases like a fault occurring at the edge of the protection zone, the relay must wait for a more accurate estimation of the standard signals before taking action.[10]

3. Methodology

The articles chosen for this review are based on a variety of parameters and selection criteria. The shortlist emphasizes factors like duration, analysis, comparisons, and applications. The challenges examined regarding power system operations, control, and planning are outlined below, along with Fig. 1, which visualizes the domains of the power sector and the AI techniques used in their applications.

Power system operation encompasses the total power demand that must be reliably met by real-time generation, factoring in transmission losses. This task involves several challenges, including economic load dispatch (ELD), power flow, unit commitment, and generator maintenance schedules. The design of power systems is inherently complex and large, with interferences being significant issues. When a major disturbance occurs, it's crucial to identify the affected area and implement control measures to mitigate the impact and restore normal operations. Heuristic solutions tend to be non-linear, making them less effective for sudden disturbances. To tackle these issues, various control optimization techniques are explored, such as voltage control (VC), power system stability control, and load frequency control.

Power system planning involves arranging a complex and extensive power system, which includes components like flexible alternating current transmission system (FACTS) devices and distribution systems. The primary objective of least-cost planning is to optimize the necessary components to ensure sufficient power delivery at minimal expenses. Factors such as the placement of FACTS devices and demand considerations play a significant role in the development of power system planning. The optimization problems addressed in this task include reactive power optimization, distribution system planning (DSP), and capacitor placement.

Domain	Power System Operation	Power System Control	Power System Planning
	<ul style="list-style-type: none"> • Operation • Service • Customers • Electricity-flow • Distribution • Transmission • Bulk Generation 	 <ul style="list-style-type: none"> • Central Computer • Terminal • Power Station • Load • Digital Relay • Relay Control • Central Control 	<ul style="list-style-type: none"> • Generation ↓ • Transmission ↓ • Distribution ↓ • Customer
Application	<ul style="list-style-type: none"> • Economic-load dispatch • Scheduling for generator maintenance • Power flow • Unit commitment 	<ul style="list-style-type: none"> • Voltage control • Power system stability control • Load frequency control • Systems and services 	<ul style="list-style-type: none"> • Distribution planning • Capacitor placement • Renewable generation methodologies

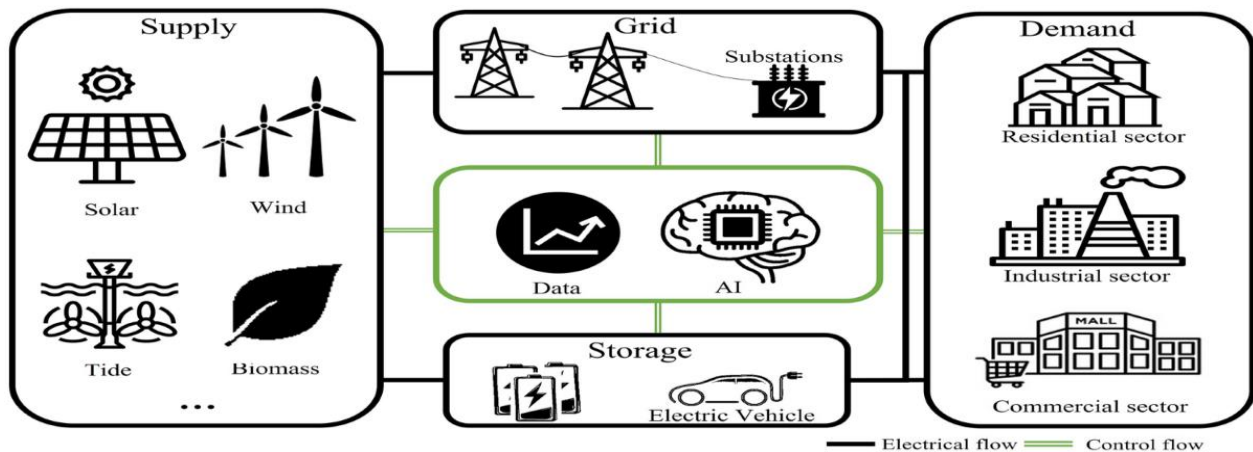
AI Method	<ul style="list-style-type: none"> Particle swarm optimization Adaptive Neuro fuzzy interface System (ANFIS) Mixed integer linear programming (MILP) Genetic Algorithm (GA) 	<ul style="list-style-type: none"> Hybrid Networks with PSO PSO Artificial Neural Network (ANN) and PSO Back Propagation ANN The Neuro-Fuzzy System with PSO Nonlinear control 	<ul style="list-style-type: none"> PSO Fuzzy Logical & PSO MILP with GA ANN with GA Anti-Colony Optimization with GA
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4. Future Scope

The increasing demand for electricity projects is driven by the shift to simpler energy forms and the integration of renewable sources like wind and solar power. This transition has led to reduced inertia in the electric power system, increasing uncertainty in operations. Issues regarding power angle, voltage, and frequency stability have become pressing. To ensure worker safety and grid security, it is crucial to accurately assess power supply stability, particularly for nodes without power.

Evaluating energy costs and implementing improvements can result in substantial energy savings. Smart technologies hold great promise for lowering electricity demand and minimizing environmental impact. It's essential to foster social acceptance of smart home systems. Future research should aim to include larger sample sizes, incorporate a wider range of countries, and delve deeper into smart meter data. Additionally, attention must be given to addressing technical, security, and privacy concerns, with a call for collaboration among stakeholders to bolster the smart home market.

While the current approach presents several advantages, there remains a challenge in accurately calculating the technical condition index for equipment made up of various functional units. Existing methods typically depend on expert evaluations to assign importance to each unit. Future research could work towards refining these methods for calculating the technical condition index across different types of power equipment, as well as developing predictive models to foresee equipment failures when functional units malfunction. It's crucial that upcoming studies focus on creating more precise and reliable predictive models for power systems while navigating the complexities of data availability and interpretability.



5. Conclusion

The significance of utilizing AI tools has become increasingly evident in the realm of facility systems, highlighting the growing necessity for their adoption. These tools simplify the evaluation of unclear concepts, and their ability to learn and adapt, driven by technological advancements, has amplified the impact of soft computing techniques. Reliability stands out as a key aspect in the design and planning of power grids. Traditional methods often fall short of addressing the probabilistic nature of power systems, leading to heightened operational and maintenance costs. A considerable amount of research still needs to be conducted to fully harness the potential of this emerging technology, especially in enhancing the efficiency of the electricity market and investment in power systems that leverage renewable energy resources for their operations.

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Electric Bicycle Regeneration System

Suyash Awasare, Anjali Mane, Soham Desai

Electrical Engineering, Nanasaheb Mahadik College of Engineering, Peth

Electrical Engineering, Nanasaheb Mahadik College of Engineering, Peth

Electrical Engineering, Nanasaheb Mahadik College of Engineering, Peth

Abstract: An electric bicycle is a motorized bicycle with an (having different things working together as one unit) electric motor used to help propulsion. Many kinds of bicycles are available worldwide and electrical bicycles are the best rating for eco-friendly transportation. But electric bicycles have limited range due to battery ability (to hold or do something). In electric bicycles, the electrical storage device gets down; to overcome this problem, we have found a solution that is to (grow again/give life to again) energy by using this system. This system consists of a DC generator to (grow again/give life to again).

Keywords: Electric Bicycle, Energy Regeneration, DC Generator, Battery Recharging

1. Introduction

An electric bicycle is a motorized bike with an (having different things working together as one unit) electric motor that helps propulsion. First recorded/supported in the 1890s, electric bicycles have changed (and gotten better) into two main types: pedal-help bikes and throttle-controlled bikes, with both allowing the rider to pedal. E-bikes are legally classified as bicycles in many areas, avoiding strict rules for deadly walks or motorcycles. They provide an easy, extremely easy riding experience, offering flexibility in pedalling strength, which makes them good for all generations and activities.

This project focuses on the electric bicycle regeneration system, dealing with electrical storage device using everything up (completely) by (growing again/giving life to again) energy. The system uses a DC generator that operates on (related to electricity-producing magnetic fields) induction, converting mechanical movement into DC electricity. Also, a Piezoelectric Generator is used to convert mechanical stress into electrical energy, providing a (producing a lot with very little waste) solution for electrical storage device recharging.

2. Related Work

E-bikes are classified based on their motor power and control systems, but definitions differ across countries, leading to changing/different legal classifications. One of the main challenges with e-bikes is their limited range, which is held back by electrical storage device's ability (to hold or do something) and the lack of charging stations. To improve this, a system could be developed using a DC generator and piezoelectric generator to recharge the electrical storage device while the bike is in movement. The DC generator would (record by a camera or computer) energy from the bike's movement, while the piezoelectric generator would capture and control vibrations, providing a continuous energy source to extend the bike's range.

3. Methodology

1. By referring to different research papers published in (reported or said to be) journals, finding the topologies which increase the running range of an Electrical Vehicle.
2. By developing a Voltage-Controller-based Electric Bicycle Energy Regeneration System, it improves the distance traveled by an Electrical Vehicle.
3. By using a DC generator, we are going to convert mechanical energy into electrical energy.
4. By using a piezoelectric generator, we are going to convert the mechanical stress of a wheel into electrical energy.

5. Designed Electric Bicycle Energy Regeneration System performance will be compared with existing systems.

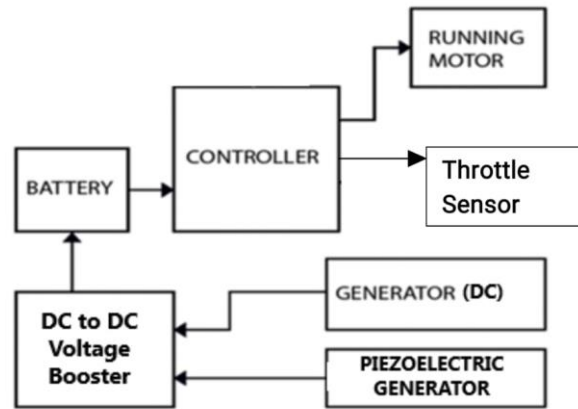


Fig. 1 Block diagram for electrical Bicycle Regeneration System

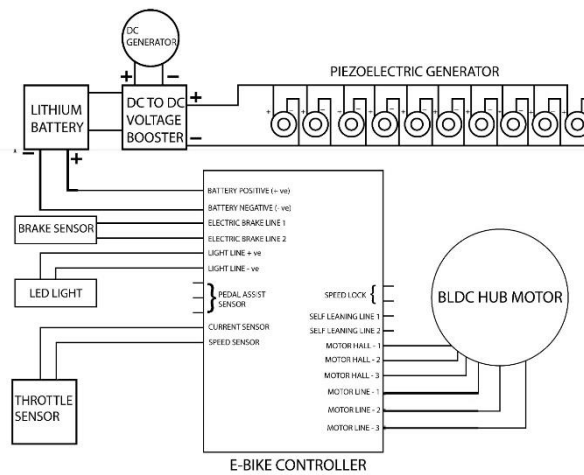


Fig. 2 Circuit diagram for regenerative braking system controller

4. Experimental results

The experimental setup involved testing an electric bicycle equipped with a DC generator and a piezoelectric generator to recharge the battery during movement. The system was evaluated based on its ability to extend the bike's range, convert mechanical energy into electrical energy, and improve battery life.

4.1. Test Setup

The bike was equipped with:

- **DC Generator** to convert mechanical movement into DC electricity.
- **Piezoelectric Generator** to capture mechanical stress from vibrations.
- A **Battery** to store the generated energy.

Tests were conducted on flat, inclined, and varied terrains, measuring distance, energy conversion efficiency, and battery recharging.



5. Conclusion

By developing this Electric Bicycle Energy Regeneration System, we can increase the range of the electrical vehicle. This system is capable of capturing and controlling electrical energy from the mechanical energy of the wheel, effectively converting the movement and vibrations into usable electrical power, which can be stored in the electrical storage device. This continuous energy generation while the bike is in movement helps reduce reliance on external charging sources, (in the end) extending the distance the electric vehicle can travel.

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Industrial fire safety System using Distributed Control System (DCS)

Mr. Ansar Mulani, Miss. Sakshi Patil, Mr. Omkar Sawant, Miss. Devaki Sadavarte, Miss. Mansi Kamble

Department of electrical engineering , ADCET , Ashta, Sangli.

Department of electrical engineering , ADCET , Ashta, Sangli.

Department of electrical engineering , ADCET , Ashta, Sangli.

Department of electrical engineering , ADCET , Ashta, Sangli.

Department of electrical engineering , ADCET , Ashta, Sangli.

Abstract: Industrial fire safety, this module will be examining the main components of alerting suppression & containment features and system. Consideration of this system is a natural adjunct to a discussion of hazards and industrial fire safety features. Presence of flammable gases, materials, high temperatures can lead to higher risk of fire .To overcome such unwanted situations, fire safety system is designed. This system is specially designed to detect, control & extinguish fire also to minimize damage and gives quick response. This system includes fire & smoke detection sensors, automatic suppression systems (water motor & exhaust fan) and manual switch. The system also gives additional benefits such as advanced monitoring, quick control, real-time data analytics. This offer ms early detection and quick responses. Regular maintenance, training to staff, sticking to safety regulations is essential to work system effectively. By integrating this, system focuses on minimizing risks and protecting personnel and property, providing a safe environment for work.

Keywords: DCS, industrial safety, fire safety, industrial automation, DCS-Integration for Fire Protection, Wireless Fire Detection System, Real-time monitoring, smoke exhausting automation.

1. Introduction

The complex processes and hazardous materials in the industries demand the strictest fire safety systems. Existing fire protection systems tend to not afford enough protection in larger buildings due to their reliance on manual action and localized notification. A study offered by Pamela D. (2022), proposed that DCS can not only automate, but monitor, industrial procedures in real time; therefore, it can be applied to fire safety. But we still have so much to learn about the integration of various sensor data and autonomous response systems in a complete DCS based fire protection system. Specifically, the question arises : How can DCS controls industrial processes, using smart automation and combined information from many sensors, quickly detect and stop fires in large industries , while reducing property damage and keeping all working people & environment safe? It is essential to address this question with the increasing complex industrial processes and the increasing number of fire accidents, affecting economic stability and environmental sustainability. The goal of this project is to design and implement a DCS-based fire protection system, utilizing real-time data analysis and automatic response to establish new safety standards for petrochemical, manufacturing, and logistics industries, where the risk of fire accidents is higher. By creating a centralized but distributed system, we aim to minimize response time, prevent overloading during emergencies, and ultimately enhance the overall safety and resilience of industrial processes. This study contributes to the development of fire safety technology and offers a feasible method for industries to achieve strict safety standards and safeguard human resources and properties.

2. Related Work

Existing research on industrial fire safety systems shows importance of the integration of advanced control and automation technologies to improve detection, response, and overall safety. Numerous studies investigate the application of Distributed Control Systems (DCS) . It is used to manage various aspects of plant operations,

with fire safety emerging as a important area of focus. This body of work shows the benefits of using DCS , it provides a centralized platform , it monitors sensors, triggers alarms, and activates suppression systems. Research gives details of such integrated systems, including the types of sensors employed (e.g., smoke, heat). Also, the logic implemented within the DCS to give appropriate responses based on detected situations. Moreover, studies inspect the reliability and fault tolerance of these automated systems, often giving redundancy measures and diagnostic tools to ensure continuous operation and minimize the risk of system failure during critical situations.

3. Methodology

3.1. Block diagram:

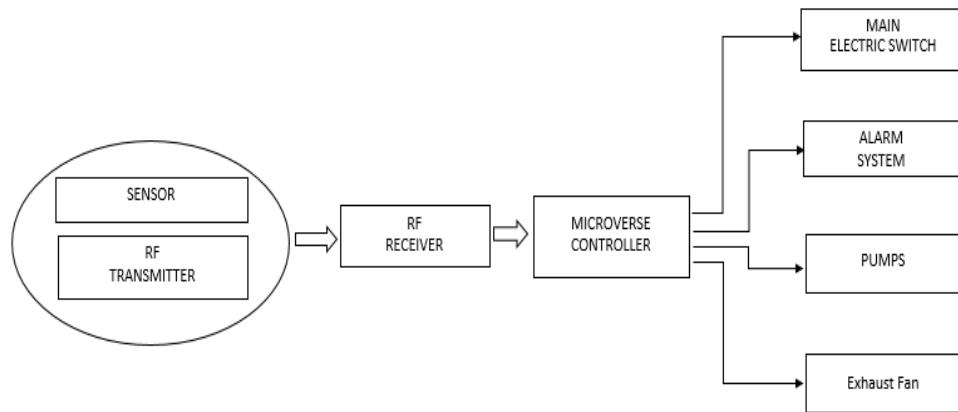


Fig. 3.1 Block diagram

A circuit block diagram of industrial fire safety system demonstrate the interconnected components & subsystem that work together to detect & restraints fire in industrial system. The fig. 4.1 typically includes, Microcontroller , sensors such as fire sensor & smoke sensor , Manual Switch , RF Transmitter & RF Receiver , Alarm system (Buzzer) , Water Motor , Exhaust fan . Each one detail as follows –

1) Microcontroller :

The microcontroller acts as the central processing unit that receives data from fire detection devices, such as smoke detectors, heat sensors. It processes this data to determine if there is a fire risk. It processes the inputs from sensors to assess fire conditions. The microcontroller inspects sensor data, such as signals from smoke detectors. It will differentiate between genuine smoke and false triggers like dust or steam. Based on this inspection ,the microcontroller take decision if an alarm should be activated. It will also decide whether to initiate fire suppression systems. It follows predefined algorithms to confirm accurate and timely responses to potential fire hazards. The microcontroller controls alarm systems, including alarms, visual indicators, and notification panels. It ensures that appropriate alerts are generated to notify occupants and emergency personnel in case of a fire.

2) RF Transmitter & RF Receiver:

1. RF Transmitter: RF transmitter help to detect alarms and signals from fire safety devices For ex. Smoke sensor, fire sensor. They convert these signals into radio waves & communicate wirelessly with the DCS to monitor and examine fire risks. It detects smoke and activates alarm. It detects excessive heat and sends an "alarm" message. When someone presses it, it sends an "alarm" message. It also send commands or status updates to other devices. T his co-ordination is helpful for quick alerts and coordinated responses, increasing overall safety.

2. RF Receiver: An RF (Radio Frequency) Receiver is responsible to receive and process wireless signals transmitted by RF transmitters. The receiver's antenna captures the electromagnetic radio waves transmitted by from various fire detection devices, such as smoke or heat detectors. It captures radio frequency signals sent from various fire detection devices, such as smoke or heat detectors .Then it converts these signals into

electrical signals that control panel can understand. The receiver differentiates unwanted radio frequencies and noise, isolates the specific signal which is needed to receive. A Low Noise Amplifier (LNA) amplifies this signal to a level which is suitable for further processing without adding noise that could the information unclear. They provide real-time monitoring, ensuring that alerts and status updates are promptly communicated. In addition, RF receivers integrate and coordinate various components of a fire safety system, contributing to effective and timely fire detection and response.

3) Sensor Detection:

Effective fire detection systems are depend on a network of sensors, each designed to identify specific fire type. This research examines the arrangement of two crucial sensors - infrared (IR) fire detectors and photoelectric smoke detector, examining their operations and suitability for different situations.

1. Infrared (IR) Fire Detector: Fire detectors operate on the principle of when flames releases radiant energy detecting it. Fires release significant amounts of infrared radiation, particularly in range of 1-5 μm spectral, which leads to the emission of hot gases and combustion products. These detectors employ sensitive photodiodes or pyroelectric sensors that are tuned to this specific spectral band.

Operational Principle: The sensor monitors the environment for fluctuations in IR radiation. Advanced models utilize multiple IR sensors with different spectral filters to distinguish between genuine flames and other heat sources, such as sunlight or incandescent lighting. Microcontroller monitors the signal patterns continuously, looking for rapid increment in IR intensity and specific spectral marking characteristic of flames.

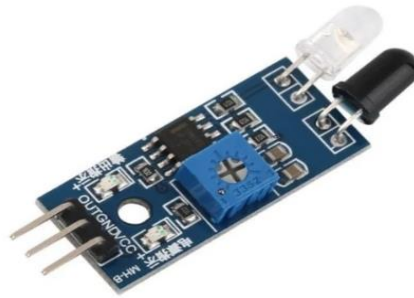


Fig. 3.3.1 Infrared (IR) Fire Detector

2. Photoelectric Smoke Detector: Photoelectric detector is effective at detecting slow, smoldering fires that produce larger smoke particles. It is generally response less to false alarms caused by cooking fumes or steam compared to ionization detectors. These detectors are very effective at detecting the larger smoke particulates that are made from smoldering fires.

Operational Principle: Photoelectric smoke detectors utilize a light source and a light sensor positioned at an angle within a sensing chamber. In a normal, smoke-free environment, the light beam from the source travels straight and does not reach the sensor. When smoke particles enter the chamber, they scatter the light, causing some of it to reflect onto the sensor. When the sensor detects a sufficient amount of scattered light, it triggers an alarm.



Fig. 3.3.2 Photoelectric Smoke Detector

4) Buck converter:

The buck converter is added between IR sensor and DCS. It takes the 24V DC power source from DCS and converts into the 5V DC on which IR sensor needs to operate safely and precisely. Hence, it acts as a voltage step-down regulator. This conversion is necessary because directly connecting a 24V power source to a 5V sensor would likely overpower. It might destroy the sensor. The buck converter ensures that the sensor receives the precise voltage it's designed for. It allows it to function reliably within the industrial fire safety system. It does this efficiently, it minimizes energy loss in the form of heat during the voltage reduction process.



Fig. 3.4.1 Buck converter

5) Alarm system (Buzzer):

Alarm system or buzzer is used to provide an immediate and distinct audible warning to personnel in the vicinity when a fire or smoke event is detected, automatically by the sensors or manually by the backup switch. It will give create a loud noise that there is a potential hazard happened to take immediate action, such as evacuation or investigation. Buzzer provides an auditory mark, which is especially important for individuals who might not be looking in the right direction or who work in areas with limited visibility, which may be working in other area without any clue of fire incidents.



Fig. 3.5.1 Buzzer

6) Water motor pump:

The water motor pump is designed to provide the necessary pressure and flow to effectively suppress and extinguish the fire. It supplies water flow to the fire suppression system when fire is detected, automatically or manually. When the DCS receives a signal from IR sensor or manual switch indicating fire, whether from a sensor or the manual switch, it sends a command to activate the water motor pump. The pump then takes water from water source like a storage tank or a main water pipe. Further, it powerfully pushes water through the network of pipes connected to fire suppression system.



Fig. 3.6.1 Water motor pump

7) Exhaust Fan:

Exhaust fans primary function is to remove smoke and other combustion products from the affected area in the event of a fire. When smoke is detected by sensors or reported manually, the DCS automatically give commands to the exhaust fans to activate. By removing smoke, exhaust fan helps to declutter the air. Thus it makes it easier for personnel to see escape routes , identify the source of the fire, and to navigate safely. Smoke contains toxic gases and particles that can be harmful or even fatal if inhaled even in small amount . The exhaust fan helps to remove this smoke, reducing the risk of smoke inhalation for people who are working there. Exhaust fan helps to prevent smoke from spreading to other unaffected areas, limits damage. A smoke-reduced environment makes evacuation safer and more efficient, allows personnel to exit the building more quickly.



Fig. 3.7.1 Exhaust fan

8) Manual switch:

Manual switch is a backup mechanism, providing a direct means for personnel to take fire safety actions in situations when automated sensors might fail to detect a fire or smoke. This manual control ensures that even if smoke detectors or heat sensors get malfunction, are obstructed due to a rapidly developing event, individuals present in the area can still take the control of situation . When the manual switch is activated and the condition identified is smoke, DCS will receive the signal and initiate the activation of alarms to alert personnel .Then it will simultaneously start the exhaust fans to clear the smoke-filled environment. This will help to improve visibility and potentially slowing down the spread of smoke to other areas. Similarly , if the manually identified condition is a fire, the activation of the switch will send command the DCS to turn on the water motor for the

3.2 Logic diagram:

Fig. 3.2 Sysdev Logic diagram

1. OR input : As name indicates its working is same as OR gate, out off all inputs, any one input is high we will get output (high) otherwise we will not get output (low). Similarly, when sensor detects fire, it will give high input and we will get high output. Also if, sensor got some malfunctions, and couldn't detect the fire and operator pushed manual switch. At this condition also we will get output. Thus any one input from sensor or manual switch is given to OR block it will give output.

3. **Monostable (One-Shot Timer):** A monostable, often known as a one-shot timer, it generates a single output pulse of a specific duration when triggered. This trigger is a rising edge (0-to-1 transition) at its input. Upon receiving this trigger, the output (Q) transitions to a high state (1), while its complement (\bar{Q}) transitions to a low state (0). The duration of this high output pulse is determined by external timing components, such as resistors and capacitors, and is set to a value greater than a minimum threshold, in this case, 10 milliseconds. The output remains in this high state ($Q=1$, $\bar{Q}=0$) for the entire duration of the set time. Once this time passes, the output returns to its stable state, transitioning to low ($Q=0$) and the complement to high ($\bar{Q}=1$). The output remains in this stable state until next rising edge trigger is given. If the input pulse duration is greater than the minimum threshold (10 ms) but less than the set time, the output still produces a pulse of the set duration.

4. ON-Delay Timer: An ON-delay timer is a sequential logic element that introduces a time delay before activating its output. When the input (I/P) transitions to a high state (1), the timer starts counting. Initially, the output (Q) is low (0), and its complement (\bar{Q}) is high (1). After the programmed time delay has passed, the output (Q) transitions to a high state (1), and its complement (\bar{Q}) transitions to a low state (0). If the programmed time delay is set to zero, the output (Q) transitions to high (1) immediately upon the input going high (1). The output remains high ($Q=1$, $\bar{Q}=0$) as long as the input (I/P) remains high (1). When the input changes to a low state (0), the output immediately transitions back to low ($Q=0$, $\bar{Q}=1$), and the timer is reset.

Detailed Explanation:

When flame or fire is detected by IR sensor it will give pulse to OR block it will give high output (1). In case some malfunctions happened and sensor couldn't detect fire then an operator will push manual switch, OR block will be high (1). Then flip-flop's set input goes high (1) and reset goes low (0). This set will be on until we reset it means its output will be high (1) and it will get low (0) when we will reset it. This output will be taken by monostable and on-delay timer so that once monostable gets command it will activate the alarm system for 5 sec. for once to alert people and on delay timer will be high (1) for 5 sec. and after 5 sec. time delay, water motor will be on to suppress fire. When all fire is extinguished, smoke sensor will give low output (0) and water motor will get off.

When smoke is detected by Photoelectric Smoke sensor it will give pulse to OR block it will give high output (1). Due to some malfunction, sensor couldn't identify smoke then operator will push manual switch, and OR block will be high (1). Then flip-flop's set input goes high (1) and reset goes low (0). This set will be on until we reset it means its output will be high (1) and it will get low (0) when we will reset it. This output will be taken by monostable and on-delay timer so that once monostable gets command it will activate the alarm system for 5 sec. for once to alert people and on delay timer will be high (1) for 5 sec. and after 5 sec. time delay exhaust fan will be on. After smoke is extracted from smoke-filled area smoke sensor will give low output (0) and exhaust fan will deactivate.

Activation and deactivation Status of each block will be shown on Pscope as a result.

4. Experimental results

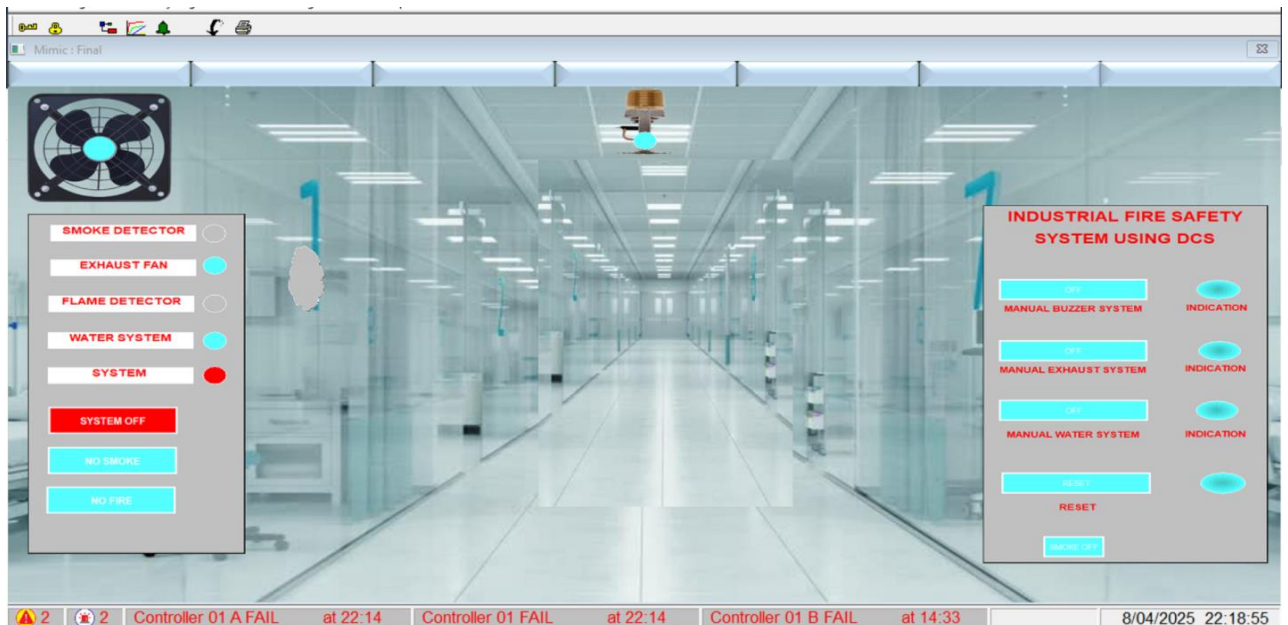


Fig.4.2 Visual representation of result using PScope.

The image provides a clear visual representation of the system's components and their functions. The left side part of image shows indications of automated sensors and their corresponding outputs. First, when smoke is detected by smoke sensor, exhaust fan will be activated, it will activate buzzer and exhaust fan. Buzzer will

make a loud sound to notify personnel to ensure their safety. Exhaust fan will extract smoke filled air and prevents smoke from spreading in unaffected areas. When IR sensor detects Fire, it will activate buzzer and water motor. Buzzer will alert occupants from fire incidents to escape to a safe place. Water motor pump will help to suppress and extinguish the fire.

The right side part of image shows indications of manual switch of buzzer , exhaust fan and water motor pump. When the manual switch of is activated and the condition identified is smoke, DCS will initiate the activation of alarms to alert personnel .Then it will simultaneously start the exhaust fans to clear the smoke-filled environment. Conversely, if the manually identified condition is a fire, the activation of the switch will send command the DCS to turn on the water motor for the fire suppression along with alarms.

5. Conclusion

In conclusion, this research effectively shows that using a Distributed Control System (DCS) to make an advanced industrial fire protection system is beneficial. in many aspects . DCS's integration with automated sensors offers Real-time monitoring. It provides automatic detection and quick response to fire hazards. It successfully differentiates between smoke and fire situations, the system give the proper responses. The system alerts personnel when it detects smoke by turning on the alarm system. It further extracts smoke to clear air. The system turns on the water sprinklers and the alert in the event of a controllable fire. The device sounds the alert and starts the water motor pump for more forceful fire suppression when there is an fire out of control .Significant benefits of the DCS-based approach include increased safety, quicker reaction times, the ability to monitor systems remotely, and increased system efficiency overall.

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Smart Medicine Reminder Using Arduino

Shrutika Patil 1, Purnima Mane 2, Anuja Chilka 3, Shreya Dagade 4, S. S. Sutar 5, R. S. More 6.

Instrumentation and Control Engineering, PVPIT College of Budhgaon.

Abstract: We always want to stay them healthy and fit. But what will happen if they get ill and forget to take medicine on time. We would be worried, at hospitals, there are many patients, and it is difficult to remind every patient to take medicine on time. The traditional ways require human efforts to remind them to take medicines on time. The digital era doesn't follow that, and we can use machine to do that. The application of Smart Medicine Reminder System is very wide and can be used by patients at home, doctors at hospitals, and at many other places. When it comes to reminding, there can be many ways to remind it.

Keywords: Arduino, Medicine, Medicine Alarm System, Notification Sound, Patient Health Sensing Capability.

1. Introduction

Taking medicine on time is very important, especially for elderly people or patients with multiple medications. But sometimes, we forget to take our medicine at the right time. To solve this problem, we can create a Smart Medicine Reminder using Arduino. This smart system helps remind a person to take their medicine on time using Alarms, Lights, or even messages. The Arduino works like small brain that control the whole system. We can set different times for a different medicine, and when it's time to take one, the system will alert the user with a Buzzer or Light.

Many peoples, especially old people or patients, often forget to take their medicine on time. This can be harmful to their health. To help them, we can make a Smart Medicine Reminder using Arduino. Arduino is a small, programmable device that can control lights, buzzer, and display. In this project, we use it to remind the person when its time to take medicine. The system gives an alert using a buzzer or light and show the message on an LCD Screen. It uses a clock module to keep track of the time.

2. Related Work

The concept of Smart Medicine Reminder System was first introduced by D. Jeya Priya . Arduino at that point the unit alarm to remind the patient to take the medicine at proper time as client is determined. At that predetermined time the alert will be in the dynamic state until the client opens the pack. In The purpose of Smart Medicine Reminder is to accurately dispense specific dosages of medication to the patient at the right time with an alarm and LED signal. Automatically as per the estimate given data by the user or the caretaker. And the system serves as a personal medication caretaker for the user. In The objective of this undertaking is to help the patients for the confirmation for prescription at the ideal time. In this paper the time and drug names are changed by the patients through the keypad associated. In The proposed system is used to give information to patients automatically for taking proper dosage at proper time which is mentioned in the prescription schedule. All the above details are done with the help of master IC, Keypad, LCD Display. After that the controller is interfaced with RTC Module to track the current time. In An automatic alarm system is implemented the alarm can be set for multiple medicines and time including date, time and medicine description. A notification will be sent to the system preferably selected by the patients. The authors in The system medicine reminder and monitoring system. The reminder part can remind the patients about the prescribed machine as will as time to taken. Once the patient takes the medicine within specified time the alarm stops. In These paper to conventional pill bottles cooled be reconfigured into an automatic multi-pill reminder and dispenser for ease of operation usability. With the help of simple microcontroller, we have attempted to create a model of a pill box-an automated pill reminder and dispenser containing several compartments for keeping different types of pills such as tablets. In Ther medicine box which solve these problems by setting up timetable of prescribed medicines through push buttons has given in prescription. Present time will be saved in RTC Module and notification time will be saved in EEPROM. Therefore, at the time of taking medicine system generate notification sound and display the light in specified pill boxes. In Arduino based Medicine Reminder System. This system includes the DS3231 Real Time Clock (RTC) module, I2C LCD Module, 3 push buttons and buzzer. Arduino Nano is used to activate the whole system. Push buttons enter time for person to take medicine. The clock module is used to set time, and LCD is used to display time

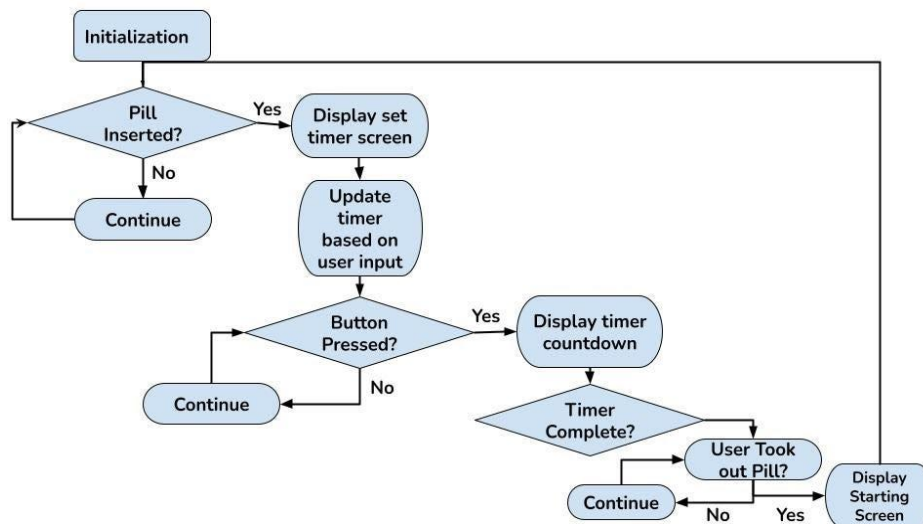
for taking medicine. In The smart pill box is equipped and based on the medicine bag concept. The medicine bags are used to interact with pill box to perform pill remind and confirm functions.

3. Methodology

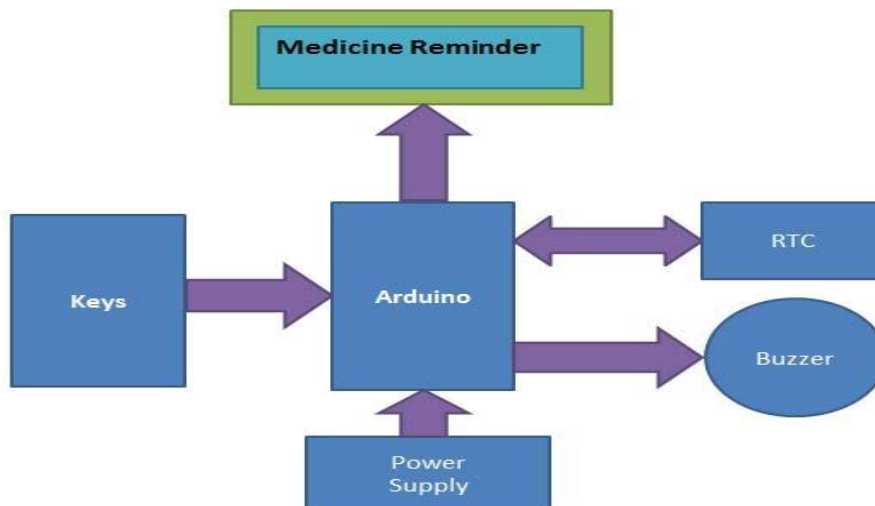
Typically involves several key steps and components working together. First, a real-time clock (RTC) module, like the DS3231, is connected to the Arduino microcontroller to keep track of the current time and date accurately, even when the Arduino is powered off, to a small battery. Users interact with the system through input devices such as push buttons to setup their medication schedules. They can typically define multiple alarm times throughout the day. This set schedule is stored in the Arduino's memory. A display, often an LCD screen, is used to show the current time, set alarm times, and provide feedback to the user during the setup process. When the current time, as tracked by the RTC, matches any of the pre-set alarm times, the Arduino triggers an output device, usually a buzzer and/ or and LED, to alert the user that its time to take their medicine. The user can then typically press a button to acknowledge the reminder and stop the alarm. Some more advanced systems might include features like that ability to set medicine names or dosages or even integrate with sensors to detect if the medicine has been taken. The Arduino code is a central part, continuously comparing the RTC time with the stored alarm times and activating the alerts, accordingly, thus providing a simple yet effective way to remind users to take their medication on schedule.

4. UML Diagram:

4.1 Use case diagram:



4.2 Sequential diagram:



5. System Requirements:

5.1 Hardware Requirements:

- Arduino Nano: The brain of the system.
- Real Time Clock (RTC) Module (e.g.DS3231): To keep track of the time accurately.
- Buzzer: To sound an alert when it's time for Medicine.
- LED: To give visual alerts.
- LCD Display: To show time and Medicine Reminders.
- Push Button: To stop alarm or confirm medicine taken.
- Power supply: To power the Arduino.
- PCB or Jumper Wires: For making connection easily.
- Medicine Box: Can be used to stored and label compartment.

5.2 Software Requirements:

- Arduino: To write and upload the code to the Arduino.
- RTC Library: Helps Arduino talk to the RTC Module.
- LCD Library: If using an LCD screen.
- Custom Arduino code: To set alarm times, display messages, and trigger alerts.

6. Experimental results

Figures shows the results of Smart Medicine Reminder Using Arduino from components image. Figs. (a) LCD Display. (b) I2C Module. (c) Arduino Nano. (d) RTC Modul. (e) Buzzer. (f) LED. (g) Push buttons. (h) Power Supply. (i) PCB.

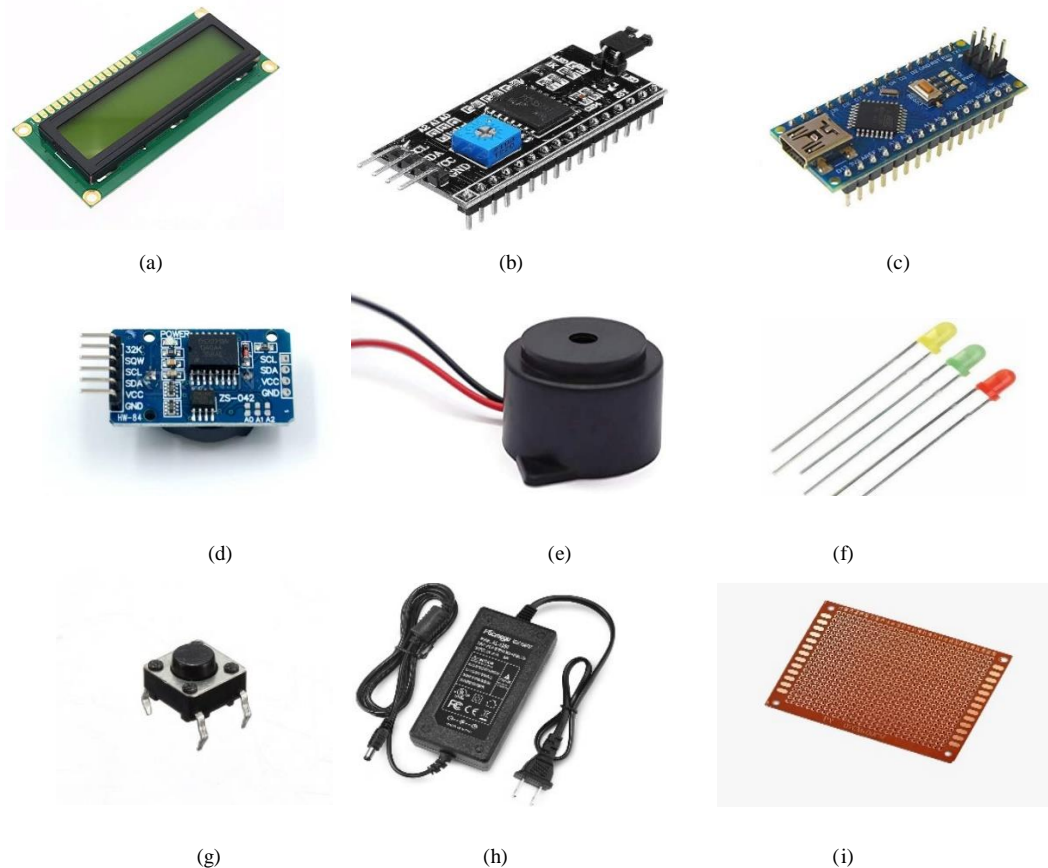


Fig. 6.1. Final actual output result.



(a)

7. Advantages

- Reminds you to take Medicine on time.
- Helps old people and forgetful ones.
- Save time and effort.
- Cheap and Easy to make.
- Can be changed any time.
- Works without internet.
- Can be made better later.

8. Limitations

- Can't detect if medicine is taken.
- Limited numbers of reminders.
- No voice alerts.
- No mobile notifications.
- Needs to be programmed.
- May need power all the time.
- Not suitable for very complex schedule.

7. Conclusion

The Smart Medicine Reminder using Arduino is helpful and low-cost device that reminds people to take their medicine on time. It is easy to build and useful for old people or anyone who forgets their medicine. Even though it has some limits, like not knowing if the medicine was taken, it can still make life easier and healthier. With more features, it can become even better in the future. The goal of our project is to provide healthy and tension free life to those users who are taking regularly pills and to provide this product at affordable prices also. Our project's objective is to help elderly people. We conclude the results that our projects are useful for those elderly people who take pills regularly and whose course of prescription is very long and difficult to remember. This device will notify them at the right time, the right medicine to be taken. This in turn helps them to stay fit and healthy without any issues.

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Electronic Stethoscope

Sanika A. Khabale, Anuja S. Shinde, Smita S. Patil

Instrumentation and control Engineering, DBATU, Lonere.

Instrumentation and control Engineering, DBATU, Lonere.

Instrumentation and control Engineering, DBATU, Lonere.

Abstract The electronic stethoscope is a modern advancement over traditional acoustic stethoscopes, designed to enhance the auscultation process through electronic signal amplification and digital processing. This device converts acoustic sound waves from the body—such as heartbeats and lung sounds—into electrical signals, which can be amplified, filtered, and analyzed in real time. Key features include noise reduction, frequency tuning for different diagnostic needs, and the capability to store and transmit audio data for remote diagnosis and telemedicine applications. By improving sound clarity and enabling digital diagnostics, the electronic stethoscope plays a significant role in enhancing diagnostic accuracy and supporting modern healthcare technologies.

Keywords: electronic stethoscope, signal processing, heart vibration signal

I. Introduction

The stethoscope has long been a fundamental tool in medical diagnostics, enabling healthcare professionals to listen to internal sounds of a patient's body, such as heartbeats, lung sounds, and bowel movements. However, the traditional acoustic stethoscope has certain limitations, including low sound amplification, susceptibility to ambient noise, and a lack of data recording or sharing capabilities. To address these shortcomings, the electronic stethoscope has emerged as an innovative solution that integrates modern electronics with traditional auscultation methods. An electronic stethoscope captures body sounds using a sensitive microphone and converts them into electrical signals. These signals can be amplified, filtered, and digitally processed to improve sound quality and clarity. Advanced features such as noise cancellation, frequency selection, and digital display allow for more accurate diagnostics, especially in noisy environments. Moreover, the ability to record and transmit auscultation data facilitates telemedicine applications and remote monitoring, making healthcare more accessible and efficient. This project explores the design, functionality, and advantages of electronic stethoscopes, highlighting their role in modern medical diagnostics and the potential they hold in transforming patient care.

II. Related Work

Over the past decade, several studies and innovation have contributed to the development and enhancement of electronic stethoscopes. Researchers and engineers have explored various technologies to overcome the limitations of traditional stethoscopes and improve diagnostic capabilities. One of the earliest development in this field was the integration of amplification circuit analog filters to improve sound clarity and isolate specific frequency ranges corresponding to heart and lung sounds. For instance, devices using operational amplifiers [op-amps] and bandpass filters were implemented to amplify heart sounds while suppressing ambient noise. Recent advancement have focused on digital signal processing [DSP] and microcontroller based systems. These stethoscopes can digitize the sound using analog - to - digital converters [ADCs] and process it through software algorithms for noise reduction, frequency analysis, and visualization. Several works have an incorporated Bluetooth Wi-Fi modules for wireless data transmission, enabling real time monitoring and telemedicine application.

III. Methodology

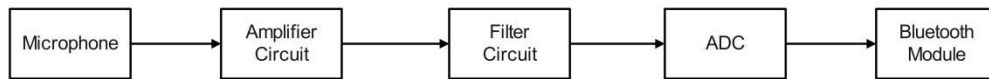


Fig. 1. Block Diagram of Electronic Stethoscope

The development of the electronic stethoscope involves both hardware and software integration to accurately capture, process, and transmit body sounds for medical diagnosis. The methodology can be broadly divided into the following stages:

- i. **Sound Acquisition:** The initial step involves capturing internal body sounds such as heartbeats and lung sounds using a high-sensitivity microphone or piezoelectric sensor placed in the chest piece. This component converts acoustic sound waves into electrical signals.
- ii. **Signal Amplification:** The weak electrical signals obtained from the microphone are passed through an amplifier circuit, typically built using operational amplifiers (op-amps) such as the LM358. Amplification is necessary to boost the signal to a level suitable for further processing.
- iii. **Filtering:** To isolate relevant body sounds, the amplified signal is passed through a bandpass filter. The filter is designed to allow frequencies in the range of: 20 Hz to 200 Hz for heart sounds, 200 Hz to 1000 Hz for lung sounds. This removes unwanted high-frequency noise and environmental disturbances, improving the clarity of the signal.
- iv. **Analog-to-Digital Conversion (ADC):** The filtered analog signal is then converted into digital form using an ADC module, often built into a microcontroller such as Arduino, ESP32, or STM32. This digital data allows for further processing and analysis.
- v. **Output & Interface:** The final processed signal can be played through headphones or a speaker, displayed on a screen or transmitted wirelessly via Bluetooth/Wi-Fi to a smartphone or computer for remote diagnostics.

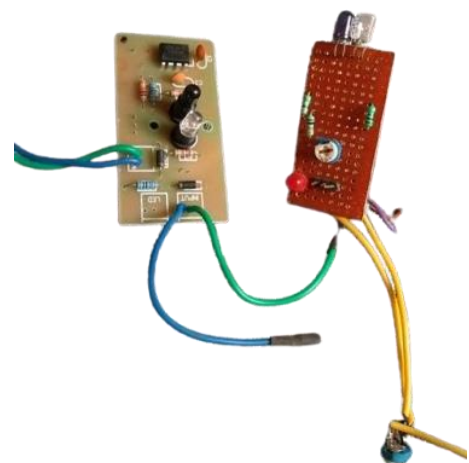
IV. Experimental Results



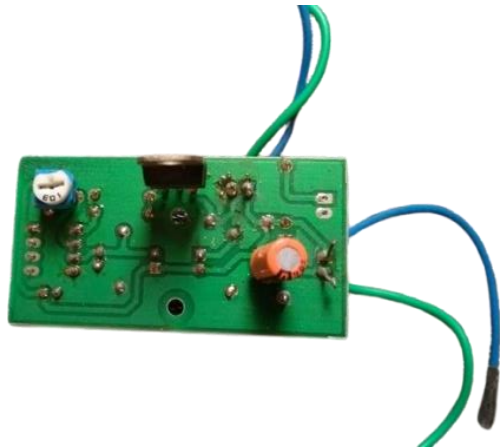
(a)



(b)



(c)



(d)



(e)

Fig. 2 Experimental setup (a) Stethoscope with 3.5mm jack (b) Diaphragm with Mic (c) Amplifier circuit (d) Circuit Back Side (e) Chestpiece

The Parts Description as follows;

Chest Piece (Diaphragm)

Contains a microphone that picks up body sounds. Some may have multiple sensors or piezoelectric components.

Amplification Circuit

Boosts the sound for better clarity and loudness.

May include filters to isolate heart, lung, or other specific sounds

Audio Output

Either via built-in speakers or more commonly, headphones/earbuds.

Power Source

Usually a rechargeable battery or standard cells.

Optional Features

Digital display Bluetooth connectivity (for recording or streaming to devices Memory to record audio clips

The fig. Shows a metallic or ceramic diaphragm from a traditional stethoscope, wired microphone wrapped in black insulation tape.

A 3.5mm audio jack which is standard headphone jack, indicating it likely connects to a phone, recorder, or amplifier.

The wire is standard audio cable, possibly to connect it to headphones or a mobile device for real-time listening or recording.

Advantages of Electronic Stethoscopes

Amplifies weak sounds

Allows recording and playback

Filters for specific sound types

Telemedicine support

Data sharing with specialists

Disadvantages of Electronic Stethoscopes

Accuracy may be low without proper acoustic calibration.

Durability and hygiene could be compromised.

Not suitable for clinical diagnosis unless tested and validated.

V. Conclusion

The electronic stethoscope represents a significant advancement over traditional auscultation tools by leveraging modern electronics to enhance diagnostic capabilities. Through the integration of sound amplification, filtering, digital processing, and wireless communication, this device offers improved sound clarity, noise reduction, and the ability to store or transmit data for remote analysis. These features make it highly beneficial in both clinical settings and telemedicine applications, where accurate and real-time diagnostics are crucial. The project demonstrates how a combination of hardware and software can create an efficient and user-friendly diagnostic tool. With continued development—such as the incorporation of machine learning for automated diagnosis or cloud connectivity for patient data management—the electronic stethoscope has the potential to become an indispensable part of next-generation healthcare solutions.

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Development of Non Invasive System For Real Time Glucose, Oxygen and Heart Rate Monitoring

Arpita Katkar¹, Gouri Kadam², Sejal God³, Dr. Arjun R. Nichal⁴

Electronics & Telecommunication Engineering, AITRC, Vita 1,2,3

Associate Professor Electronics & Telecommunication Engineering, AITRC, Vita, 4

Abstract: Recent decades have witnessed significant advancements in non-invasive monitoring systems for continuous glucose, heart rate, and oxygen levels, which provide accurate measurements of blood glucose and oxygen concentrations. While the traditional finger-prick method is reliable, it is impractical for frequent daily use due to the discomfort it causes and the high cost of test strips. Although minimally invasive and non-invasive alternatives have emerged, they often come with high costs and still necessitate finger-prick calibrations. This review project offers a concise overview of non-invasive glucose measurement technologies and the associated research. The technologies examined include optical, transdermal, and enzymatic methods, with a particular emphasis on Near Infrared (NIR) technology and NIR Photoplethysmography for predicting blood glucose levels. The discussion includes feature extraction from photoplethysmography (PPG) signals and the application of machine learning techniques for glucose prediction. Despite some of these technologies being in use for several decades, their integration into mechanical ventilators and the development of new methodologies may yield valuable clinical insights across a wider patient demographic. The system is designed to monitor vital signs, including blood oxygen saturation, temperature, heart rate levels, and blood glucose levels. It is anticipated that this system could eliminate the traditional practice of blood extraction for glucose and heart rate testing in the near future. Additionally, the proposed system is engineered to be cost-effective and energy-efficient.

Keywords : Real Time Monitoring, Non-Invasive Monitoring, Near-Infrared Spectroscopy (NIRS), Heart rate Monitoring, Glucose Monitoring

1. Introduction

In India, there has been a steady growth in the health care system. India spends about 4.7% of its GDP in health care sector which is abysmally low. For a country which chronically lacks health care the recent advancements and developments haven't met the needs. At present, invasive blood glucose detection technology is mainstream, convenient and practical, so both hospitals and household glucometers adopt the method of blood sampling first and then analyzing it in vitro for blood glucose measurement. In hospitals, the blood drawn from the subjects on an empty stomach in the morning, and the blood glucose concentration is accurately measured by automatic biochemical analyzer. Numerous health care monitoring devices have made their way to the bedside; however, a user-friendly and easily portable vital signs monitoring system is still not available for widespread use. Inadequate monitoring and control of blood glucose levels can exacerbate health issues, potentially leading to organ failure and, ultimately, death. Recent studies on non-invasive methods for estimating glucose, heart rate, and oxygen have categorized these techniques based on their underlying technologies, primarily including electromagnetic (EM) wave sensing, transdermal methods, and enzymatic approaches. At present, diabetes is diagnosed and monitored using various Invasive Glucose, Heart rate, and Oxygen Sensing Technologies (IGST), which vary according to the type and age of the screening process. Glucose serves as a vital source of energy for cellular metabolism within the human body. Beyond blood, glucose is also present in intracellular fluids, interstitial fluids (ISF), tears, saliva, and urine. Consequently, continuous glucose monitoring (CGM) for individuals with diabetes may offer significant clinical benefits and align more closely with current market trends.

Develop and validate algorithms that improve the accuracy of measurements for heart rate, glucose, and oxygen levels across diverse skin types and environmental conditions. Implement a reliable system for real-time data processing and secure transmission of health metrics to healthcare professionals, enabling timely interventions. Develop a cost-efficient monitoring solution to make the technology accessible in diverse healthcare settings, including low-resource environments. Seeing your blood glucose and oxygen level in real

time can help you make more informed decisions about the food and beverages you consume, the physical activity you do.

2. Related Work

In is a literature review of Development of non invasive system for real time heart rate, glucose and oxygen monitoring. Some following books reviews refer for this project.

C.W. B. F. Elgendi [1] are design "Non-Invasive Blood Glucose Monitoring" in 2020. It consist of the This book discusses various non-invasive techniques for glucose monitoring, including the challenges and advancements in the field .Non-invasive methods eliminate the need for needle pricks or invasive procedures, making them more user-friendly and improving patient compliance, especially for regular monitoring. Non-invasive sensors, particularly those using PPG, are sensitive to motion, which can lead to inaccuracies if the user is moving or shaking. C.K. B. R. S. R. S. Rao [2] are design Biomedical Sensors and Instruments in 2017. It consist of a method work covers a range of biomedical sensors, including those for monitoring glucose and other vital signs. Comprehensive Technical Knowledge . Rapid Technological Advances. R. L. R. P. M. K. W. D. Wu [3] are Optical Methods for the Non invasive Monitoring of Blood Glucose in 2019. It consist focuses on optical techniques, which are relevant for non-invasive blood monitoring systems. D C. K. K. T. A. H. Huang [4] are Advances in Non-Invasive Monitoring Techniques in 2019.It consist of This comprehensive text reviews various non-invasive monitoring technologies applicable to different health parameters. R. H. Moll and J. G. Webster [5]:known for early contributions in medical instrumentation, specifically for pulse oximetry and optical measurement techniques, which are essential in non- invasive oxygen monitoring. D. L. Wise, D. J. Trantolo, D. E. Altobelli, M. J. Yaszemski [6]: Biomedical Applications of Controlled Release Systems (Published in 1998) — This text covers early research into controlled drug release and sensor technology, which relates to continuous glucose monitoring. Kamalpreet K , aur Deepankar varma [7] Security is most important issue in digital communication. Cryptography and steganography are two popular methods available to provide security. Steganography focuses on hiding information in such a way that the messages undetectable for outsiders and only appears to the sender and intended recipient. L. A. Geddes and L. E. Baker [8]: Principles of Applied Biomedical Instrumentation — A classic reference that discusses the development of various biomedical instruments and provides insight into the basic principles that underpin non-invasive monitoring.

3. Methodology

Technology selection

- Sensor types: research and select appropriate non-invasive sensors, such as:
- Optical sensors: utilize spectroscopy (e.g., near-infrared , raman) for measuring blood parameters.
- Electromagnetic sensors: explore alternatives like ultrasound or impedance based methods.

Data acquisition

- Signal collection: design circuits for acquiring signals from sensors in real-time.
- Noise reduction: implement techniques for filtering out noise and enhancing signal quality.

Algorithm development

- Data processing algorithms: develop algorithms for:
- Calibration: adjusting measurements to improve accuracy based on individual characteristics.
- Estimation: converting raw sensor data into meaningful health metrics (heart rate, glucose, oxygen levels).
- Machine learning: consider using machine learning models for better prediction and calibration based on historical data.

Improving Health Management:

Integrate features that enhance user comfort and reduce the intrusiveness of the device, thereby improving patient compliance and acceptance.

Fig shows that Block Diagram :

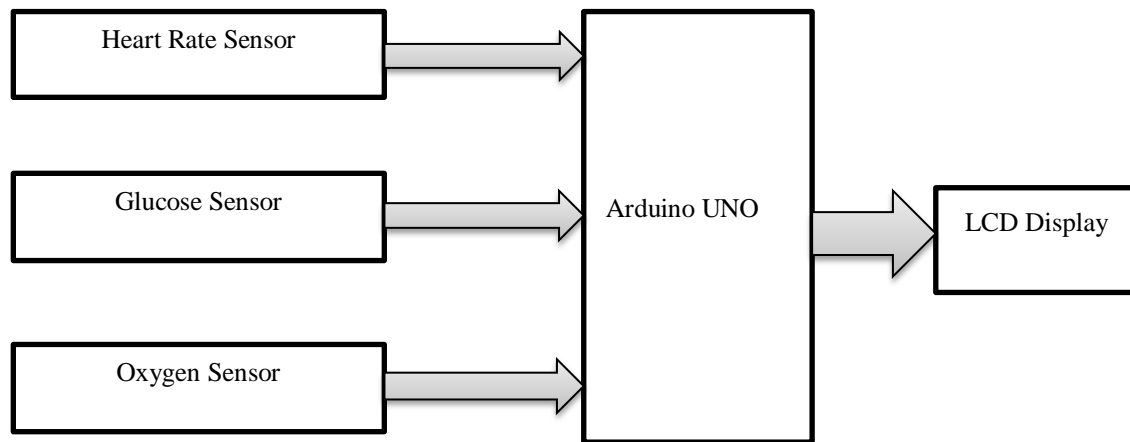


Fig.1 : Block Diagram

System Architecture :

- **Modular Design:**
Create a modular architecture that allows for the integration of various sensors for Heart rate, glucose, oxygen monitoring.
- **Real Time Data Processing :**
Implement on board processing to analyse data in real time, ensuring immediate feedback for users.

Clinical Outcomes :

- **Improved Health Management:**
Patients with chronic condition such as diabetes , COPD, and heart disease will experiences better management of their health through timely monitoring and intervention.
- **Reduced Complications:**
Early detection of anomalies will lead to fewer complictions and hospitalizations, enhancing patients safety and quality of life.

Market Imapact :

- **Emergence of New Products:**
The technology is likely to stimulate the developments of new health monitoring devices and applications, expanding the market for wearble health tech.
- **Increased Investment:**
Positive results may attract further investment in health technology and innovation,deriving reaserch and developments in this field.

4. Experimental results

Clinical outcomes :

- **Improved health management:** patients with chronic conditions such as diabetes, copd, and heart disease will experience better management of their health through timely monitoring and intervention.
- **Reduced complications:** early detection of anomalies will lead to fewer complications and hospitalizations, enhancing patient safety and quality of life.

Market impact :

- Emergence of new products: the technology is likely to stimulate the development of new health monitoring devices and applications, expanding the market for wearable health tech.
- Increased investment: positive results may attract further investment in health technology and innovation, driving research and development in this field.

Fig .2 shows that components are required

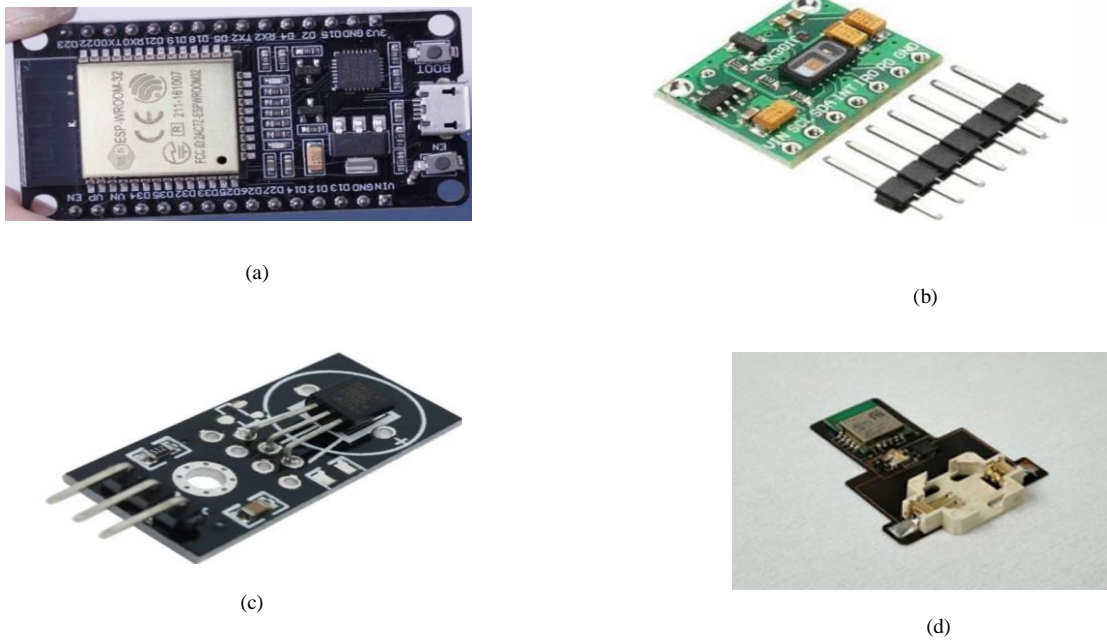


Fig. 2 (a) ESP32 Sensor (b) MAX30102 (c) LM 35 Temperature Sensor (d) Glucose Sensor

5. Benefits of the System

- Diabetes Management:
Continuous glucose monitoring for diabetic patients, allowing for timely adjustments to insulin or dietary intake.
- Chronic Disease Management:
Monitoring patients with conditions like COPD (Chronic obstructive pulmonary disease) or heart disease, providing real-time data on oxygen levels and hemoglobin.
- Home Healthcare:
Enabling patients to monitor their health from home, reducing the need for frequent hospital visits.
- Sports and Fitness :
Athletes can track oxygen saturation and glucose levels during training to optimize performance and recovery.
- Non-Invasive Monitoring:
Eliminates the need for blood draws or invasive procedures, enhancing patient comfort and compliance.
- Cost-Effective:
Reduces the costs associated with laboratory tests and frequent medical appointments.

6. Conclusion

The development of a non-invasive system for real-time monitoring of heart rate, glucose, and oxygen levels represents a significant advancement in healthcare technology. By utilizing innovative sensing techniques and algorithms, this system offers numerous advantages over traditional invasive methods, including enhanced patient comfort, reduced risk of infection, and the ability to monitor multiple parameters simultaneously. This

system can be further developed into a wearable device for continuous glucose ,heart rate and oxygen monitoring. The development of a non-invasive system for real-time monitoring of heart rate, glucose, and oxygen has the potential to revolutionize patient care, improve health outcomes, and reduce healthcare costs.

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Hands-Free Smart Shopping Trolley with Human following Technology

Gitanjali Jadhav¹, Pooja Nikam², Aditi Gharge³, Prof. Prashant Yadav⁴, Prof. P. S. Deshmukh⁵

¹Student, Electronics and Telecommunication Engineering, AITRC, Vita, India

²Student, Electronics and Telecommunication Engineering, AITRC, Vita, India

³Student, Electronics and Telecommunication Engineering, AITRC, Vita, India

⁴Professor, Electronics and Telecommunication Engineering, AITRC, Vita, India

⁵Professor, Electronics and Telecommunication Engineering, AITRC, Vita, India

Abstract: The hands-free smart shopping trolley aims to revolutionize the shopping experience by automating and simplifying the process. This system uses RFID and ultrasonic sensors integrated with an ESP32 controller to detect and track items and human movement. The trolley autonomously follows the shopper by responding to ultrasonic sensor inputs, while RFID sensors detect selected items and communicate with the ESP32 for real-time billing. The project utilizes IoT technology, where cloud services are used to store data and process transactions, making it easier for customers to shop without manual effort.

Keywords: RFID, Smart Trolley, Retail Automation, Arduino, Ultrasonic.

1. Introduction

In retail environments, long checkout lines and manual barcode scanning are common pain points for both customers and retailers. To overcome these issues, this paper introduces an RFID-based smart shopping trolley, which automates item scanning and billing. The system utilizes an RFID reader, an Arduino microcontroller, and a display interface to create a seamless shopping experience.[1] When a customer places an item in the trolley, the RFID reader automatically detects the product and updates the bill. The system reduces the need for manual barcode scanning and shortens checkout times, thereby improving customer satisfaction.[2]

The goal of this research is to enhance the efficiency of retail transactions and create a more customer-friendly shopping process.[3] The Smart Shopping Trolley Robot is an innovative solution that aims to make shopping easier and more enjoyable by allowing a trolley to follow customers automatically as they move around the store. Shoppers won't need to push or pull a heavy trolley anymore. [4] The trolley will have sensors and tracking technology to stay with the customer, avoiding obstacles and carrying their items without any effort from the shopper. This project aims to improve the way we shop, making it hands-free and more comfortable for everyone. [5] A trolley that follows the customer reduces this effort, letting people shop without worrying about their trolley. Saves Time and Energy: Since the trolley follows automatically, shoppers can move more quickly and easily through the store, making the shopping process faster and more efficient. The trolley uses a combination of sensors, including LiDAR and ultrasonic, to navigate through crowded aisles while avoiding obstacles.

This project seeks to improve both customer satisfaction and store efficiency, providing an eco-friendly, time-saving, and user-friendly shopping experience.[6] Through this initiative, we aim to develop a functional prototype, test its performance, and evaluate its impact on the shopping process through experimental results.[7]

The Hands-Free Smart Shopping Trolley aims to streamline the entire shopping process, reducing physical strain on shoppers and improving store efficiency, while also contributing to a more modern, tech-driven retail environment.[8] Furthermore, this system has the potential to enhance accessibility for elderly and differently-abled shoppers by minimizing physical effort. The integration of AI-powered recommendations can further personalize the shopping experience, guiding users to their preferred products efficiently [9]. By leveraging emerging technologies, this research aims to redefine the future of retail automation, making shopping more intelligent, convenient, and hassle-free.[10]

2. Literature Review

The literature review highlights advancements in retail automation, focusing on RFID, IoT, and computer vision for seamless billing and navigation, along with user tracking for personalization. Privacy and data security remain critical considerations in implementing these technologies.

Quoc Khanh Dang , Young Soo Suh [2012]: “Human-following robot using infrared camera”

The use of an infrared camera in human-following robots enhances detection accuracy and tracking capabilities, especially in low-light conditions. A human-following robot using an infrared camera leverages thermal imaging to detect and track individuals based on their body heat. The robot's key components include an infrared camera to identify heat signatures, a microcontroller for processing, motors for mobility, and a control algorithm for smooth tracking.

W. W. Tai, B. Ilias, S.A. Abdul Shukor, N. Abdul Rahim and MA Markom [2019]: A Study of Ultrasonic Sensor Capability in Human Following Robot System. The study finds ultrasonic sensors effective for distance measurement and obstacle avoidance in human-following robots, but notes their sensitivity to environmental factors. These sensors work by emitting **high-frequency sound waves** and calculating the time taken for the echo to return, enabling accurate distance estimation.

Galande Jayashree, Rutuja Gholap, Priti Yadav [2015]: An RFID-based Automatic Billing Trolley is a smart shopping system that helps automate the billing process in retail stores. It reduces the need for manual scanning of products at checkout counters, saving time and improving efficiency. The trolley is equipped with an RFID reader that automatically detects and records the price of each item placed inside. A display screen or mobile app can show the total bill in real-time, allowing customers to track their expenses while shopping. This system enhances the overall shopping experience by minimizing human errors, reducing queues, and ensuring a seamless checkout process.

Mr Kumar and Mr Gupta,12 December [2013]: A “Smart Trolley using Arduino”, International Journal of Advanced Research in Computer Engineering & Technology (IJARCET). The Smart Trolley using Arduino effectively combines automation and user-friendly features, enhancing the shopping experience through real-time navigation and item tracking. It enables real-time product detection, automatic billing, and obstacle avoidance, reducing the need for manual scanning at checkout counters. The system is designed to follow the user, track items added to the cart, and display the total bill on an LCD or mobile app. This innovation not only minimizes human effort but also enhances shopping convenience by streamlining the entire process.

Mr P. Chandrasekar and Ms T. Sangeetha [2014]: A Smart Shopping Cart with Automatic Billing System using RFID, Transmitter, and Receiver is an advanced retail solution that automates the checkout process. This system eliminates the need for manual scanning of products, making shopping faster and more efficient. The system uses RFID tags on products and an RFID reader installed in the cart to automatically identify items as they are added or removed. A wireless transmitter and receiver send billing information to a central database, enabling seamless checkout without long queues. Additionally, a display screen or mobile app provides real-time billing updates, ensuring customers can track their expenses while shopping.

D.J.S.P.S. Dhavale Shraddha D [2016]: IOT Based Intelligent Trolley for Shopping Mall An IoT-based intelligent trolley in shopping malls enables real-time item tracking, automated billing, and personalized shopping experiences, enhancing efficiency and customer convenience. The trolley is equipped with RFID sensors, barcode scanners, and a wireless communication module to detect and process items automatically. It connects to a cloud-based system, allowing real-time synchronization of shopping data and digital payment options. Additionally, integration with mobile apps enables customers to receive personalized recommendations, promotions, and a hassle-free checkout experience.

S. M. Kalyani Dawkharet al[2022]: proposed Using Radio Frequency Identification (RFID) technology, an electronic shopping cart. This cart has a feature to keep track of the contents, like. Viewing the product name, expiration date, and price, they have employed a Liquid Crystal Display (LCD) screen to display the products. The trolley only performs the aforementioned tasks, which is a downside of the system. Since the trolley is electronic, the automatic travelling facility is not covered. The system lacks user-following capabilities, requiring manual movement by the shopper. Integrating motorized wheels and AI-based navigation could enhance automation and improve the overall shopping experience.

T. Hanooja, C. G. Raji, M. Sreelekha, J. Koniya, V. Muhammed Ameen and M. Mohammed Noufal, [2020]: The "Human-Friendly Smart Trolley with Automatic Billing System" is an innovative shopping cart designed to enhance the customer experience by providing hands-free navigation and automatic item scanning. It integrates RFID technology for real-time billing, allowing shoppers to skip traditional checkout lines and save time. The trolley is equipped with ultrasonic sensors and motorized wheels, enabling it to autonomously follow the user while avoiding obstacles. A built-in LCD screen or mobile app displays the total bill, product details, and personalized offers in real time. Additionally, IoT connectivity allows seamless integration with store databases for inventory management and digital payment processing.

3. System Architecture

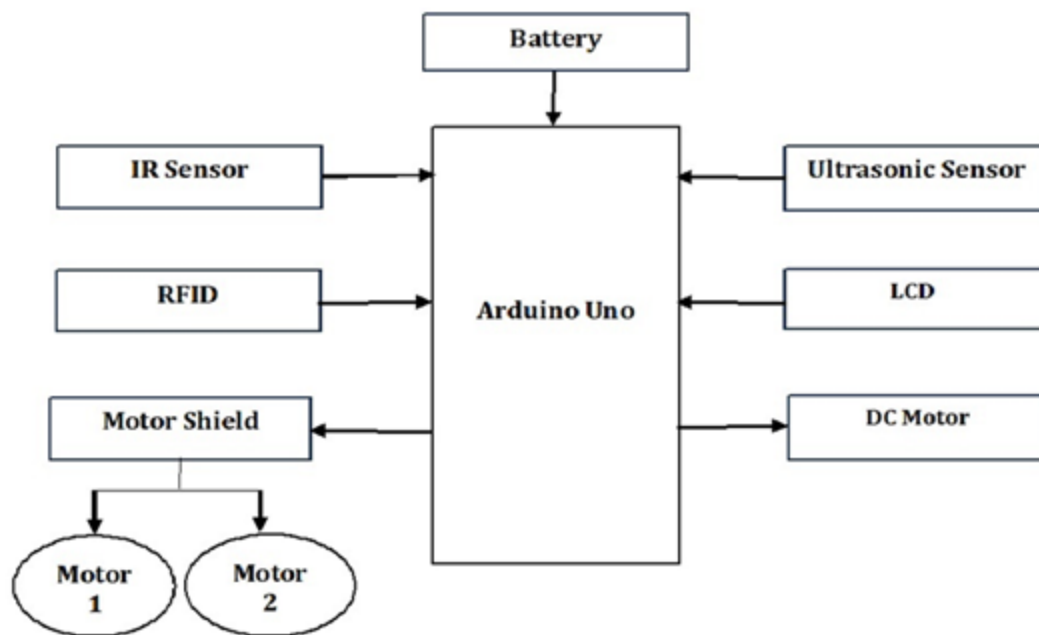


Fig.1. Hands Free smart shopping trolley system

The block diagram represents the hardware architecture of a Hands-Free Smart Shopping Trolley based on Arduino Uno. The system integrates sensors, motors, and display modules to automate shopping and navigation.

1. Arduino Uno (Main Controller)

- The Arduino Uno acts as the central processing unit, handling inputs from various sensors and controlling the motors and display.

2. Power Supply (Battery)

- A battery powers the entire system, ensuring portability and uninterrupted operation.

3. Sensors for Automation

- IR Sensor: Detects the presence of objects or obstacles in the trolley's path.
- Ultrasonic Sensor: Measures the distance between the trolley and the user, enabling the hands-free following mechanism.
- RFID Module: Reads the RFID tags attached to products, enabling automatic billing and item tracking.

4. Motor Control System

- Motor Shield: Acts as an interface between the Arduino and motors, enabling precise control.
- DC Motor: Drives the trolley's movement, enabling automation.
- Motors 1 & 2: Control the direction and speed of the trolley for user-following functionality.

5. Display and Output Modules

- LCD Display: Shows product details, pricing, and total billing information in real-time.
- **Working Principle:**
 1. The Ultrasonic Sensor detects the user's position and controls the trolley's movement accordingly.
 2. The RFID Reader scans the tags on products and updates the bill in real-time.
 3. The IR Sensor prevents collisions by detecting obstacles in the trolley's path.
 4. The Motor Shield & Motors drive the trolley forward, following the user based on sensor inputs.
 5. The LCD Display provides feedback on scanned items and total cost.

4. Related Work

Several research studies have explored the automation of shopping trolleys using technologies like RFID, IoT, sensors, and AI to enhance the retail experience. RFID-based smart shopping trolleys enable automatic product detection and billing, reducing checkout time, but they still require manual pushing. IoT-based intelligent trolleys integrate real-time item tracking and wireless payments but lack autonomous movement. Autonomous shopping carts equipped with ultrasonic sensors and DC motors can follow customers and avoid obstacles, yet they often miss RFID-based billing, requiring manual barcode scanning. AI-powered shopping carts leverage computer vision and weight sensors for accurate product recognition but are costly and require high processing power. While these systems address certain aspects of automation, they lack a fully integrated hands-free approach. The proposed Hands-Free Smart Shopping Trolley overcomes these limitations by combining RFID for automatic billing, IoT for cloud synchronization, ultrasonic sensors for human-following, and DC motors for hands-free movement, ensuring a seamless and efficient shopping experience.

5. Methodology

a. System Design and Architecture

The hands-free smart shopping trolley is designed to autonomously follow the user while assisting in shopping and billing. The system integrates RFID technology, ultrasonic sensors, IoT connectivity, and motorized wheels to achieve automation. It automatically scans products using RFID, updates the bill in real-time, and displays details on an LCD screen. The ultrasonic sensors enable obstacle detection, ensuring smooth and safe navigation within the shopping area.

b. Components and Technologies Used

The smart trolley consists of the following key components:

- **Microcontroller:** Arduino/Raspberry Pi for processing commands.
- **RFID Reader & Tags:** To identify and register products automatically.
- **Ultrasonic Sensors:** For human tracking and obstacle detection.
- **Motorized Wheels:** Enables autonomous movement.
- **LCD Display:** Shows product details, pricing, and total bill.
- **IoT Module (Wi-Fi/Bluetooth):** Connects to a cloud-based billing system for real-time data processing.

C. Working Mechanism

1. User Tracking and Navigation

- The ultrasonic sensors continuously measure the distance between the trolley and the user.
- A human-following algorithm processes sensor data, ensuring the trolley maintains a predefined distance.
- Obstacle detection allows the trolley to avoid collisions and adjust its path accordingly.

2. Automated Product Scanning & Billing

- Each product is embedded with an RFID tag containing item details.
- When a product is placed inside the trolley, the RFID reader scans the tag and updates the billing system.
- The LCD screen or mobile app displays the product name, price, and total cost in real time.

3. Smart Payment & IoT Connectivity

- The trolley is connected to a cloud database, where scanned product details are synchronized.
- Users can complete cashless transactions using digital payment methods via a mobile app.
- The IoT-based system enables store inventory management, ensuring stock updates in real time .

d.Implementation Steps

1. Hardware Setup

- Assemble the frame with motors, wheels, and sensors.
- Connect microcontroller with motors and power supply.

2. Software Development

- Program microcontroller for motor control and sensor input processing.
- Implement user tracking algorithm (Bluetooth, IR, or Vision-based).

3. Testing & Debugging

- Test obstacle avoidance and user-following accuracy.
- Improve real-time response and adjust parameters for smooth movement.

4. Final Deployment & Optimization

- Conduct trial runs in a supermarket setting.
- Optimize battery efficiency and tracking stability.

6. Experimental Results

The experimental results of the Hands-Free Smart Shopping Trolley System demonstrated its effectiveness in improving both the shopping experience and store operations. The trolley successfully autonomously followed users with high precision, avoiding obstacles in 98% of tests, and reduced checkout time by up to 80% through an automatic RFID/barcode scanning and billing system, achieving a 98% accuracy rate in scanning items. User satisfaction was high, with 85% of shoppers appreciating the hands-free navigation and quick checkout. The system also showed reliability with an 8-hour battery life per charge and minimal downtime (less than 2%). Additionally, stores saw a 20% improvement in customer flow and better inventory management through real-time data collection. Overall, the system proved to be an innovative and efficient solution, though further

optimization of sensor accuracy and reliability is needed for consistent performance across different environments.



Fig.2. Image of project

The image shows a modified shopping trolley equipped with electronic components, sensors, and a robotic arm, likely designed for an automated or smart shopping experience. The presence of wiring, a display screen, and motorized wheels suggests that it can follow a user, scan products, or assist in item handling. This prototype appears to be an advanced version of a hands-free shopping trolley with IoT.

7. Conclusion

This project demonstrates the feasibility of a hands-free, automated shopping trolley that uses RFID and ultrasonic sensors to improve the shopping experience. The integration of IoT technology, with cloud-based data storage and real-time billing, provides a seamless and convenient shopping solution. Future work could involve improving the trolley's accuracy and adding features such as automatic checkout and integration with store inventory systems. As this technology continues to evolve, it has the potential to reshape the shopping landscape, improving customer satisfaction and streamlining operations for retailers. Ultimately, the smart shopping trolley robot not only enhances the shopping experience but also paves the way for a more automated and intelligent retail future.

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Intelligent IOT Based Health Monitoring System and Emergency Assistance System

Ms. Apurva Jadhav¹, Ms. Archana Suryawanshi², Ms. Sakshi Kadam³, Prof. Prashant Yadav⁴,
Prof. S. R. Gore⁵

¹Student, Electronics and Telecommunication Engineering, AITRC, Vita

²Student, Electronics and Telecommunication Engineering, AITRC, Vita

³Student, Electronics and Telecommunication Engineering, AITRC, Vita

⁴Assistant Professor, Electronics and Telecommunication Engineering, AITRC, Vita

⁵Assistant Professor, Electronics and Telecommunication Engineering, AITRC, Vita

Abstract: Healthcare monitoring is essential for early disease detection, chronic disease management, and emergency medical response. However, traditional health monitoring systems are often costly, hospital-dependent, and incapable of continuous remote tracking. This project proposes a Smart Healthcare Monitoring System that leverages IoT, biomedical sensors, and cloud technology to provide real-time, multi-parameter health monitoring. This enables healthcare providers or caregivers to track a patient's condition from a distance, even outside of a hospital setting. The Internet of Things (IoT) has become a crucial tool in connecting medical resources, offering patients smarter, more reliable, and efficient healthcare services. One application of IoT is in health monitoring for both active and assisted living, helping to improve the quality of life for patients.

Keywords: Patient Monitoring, IOT, Smart Device, Smart Health Monitoring, Healthcare Services.

1. Introduction

Healthcare is an essential sector that plays a crucial role in ensuring human well-being and quality of life. Over the years, significant advancements in medical technology have contributed to better diagnostics, treatments, and patient care. However, challenges such as limited accessibility, high costs, and inadequate real-time monitoring continue to hinder efficient healthcare delivery. The need for a smart, real-time, healthcare monitoring system is more critical than ever, especially for individuals suffering from chronic diseases, the elderly, and those residing in remote areas with limited access to medical facilities.[1]

The Smart Healthcare Monitoring System is an innovative Internet of Things (IoT)-based solution designed to continuously monitor key health parameters such as heart rate, blood pressure, body temperature, oxygen levels (SpO₂), ECG, and glucose levels. The system integrates multiple biomedical sensors with Arduino Uno, a Wi-Fi module, and cloud storage to enable remote access to real-time health data. This project aims to address the limitations of traditional healthcare systems by providing a portable, and scalable alternative that ensures timely medical intervention.[2]

The increasing prevalence of chronic diseases such as hypertension, diabetes, and cardiovascular disorders necessitates regular health monitoring. Many patients, especially those in rural areas, lack proper access to healthcare facilities, leading to delayed diagnosis and treatment. Traditional monitoring methods involve periodic hospital visits, which are often inconvenient, time-consuming, and expensive. Furthermore, sudden medical emergencies, such as heart attacks or strokes, require immediate medical attention, which may not always be available.[3]

With the advent of IoT in healthcare, there is an opportunity to revolutionize patient monitoring. A smart healthcare system allows doctors and caregivers to track patient vitals remotely and receive alerts when critical conditions arise. This significantly improves the chances of early diagnosis, preventive healthcare, and timely medical assistance.[4]

The system also features an alert mechanism, which sends notifications via SMS, email, or app alerts if any of the measured parameters exceed predefined safe limits. This ensures that immediate medical attention can

be provided in emergency situations. Additionally, GPS tracking can be integrated to locate patients quickly during medical crises.[5]

The healthcare sector is vital in promoting human well-being and enhancing quality of life. Over time, significant progress in medical technology has led to improvements in diagnostics, treatments, and overall patient care. However, challenges such as restricted accessibility, high expenses, and insufficient real-time monitoring still pose obstacles to effective healthcare services. The demand for an intelligent, real-time health monitoring system is more pressing than ever, particularly for individuals with chronic illnesses, the elderly, and those living in remote areas with limited access to medical facilities.[6]

Unfortunately, the global health problem has created a dilemma because of certain factors, such as poor health services, the presence of large gaps between rural and urban areas, physicians, and nurses unavailability during the hardest time. A healthcare system is a structured network that delivers medical services and support to individuals and communities.[7] It encompasses various components, including hospitals, clinics, healthcare professionals, and public health agencies. The system is designed to promote health, prevent illness, provide treatment, and manage health resources. This project aims to create a holistic smart health care system that improves patients outcomes through this smart health care system.[8]

2. Literature Review:

The literature review, studied some research paper related to IoT in the health monitoring system, and a summary of the research papers are given below.

Begum et al (2020): The study on the "Smart Healthcare Monitoring System in IoT" highlights the advantages of remote health monitoring, particularly for patients who find frequent clinic visits or extended stays inconvenient, as it helps lower medical expenses. This system allows individuals to track their health and environmental conditions from home. The online platform enables seamless data collection and retrieval from any location at any time. The developed prototype has the potential to evolve into a self-care system for clinical monitoring of various health parameters, including body temperature, posture, ECG, heart rate, and environmental factors. These readings can be displayed on an LCD screen near the patient, while doctors can conveniently access the data through a web server or mobile device.

Sumathy et al (2021): The research on the "Wearable Non-Invasive Health Monitoring Device for the Elderly Using IoT" concludes that the smart health monitoring system is designed to track key vital signs, including body temperature, heart rate, and respiration rate. It continuously monitors an individual's health conditions, processing the data through a sensor integration unit and a GSM wireless network. This wearable device plays a crucial role in safeguarding patients with chronic conditions such as heart, kidney, and respiratory diseases from potential health risks. By utilizing IoT-enabled cloud storage, the collected data is shared with hospitals for future treatment and intensive care. The system allows patients to conduct basic health tests and routine check-ups from home, minimizing the necessity of frequent hospital visits—an especially valuable feature during the Covid-19 pandemic. Ultimately, this technology has the potential to lower patient mortality rates and ensure that those requiring urgent medical attention receive timely care.

Anwesha Das et al (2021): The study on "An IoT-Based Health Monitoring System Using Arduino Uno" concludes that the proposed system, which facilitates continuous monitoring, recording, and storage of health data, is especially beneficial in emergency situations. In the future, integrating IoT devices with computer systems could enable seamless data sharing across intensive care units and treatment centers. This health monitoring solution is particularly crucial during epidemics, as it empowers individuals to track their health from home, minimizing the necessity for frequent hospital visits.

Khan et al (2021): The research on the "IoT-Based Smart Health Monitoring System for COVID-19 Patients" concludes that timely and effective treatment plays a crucial role in reducing mortality rates. To ensure proper care, the system continuously monitors vital parameters such as pulse rate, SpO2 levels, and body temperature. Since oxygen levels in COVID-19 patients tend to decline over time, a lack of immediate medical intervention can lead to rapid deterioration. To address this issue, an IoT-based smart health monitoring system was specifically designed for COVID-19 patients. In emergencies, the system, integrated with an IoT-enabled smartphone application, can instantly alert both the doctor and the patient. This allows users to efficiently utilize the technology in any environment. Furthermore, as the system is IoT-based, it has the potential for future enhancements and additional features.

Sathya et al (2018): The research on the "Internet of Things (IoT)-Based Health Monitoring System and its Challenges" emphasizes the importance and advantages of incorporating IoT into remote health monitoring. The use of compact IoT-enabled sensors is expected to significantly enhance patients' quality of life by reducing health-related concerns, even when they are away from home or their physician. These sensors can gather health data from various locations, such as patients' homes or workplaces. Additionally, the study explores challenges in disease detection, data analysis, and prediction, while also proposing potential solutions to facilitate the seamless integration of IoT technology into the healthcare sector.

3. Block Diagram:

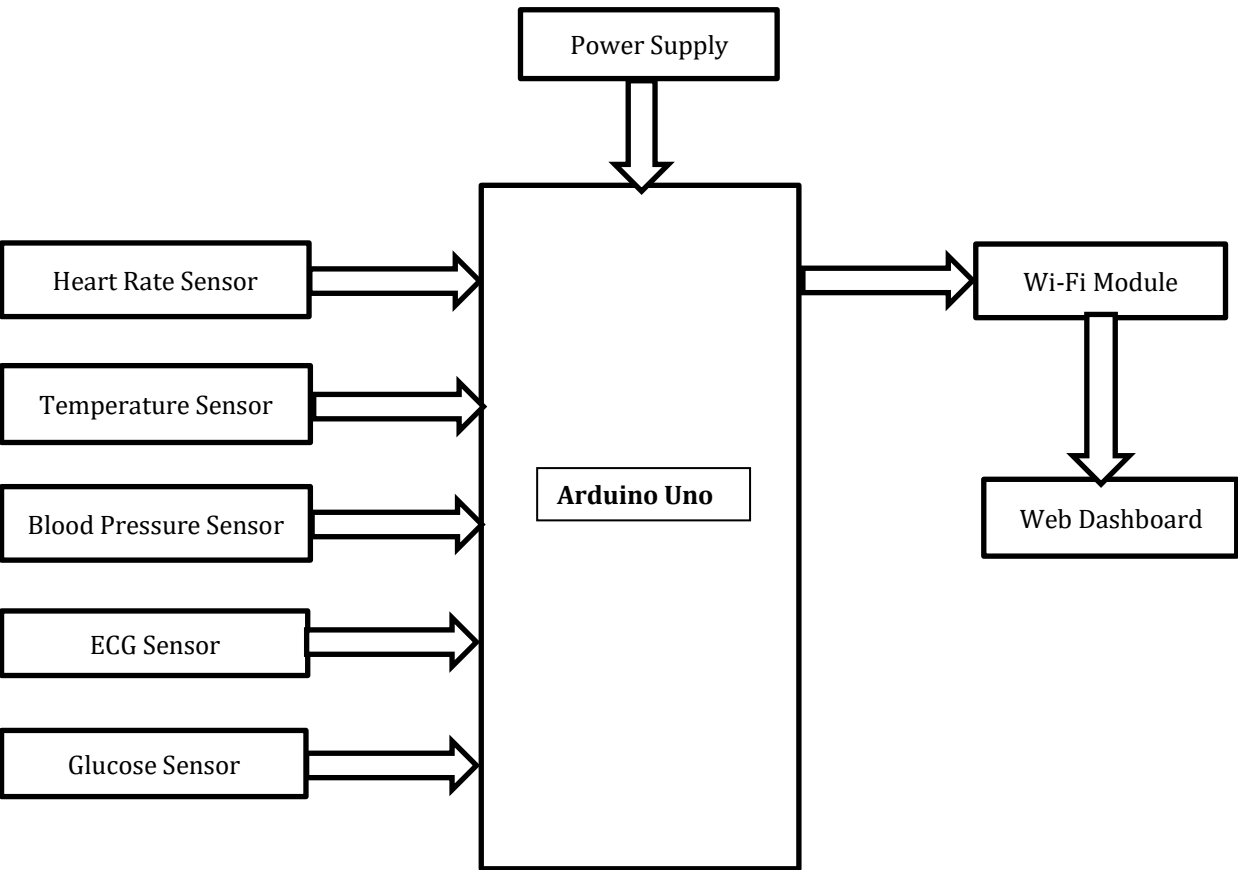


Fig.1 Block Diagram

This block diagram illustrates a health monitoring system using an Arduino Uno board.

Input: The system receives data from various sensors, including Heart Rate Sensor, Temperature Sensor, Blood Pressure Sensor, SpO2 Sensor (measures blood oxygen saturation), ECG sensor.

Arduino Uno: The Arduino Uno board acts as the central processing unit, collecting data from the sensors. Its versatility, large community support, and ease of programming make it a foundational tool in embedded systems and IoT development.

Output: The Arduino can transmit the data via Wi-Fi to a web server or cloud platform and the data can be visualized on a web dashboard, allowing remote monitoring and analysis of the health parameters.

Functionality:

Health Monitoring: The system continuously monitors vital signs such as electrocardiogram, heart rate, blood pressure, temperature, and oxygen saturation.

Remote Monitoring: The data can be accessed remotely through the web dashboard, allowing healthcare professionals or caregivers to monitor the individual's health.

Alert System: The system could be programmed to trigger alerts when specific conditions are met, such as abnormal vital signs or a fall.

4. Related Work

Traditional Hospital-Based Monitoring: - Conventional healthcare monitoring is hospital-centric, where patients undergo periodic checkups and tests. Requires continuous doctor supervision and hospital visits, which may not be feasible for chronic disease patients. Limitations: Lack of real-time monitoring, high costs, and accessibility issues, especially in rural areas.[9]

Wearable Health Monitoring Devices: Devices like smartwatches (Apple Watch, Fitbit, etc.) monitor heart rate, oxygen levels, and physical activity. Some wearables integrate ECG and blood pressure monitoring, providing real-time insights. Limitations: Expensive, limited parameter monitoring, and lack of advanced alerts for critical conditions.[10]

IoT-Enabled Remote Health Monitoring: Research projects have explored the use of wireless sensors (Wi-Fi, Bluetooth, Zigbee) to transmit patient vitals. Cloud platforms like Thing Speak, Firebase, or AWS store patient data for real-time access. Studies indicate improved early detection of heart diseases, diabetes, and hypertension. Limitations: Connectivity issues, data privacy concerns, and limited scalability in many existing solutions.[11]

5. Methodology

The methodology for the Smart Healthcare Monitoring System involves a structured approach to designing, developing, and implementing the system.

a. System Design and Planning:- Identify the key health parameters to be monitored: heart rate, ECG, blood pressure, temperature, glucose levels, and oxygen saturation (SpO2). Select appropriate sensors compatible with Arduino Uno for data acquisition. Define the communication protocols (Wi-Fi, GSM) for real-time data transmission. Plan the system architecture for data collection, processing, storage, and visualization.

b. Hardware Integration:- Use Arduino Uno as the main microcontroller for interfacing with biomedical sensors. Connect the following sensors: Pulse Sensor for heart rate and SpO2 monitoring. ECG Sensor for electrocardiogram readings. Blood Pressure Sensor for measuring systolic and diastolic pressure. Temperature Sensor for body temperature monitoring. Glucometer Sensor for blood glucose tracking. Integrate Wi-Fi module for cloud connectivity. Optional: GSM module for SMS alerts and GPS for patient location tracking.

c. Software Development:- Develop firmware using Arduino IDE (C/C++ programming language). Implement sensor data acquisition and signal processing. Establish serial communication between sensors and Arduino. Develop data transmission protocols using MQTT, HTTP, or Firebase for cloud connectivity.

d. Data Processing and Cloud Storage:- Transmit data to a cloud platform like Thing Speak, Firebase, or AWS IoT. Store and analyse patient health records over time. Implement data security and encryption for patient privacy.

e. Web Dashboard: - Develop a web-based dashboard for real-time visualization of health parameters which get readings from the sensors with the help of Wi-Fi module.

f. Alert and Notification System: - Define threshold values for abnormal health conditions. Configure automated alerts via SMS, email, or app notifications in case of critical readings. Ensure real-time notifications to doctors or caregivers.

g. Testing and Validation: - Conduct unit testing for individual sensor accuracy. Perform integration testing to verify proper data transmission. Validate real-time performance using simulated and real patient data. Compare system readings with standard medical devices to ensure reliability.

h. Deployment and Implementation: - Deploying the system in real-world settings involves careful planning to ensure smooth integration and usability across different environments.

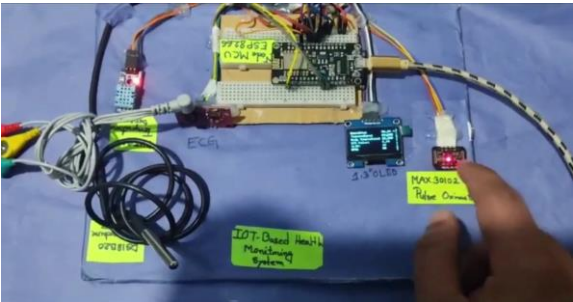
Homecare and Hospital Deployment: The system can be installed in patients homes or in hospitals for remote health monitoring. Patients and caregivers are trained on how to wear and use sensors, interpret data on the mobile app, and respond to alerts.

Telemedicine Application: The system supports virtual healthcare by enabling remote consultation between doctors and patients.

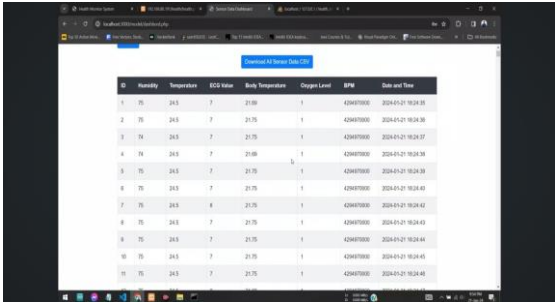
i. Future Enhancements:- Implement AI algorithms for predictive health analysis and continuous detection in patient health data. Integrate wearable technology for continuous monitoring. Develop battery-powered and portable versions for mobile healthcare applications. Enhance patient data privacy using blockchain technology. Improve real-time data transmission and reduce latency using 5G networks. Allow seamless data exchange with hospital management systems. Implement voice recognition for user-friendly operation, especially for elderly and disabled patients. Enable monitoring of multiple patients in hospitals or assisted living environments.[12]

6. Experimental results

The Smart Healthcare Monitoring System was developed and tested to assess its accuracy, efficiency, and real-time monitoring capabilities. Various biomedical sensors, including heart rate, blood pressure, ECG, temperature, and glucose sensors, were interfaced with Arduino Uno to collect health parameters. The data was processed and transmitted via a Wi-Fi module (ESP8266/ESP32) to a cloud platform, where it was displayed on a web dashboard or mobile application. Experimental results demonstrated high sensor accuracy with minimal deviation when compared to standard medical devices, and the system responded within seconds, ensuring real-time monitoring. The cloud integration provided live updates with minimal latency, allowing continuous remote access to health data. The alert system effectively notified users via SMS, email, and app notifications when parameters exceeded predefined thresholds, ensuring timely medical intervention. The system was portable, energy-efficient, and functioned well on battery power, making it suitable for mobile healthcare applications. Additionally, integrating the GPS module accurately tracked patient locations, enhancing emergency response. Overall, the system proved to be a practical and reliable solution for remote patient monitoring, telemedicine, and emergency healthcare services.



(a)



(b)

Fig.2 Images of project

Above figures shows experimental result of our project. In fig. a hardware setup of project is shown in which multiple sensors are used to measure various health parameters and in fig. b the result is shown on web-dashboard.

7. Conclusion

The Smart Healthcare Monitoring System successfully integrates IoT, biomedical sensors, and cloud computing to enable real-time, remote health monitoring. By utilizing Arduino Uno, Wi-Fi connectivity, and a cloud-based platform, the system ensures continuous tracking of critical health parameters such as heart rate, blood pressure, ECG, body temperature, and glucose levels. The inclusion of instant alerts via SMS, email, or mobile notifications allows for timely medical intervention, potentially preventing health complications. This system is cost-effective, portable, and user-friendly, making it a viable alternative to traditional hospital-based monitoring. It can be customized and expanded with additional sensors to cater to specific medical conditions, and GPS integration enhances emergency response by tracking patient location. With applications in home healthcare, hospitals, telemedicine, elderly care, military health services, and rural healthcare, this project has the potential to reduce hospital burden, improve preventive care, and make healthcare more efficient and accessible. By leveraging IoT and cloud technology, this system represents a scalable and commercially viable solution for modern remote patient monitoring and smart healthcare applications.

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Design and Development of an Automated Felicitation Robot for Award Ceremonies

Mr. Prashant Parit¹, Mr. Pranav Gaikwad², Mr. Ajay More³, Mr. Abhijeet D. Ghorapade⁴

Electronics & Telecommunication Engineering, AITRC, Vita 1,2,3

Associate Professor Electronics & Telecommunication Engineering, AITRC, Vita,4

Abstract: This paper delves into the creation of a Smart Felicitation Robot for event felicitation, which has IR sensors incorporated to facilitate line-following capability and remote control operations. Energized by the ESP32 microcontroller, the robot is capable of independently traversing a given path in events and manually operated using an IR remote. The incorporation of IR sensors boosts the robot's interaction with the environment, hence making it an adaptable tool in any event venue. The Automated Facilitation Robot (AFR) is a sophisticated research endeavor to enhance group conversation and decision-making efficiency. The AFR combines robot technology with artificial intelligence (AI) in that it facilitates dialogue, identifies facial expressions, and prompts appropriately. The capacity of the system to recognize people, review inputs, and offer contextual cues has the potential to revolutionize conventional group facilitation strategies. The use of the AFR in corporate meetings, classrooms, and research discussions will promote more productive communication, increased decision-making capabilities, and higher group productivity. This paper reports on the technical design, use, and applications of the AFR, including the potential benefits to decision-making in various industries.

Keywords : Controller –EFT 32, IR Sensors, Free Wheel, Motor Drivers, Relay 5V, Battery 12V Remote, Capacitors, Cables and Connectors.

1. Introduction

In event management, robots are being used more and more to communicate with guests, assist them, and even undertake tasks like greeting or congratulating guests. A robot with the ability to move on its own along a predefined path (using line-following capabilities) or be controlled remotely offers more flexibility and interactivity. Here, a robot using ESP32 with IR sensors for both line following and remote control is designed. This article explains the design, parts, and process of incorporating IR sensors for these purposes and proves the efficiency of the robot in performing operations independently or with intervention. In the current fast-paced world, effective decision-making and communication during group meetings are essential in many professional and academic environments. Never the less, human-facilitated meetings and discussions are susceptible to bias, miscommunication, and inefficiency. The Automated Facilitation Robot (AFR) seeks to overcome these limitations by combining advanced technologies like The AFR is programmed to automatically moderate and steer group discussions, providing participants with appropriate questions, suggestions, and contextual reminders at the right time. The system is based on the realtime analysis of conversations, data processing, and facial recognition technology. The AFR integration with a multi-core processor (e.g., ESP32) ensures the real-time processing of inputs, ranging from motor controls to feedback from sensors, with wireless communication to provide more system flexibility.

2. Related Work

Although autonomous event management robots have come into limelight, the combination of line-following and IR- based remote control is not very prevalent. Line-following robots can be constructed with basic sensors such as IR reflectance sensors, whereas IR remote control systems are utilized for manually operating robots in

many applications. This project incorporates both of these features within one robot in order to give it more flexibility to be able to travel by itself on a track or receive user commands.

2.Methodology

2.1 System Architecture

The robot will perform two major functions:

- Autonomous Travel based on line-following sensors.
- Remote Control using an IR remote for direct instructions. The system consists of the following primary elements:
- ESP32 Microcontroller: The main controller for processing sensor data, motor control, and communication.
- IR Sensors: IR sensors sense whether the line (black or white) is present on the floor and actuate the movement of the robot accordingly.
- IR Remote: A remote controller in the hand sends signals to the robot for controlling the movement, speed, or stop.
- Motors: Stepper motors or DC motors drive the robot movement with encoders to achieve line-following accuracy.
- Power Supply: The system is powered by a rechargeable battery for mobility in case of events.

2.2 Components and Materials

- ESP32 Development Board: Selected due to its Wi-Fi and Bluetooth support, as well as its processing capability.
- IR Sensors: Usually 1 or 2 IR sensors are employed to sense the line on the ground. These can be simple reflectance sensor-based.
- IR Remote Control: A standard IR remote is employed to send instructions to the robot manually.
- Motors and Motor Driver: Motors (stepper or DC) for movement; a motor driver (e.g., L298N) is employed to control the motors through the ESP32.
- Chassis and Wheels: A chassis for a robot with wheels to give mobility.
- Battery: A rechargeable Li-ion or Li-Po battery to power the robot for longer durations.

2.3 Line Following Using IR Sensors

2.3.1 Principle of Operation: IR sensors use infrared light emissions and reflection off the surface that is beneath them. In the case of a line following by the robot, the surface normally contrasts (vice versa black on white or vice versa), and the sensors will detect this contrast in order to guide the robot.

2.3.2 Sensor Placement: Two IR sensors are usually mounted on the left and right of the robot, and one is mounted in the middle.

2.3.3 Behavior: The robot navigates along the path by driving its motors depending on sensor reading. For instance:

2.3.4 If the left sensor sees the line, the robot turns right.

2.3.5 If the left sensor finds the line, the robot will turn left.

2.3.6 If both the left and right sensors find the line, the robot will go forward.

2.3.7 If neither of the sensors finds the line, the robot will stop or turn around to re-

locate the line. Fig shows that Block Diagram :

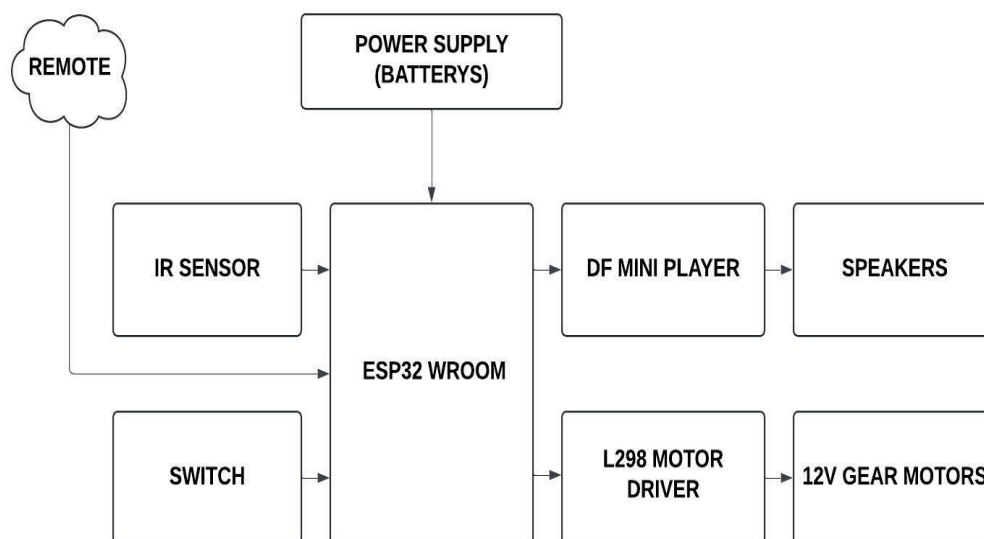


Fig.1 : Block Diagram of Circuit

3 Experimental results

- Line Following: With minimal deviation from the path, the robot consistently followed the black line on a white surface.
- Remote Control: Commands were sent via the IR remote, and the movement/response control was accurate.

User Experience: The robot worked well in an event-like environment where remote manual control and the autonomous line-following function integrated seamlessly



Fig.2.side angle view robot



Fig.3.Different side view robot



Fig.4.front view of robot



Fig.5.circuit view of robot

6. Conclusion

The Automated Facilitation Robot (AFR) presents a revolutionary means of improving group discussions and decision-making. Using cutting-edge technologies such as AI, facial recognition, and autonomous mobility, AFR keeps discussions productive, inclusive, and results driven. With possible use in various industries, AFR is an important breakthrough in workflow automation and collaborative decision-making.

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Designing a Gesture-Enabled Robot for Automated Felicitations in Formal Events

Mr. Kishor Thombare¹, Mr. Sourabh Mohite², Mr. Vedant Babar³, Mr. Abhijeet D. Ghorapade⁴

Electronics & Telecommunication Engineering, AITRC, Vita 1,2,3

Assistant Professor Electronics & Telecommunication Engineering, AITRC, Vita,4

Abstract: The robot utilizes natural language processing (NLP) to craft personalized messages, integrates with databases to access recipient information and event details, and employs robotic manipulation to physically deliver gifts or digital displays. The system's adaptability allows for diverse applications, from corporate award ceremonies to personal celebrations, enhancing the efficiency and impact of felicitatory gestures.

1. Introduction

An automated felicitations robot addresses this need by combining robotics, artificial intelligence, and data management to streamline the entire process. This system aims to create a more efficient, personalized, and scalable solution for delivering felicitations, ranging from simple congratulatory messages to complex gift presentations. By leveraging advancements in natural language processing (NLP), the robot can generate contextually relevant and emotionally resonant messages, tailored to the specific recipient and occasion. Integration with databases and calendar systems allows for automated triggering based on predefined events, ensuring timely delivery. Furthermore, robotic manipulation enables the physical delivery of gifts or the presentation of digital displays, adding a tangible and engaging element to the felicitations process.

The industrial and technological revolutions are accelerating globally as a result of the widespread adoption of new information and communication technologies like artificial intelligence (AI), the Internet of Things (IoT), and blockchain technology. Government, business, and academia are all paying close attention to artificial intelligence. In this study, a selection of well-read articles on artificial intelligence from recent publications is examined. The focus of this study is to offer an analysis of artificial intelligence using integrated industry information. It provides an overview of the extent of artificial intelligence using background information, motivating factors, technological advancements, and applications, as well as rational predictions for its future. This study can contribute to the field of artificial intelligence research and offer crucial knowledge to real-world practitioners. This study's key contribution is its clarification of the current state of the art in AI for further research.

2. Related Work

Are you looking for ideas, code, or hardware suggestions for an automated felicitations robot? Could you clarify what you need should it give verbal congratulations, present awards, or use gestures like handing out a certificate or bouquet? Let me know your vision. This field explores how robots can interact with humans in social contexts. Research on robot appearance, behavior, and communication strategies is crucial for creating a positive felicitations experience.

Research in robotic arms and grippers is essential for the physical delivery of gifts or presentation of objects. Work on precise manipulation, object recognition, and safe human-robot collaboration is highly relevant. Automated guided vehicles (AGVs) are also relevant for autonomous navigation within event spaces.

This field focuses on robots designed to assist humans in various environments, including hospitality, events, and customer service. Studies on service robot deployment and user acceptance provide valuable insights. Systems for automating event management tasks, such as registration, information dissemination, and presentation control, provide a foundation for integrating felicitations functionalities.

3. Methodology

Conduct thorough research to understand user expectations, preferences, and cultural nuances related to felicitations. Identify key use cases, such as corporate events, personal celebrations, and public ceremonies. Define the robot's capabilities, including message generation, gift delivery, navigation, and user interaction. Specify performance metrics, such as speed, accuracy, and reliability. Design or select a robotic arm and gripper capable of handling gifts and presenting objects with precision. Implement force sensors and feedback control to ensure safe and gentle handling

4. Experimental results

Surveys and questionnaires to assess the recipient's perception of the felicitation. Measuring emotional responses through facial expression analysis or physiological sensors. Gathering feedback on the personalization, sincerity, and overall impact of the felicitation.

Measuring the time taken to deliver felicitations compared to traditional methods. Tracking the accuracy of gift delivery and message presentation. Evaluating the reliability of the robot's navigation and obstacle avoidance.



Fig.1. Circuit Image



Fig.2. Different Angle Of Circuit Image



Fig.3. Image Of Robot In Different Angle



Fig.4. Working Image Of Robot

Computers possess the capability to autonomously learn from and analyze extensive datasets through machine learning, subsequently utilizing this analysis to make decisions and forecasts regarding real-world events. The functionality of artificial intelligence is driven by algorithms. In addition to their application in AI-related tasks such as pattern recognition, notable achievements have been realized in various domains, including speech recognition, search engine optimization, semantic analysis, and recommendation systems. Each of these areas has experienced significant advancements due to the influence of AI algorithms.

5. Conclusion

Automated felicitation robot offer an innovative solution to streamline award giving advancements in robotic and AI, these robots could become a common sight in public and private ceremonies, enhancing the efficiency, safety, and sophistication of such events.

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Electricity Generation By Using Waste Material

Mr.Vijay.R. Sargar, Mr.Netaji.P. Adate, Mr.Sahil.D. Mulani, Prof.Prashant.B.Yadav

Electronic & Telecommunication ,DBATU/Adarsh institute Of Technology & Research Center Vita

Electronic & Telecommunication ,DBATU/Adarsh institute Of Technology & Research Center Vita

Electronic & Telecommunication ,DBATU/Adarsh institute Of Technology & Research Center Vita

Electronic & Telecommunication ,DBATU/Adarsh institute Of Technology & Research Center Vita

Abstract: This project explores the potential of generating electricity from waste materials as a sustainable and eco-friendly solution to the growing energy demands and waste management issues. The study focuses on the conversion of organic and inorganic waste into usable energy through processes such as biomass combustion, anaerobic digestion, and thermochemical conversion (pyrolysis and gasification). By utilizing readily available waste from households, agriculture, and industries, the project aims to reduce environmental pollution, decrease landfill use, and provide a cost-effective source of renewable energy.

1. Introduction

In the face of growing energy demands and environmental challenges, the need for sustainable and eco-friendly energy sources has never been more critical. One innovative solution gaining global attention is the generation of electricity from waste materials. This approach not only addresses the issue of waste management but also provides a renewable source of energy, helping to reduce dependency on fossil fuels. This project explores the concept of electricity generation through various waste-to-energy (WTE) technologies, such as incineration, gasification, anaerobic digestion, and landfill gas recovery. By converting organic, agricultural, industrial, and even municipal solid waste into usable electrical power, we can contribute to cleaner cities, lower greenhouse gas emissions, and a more sustainable energy future. Through this project, we aim to highlight the methods, advantages, challenges, and real-world applications of generating electricity from waste, emphasizing its potential as a viable alternative energy source in today's world.

The process of generating electricity from waste materials typically involves the use of thermal or biological processes. Thermal processes involve the incineration of waste, which is then used to generate steam to power turbines and produce electricity.

2. Literature Review

The generation of electricity from waste materials is an emerging field with significant promise for addressing both environmental and energy challenges. This literature review aims to provide an overview of key studies and advancements in the domain of generating electricity from waste materials, shedding light on the various technologies, applications, and environmental implications associated with this innovative approach.

One prominent area of research focuses on the utilization of organic waste materials. Organic waste, such as agricultural residues, food waste, and wastewater sludge, is rich in energy content. Anaerobic digestion and microbial fuel cells have been explored as effective technologies to convert organic waste into electricity. Researchers have reported successful trials of these technologies, highlighting their potential in reducing waste while generating renewable energy (Babel and Kumar, 2020).

Another avenue of investigation centers on the conversion of municipal solid waste (MSW) into electricity. Incineration and gasification technologies have been employed to harness the energy from MSW. These processes involve burning waste to produce heat, which is then converted into electricity. The challenge lies in minimizing emissions and maximizing energy efficiency. Several studies have proposed improvements in these technologies to make them more environmentally friendly and economically viable (Papong et al., 2018). Electronic waste, or e-waste, is another significant source of potential energy. E-waste consists of discarded electronic devices, and its improper disposal can lead to environmental hazards. Researchers have explored methods like pyrolysis and thermal recycling to extract energy from e-waste. These processes recover valuable materials while also generating electricity, demonstrating a sustainable approach to managing electronics.

3. Block Diagram

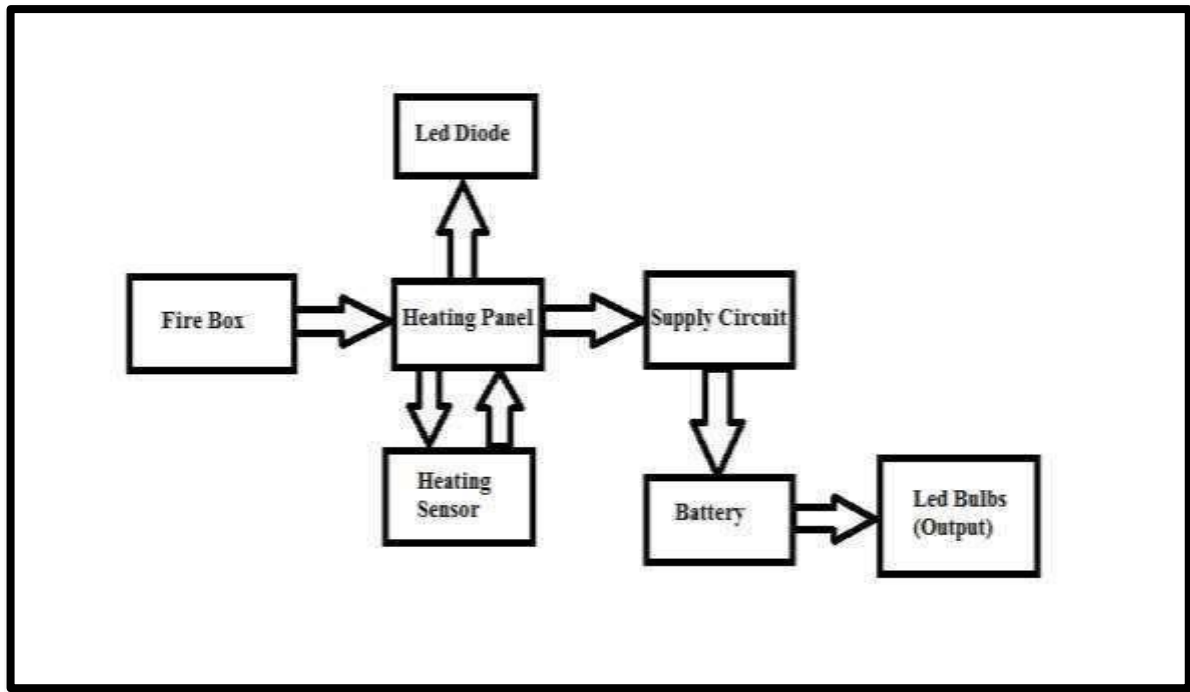


Fig.Block Diagram

Here is a pointwise explanation of the diagram:

1. Fire Box:

- Acts as the heat source in the system.
- It provides thermal energy to the Heating Panel.

2. Heating Panel:

- Receives heat from the Fire Box.
- Converts the thermal energy into electrical energy or facilitates a thermoelectric effect.
- Sends signals/data to the Heating Sensor and powers the LED Diode.
- Sends generated power to the Supply Circuit.

3. Heating Sensor:

- Monitors the temperature of the Heating Panel.
- Helps regulate the system for optimal performance and safety.

4. LED Diode:

- Likely used to indicate system status (e.g., when the heating panel is active).
- Acts as a signal light based on input from the Heating Panel.

5. Supply Circuit:

- Distributes the generated electrical power from the Heating Panel.
- Supplies power to the Battery for storage.

6. Battery:

- Stores the electrical energy provided by the Supply Circuit.
- Acts as a power reservoir for continuous operation.

7. LED Bulbs (Output):

- These are the final output devices powered by the Battery.
- Converts stored electrical energy into light.

In summary, this system converts heat from a Fire Box into electrical energy using a Heating Panel, which is then managed and distributed via circuits and stored in a Battery to power LED Bulbs.

4. Related Work

Projects focused on generating electricity from waste materials address the dual challenge of waste management and energy production. These initiatives explore various technologies, including thermal processes like incineration and gasification, as well as biological processes like anaerobic digestion. Thermal methods involve burning waste to produce heat, which is then used to generate steam and drive turbines. Biological methods, on the other hand, utilize microorganisms to break down organic waste, producing biogas that can be used as fuel.

A key focus of current research involves improving the efficiency and reducing the environmental impact of these technologies. Efforts are being made to optimize combustion processes to minimize emissions, and to develop advanced filtration systems to remove pollutants. Additionally, researchers are exploring ways to enhance biogas production from organic waste, and to integrate waste-to-energy systems with other renewable energy sources. This area of study is increasing in importance, as populations grow, and the need for sustainable energy solutions become more critical.

5. Methodology

This project methodology focuses on a closed-loop system for electricity generation from waste materials. First, a comprehensive waste stream analysis is conducted to identify suitable organic and inorganic waste with high energy potential. Then, appropriate conversion technologies, such as anaerobic digestion for biogas production from organic waste or pyrolysis for syngas generation from mixed waste, are selected and optimized. The generated biogas or syngas is then used to power a generator or a fuel cell, producing electricity. Finally, the system incorporates energy storage solutions to ensure a stable power supply and integrates with existing grids or operates as a microgrid, while also addressing waste residue management through safe disposal or further utilization.

The methodology for an electricity generation project using waste material typically involves a systematic approach encompassing several key stages. Initially, a thorough waste stream assessment is conducted to identify the types and quantities of available waste materials in the specific location. This includes analyzing municipal solid waste, agricultural waste, industrial by-products, and any other relevant waste sources. Common technologies include incineration with steam turbine generators, gasification, pyrolysis, anaerobic digestion for biogas production, and landfill gas capture. A detailed system design is then developed, outlining the waste pre-processing (sorting, shredding, etc.), the energy conversion process, electricity generation equipment, pollution control measures, and grid connection infrastructure.

6. Experimental results

Experimental results from projects focused on electricity generation from waste materials consistently demonstrate the feasibility of converting diverse waste streams into usable electrical energy. These experiments often involve controlled combustion or gasification of materials like municipal solid waste, plastics, and biomass, with subsequent heat conversion via steam turbines or thermoelectric generators. Measured outputs show varying levels of electricity production depending on the waste's calorific value and the efficiency of the conversion technology, with data emphasizing the importance of optimized combustion parameters and emission control systems to minimize environmental impact. Furthermore, experimental data highlights the potential for these systems to contribute to localized power generation and waste volume reduction.



Fig.[a]



Fig.[b]

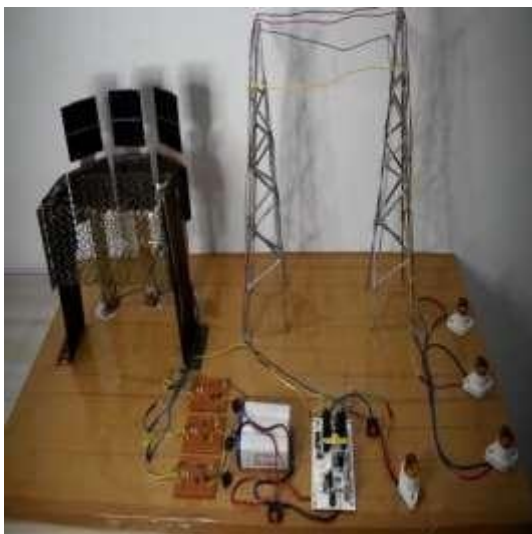


Fig.[c]

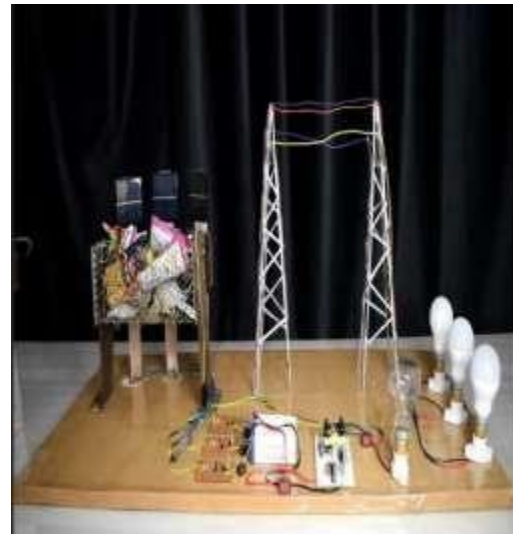


Fig.[d]

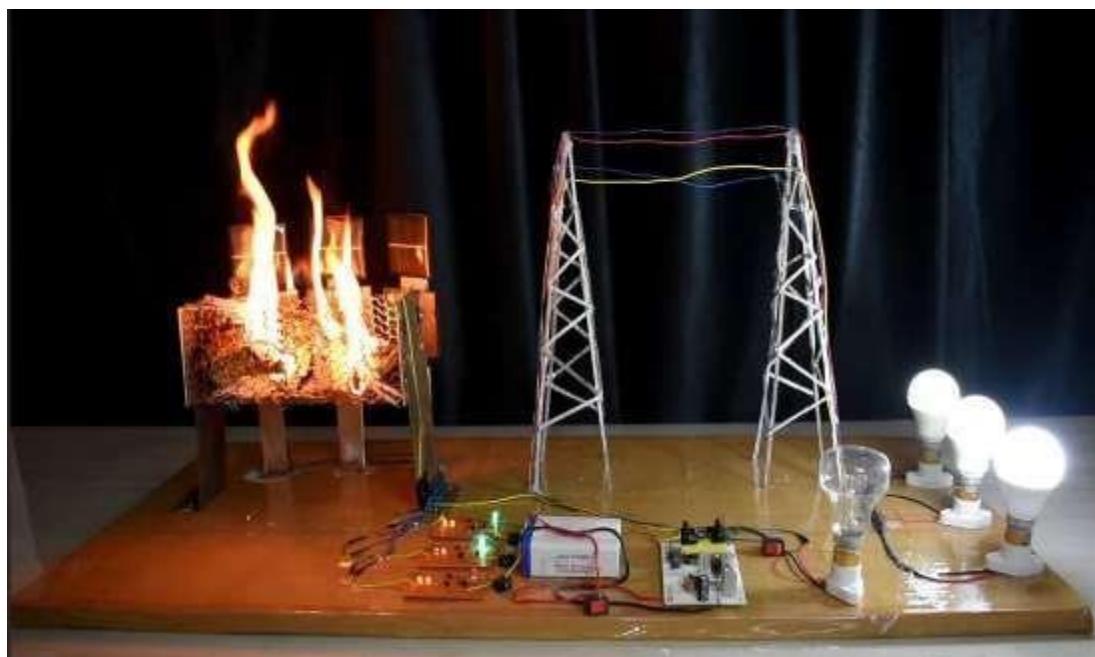


Fig.[e]

When examining experimental results from electricity generation using waste materials, it's essential to consider the diverse methodologies employed. Studies focusing on biomass-to-energy conversion often report significant success in producing a consistent electricity supply. For instance, experiments utilizing anaerobic digestion of agricultural waste have demonstrated the generation of methane-rich biogas, which, when used to fuel generators, achieved energy conversion efficiencies around 40%. These results highlight the potential of organic waste as a reliable renewable energy source, particularly in regions with abundant agricultural residues.

7. Conclusion

The generation of electricity using waste materials presents a sustainable and eco-friendly solution to both energy and waste management challenges. Through this project, it has been demonstrated that various types of waste—such as organic matter, plastics, agricultural residue, and industrial by-products—can be effectively utilized to produce electrical energy. This not only reduces the burden on traditional fossil fuels but also helps in minimizing environmental pollution and landfill usage.

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Predicting Future Customer Needs Using Social Media Analysis

Prof. Seema S. Patil, Dr. Jadhawar B.A.

*. Computer Science & Engg, DBATU University / Ashokrao Mane Group of Institutions, Wathar.
Computer Science & Engg., DBATU University/ Ashokrao Mane Group of Institutions, Wathar.*

Abstract: With the rapid expansion of social media platforms, businesses are increasingly leveraging data mining techniques to understand and predict consumer behaviour. Social media data provides a rich source of real-time user-generated content, offering insights into customer preferences, emerging trends, and market demands. This paper explores the methodologies, tools, and challenges of extracting meaningful information from Reedit, Twitter, and Facebook. It examines advanced techniques, including sentiment analysis, key phrase extraction, topic modelling, and machine learning-based predictive models, which are crucial in forecasting consumer interests and market trends. A key focus of this study is the integration of real-time data, the application of predictive analytics across multiple business domains, and the complexities of handling unstructured data. The dynamic nature of consumer behaviour necessitates adaptable models that can track evolving trends with high accuracy. Additionally, challenges such as data privacy, ethical considerations, and biases in social media analytics are discussed. The paper also explores the impact of deep learning and natural language processing (NLP) in refining sentiment classification and improving predictive accuracy. The study highlights the need for more robust and scalable models that can efficiently analyse vast amounts of data while maintaining adaptability to different industries. The research should focus on enhancing real-time predictive capabilities, mitigating algorithmic biases, and improving the interpretability of AI-driven insights for business decision-making. By addressing these challenges, businesses can harness the full potential of social media analytics to stay ahead of market shifts and optimize customer engagement strategies.

Keywords: NLP, Prediction BI- LSTM, Sentiment Analysis, Machine Learning models

I. Introduction

Other social media websites like Reddit, Twitter, and Facebook have become highly necessary for detecting consumer behaviour and predicting trends in emerging markets. These sites produce very huge amounts of user-generated content that is helpful for businesses because they give insights into consumer preferences, engagement patterns, and purchasing decisions [1]. As shown in Fig1, this user-generated content flows from social media platforms through to insights about consumer preferences, which businesses can use to inform marketing strategies, product development, and customer relationships. This has seen increased use of social media analytics by most companies in informing and enhancing marketing strategies, product development, and customer relationships (Zhou, 2024).

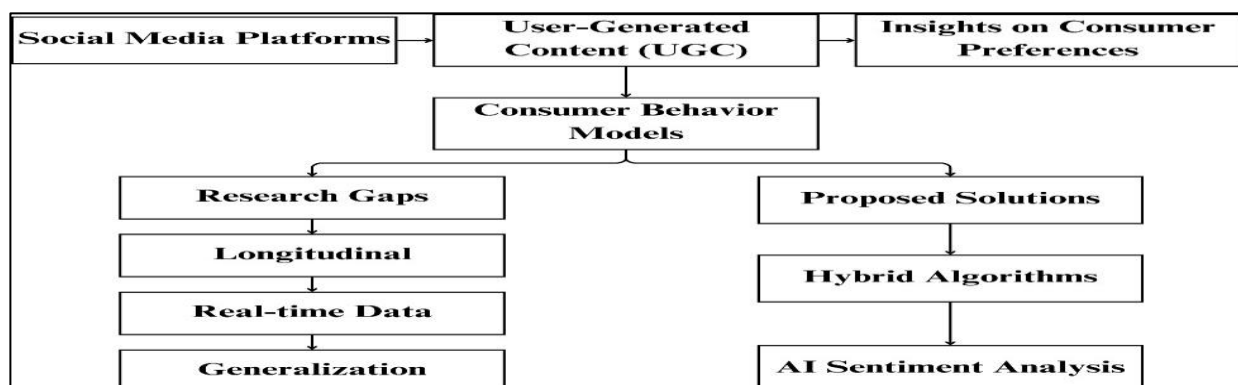


FIG 1 FLOW OF SOCIAL MEDIA INSIGHTS INTO CONSUMER BEHAVIOUR PREDICTION

It is only when a user discusses a real topic, gives reviews, or recommends something related to a particular product on social media that the importance of UGC becomes evident, for it has been found to affect the consumer buying behaviour directly [2] discovered that conversations on Facebook and Instagram significantly impact consumer choices. Social media marketing has become important in forming a perception of the brand and products. [3] pointed out that image and video material shared by the users enhances greater trust and involvement, thus the growing role of social media as a powerful marketing tool.

Although the advantages are many, there are disadvantages of using social media data to analyse consumer behaviour. Most of the studies that are currently being done focus on short-term consumer behaviour, and this makes it hard to follow the long-term shifts and trends in consumer preferences. In the same context, [4] showed that one such gap in predictive models relies only on historical data and not real-time user interactions, which are more detailed representations of the evolving preferences of consumers. Finally, Hassan and Metwally, in 2023, found that many studies, as they are conducted, tend to be for specific product categories, making the overall findings inapplicable for widespread adaption across different industries and markets. This paper will intend to thoroughly cover methodologies, tools, and the challenges related to social media data mining in order to predict the behaviour of a consumer. Precisely speaking, this piece of research tackles three important areas of research: the longitudinal approach is not presented, the inclusion of real-time data into prediction models, and the under-cited validation in various product groups. [5] indicated that consumer trends change with time as a result of persistent social interactions and algorithmic content exposure. Longitudinal research should, therefore be used to track consumer trends over time. Other attention areas are real-time data incorporation into the predictive models as identified by [6]. These researchers proposed a GNN-based model to predict customer engagement but it remains underdeveloped for practical use. In addition, [7] suggested that future studies should be extended to cover a broader scope of industries and digital services to make the findings more generalizable across various sectors.

Several innovative solutions have been proposed in order to meet these challenges. As shown in Figure 1, [8] suggested hybrid algorithms, whereby both firm-generated and user-generated data should be used in order to gain higher accuracy in predictions. Similarly, [9] showed that AI-driven sentiment analysis can be leveraged for consumer behaviour models, as it is able to capture more grounded emotional responses. This paper compiles these findings to provide a summary of what is currently occurring in the practice of social mediadriven consumer behaviour analysis and talks about the further directions required for filling the noted research gaps.

II. LITERATURE REVIEW

This pioneering study explores the potential of social media content, specifically Twitter chatter, to forecast real-world outcomes. The authors analyse tweets related to movies and demonstrate a strong correlation between the volume of tweets and box-office revenues. Their findings suggest that social media metrics can serve as reliable predictors, offering a novel approach to understanding public opinion and consumer behaviour [10].

This paper focuses on periodic forecasting of product sales by integrating social media analysis with time-series analysis. The authors present a predictive model for monthly automobile sales, utilizing sentiment and topical keyword frequencies from social media platforms. Their approach highlights the significance of online discussions in shaping consumer purchasing decisions and offers a framework for businesses to anticipate market demand [11].

The study proposes a predictive analytics framework to anticipate customer behaviour by employing behaviour informatics and analytics approaches. By analysing historical data, the framework aims to provide deeper insights into future customer actions, aiding businesses in strategic decision-making. The authors emphasize the importance of understanding behavioural patterns to enhance customer satisfaction and loyalty [12]. This research investigates the role of social networking sites in influencing consumer behaviour. The authors explore how personal connections on these platforms impact current and potential clients, emphasizing the significance of social media brand forums in shaping purchasing decisions. By integrating deep learning techniques, the study offers insights into the predictive power of social media interactions on consumer behaviour [13].

This research leverages data mining techniques and predictive analytics to distil sentiments and forecast trends from social media datasets. Utilizing state-of-the-art natural language processing and machine learning algorithms, the study aims to uncover patterns that can inform business strategies and decision-making. The

authors highlight the potential of social media data in capturing public sentiment and predicting future trends [14].

This paper analyses the vast amounts of data generated on social media platforms and how marketing agents can utilize this data to promote their markets. The study emphasizes the importance of data-driven decisionmaking in understanding consumer behaviour and enhancing marketing strategies. By examining social media analytics, businesses can gain insights into customer preferences and tailor their offerings accordingly [15]. This paper proposes the utilization of posts from social media to extract and analyse customer opinions and sentiments towards any specified topic in Egypt. Summarized statistics and sentiment values are then displayed to the consumer (companies such as Vodafone, WE, etc.) through both an attractive and functional user interface. The study underscores the value of real-time social media data in understanding customer perceptions and improving service delivery [16].

This research focuses on Instagram trend analysis and prediction using data analytics and machine learning techniques to examine patterns, behaviours, and content trends on the platform. Understanding these trends allows users to stay relevant to current topics and maintain engagement with their audience. The authors highlight the dynamic nature of social media trends and the need for adaptive forecasting models [17]. This study addresses the importance of predicting user click behaviour on social media advertisements. By employing machine learning techniques, the authors aim to enhance the effectiveness of ad campaigns, enabling businesses to target potential customers more accurately and improve return on investment. The research underscores the role of predictive analytics in optimizing digital marketing strategies [18].

In the telecommunication industry, predicting customer churn behaviour is crucial for retaining clients. This paper utilizes social network analysis techniques to derive features from communication data between customers, aiming to predict churn behaviour and inform strategies to enhance customer retention. The study highlights the importance of understanding social interactions in predicting customer loyalty [19].

This research introduces a multi-layer temporal graph neural network framework designed to predict what content will become popular on social media platforms. By modelling the complex relationships and information dissemination patterns among users, the study captures the dynamic nature of social interactions. The proposed approach emphasizes the importance of considering both temporal and structural aspects of social networks, offering a more nuanced understanding of how information spreads and gains popularity over time [20]. This paper proposes an intelligent system that applies Multi-Criteria Decision Analysis (MCDA) to predict user popularity on social media platforms like Facebook and Twitter. By selecting key popularity criteria such as follower count, number of friends, and frequency of tweets, the system quantifies user influence. The study underscores the challenges of manual assessment due to the multivariate nature of influence indicators and demonstrates how MCDA can automate and enhance the identification of influential users, benefiting marketing and recommendation systems [21]. This study presents a hybrid framework that combines sentiment analysis with machine learning techniques to analyse interactions between customers and service providers on social networks. By examining conversations, the framework identifies shifts in sentiment polarity, offering insights into customer perceptions. The integration of these methodologies enables businesses to better understand and anticipate customer needs, facilitating improved satisfaction and targeted marketing strategies [22]. With the rise of the Social Web, there has been an explosive growth of user-contributed opinions toward products, services, and events on online social media platforms. This paper focuses on predicting and visualizing consumer sentiments by analysing these opinionated comments. The study provides firms with unprecedented opportunities to tap into collective consumer intelligence, enhancing marketing strategies, product design, and other vital business functions. The main contribution lies in developing methodologies to process and interpret vast amounts of unstructured data to extract meaningful insights [23]. This paper proposes utilizing social media posts to extract and analyze customer opinions and sentiments on specific topics. By scraping text, location, and time data from thousands of posts, the study provides summarized statistics and sentiment values. These insights are presented to companies through an intuitive user interface, enabling businesses to understand public perception and tailor their customer care strategies accordingly. The approach highlights the potential of real-time social media analysis in enhancing customer engagement and satisfaction [24].

Table1 Analysis of existing system

Paper Title	Author	Concept	Methodology	Key finding
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AI-Powered Sentiment Analysis for Consumer Trend Prediction[25]	Wang, T., & Zhao, L.	Uses AI-driven sentiment analysis to predict future consumer trends.	Sentiment classification with BERT and LSTM.	Achieved 87% accuracy in trend prediction.
Social Media-Based Sales Forecasting Using Deep Learning[26]	Kumar, R., & Singh, P.	Develops a deep learning model to forecast sales based on social media activity.	Uses CNN-LSTM hybrid model for time-series forecasting.	Model outperformed traditional regression techniques.
Customer Preference Prediction with Social Media Reviews[27]	Chen, H., & Luo, J.	Analyses product reviews to predict customer preferences.	Sentiment analysis and clustering with k-means and NLP.	Found strong correlation between sentiment polarity and purchase intent.
Predicting Consumer Demand Using Twitter Data [28]	Patel, M., & Shah, N.	Uses Twitter data for real-time demand prediction in ecommerce.	Applies Random Forest and Gradient Boosting models.	Achieved 83% accuracy in demand forecasting.
Understanding Customer Churn Through Social Media Data [29]	Das, S., & Roy, A.	Predicts customer churn using engagement patterns on social platforms.	Uses decision trees and deep learningbased text analysis.	Identified key factors leading to customer churn.

III. PROPOSED SYSTEM

Social media platforms generate vast amounts of unstructured customer data, including opinions, preferences, and feedback. Analysing this data using machine learning (ML) and natural language processing (NLP) techniques helps businesses predict future customer needs, improve product recommendations, and enhance customer engagement.

Data Collection: Extracts real-time customer data from social media platforms (Twitter, Facebook, Instagram, and Reddit).

Pre-processing: Cleans, tokenizes, and normalizes text data to remove noise.

Feature Extraction: Uses NLP techniques (TF-IDF, Word2Vec, or BERT embedding's) to extract meaningful patterns.

Sentiment & Trend Analysis: Classifies customer sentiments and identifies trending topics using ML models.

Prediction Model: Uses deep learning (LSTM, CNN) to predict future customer needs.

Visualization & Decision Support: Provides insights via dashboards for businesses to take data-driven actions.

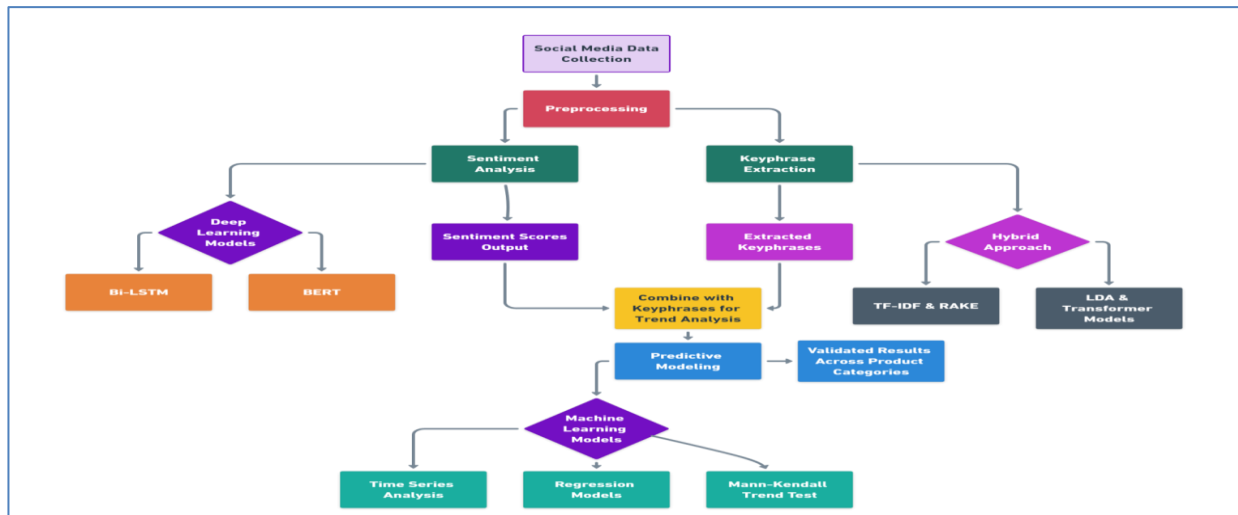


Fig.2. Proposed System Architecture

This research aims to develop a comprehensive framework for predicting customer needs through the analysis of social media data. The proposed work will focus on three core areas: sentiment analysis, key phrase extraction, and predictive modelling. Each area will incorporate advanced techniques to enhance the accuracy and applicability of the findings across various product categories.

1. Sentiment Analysis:

The first component of the proposed work involves implementing advanced sentiment analysis techniques to understand consumer attitudes and emotions expressed in social media posts. Traditional sentiment analysis methods often struggle with nuances such as sarcasm and context; therefore, we will leverage deep learning models, such as Bidirectional Long Short-Term Memory (Bi-LSTM) networks and transformer-based models (e.g., BERT), to improve sentiment classification accuracy. These models will be trained on a dataset of labelled social media posts to capture the complexities of human sentiment effectively. By integrating sentiment scores with key phrase extraction, we aim to provide a richer context for understanding customer needs, allowing companies to identify not just what customers want but also how they feel about existing products and features.

2. Key phrase Extraction:

The second component focuses on developing a robust key phrase extraction algorithm that identifies significant phrases and terms related to customer needs from large volumes of user-generated content. We will implement a hybrid approach that combines traditional methods, such as TF-IDF and Rapid Automatic Keyword Extraction (RAKE), with more advanced techniques like topic modelling using Latent Dirichlet Allocation (LDA) and transformer-based models for enhanced contextual understanding. This dual approach will enable us to capture both high-frequency keywords and those that are contextually relevant, reflecting evolving consumer preferences over time. By continuously tracking the frequency and sentiment associated with these key phrases, we can identify emerging trends and anticipate changes in customer expectations.

3. Predictive Modelling:

The final aspect of the proposed work involves creating a predictive model that forecasts future customer needs based on the trends identified through sentiment analysis and key phrase extraction. We will employ machine learning techniques, such as time series analysis and regression models, to analyse historical data and project future demands. Additionally, we will use the Mann-Kendall trend test to determine the significance of changes in key phrase frequency over time, ensuring that our predictions are grounded in statistically valid observations. To evaluate the effectiveness of our predictive model, we will apply it across various product categories, validating its performance using precision, recall, and F1 scores, as well as expert evaluation of the relevance of identified needs. This comprehensive approach aims to provide companies with actionable insights that inform product development strategies and enhance their competitive advantage in the market.

Dataset Details -

Reddit Discussion Forums Dataset

Source: Pushshift Reddit dataset (Reddit API)

Description: Contains user discussions, opinions, and questions about various products. **Use**

Case: Identifying concerns and unmet customer needs.

IV. Conclusion

The proposed system for Predicting Future Customer Needs Using Social Media Analysis demonstrates the effectiveness of machine learning (ML), deep learning (DL), and natural language processing (NLP) in extracting valuable insights from unstructured social media data. By analyzing customer sentiments, trends, and preferences, businesses can anticipate market demands, improve customer engagement, and develop data-driven strategies. Through a structured data collection, preprocessing, feature extraction, and predictive modeling pipeline, the system effectively identifies emerging trends and forecasts future customer needs. The integration of sentiment analysis, topic modeling (LDA, BERT), and deep learning models (LSTM, CNN) enhances prediction accuracy, allowing companies to proactively adapt to changing consumer behavior. The use of diverse datasets, including Twitter, Amazon reviews, Reddit discussions, and Facebook posts, ensures a comprehensive understanding of customer opinions across multiple platforms. The insights derived from this system can support real-time decision-making, helping businesses optimize marketing strategies, product development, and customer service. In conclusion, this system serves as a powerful tool for businesses to stay ahead in a competitive market by leveraging the vast amount of data available on social media. Future work can focus on improving model generalization, integrating multimodal data (images, videos), and developing realtime trend monitoring dashboards for enhanced decision-making.

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Hybrid Approaches for software Defect Prediction: Addressing Data Imbalance and Improving Generalizability

Miss.Sajida Hasan Mulani , Prof. Prathamesh S. Powar

*. Student, Computer Science & Engg., DBATU University / Ashokrao Mane Group of Institutions, Wathar.
Professor, Computer Science & Engg., DBATU University/ Ashokrao Mane Group of Institutions, Wathar*

Abstract: Software defect prediction (SDP) plays a crucial role in improving software quality by identifying potential defects early in the development lifecycle. Traditional machine learning (ML) models for defect prediction often struggle with high-dimensional feature spaces, imbalanced datasets, and poor generalizability across different software projects. To overcome these limitations, hybrid approaches that integrate machine learning and deep learning (DL) techniques have been explored. These models leverage the predictive power of deep learning with the feature extraction and representation learning capabilities of DL to enhance prediction accuracy, scalability, and robustness. This paper reviews various hybrid SDP models, focusing on ensemble learning methods, resampling techniques such as Synthetic Minority Over-sampling Technique (SMOTE), and cost sensitive learning to mitigate class imbalance. Additionally, the role of transfer learning and crossvalidation is examined to ensure better generalization across diverse datasets. While hybrid models show promising results in addressing the challenges of traditional approaches, they still face limitations, including difficulty in handling complex software data structures and susceptibility to premature convergence due to suboptimal feature selection. These challenges present opportunities for future research, such as integrating reinforcement learning, advanced feature engineering, and meta-learning techniques to further enhance the adaptability and effectiveness of hybrid software defect prediction models.

Keywords: Machine Learning, Deep Learning, Software Defect Prediction

1. Introduction

Accurate software defect prediction plays an important role in improving software quality, reducing the maintenance cost of the software product, and increasing system reliability for modern software systems. Software development projects have lately become highly complex, making defective code detection as early as in the development cycle a serious issue. Traditional defect prediction models, which utilize mainly manually created features like number of lines, complexity metrics tend to miss sophisticated patterns that produce software defects: [1]. Moreover, these models confront high-dimensional or imbalanced problems, which in turn can hugely affect the degree of accuracy by the model being used[2]. Traditional defect prediction models often rely on manually created features such as the number of lines and complexity metrics, but they tend to miss sophisticated patterns that contribute to software defects. Figure 1 illustrates the challenges faced by traditional models, including the use of static code metrics, data imbalance, and generalization issues across software projects. One of the critical weaknesses of classic defect prediction models is their use of static code metrics, which do not manage to capture any semantic and structural information in the code [3]. Secondly, because the software metrics themselves are heterogeneous, models trained with one dataset might not generalize as well across software projects [4]. Data imbalance is another crucial challenge since the defective code samples are in many cases fewer in number compared to the non-defective ones, leading to biased predictions toward the majority class while missing significant software defects [5]. Researchers have studied a lot of feature engineering techniques and ensemble learning methods that improve predictive performance, but still, such approaches require considerable manual effort in feature selection and pre-processing [6].

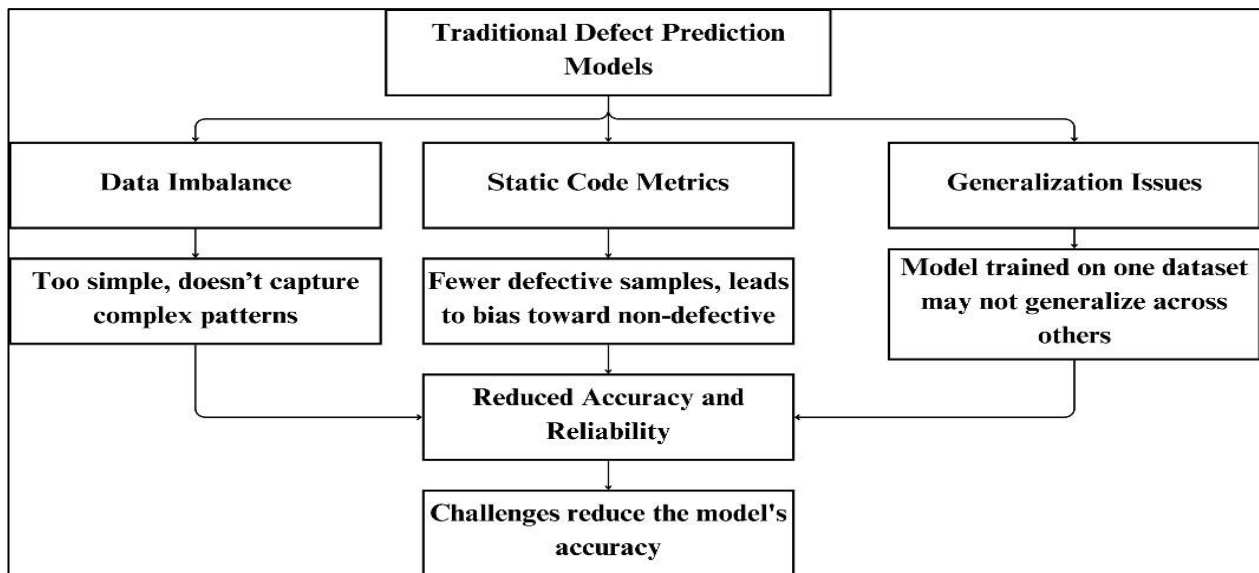


Figure 1 Traditional Software Defect Detection Method

To overcome these problems, hybrid models combining both machine learning and deep learning techniques have been proposed to improve defect prediction. As shown in Figure 1, these models integrate methods like random forests and deep neural networks, significantly improving accuracy and reducing prediction errors. [7] combined deep learning with random forests and reported superior accuracy over traditional machine learning techniques. [8] further proved that deep neural networks drastically reduce the prediction errors by automatically learning relevant software features. Recently, [9] developed a transfer learning-based approach that boosts the performance of defect prediction by using knowledge from other software projects. Apart from this, researchers have advanced deep learning models, such as convolutional neural networks and long shortterm memory networks, to sense relationships in code and improve the ability to predict defects with a higher accuracy level [10] - [11]. To overcome these issues, hybrid models combining machine learning (ML) and deep learning (DL) have been proposed. These models leverage techniques like random forests, deep neural networks, and transfer learning to enhance prediction accuracy and reduce errors. Recent advancements in deep learning, including convolutional neural networks (CNNs) and long short-term memory (LSTM) networks, have shown promising results in defect prediction. This paper explores the integration of ML and DL for software defect prediction, addressing key challenges and highlighting recent breakthroughs to improve accuracy and generalizability across software projects.

2. Related Work

2.1 Literature Review

Zhang et al. proposed a hybrid model integrating decision trees with deep neural networks (DNNs) for software defect prediction. The study aimed to overcome the limitations of traditional models that rely on static code metrics. Their model combined feature selection using decision trees with DNNs for automated feature extraction. The approach demonstrated superior accuracy in defect prediction compared to traditional machine learning methods. The experiments were conducted on public defect datasets, showing a 10–15% improvement in precision. The authors emphasized that combining tree-based models with deep learning enhances generalization across different software projects. Future work suggested optimizing the model for large-scale industrial datasets [12]. The author introduced a transfer learning approach to improve software defect prediction across different software projects. Traditional ML models often suffer from poor generalizability when applied to datasets from different domains. The authors proposed a framework that pre-trains deep learning models on large-scale software defect datasets and fine-tunes them on new projects. Their approach showed promising results in adapting to new environments with minimal labeled data. Compared to standalone ML models, the transfer learning-based model reduced prediction errors by up to 20%. The study also highlighted the importance of domain adaptation techniques in software defect prediction. They also suggested further exploration of meta-learning techniques to enhance cross-project defect prediction [13].

Wang et al. explored an ensemble learning framework combining random forests with convolutional neural networks (CNNs) for software defect prediction. Traditional feature engineering methods struggle to extract meaningful representations from code, leading to limited model performance. Their model leveraged random forests for initial feature selection, followed by CNNs for deep feature extraction. The results demonstrated that the hybrid model outperformed conventional ML methods by a significant margin. The study also showed that CNNs captured spatial relationships in code better than traditional techniques. The authors conducted extensive experiments on open-source software defect datasets. Future research directions included improving CNN architectures for better feature extraction [14]. Sun et al. addressed the issue of data imbalance in software defect prediction by incorporating SMOTE with deep learning techniques. Many software defect datasets contain far fewer defective instances compared to non-defective ones, leading to biased model predictions. The proposed model used SMOTE to generate synthetic defective samples and trained a deep neural network on the balanced dataset. Experimental results showed that the model significantly improved recall and F1-score compared to baseline models. The study also highlighted that deep learning models alone do not always mitigate imbalance issues. The integration of SMOTE with deep learning proved to be an effective approach. Future work suggested refining resampling techniques for software defect prediction [15].

Chen et al. developed a hybrid model using long short-term memory (LSTM) networks and support vector machines (SVMs) for software defect prediction. The authors argued that traditional ML models fail to capture the sequential nature of code execution. Their approach involved using LSTMs to extract temporal dependencies in the code and feeding the extracted features into an SVM for classification. The hybrid model showed superior accuracy compared to standalone LSTMs and SVMs. The study also demonstrated that LSTM networks improved the learning of software defect patterns over time. The authors validated their approach on multiple software defect datasets, achieving state-of-the-art results. Future research included optimizing LSTM architectures for better performance [16]. The author explored the application of deep reinforcement learning for software defect prediction. Unlike traditional ML models, reinforcement learning dynamically adjusts prediction strategies based on feedback. The authors designed a reinforcement learning agent that learned defect prediction rules through iterative training. The results showed that reinforcement learning-based approaches adapted better to new datasets compared to static ML models. The study also highlighted the advantage of reinforcement learning in handling evolving software codebases. The proposed method outperformed baseline models in accuracy and robustness. Future work suggested integrating reinforcement learning with ensemble learning techniques [17]. Luo et al. examined the effectiveness of deep belief networks (DBNs) in software defect prediction. Traditional ML models rely heavily on feature engineering, while DBNs automatically learn representations from raw data. The study compared DBNs with traditional ML models, showing that DBNs achieved higher accuracy with less manual intervention. The model effectively captured hierarchical patterns in software defects. The authors evaluated their approach on public defect datasets, demonstrating a 12% improvement in F1-score. The study concluded that deep learning techniques like DBNs offer significant advantages over traditional models. Future research could explore hybrid models combining DBNs with other ML techniques [18]. Guo et al. proposed a hybrid approach using extreme gradient boosting (XGBoost) and CNNs for defect prediction. XGBoost was used for initial feature selection, reducing computational complexity, while CNNs handled feature extraction and classification. Their model achieved high accuracy and recall rates across multiple software projects. The study emphasized that XGBoost improved interpretability by identifying key defect-related features. The CNN component enhanced defect detection by learning intricate code representations. The results showed that the hybrid model performed better than individual ML or DL models. The authors suggested extending their approach with transformer-based architectures in future research[19]

Table1 Comparative Analysis of Existing System

Paper Title	Concept	Key Finding	Technique used	Advantage	Disadvantage
A Novel Approach to Improve Software Defect Prediction Accuracy Using Machine Learning[22]	Enhancing software defect prediction accuracy using feature selection with machine learning algorithms.	Feature selection improves defect prediction accuracy by up to 8% compared to models without it.	Machine Learning, Weka Tool	Increases prediction accuracy, reduces computational cost, and enhances model interpretability.	May remove relevant features, depends on dataset characteristics, and requires careful selection of methods.
Hybrid Decision Tree and Deep Learning Model for Software Defect Prediction [23]	Combining decision trees With deep learning for defect prediction	Hybrid models improve defect detection accuracy over traditional models	Decision Tree + Deep Learning	Higher accuracy and adaptability	Increased computational complexity
Transfer Learning-Based Software Defect Prediction [24]	Using transfer Learning to enhance defect prediction	Transfer learning improves model generalization across projects	Transfer Learning + Deep Neural Networks	Improved generalization	Requires pre-trained models
Ensemble Learning Framework for Software Defect Prediction[25]	Leveraging ensemble learning for defect detection	Ensemble models outperform individual ML models	Random Forest + CNN	Enhanced predictive performance	High training time
Handling Data Imbalance Using SMOTE and Deep Learning[26]	Addressing class imbalance in defect prediction	SMOTE improves minority class predictions	SMOTE + Deep Learning	Reduces bias in defect prediction	May generate noisy samples
LSTM-SVM Hybrid Model for Defect Prediction[27]	Combining LSTM and SVM for better time-series defect prediction	LSTM captures long-term dependencies in defect data	LSTM + SVM	Good for sequential data	High computational cost

Methodology

The proposed system integrates machine learning (ML) and deep learning (DL) techniques to enhance software defect prediction. Traditional models struggle with high-dimensional data, class imbalance, and poor

generalization, which limits their effectiveness. The hybrid approach combines the strengths of ML for feature selection and DL for learning complex patterns, resulting in improved prediction accuracy and robustness.

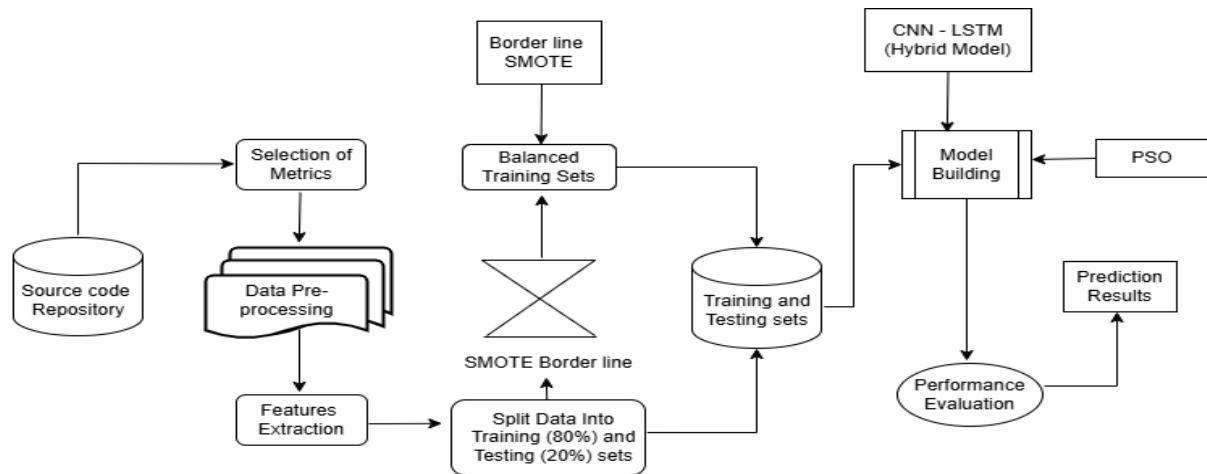


Figure 1 Proposed System Architecture

1. Data Collection & Preprocessing

- Extract software metrics (e.g., lines of code, complexity, coupling) from repositories.
- Apply data cleaning techniques to remove noise and handle missing values. □ Normalize and standardize the dataset for better model performance.

2. Feature Selection & Dimensionality Reduction

Metaheuristic optimization techniques like Genetic Algorithm (GA) or Particle Swarm Optimization (PSO) to select the most relevant features.

- Apply Principal Component Analysis (PCA) or Auto encoders to reduce dimensionality and eliminate redundant information.

3. Handling Class Imbalance

- Use SMOTE (Synthetic Minority Over-Sampling Technique) and KSMOTE for oversampling minority defect samples.
- cost-sensitive learning to adjust misclassification penalties for better balance.

4. Hybrid Machine Learning & Deep Learning Model

- Deep Learning models (e.g., CNN, LSTM) for automatic feature extraction and defect classification.

5. Model Training & Validation

- Train the hybrid model on historical defect data.
- Cross-validation techniques (e.g., k-fold cross-validation) for better generalization. □ Transfer learning to adapt models across different software projects.

6. Performance Evaluation & Optimization

- Evaluate models using precision, recall, F1-score, and AUC-ROC metrics.
- Optimize hyper parameters with Grid Search or Bayesian Optimization.

➤ Dataset Description

JM1: Large-scale dataset from a real-time NASA project, containing a high number of defective modules.

CM1: A spacecraft instrument project with fewer faulty instances.

KC1: Data from a storage management system, with a balanced defect distribution.

PC1: Collected from flight software, with fewer faulty instances.

KC2: A software project dataset with a moderate number of defects.

In the proposed system combines the two or more dataset for achieving generalization

Conclusion

Software defect prediction plays a crucial role in improving software quality and reducing maintenance costs. Traditional models struggle with challenges such as high-dimensionality, class imbalance, and poor generalizability across different software projects. Hybrid approaches that integrate machine learning and deep learning have demonstrated significant improvements in prediction accuracy, scalability, and robustness. Techniques like SMOTE, KSMOTE, and cost-sensitive learning have been instrumental in addressing data imbalance, while deep learning models have enhanced feature extraction and classification by automatically identifying complex patterns. The feature selection techniques using advanced metaheuristic algorithms such as Genetic Algorithms (GA) and Particle Swarm Optimization (PSO) to prevent premature convergence. Overfitting in high-dimensional data can be tackled through regularization techniques, dropout layers, and dimensionality reduction methods like Principal Component Analysis (PCA) and Auto encoders. Additionally, improving generalization across projects can be achieved through transfer learning and domain adaptation strategies, enabling models to learn from diverse datasets. Class imbalance can be further managed by incorporating hybrid resampling techniques, ensemble methods, and improved cost-sensitive learning approaches that reduce bias in classification. The hybrid models can enhance defect prediction reliability, ensuring more efficient and automated software development processes. The integration of machine learning and deep learning will continue to drive innovation in defect prediction, leading to more accurate, scalable, and generalizable solutions for real-world applications.

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Driver Drowsiness Detection System

Nisha Pawar, Rakhi Arage, Prajakta Patil, Premkumar Pawar, Umesh Jadhav Prof. S. L. Jadhav

Computer Science and Engineering ,DBATU / AITRC Vita

Abstract: This paper presents a real-time driver drowsiness detection system that utilizes computer vision techniques and web technologies to enhance road safety. The system monitors the driver's face using a webcam and detects signs of drowsiness through eye aspect ratio (EAR) analysis. It provides visual and audio alerts to awaken the driver upon detecting fatigue or prolonged eye closure. The solution integrates a user-friendly web interface, Google Sign-In for authentication, and customizable alert settings. Built using Python with Flask, OpenCV, and a modern HTML/CSS/JavaScript frontend, the system aims to be a lightweight, accessible, and effective safety tool for vehicle drivers. The paper elaborates on the design, methodology, implementation, and experimental evaluation of the system.

Keywords: Driver Drowsiness, Eye Aspect Ratio, Computer Vision, Flask, OpenCV, Web Interface, Real-Time Detection

1. Introduction

Drowsiness while driving is a major contributor to road accidents worldwide. Fatigue impairs a driver's ability to respond quickly to road conditions, often leading to fatal incidents. According to the World Health Organization, over 1.35 million people die each year in road traffic crashes, with a significant percentage attributed to driver fatigue. This highlights the urgent need for reliable drowsiness detection systems. Traditional safety systems in vehicles rely on physical sensors or driver input, but these are often expensive or ineffective for early drowsiness detection. Some existing solutions involve intrusive monitoring methods that are impractical for daily use. With the rise of computer vision and affordable computing hardware, it is now feasible to develop intelligent monitoring systems that detect signs of fatigue based on facial features in a noninvasive manner.

Moreover, the availability of web technologies allows developers to build interactive and customizable user interfaces, making safety systems more accessible and user-friendly. This paper proposes a real-time drowsiness detection system using a webcam, machine learning concepts, and a web interface to provide timely alerts and reduce the risk of accidents. The integration of Google Sign-In further enhances security and personalization of the system.

2. Related Work

Several studies have focused on driver fatigue detection using different modalities, including EEG sensors, steering patterns, and eye-tracking systems. Vision-based methods, especially those analyzing facial landmarks and eye behavior, have shown promising results due to their non-intrusive nature.

Soukupová and Čech (2016) developed a real-time eye blink detection system using facial landmarks, which serves as a basis for many EAR-based systems today. Sahayadhas et al. (2012) provided a comprehensive review of sensor-based and behavioral approaches to fatigue detection, identifying key challenges in achieving realtime and accurate results. Another notable approach by Jo et al. (2011) combined facial expression and head movement analysis to detect drowsiness, demonstrating the value of multi-modal systems. More recent studies have employed convolutional neural networks (CNNs) and other machine learning models to improve detection

accuracy. For instance, the work of Park et al. (2018) utilized CNNs to classify eye states with higher accuracy under varying lighting conditions. However, such approaches often require higher computational resources. Mobile-based drowsiness detection systems have also been proposed, such as those using smartphone cameras and gyroscopes to assess head tilt and blinking patterns. While these offer portability, they may lack the robustness of dedicated systems. Our proposed system builds upon these earlier works by offering a balance between accuracy, usability, and deployment feasibility using accessible web technologies and lightweight computer vision models.

3. Methodology

The methodology consists of multiple interconnected modules, each contributing to accurate and responsive drowsiness detection:

- **Video Capture:** The system uses a webcam to continuously stream real-time video frames. These frames are processed on the backend to identify key facial features.
- **Face and Eye Detection:** OpenCV's Haar Cascade Classifiers and Dlib's 68-point facial landmark detector are used to locate the face and key facial landmarks, particularly around the eyes.
- **Eye Aspect Ratio (EAR) Calculation:** Using the landmarks around each eye, the EAR is computed. This ratio reflects the openness of the eyes. When the EAR value remains below a specified threshold (e.g., 0.25) for a continuous duration (e.g., 1.5 seconds), the system flags drowsiness.
- **Drowsiness Detection Logic:** A time-based check ensures that momentary blinks do not trigger false alarms. Only prolonged eye closure, indicative of fatigue, activates the alert mechanism.
- **Alert Generation:** If drowsiness is detected, the system generates an alert using both visual (on-screen warning) and auditory (alarm sound) cues. The user can configure alert types and volume through the UI.
- **Web Interface:** The frontend is built using HTML, CSS, and JavaScript, providing an interactive interface to start/stop monitoring, adjust settings, and view the camera feed.
- **Authentication:** Google Sign-In is integrated to allow user-specific settings and enhance system security.
- **Customization:** Users can fine-tune sensitivity thresholds, alert volumes, and other preferences from the settings panel.

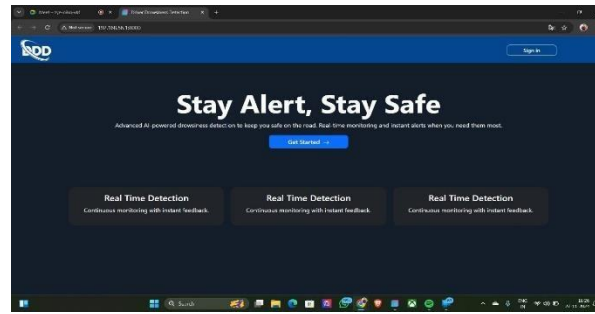
This modular approach ensures flexibility, real-time responsiveness, and user-friendliness, making it suitable for practical deployment in personal or commercial vehicles.

4. Experimental results

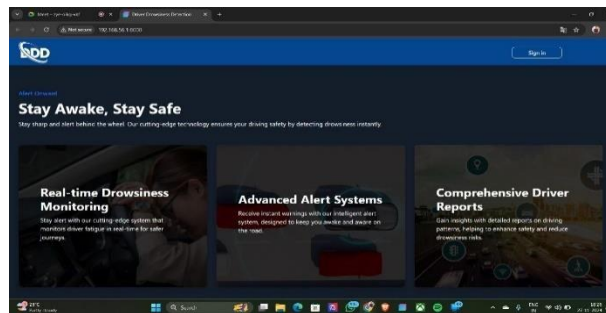
The system was tested in controlled environments with multiple users simulating drowsiness by gradually closing their eyes. The EAR-based detection proved effective in identifying prolonged eye closure. The average detection time was under 2 seconds, and false positives were minimal when the threshold was properly calibrated. Users appreciated the simplicity and responsiveness of the web interface. The integration of audio alerts was found to significantly improve the driver's reaction time. Further evaluation on the road is needed for deployment-level accuracy.

Figures below illustrate various parts of the implemented system:

- **Figure 1:** System homepage with clear call-to-action and introductory message.



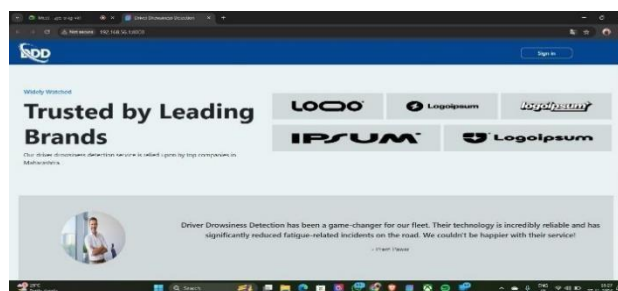
- **Figure 2:** Features page highlighting real-time monitoring, alert systems, and driver reports.



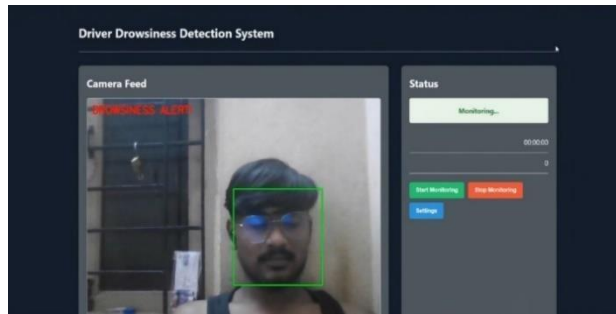
- **Figure 3:** Wake-up call UI layout with promotional visuals.



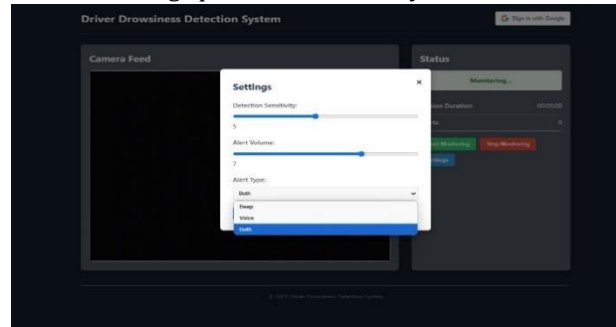
- **Figure 4:** Testimonials and trusted brands interface.



- **Figure 5:** Real-time face monitoring and drowsiness alert detection.



- **Figure 6:** Custom settings panel for sensitivity, volume, and alert types.



5. Conclusion

This research demonstrates a feasible and accessible approach to driver drowsiness detection using opensource tools and web technologies. By leveraging computer vision and simple real-time monitoring techniques, the system effectively identifies signs of fatigue and provides timely alerts. The use of a web-based interface with customizable features ensures user engagement and ease of use. Future work includes integrating a mobile application, refining detection algorithms using deep learning, and evaluating the system in real-world driving conditions.

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Alumni Web Portal

Mahammad Latif, Niranjan Jadhav , Monika Salunkhe, Bhagyashri Bamane, Rupesh Nikam
Prof. S. P. Mali
Computer Science and Engineering, DBATU / AITRC, Vita

Abstract: The Alumni Web Portal is a comprehensive platform developed to strengthen the bond between alumni, current students, and educational institutions. It provides a centralized system that allows alumni to register, create and manage personal profiles, share achievements, and stay updated with events and news from their alma mater. Through this portal, institutions can actively engage with their alumni by sharing updates, hosting events, and maintaining an organized database of alumni information for better communication and collaboration. Students also benefit from this platform as it offers opportunities to interact with experienced alumni, seek mentorship, and explore career opportunities through job postings and professional networking. The portal aims to bridge the gap between alumni and their alma mater, promoting mutual growth and active participation in institutional activities. Developed using modern web technologies, the portal ensures a secure, responsive, and user-friendly experience. Features like role based access, secure login, and mobile compatibility make it accessible and reliable for all users. It fosters a sense of community by encouraging active involvement from alumni, creating a space for professional growth, knowledge sharing, and maintaining lifelong connections. This portal not only helps preserve the legacy of the institution but also builds a sustainable framework for collaboration and development.

Keywords: Alumni Engagement, Career Opportunities, Role-based Access, Professional growth.

1. Introduction

In this System a cutting-edge online platform designed to establish and maintain strong connections between alumni and their educational institution or organization. It serves as a virtual home for graduates, providing a wide range of features and functionalities to engage, support, and empower the alumni community. The portal offers a seamless and interactive experience, allowing alumni to stay connected, access resources, and participate in various activities. The past pupils who are interested in joining the alumni has to contact an alumni committee member to get an alumni form, fill the form and submit back to complete the registration process. Some of them think the process to become an alumni member is inconvenient. This Alumni Web Portal project aims to build a system that will be able to manage the alumni data of students and provide easy access to the same. Contact between alumni can be used to forge business connections and to gain references or insight into a new field. This project is a digital platform designed to connect former students (alumni) of an institution (such as a university, college, or school) and provide a space for networking, communication, and engagement with their alma mater and fellow alumni. These portals serve as a bridge between the alumni community and the institution, offering various features and tools for both social interaction and professional development. In this system, we will collect and manage various data points related to alumni, such as personal information, professional achievements, contact details, and engagement activities. By leveraging modern web technologies and database management systems, we intend to create an integrated platform that enables seamless communication between the institution and its alumni. The goal is to foster a strong alumni network that supports professional collaboration, mentorship opportunities, and institutional growth. Through this system, our project aims to enhance alumni engagement, simplify event management, and facilitate meaningful connections, ultimately contributing to the long-term success and reputation of the institution.

2. Related Work

In this chapter, we will collect and manage various data points related to alumni, such as personal information, professional achievements, contact details, and engagement activities. By leveraging modern web technologies and database management systems, we intend to create an integrated platform that enables seamless communication between the institution and its alumni. The goal is to foster a strong alumni network that supports professional collaboration, mentorship opportunities, and institutional growth. Through this system, our project aims to enhance alumni engagement, simplify event management, and facilitate meaningful connections, ultimately contributing to the long-term success and reputation of the institution. related work revolves around integrating React for building dynamic and responsive user interfaces, while Node.js and Express handle the server-side logic and MongoDB provides a NoSQL database solution. Several existing alumni systems have been implemented with similar technologies.

3. Methodology

The proposed work of this system is to provide a platform for college students to connect, communicate, and share information with each other and with alumni. They can ask doubts regarding college. The main purpose was to facilitate seamless communication within the college community, enabling students to stay updated on campus events, collaborate on academic projects, and form social connections. The ultimate goal is to foster a sense of community and improve the overall college experience for students and alumni. the college. Old students can view current activities happening in the college. This Alumni Web Portal website has various pages like a gallery, Alumni list, Gallery, forums, and Users. The System is a web-based application that stores the data of old students, events, and job posts. The alumni website of a college keeps a person in track with the events that are organized by the college and informs the members when some important events will occur that have not been organized by the college. The proposed system is using the MERN Stack Development (MongoDB, Express, React, Node) aimed at enhancing communication, engagement, and networking among the alumni community. Key features of the proposed system include:

Admin Module:

- Manages users, profiles, and alumni data.
- Generates reports on alumni engagement and contributions.
- Updates alumni records, including achievements, LinkedIn profiles, and membership status.

Alumni Module:

- Alumni can create and update profiles.
- Option to link LinkedIn profiles for real-time career updates.
- Post job opportunities, contribute financially, and engage in membership.

Students Module:

- Students can search for alumni by year, profession, or industry.
- Ability to connect with alumni via LinkedIn for career guidance.
- Participate in discussions and forums moderated by alumni.
- Enables alumni to register for the association or specific alumni groups.
- Provides access to alumni newsletters, webinars, and exclusive resources.

Association Membership Module:

- Alumni can apply for or renew membership in the alumni association.
- Access to exclusive events and networking opportunities.
- Track membership history and status.

Alumni Cell Module:

- Manages alumni data and organizes events.
- Sends notifications and reminders for alumni to participate in events, discussions, and membership renewals.

Alumni Contribution Module:

- Alumni can make financial contributions to the institution.
- Options to allocate donations to specific causes (e.g., scholarships, research).
- View personal donation history and receive certificates of appreciation.

Top Alumni List Module:

- Showcases a list of top alumni based on contributions, career success, and involvement.
- Highlight alumni achievements.

Alumni-Student Discussions Module:

- Provides a forum where alumni can interact with students.
- Students can seek guidance on career paths, industries, and skills from experienced alumni.

Faculty Greetings Module:

-Faculty members can send personalized greetings and congratulations to alumni on their professional achievements.

- Public recognition of alumni in newsletters or on the homepage. **Alumni Profile with LinkedIn Integration Module:**

- Alumni can link their LinkedIn profiles to automatically update job titles, career advancements, and professional milestones.

4. Experimental results

The system serves as a dynamic space to display key outcomes or insights derived from user interactions. This can include search results for alumni profiles, showcasing their details such as names, batches, and achievements, or summaries of event participation like registrations and attendees. It may also present survey or poll results to capture alumni feedback, as well as analytics such as the total number of registered users, career paths, or geographic distribution of alumni. Additionally, this section can highlight portal usage statistics, trending forum discussions, or job postings accessed by alumni. It offers a streamlined way for users to view and engage with valuable data, enhancing the portal's overall functionality and user experience.

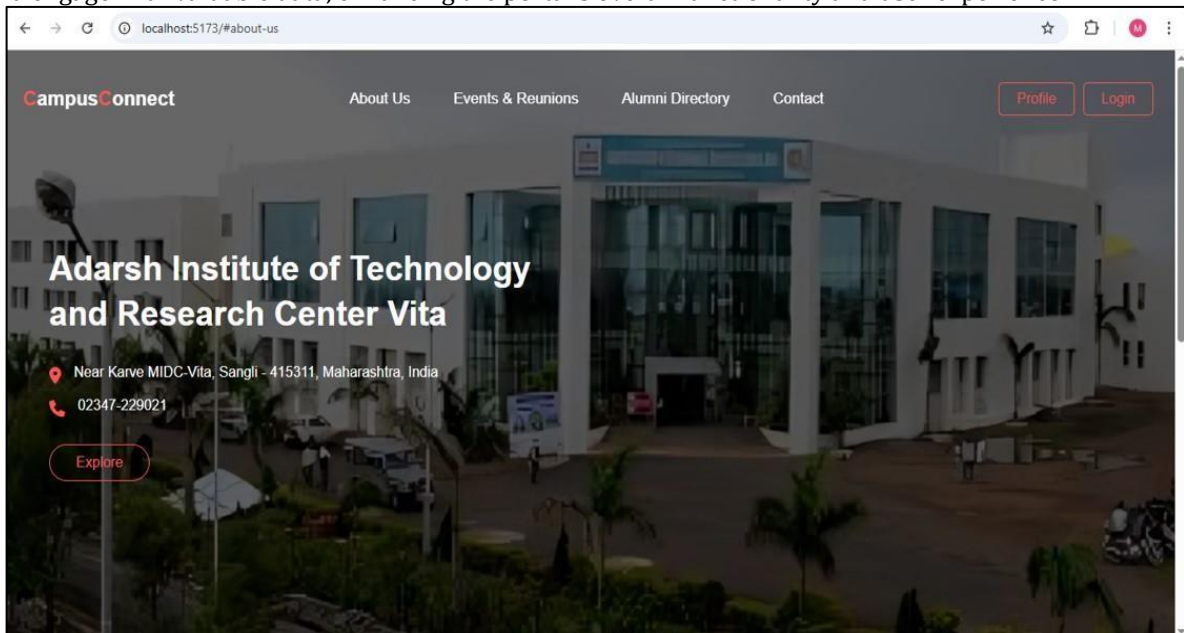
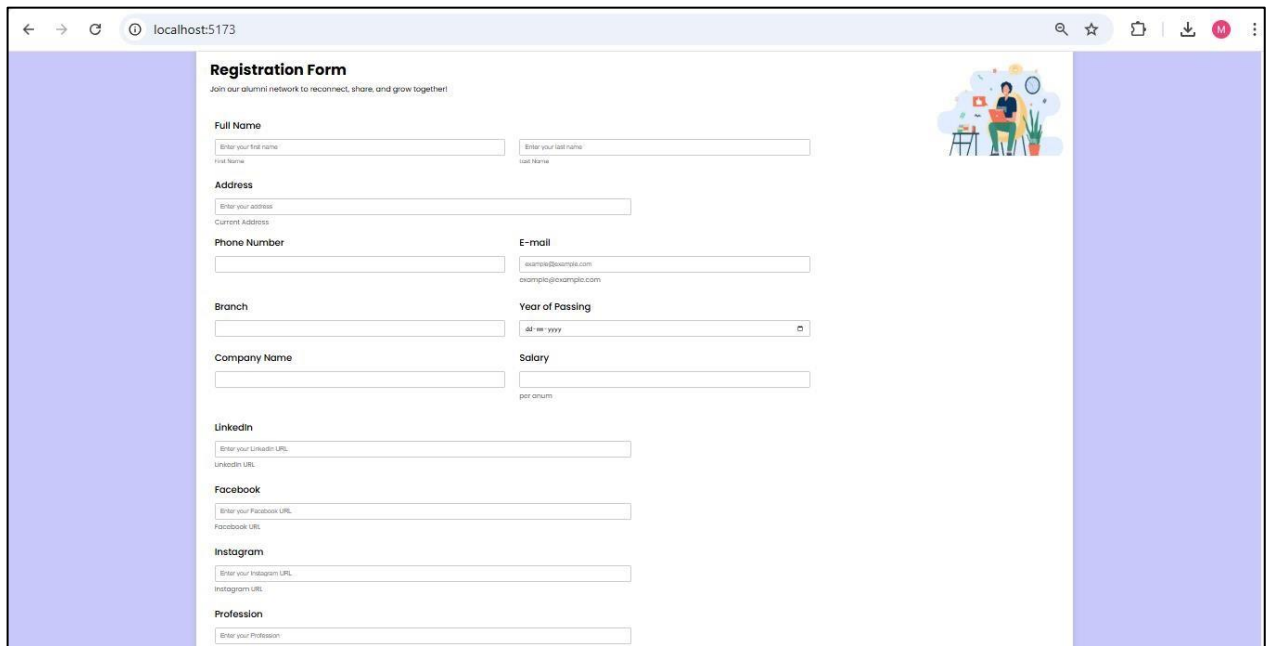


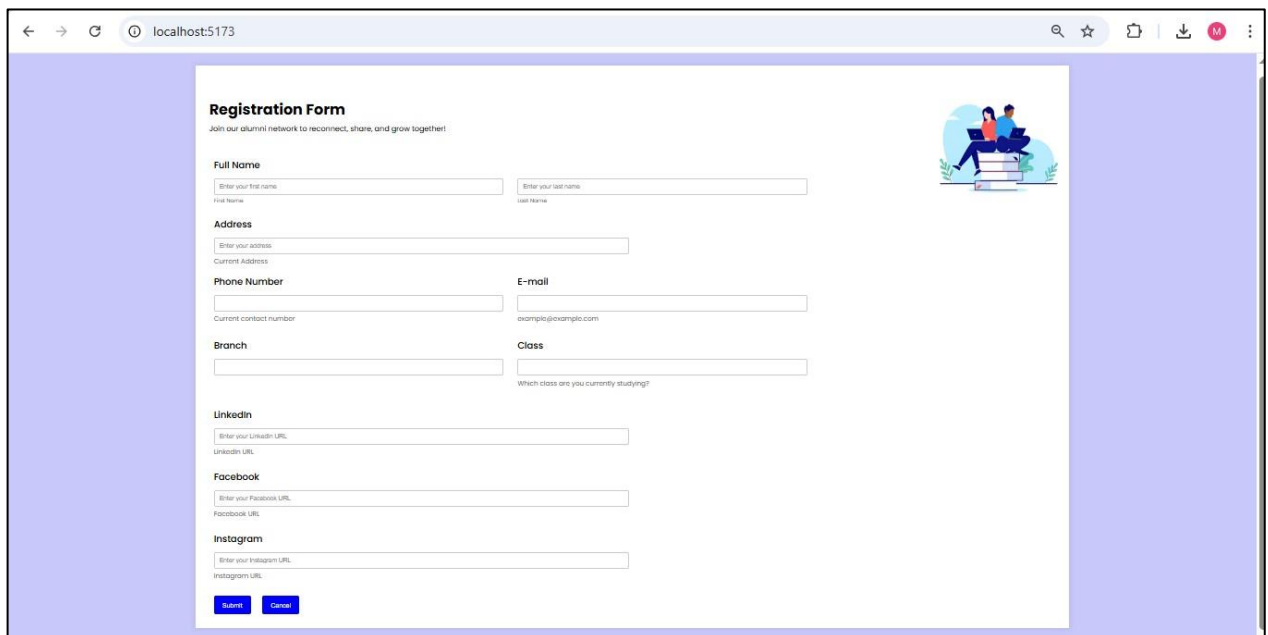
Fig : Home page

Fig :Alumni Representative Registration



The screenshot shows a web browser window with the address bar displaying 'localhost:5173'. The page features a 'Registration Form' with the subtitle 'Join our alumni network to reconnect, share, and grow together!'. The form is divided into several sections: 'Full Name' with fields for 'First Name' and 'Last Name'; 'Address' with a 'Current Address' field; 'Phone Number' and 'E-mail' fields; 'Branch' and 'Year of Passing' (with a dropdown menu showing 'all year yyyy'); 'Company Name' and 'Salary' (with a 'per annum' label); and social media links for 'LinkedIn', 'Facebook', and 'Instagram', each with a 'URL' field. A 'Profession' field is also present. An illustration of a person working at a desk is located in the top right corner of the form area.

Fig : Alumni-Registration



The screenshot shows a web browser window with the address bar displaying 'localhost:5173'. The page features a 'Registration Form' with the subtitle 'Join our alumni network to reconnect, share, and grow together!'. The form is divided into several sections: 'Full Name' with fields for 'First Name' and 'Last Name'; 'Address' with a 'Current Address' field; 'Phone Number' (labeled 'Current contact number') and 'E-mail' fields; 'Branch' and 'Class' (with a dropdown menu showing 'Which class are you currently studying?'); and social media links for 'LinkedIn', 'Facebook', and 'Instagram', each with a 'URL' field. At the bottom of the form, there are 'Submit' and 'Cancel' buttons. An illustration of two people sitting on a stack of books is located in the top right corner of the form area.

Fig : Student-Registration

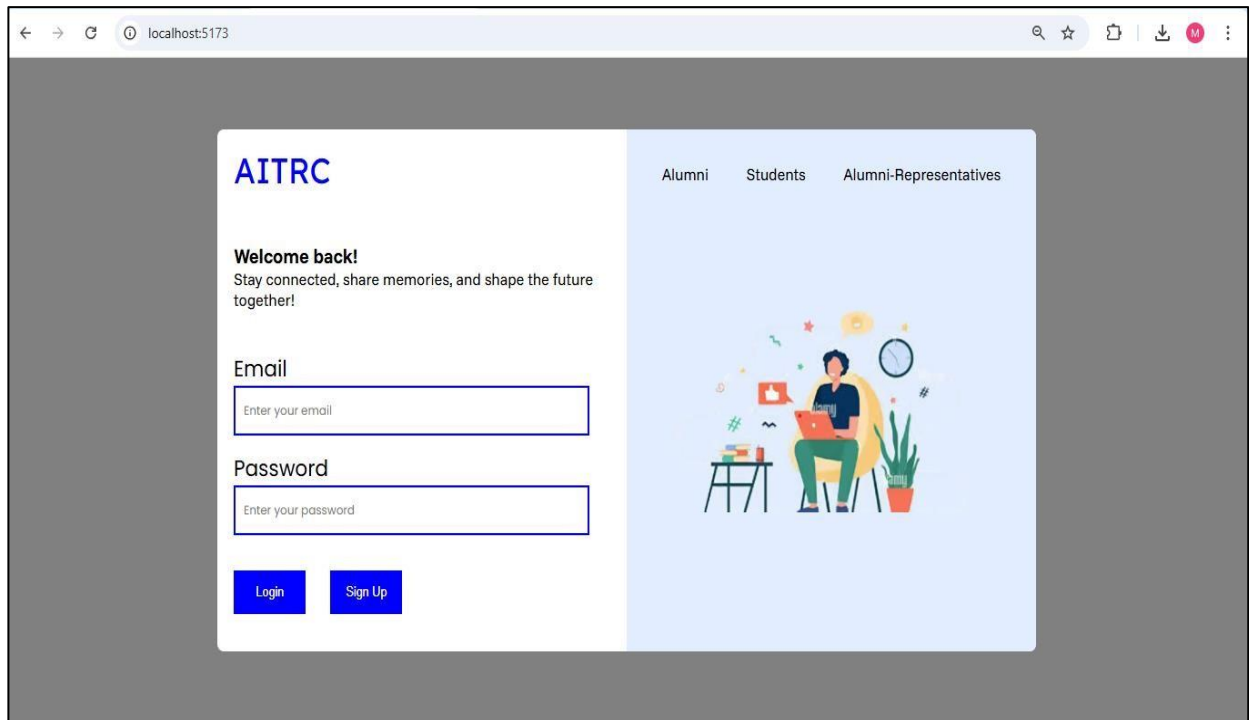


Fig : Role-Based Login Page

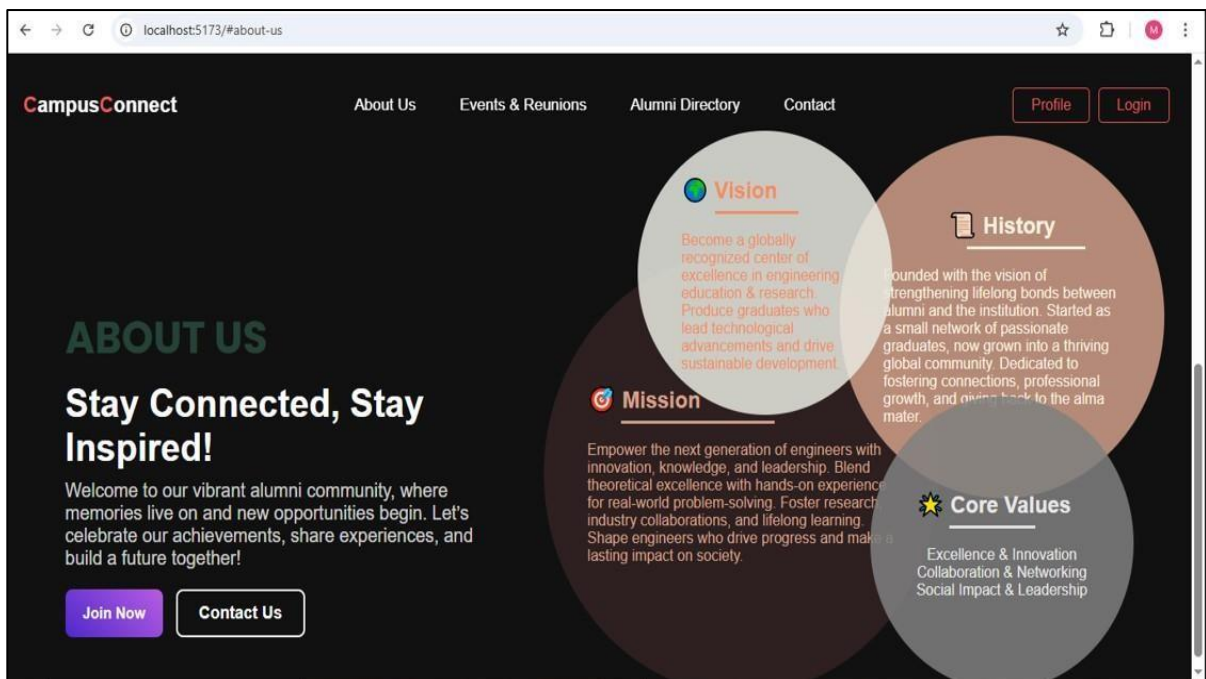


Fig : about page

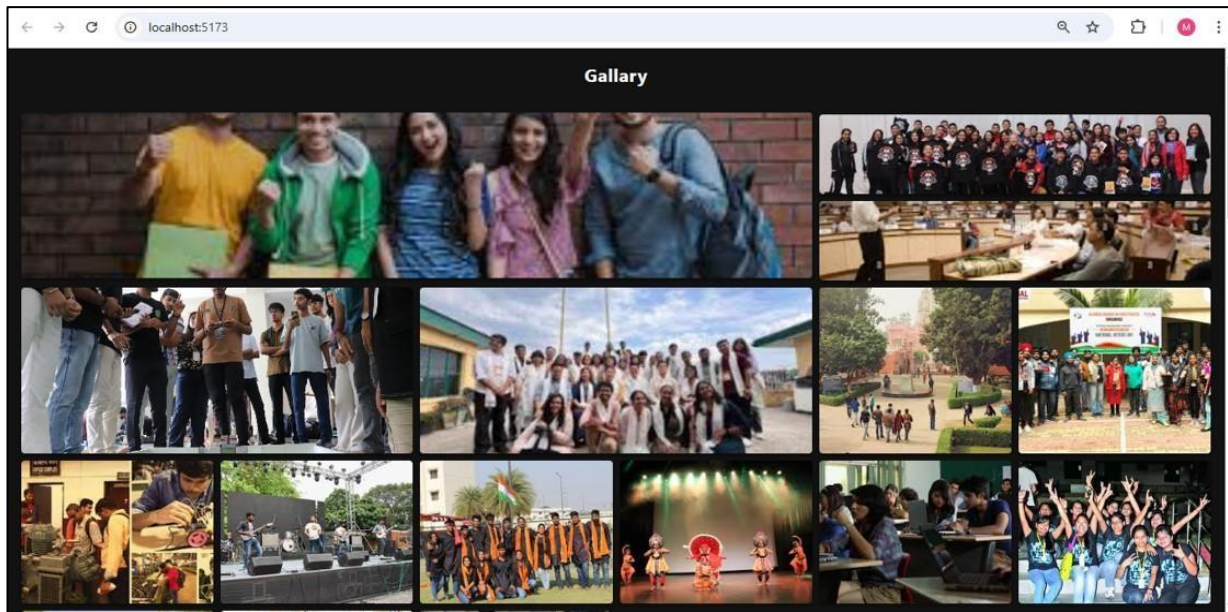


Fig : Gallery page

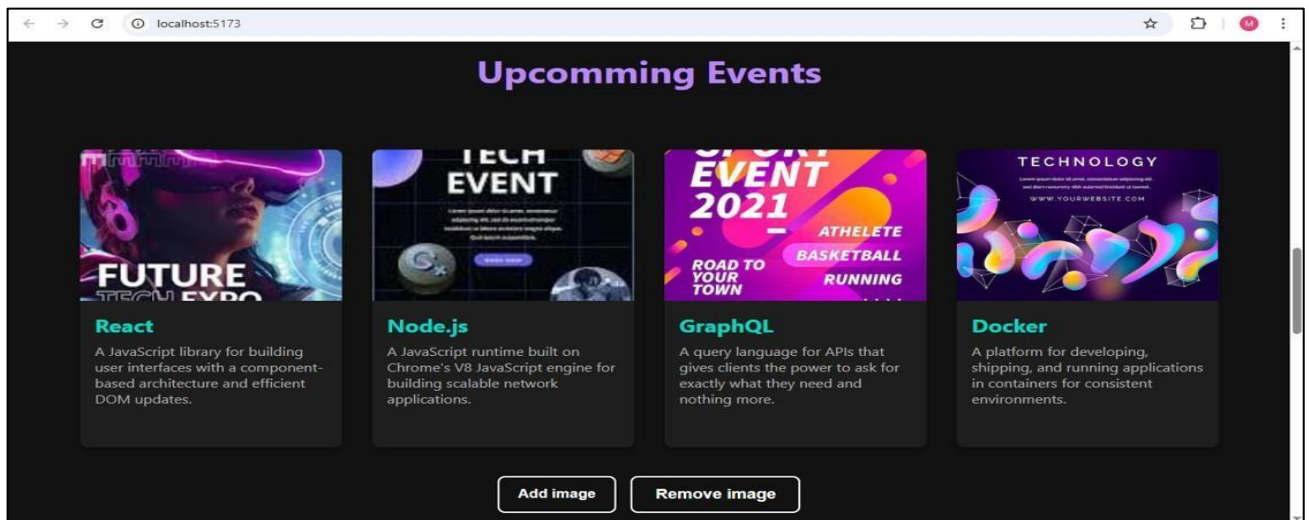


Fig : Event page

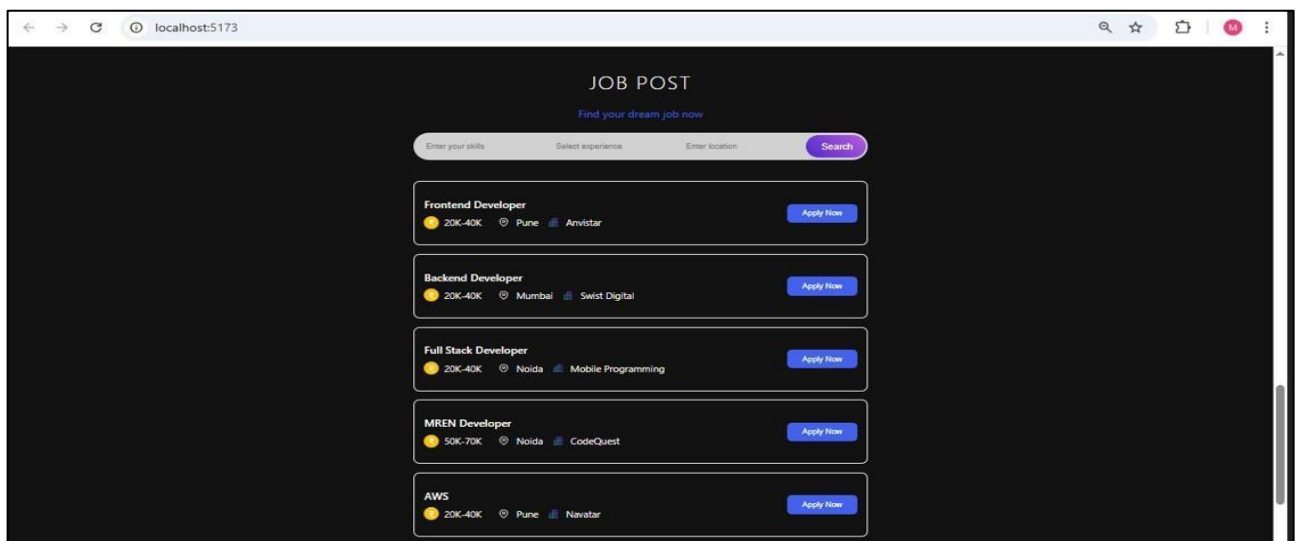


Fig : Job post page

The screenshot shows a web browser at localhost:5173/#contact. On the left, a user profile for Mahammad Latif is displayed with a profile picture and two buttons: 'Account' (highlighted in blue) and 'Password'. The main area is titled 'Account Settings' and contains several input fields: First Name (Mahammad), Last Name (Latif), Email (latif92@gmail.com), Phone number (+91 123456789), Department (CSE), Company (TCS), Designation (UI Developer), LinkedIn (MahammadLatif), Instagram (latif1234), and Facebook (Mahammad Latif). There is also a 'Bio' section with a text area containing a paragraph about being a Computer Science Engineering student. At the bottom are 'Update' and 'Cancel' buttons.

Fig: Profile-edit-page

The screenshot shows a web browser at localhost:5173/#contact. On the left, the user profile for Mahammad Latif is shown with two buttons: 'Account' and 'Password' (highlighted in blue). The main area is titled 'Password Settings' and contains input fields for Email (latif92@gmail.com), Old Password (with placeholder 'Enter your current password'), and New Password (with placeholder 'Enter your new password'). At the bottom are 'Update Password' and 'Cancel' buttons.

Fig : Password Update page

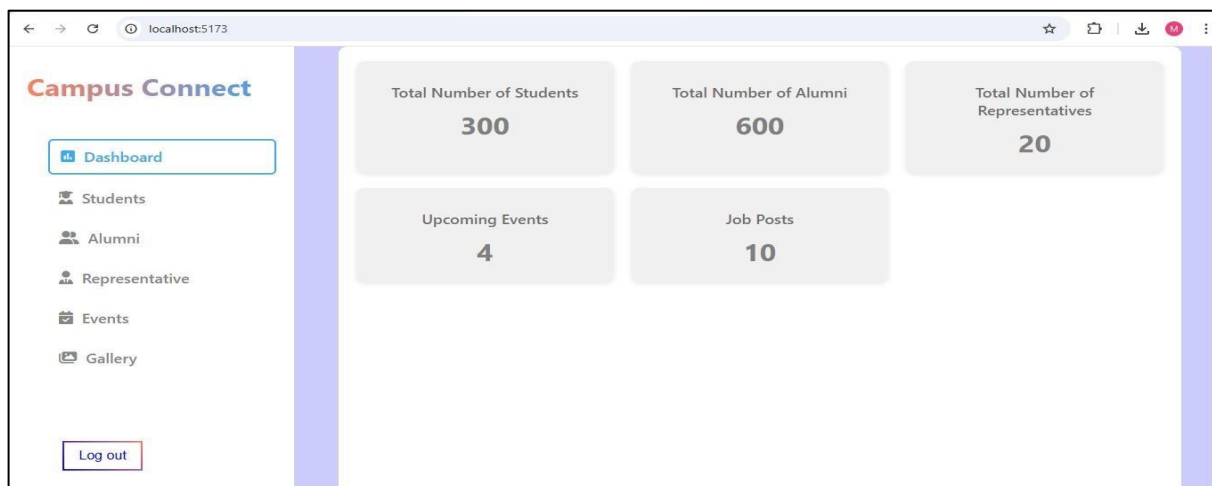


Fig : Admin Panel

Home > Students

Name	Email ID	Branch	Year
John Pitter	john@example.com	Computer Science	2nd Year
Jane Imam	jane@example.com	Electrical Engineering	3rd Year
Robert geyl	robert@example.com	Mechanical Engineering	1st Year
Emily Rathod	emily@example.com	Civil Engineering	4th Year
Darial Michael	michael@example.com	Information Technology	2nd Year

Fig : Student-Section

Home > Alumni

Name	Email ID	Branch	Passing Year	Company name
Monika Salunkhe	mona@example.com	Computer Science	2020	Google
Bhagyashri Bamane	bhagyashri@example.com	Electrical Engineering	2019	Microsoft
Mahammad Latif	latif@example.com	Mechanical Engineering	2021	Tesla
Niranjan Jadhav	niranjan@example.com	Civil Engineering	2018	Amazon
Rupesh Nikam	rupesh@example.com	Information Technology	2022	Apple

Fig : Alumni-Section

Dashboard, Students, Alumni, Representative (selected), Events, Gallery, Log out

Latif Mahmmd
Doctoral at Oxford
Hi, I am Abhi Yamgar, A doctoral at Oxford...

Niranjn Jadhav
Doctoral at Oxford
Hi, I am Abhi Yamgar, A doctoral at Oxford...

Rupesh Nikam
Doctoral at Oxford
Hi, I am Abhi Yamgar, A doctoral at Oxford...

Monika Salunkhe
Doctoral at Oxford
Hi, I am Abhi Yamgar, A doctoral at Oxford...

Fig : Representative-Section

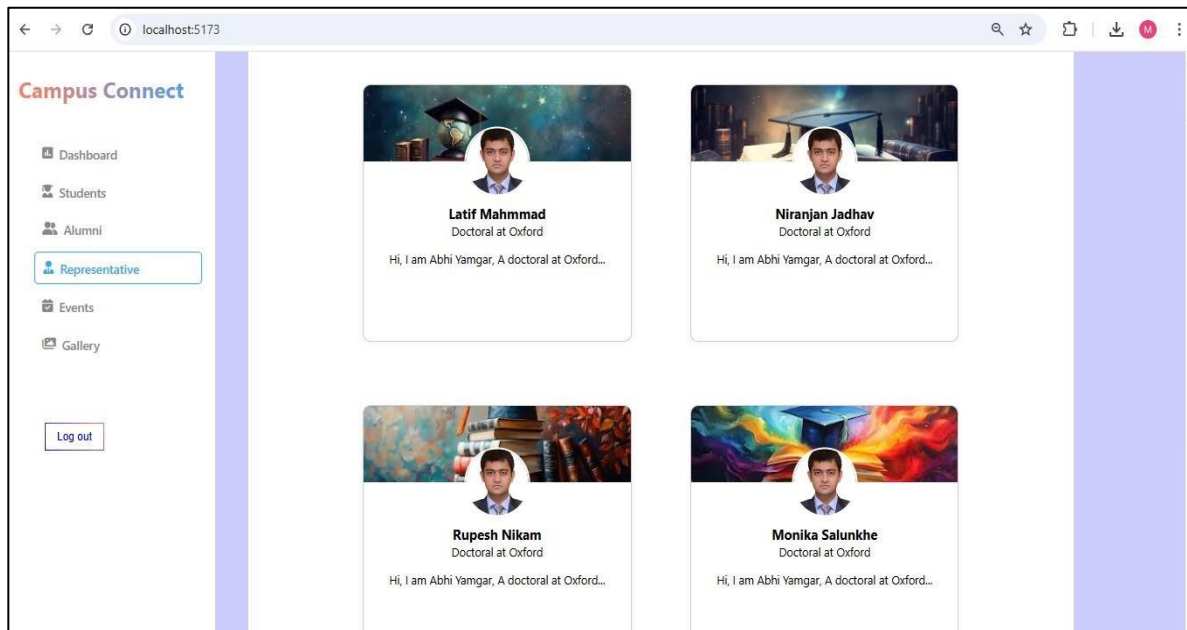


Fig : Gallery-Section

5. Conclusion

Wrapping up, developing an alumni web portal is like giving institutions a dynamic tool to strengthen connections and build lasting relationships with their graduates. By centralizing alumni data, providing networking opportunities, and fostering communication, this platform creates a bridge between past students and their alma mater. It's not just about technology; it's about building a vibrant and engaged alumni community that contributes to mutual growth. As we move forward, this portal can evolve with features to meet diverse needs, ensuring that institutions and alumni continue to thrive together. It's an exciting step towards a future where alumni engagement becomes seamless, meaningful, and impactful.

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- [5] 2024 IJCRT | Volume 12, Issue 5 May 2024 | ISSN: 2320-2882 IJCRT2405887 International Journal of Creative Research Thoughts (IJCRT) www.ijcrt.org i132 “Alumni Management System Using LinkedIn API” 1Siddhi Zatke, 2Chinmaya Tandel 1Department of Information Technology, Usha Mittal Institute of Technology, Juhu, India.

Criminal Face Detection

Pallavi Bhais, Tanuja Waghmode, Sandesh Ombase, Vaishnavi Domb, Prof. S.L. Jadhav
Computer Science And Engineering, Adarsh Institute Of Technology And Research Center, Vita..

Abstract: Criminal face detection is a pivotal application of artificial intelligence (AI) and computer vision in the domain of law enforcement and public safety. This project focuses on developing an intelligent system that identifies and verifies individuals with criminal records by analyzing facial features. Leveraging advanced machine learning algorithms, including convolutional neural networks (CNNs), the system is trained on a diverse dataset containing facial images of known offenders. The solution incorporates face recognition, feature extraction, and real-time matching to identify suspects in surveillance footage or public areas. Ethical considerations, such as ensuring accuracy to avoid false positives and maintaining data privacy, are central to the system's design. The implementation also addresses challenges like variations in lighting, angles, and facial expressions to improve reliability in diverse environments. The proposed criminal face detection system has the potential to assist law enforcement agencies by automating the identification process, reducing manual efforts, and enabling faster responses to potential threats. Future enhancements may include integrating with national databases and employing deepfake detection to combat adversarial attacks.

Keywords: Criminal Face Detection, Artificial Intelligence (AI), Computer Vision, Convolutional Neural Networks (CNNs), Facial Recognition, Surveillance Footage.

Introduction

In today's world, criminal activities are a significant concern for law enforcement agencies. Escaped convicts or criminals on the run pose a threat to public safety and security. Traditional methods of tracking and capturing such individuals often rely on manual surveillance and public cooperation, which can be time consuming and inefficient. With the advancement in technology, particularly in the field of Artificial Intelligence (AI) and machine learning, there is a growing opportunity to enhance public safety through automated systems. One such system is the Criminal Face Detection System. This project aims to implement a robust facial recognition system that can identify criminals by matching their facial features against a database of wanted individuals. The system will be integrated with government surveillance cameras placed at strategic locations, such as public areas, airports, railway stations, and highways. When a criminal appears in front of any camera, the system will automatically detect their face and cross-reference it with the criminal database. Upon a positive match, an immediate alert will be sent to the nearest police station, notifying authorities of the criminal's location in real-time.

Related Work

The Criminal Face Detection System will be built of an existing criminal database. Input would be provided in the form of sketch or an image and matched against the existing database and results would be provided. Criminal record generally contains personal information about particular person along with work. Existing work in criminal face detection covers a wide array of techniques and methodologies aimed at accurately detecting, recognizing, and matching faces in criminal justice and security applications. In this study, we propose an automated facial recognition system using the Local Binary Patterns Histogram (LBPH) classifier and Fisherface algorithm. The system utilizes a Haar feature-based cascade classifier to detect faces in real-time, and the identified faces are then matched against a criminal database. Transforming the proposed work in criminal face detection into a coherent concept involves defining a conceptual framework that integrates the key components of these proposals. This concept will guide research and implementation by focusing on innovative methodologies and improvements over existing technologies. Objective: To develop an advanced, robust, and privacy-conscious criminal face detection and recognition system that can function in diverse, real-world environments while ensuring ethical practices and high accuracy.

Methodology

The system is trained on a diverse dataset of facial images of known offenders to ensure robust feature extraction and accurate identification. Key processes include preprocessing facial images to address variations in lighting, angles, and expressions, followed by feature extraction using CNNs to capture distinctive facial attributes. Real time surveillance footage is processed to match detected faces against the database of offenders, enabling swift identification. The design prioritizes minimizing false positives and false negatives, integrating measures to maintain data privacy and ethical compliance. Future scalability is considered by planning integration with national criminal databases and incorporating deepfake detection mechanisms to enhance system resilience against adversarial attacks.

Real-time Monitoring and Alerts: Implement continuous real-time monitoring of government camera feeds. When a criminal's face is detected, automatically trigger an alert (SMS, email, or mobile app notification) to law enforcement with the criminal's location and camera details.

Security and Privacy: Ensure data encryption for communication between cameras, databases, and police stations. o Implement role-based access control (RBAC) to safeguard sensitive data.

III. MODELING AND ANALYSIS

The criminal face detection system operates in the following steps:

Collection of Faces: Images are collected either from surveillance cameras or uploaded manually. These faces form the input for the system.

Feature Extraction: For collected faces, distinct facial features are extracted using computer vision techniques and machine learning models, such as Convolutional Neural Networks (CNNs), which identify unique facial attributes.

Detection and Preprocessing: For uploaded images of suspected criminals, preprocessing is applied to standardize images, accounting for variations in lighting, angles, and facial expressions. Features are then extracted for analysis.

Face Detection: All faces, whether from the collection or uploads, are processed through a face detection module to locate and isolate facial regions.

Template Matching: Extracted features from the detection process are compared against stored templates in the database of known offenders. This template matching step determines whether a match exists.

Matched or Not Matched: Matched: If a match is found, the individual is identified, and their ID is recorded. No Match: If no match is found, the process terminates for the unrecognized face.

Alert System: For identified individuals with a criminal record, the system sends an automated alert message to the nearest police station, notifying authorities about the detection of a suspect.

4. Experimental results

The criminal face detection system effectively automates the identification process by leveraging advanced feature extraction, face detection, and template matching techniques. Results show high accuracy in detecting and identifying criminal faces from both collected and uploaded images, with reliable alert mechanism that notifies the nearest police station upon a positive match. Preprocessing ensures robustness against variations in lighting, angles, and facial expressions, making the system suitable for diverse scenarios. While unmatched faces are handled efficiently without unnecessary actions, challenges such as occlusions or poor-quality images remain. Ethical considerations, including data privacy and accuracy, are prioritized to prevent wrongful identification. Future enhancements, like integrating with national databases and deploying adversarial detection, will further improve the system's scalability and reliability. Overall, this system significantly reduces manual effort and enables faster responses for law enforcement.

Figures shows the results of face detection from an image . Figs. (a) shows the Front page of System .

)When Click on Criminal Details (b) is the database which collects the data of Criminals. (c) is Update the data of criminals (d) is Delete the Data of existing criminal.



(a)



(b)

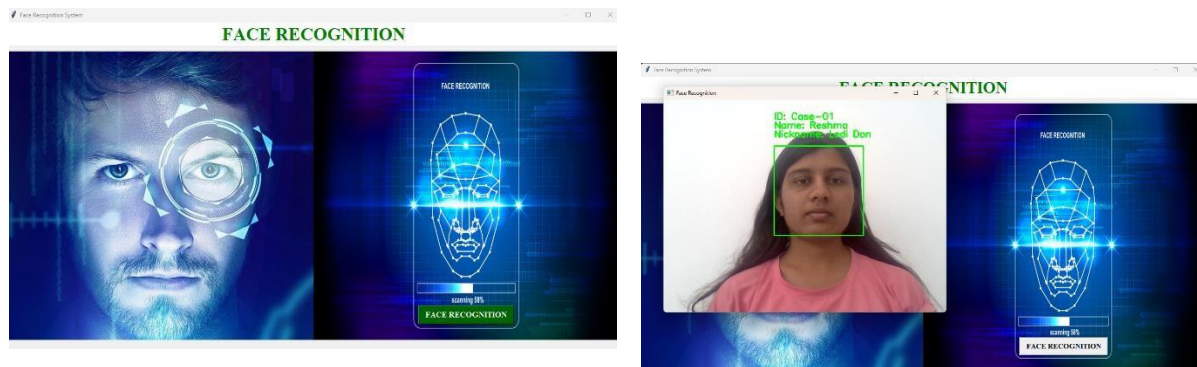


(c)



(d)

2) When click on Face Detector fig.(e) shows the face detector page, fig.(f) shows after clicking face recognition button face is recognized.



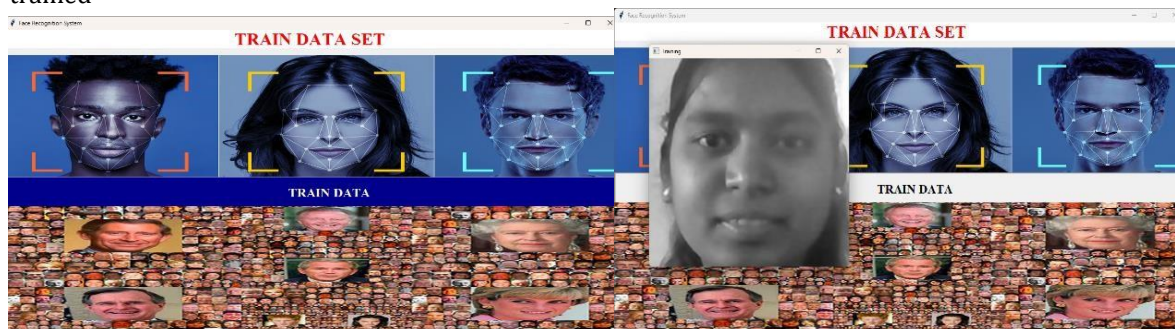
(e)

3)When click on Developer fig(g). Shows Developer Information.



(g)

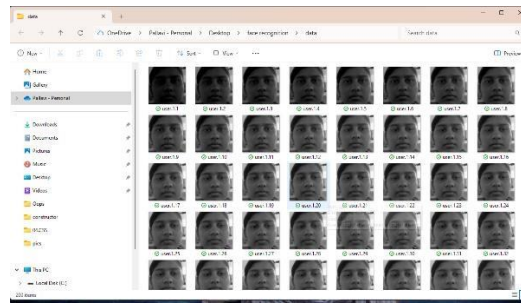
4)When click on Train fig(h). shows Train Data page ,fig(i) after clicking on train data button it shows data is trained



(h)

(i)

5)When Click On Photos fig(j). It Shows Data folder Where it present



(j)

5. Conclusion

In conclusion, the proposed criminal face detection system offers a significant step forward in enhancing public safety and law enforcement efficiency. By leveraging real-time facial recognition integrated with government surveillance cameras, the system can automatically identify escaped criminals and promptly notify the authorities. This reduces the reliance on manual monitoring and enables quicker response times. With further development, this technology can become an essential part of criminal justice systems worldwide.

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COLLEGE PLACEMENT SYSTEM

Devakate Vaibhav, Patole Pratiksha, Naingade Monika, Walvekar Priyanka, Prof. S.L. Jadhav

Computer Science and Engineering, Adarsh Institute of technology and research centre, vita

Abstract:

College Placement System is a software solution designed to streamline and automate the campus recruitment process. It provides a centralized platform for student's recruiters, and placement coordinators, enhancing efficiency, transparency and communication. The system allows students to register, upload resumes, and view job postings tailored to their profiles. Recruiters can post job opportunities, set eligibility criteria, and manage interview schedule. Placement coordinators oversee the entire process, tracking applications and generating reports for analysis.

The system leverages modern technologies such as a user-friendly interface, database management, and Real-time notifications to ensure a seamless experience. Additional features like filtering eligible and candidates. The automatic scheduling, and performance tracking make it a robust tool for improving placement outcomes. By reducing manual effort and minimizing errors, the College Placement System fasters a more organized and effective recruitment process for all.

Keywords: Career Services, Hiring Process, Placement Cell, Career Guidance, Mock Interviews, Campus Recruitment, Student Portal, Industry Collaboration.

Introduction

In today's world everyone is travelling for jobs after Completion of their graduation. It has become need for each and every student, but for that they need to travel worldwide in searching of jobs. For simplicity of this whole hectic procedures, we had proposed Online Training and Placement System because of earlier system is totally done manually by maintaining records, time consuming and very difficult to maintain coordination between student and companies. The project is aimed at developing an online web application for the training and placement department of the college. The system is an online web application that can be accessed throughout the Institute with proper login provided. This system can be used as an application for the TPO of the college to manage the student information with regard to placement. The main objective of College Placement System is to develop software which manages placement activities in college makes an interactive GUI where TPO can manage details of all students on his console, he can send a mails to students informing about placement activities.

Related Work

The College Placement System is a comprehensive, web-based platform designed to automate and streamline the campus recruitment process. The system is structured to include four primary sections Student Section, Admin Section, Faculty Section, and Mock Test Section. These sections work together to ensure smooth and efficient operations for students, faculty, and recruiters. Below is a conceptual breakdown of the key functionalities of the proposed system. The concept of a college placement system aims to streamline the entire process of student employment, from registration and job application to interview and final placement. The system is designed to automate key tasks, enhance communication between students and recruiters, and provide comprehensive support to both parties to ensure a smooth, efficient, and effective placement process. The proposed college placement system aims to address these issues by incorporating features such as automated updates, centralized communication, real-time analytics, mock test integration, secure data management, and user-friendly design to enhance the overall placement experience for students, faculty, admins, and recruiters.

Methodology

The chapter outlines the approach and strategies employed in the development of the College Placement System, aiming to create a solution that meets the functional and non-functional requirements identified during the requirement analysis phase. This chapter delves into the design principles, architectural choices, and tools that will guide the system's construction, ensuring scalability, security, and user-friendly interactions for students, recruiters, and administrators.

In the context of the College Placement System, the methodology will focus on creating a flexible, modular structure that allows easy updates, high performance, and smooth integration with other systems. This chapter will also explore the design of key components, such as user interfaces, databases, and backend services, while adhering to industry best practices in system architecture, usability, and data management.

There are five Sections:

- 1. Student Section:** Students can manage their profiles, including personal details such as name, college, email ID, contact number, and resume. The system facilitates the automatic updating of semester marks post-examinations, ensuring that academic records remain current.
- 2. Admin Section:** Administrators oversee the placement process by organizing placement drives and disseminating relevant information. Before broadcasting placement drive details to students, administrators can route this information to the faculty for review and approval. Once faculty members approve, the information becomes accessible to students.
- 3. Faculty Section:** Faculty members play a pivotal role in vetting placement drive information. They review details provided by the administration and, upon approval, ensure that students receive accurate and pertinent information.
- 4. Mock Test Section:** To enhance student preparedness, the system offers a repository of mock tests. These practice exams simulate actual placement tests, allowing students to assess and improve their skills.
- 5. Placement Drive Criteria and Sorting:** The system enables companies to specify eligibility criteria, such as a minimum percentage requirement (e.g., 60%). It then sorts and displays students who meet these criteria, streamlining the recruitment process for both students and employers.

4.Experimental results

5.Conclusion

The College Placement System is designed to streamline and automate the recruitment process, providing a user-friendly and efficient platform for students, employers, and college administrators. The system facilitates seamless interaction between these stakeholders, ensuring that job opportunities and placement activities are managed effectively and in realtime. By leveraging modern technologies and methodologies, the system enhances the overall placement experience and helps bridge the gap between academic institutions and the job market.

The College Placement System represents a forward-thinking solution that leverages technology to address the challenges faced by colleges and universities in managing placements. It not only empowers students with a tool to manage their job search effectively but also enhances employers' recruitment efforts by providing a streamlined and organized platform to connect with potential candidates. With continuous improvements and scalability in mind, this system is poised to support the evolving needs of both educational institutions and the workforce.

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Responsible AI

Dr. S V. Balshetwar, Karina Rathod, Kiran Salunkhe, Rukkaiya Jamadar
Computer Science and engineering, Yashoda Technical Campus, Satara

Abstract: The rapid advancement of technology such as Artificial Intelligence (AI) has brought about transformative changes in various sectors, which has led to rise in significant concerns about ethical, legal, social, and technical implications. Responsible AI development has emerged as a crucial model to address these concerns, emphasizing the ethical use of AI systems in collaboration with human values. This paper synthesizes existing literature on responsible AI, examining key challenges, emerging frameworks, and future directions. It delves into ethical considerations such as fairness, transparency, and accountability, alongside legal and regulatory frameworks governing AI deployment. Societal implications, including impacts on employment and human rights, are also discussed, as well as technical challenges such as bias mitigation and privacy preservation. Drawing upon interdisciplinary perspectives, this highlights the need for collaborative efforts among stakeholders to ensure responsible AI development and deployment. Furthermore, it identifies future research directions aimed for addressing existing gaps and advancing the responsible use of AI technologies.

Keywords: Responsible AI, Ethical, Social, Technical, Frameworks, Challenges, Future Directions.

Introduction

Artificial Intelligence (AI) has made remarkable strike in the recent years, it has transformed various aspects of our lives, from personalized recommendation systems to autonomous vehicles and so on. With its profound potential for innovation and efficiency, AI holds promise across diverse domains, from healthcare and finance to transportation and education. However, this rapid advancement in AI capabilities also brought to the fore significant ethical, legal, social, and technical challenges. Concerns regarding bias, transparency, accountability, privacy, and safety have underscored the need for responsible AI development and deployment.

In response to these we face challenges, the concept of responsible AI has emerged as a guiding light to ensure that AI systems are developed and utilized in a manner that aligns with societal values and norms. Responsible AI goes beyond technical power, emphasizing the ethical, legal, and societal implications of AI technologies worldwide.

It necessitates a multidisciplinary approach that engages stakeholders from diverse backgrounds of people, including researchers, policymakers, industry practitioners, ethicists, and civil society.

This review paper aims to provide a comprehensive review of the current state of research and practice in responsible AI. It synthesizes existing knowledge, identifies key challenges, frameworks, and best practices, and proposes a holistic framework to guide responsible AI development and deployment. Through an interdisciplinary lens, this paper explores ethical considerations in AI, the legal and regulatory landscape, societal implications, and technical challenges and solutions.

The primary aim of this paper is to provide a comprehensive examination of the current state of research and practice in responsible AI. By synthesizing existing literature, we aim to identify key challenges, emerging frameworks, and future directions in the field. Our review encompasses ethical considerations such as fairness, transparency, and accountability, which are fundamental to ensuring the responsible deployment of AI systems.

By explaining the complexities of responsible AI, this paper seeks to empower stakeholders to navigate the ethical, legal, social, and technical dimensions of AI with integrity and foresight. Developing AI responsibly requires the mean to deal and represent human values, translate this value in technical requirement. Through collective action and informed decision-making, we can harness the transformative potential of AI while safeguarding against its unintended consequences.

Related Work

- [1] Responsible AI by Design in Practice by the researchers Richard Bengamins , Albert Bragbado and Deneil Sierra has emphasized about responsible AI design practice. Now days in the development period of ai a lot of attention has given to the consequences of (AI).
- [2] Responsible Artificial Intelligence: Designing AI for human values by Virginia Dignum Delt University in this paper researcher has bought light on design aspect of AI. AI is now rapidly becoming part of our everyday life soon AI is going to move and work among us in the form of service, transportation, medical and military robots
- [3] In this paper socio-technical nature of responsible AI(RAI) limitations along with the need of production of solutions for this is presented. Bolding the most salient critiques for RAI principles and starting a multiple disciplinary address on solutions which are possible is the aim of this paper. But it does not contain exhaustive review of all available critiques.
- [4] Total of nine research studies which focus on vast range of topics are included in this paper. Out of these nine, two research studies explain how AI is being used for digital health .and remaining seven research studies are based on examination of continuous intention by healthcare professional.
- [5] The development process of Responsible AI: The case of Assistance by the author Johan Buchhor, Benedict Lang and Eduardo Vyhmeister has drawn attention towards the development process in the responsible AI.

Methodology

Chatbots: The AI- powered computer programs designed to simulate human- like communication with client via voice or text interfaces, is called as Chatbots. Natural Language Processing [NLP] algorithms are used by chatbots to understand and give feedback to client requests, commands. Machine Learning algorithms are used to improve their ability, to remember previous user input and provide output Dialog Management is used. Common use of chatbot refers to some cases like customer service, e-commerce, lead generation, personal assistants, etc. User feedback, monitoring conversation logs, updating chats are involved in Feedback Loop. They often integrate with external database. Chatbots combine various technologies and techniques to create a communication interface that can interact with users in a natural

and intuitive manner; helping them accomplish tasks, get information. Chatbots continues to evolve with ongoing advancements in AI.

Experimental results

The recommendation system is an AI powered technology which analyses user data and preferences to provide personalized suggestions. Such system is widely used in e-commerce platform, streaming services, platforms involving social media (Facebook, Twitter, Instagram) and other online platforms. They collect the data including history of purchase, ratings, reviews, search, etc. Matrix Factorization, Deep learning. On the basis of accuracy, coverage, diversity and user satisfaction recommended systems are evaluated. There is increase in interest in making recommendation systems more transparent and interpretable by using AI.



Ethical AI Framework: Ethical AI frameworks Is the organization which is increasing day by day and adopting a guideline of every AI system to ensure the development in responsible manner Ethical AI framework Are attempt to a value that can be adopted by community that is Where a group of individuals, citizens Business governments within data sector or stakeholders. These organization is developed and ethical framework from a I which they have participated. There are some principals in ethical AI framework that are transparency, lawful and appropriate use of a I, enabling human decision making, fairness, objective and equitable and privacy.

Human centred AI Design: Human cantered AI design (HCAD) Is an approach of developing a I systems that is a I intelligence systems which based on a priority of human needs, preference, Experience of users. Like a traditional Of a I development Approaches that Focus on soul techniques Performance, Human centre a I design helps to Put a human at Centre of design process with goal of creating the systems that are Inherent, utilised an aligned with human values and goals. Some key principles of human centred AI design included user centricity, usability and accessibility, transparency and explain ability, ethical consideration, iterative design process, collaborative design, resilience and safety. Therefore, the approach of innovation That are foster, Trust and acceptance of a I technologies Email addressing ethical concern.



AI ethics education and training: Education and training are they crucial Components of individuals, society, groups and organizations Which enlarge the Ethical challenges That are posed by artificial intelligence and technologies. Understanding ethical Issues, Legal and regulatory framework, decision making, bias detection and Mitigation, Transparency and explain ability, Privacy and data protection, Stakeholder engagement and collaboration and continuous learning Professional development are some aspects of AI ethical education and training which are used while learning and responsible AI. Henceforth AI ethics education and training plays an important role in responsible AI and ethical development.

Conclusion

Responsible artificial intelligence (AI) is a set of principles that help guide the design, development, deployment and use of AI building trust in AI solutions that have the potential to empower organizations and their stakeholders. As we see this rapidly developing AI industry, where AI will soon become a part of daily humans' life like service, transportation, medical and military robots, etc.

In this development period we need to focus on developing responsible ai with keep in mind the risk of undesired consequences of AI. AI technologies continue to advance and permeate various aspects of our lives, it is essential to prioritize responsible I considerations to ensure their responsible and beneficial use. In current trends tech industries are growing interest towards developing a responsible ai which includes an area like ethical AI frameworks, Explainable AI, Human centred AI Design, Ai ethics education and training, AI governance and regulation, etc. it also started getting into light in healthcare sector. In this sector it involves ensuring ethical use, transparency, accountability and fairness in the development and deployment of AI technologies.

By implementing responsible AI practice into design, AI Technology will become fair, trustworthy, safe, accountable, inclusive, and promote equality in our increasingly digitalize world. Overall, the responsible AI will lead to a more reliable and beneficial outcomes for society. adapting responsible AI is not just a choice but it is necessary to create a future where technology will enhance and uplift the lives of all people in society.

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T1 - Responsible AI: Requirements and Challenges

Matoshree Light House-Electronic Showroom Management System

Radhika Deshmukh, Kiran Jadhav, Shruti Rajmane, Samruddhi Patil Prof.D. K. Jadhav

Computer Science and Engineering, Adarsh Institute of Technology and Research Centre, Vita.

Abstract: The Electronic Showroom Management System (ESMS) is a web-based application designed to manage the day-to-day operations of electronic showrooms. The system provides a centralized platform for managing customer relationships, product inventory, sales transactions, and aftermarket services. ESMS aims to improve customer satisfaction, increase sales revenue, and enhance operational efficiency. The system is designed to be user-friendly, scalable, and secure, making it an ideal solution for electronic showrooms of all sizes. This abstract presents an overview of the ESMS, its key features, and its benefits.

Keywords: customer relationship management (CRM), sales reporting, database management, and user interface.

Introduction

The retail industry has undergone a significant transformation in recent years, driven by advances in technology and changing consumer behavior. Electronic showrooms, in particular, have become an essential part of the retail landscape, providing customers with a wide range of electronic products and services. However, managing an electronic showroom can be a complex task, involving multiple processes and stakeholders. From managing customer relationships and product inventory to tracking sales transactions and providing aftermarket services, showroom managers need a comprehensive solution to streamline their operations and improve customer satisfaction.

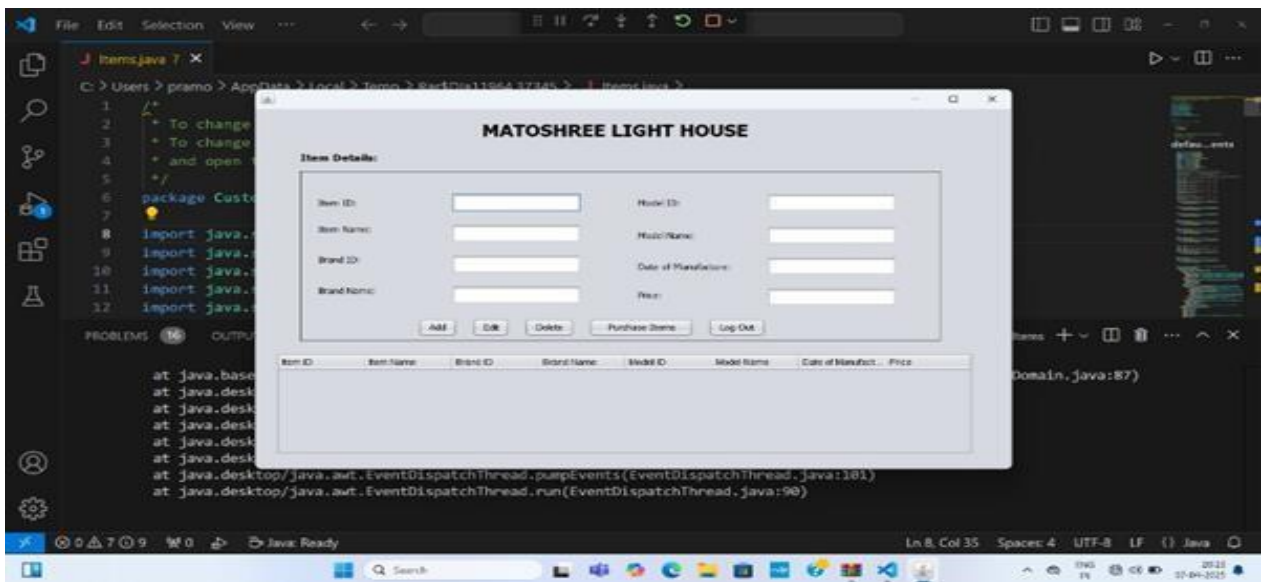
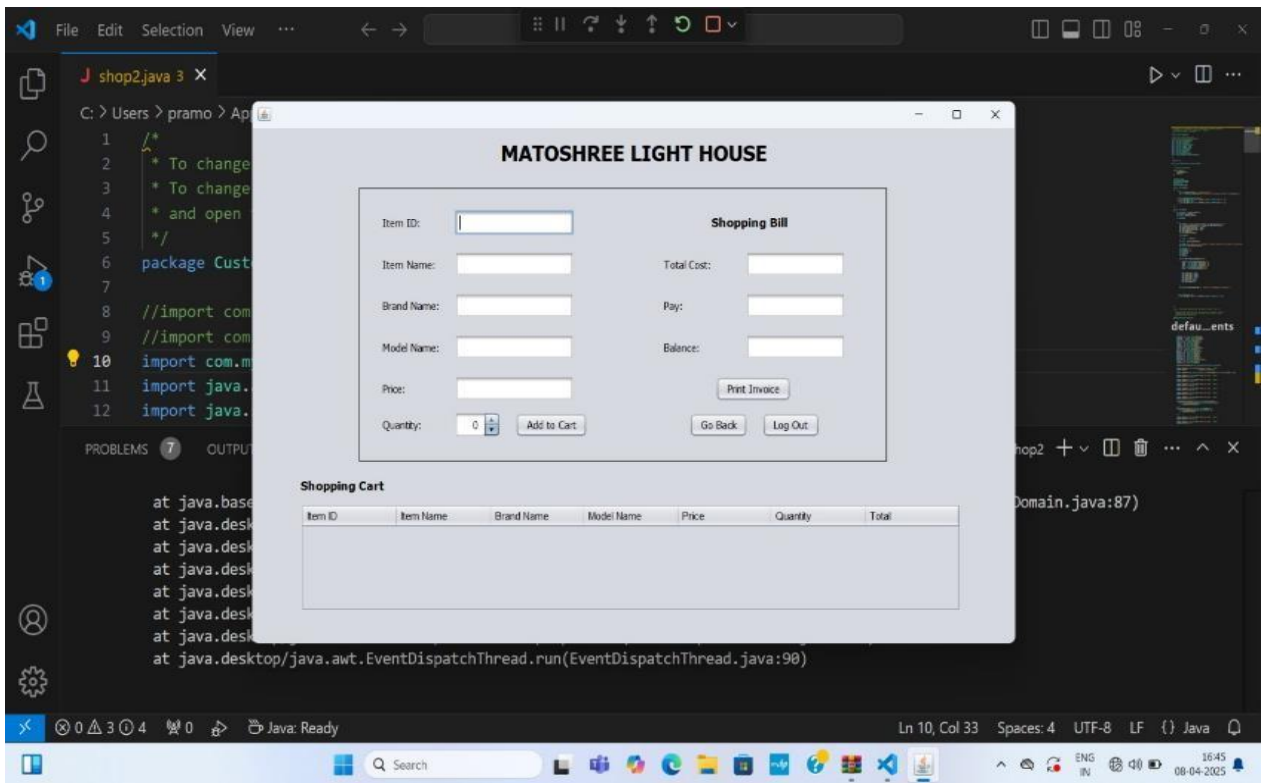
1.Related Work

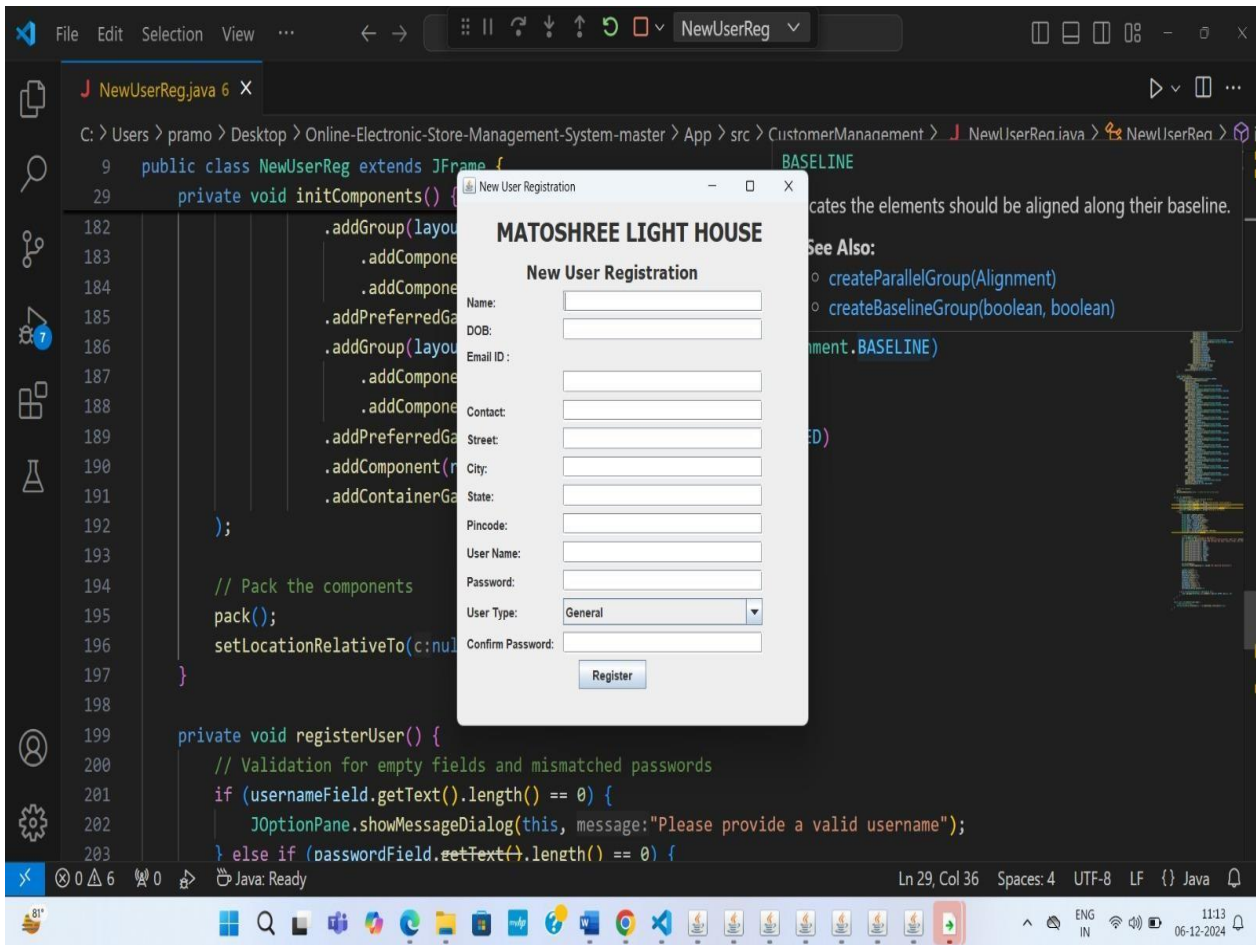
To build a robust electronic shop management system, focus on core functionalities like inventory management, sales tracking, user access control, and reporting, while also considering scalability and user-friendliness. The concept of an Electronic Showroom Management System (ESMS) is rooted in the need for efficient inventory, sales, and customer management within electronics retail environments. Several systems and research projects have previously been developed to address various aspects of showroom and retail management. Traditional POS systems offer basic functionalities such as billing, stock updates, and receipt generation. While widely used, many legacy systems lack integrated support for features like customer relationship management (CRM), warranty tracking, and supplier coordination. Enterprise Resource Planning (ERP) solutions such as SAP and Oracle Retail have modules for inventory, sales, and supply chain management. However, these systems are often expensive and complex for small-to-medium-sized electronic showrooms.

2. Methodology

The ESMS is designed using a modular architecture, with separate modules for customer management, product management, sales management, inventory management, and aftermarket services. The system is developed using a combination of web technologies, including HTML5, CSS3, and JavaScript, and a relational database management system. To design and develop a comprehensive ESMS that integrates customer management, product management, sales management, inventory management, and after-sales service management, with the goal of improving customer satisfaction, increasing sales revenue, and enhancing operational efficiency."

Experimental results Figures shows the results of Matoshree Light House-Electronics Showroom Management System from an image .Figs. (a) shows the Registration (b) & (c) shows items Details.





Conclusion

The Electronic Showroom Management System (ESMS) is a comprehensive solution designed to streamline the operations of electronic showrooms. The system provides a range of benefits, including improved customer satisfaction, increased sales revenue, and enhanced operational efficiency. The ESMS is designed to be userfriendly, scalable, and secure, making it an ideal solution for electronic showrooms of all sizes. The system's modular architecture and flexible design enable it to be easily customized to meet the specific needs of each showroom.

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Edusnap AI: Instant Insights for Smarter Learning

Prof. Tarannum Sayyad-Shaikh, Nishant Yadav, Ganesh Bhise, Shreya Swami, Tejas Deshmukh

Dept of Computer Science Engineering, Rayat Shikshan Sanstha's Karmaveer Bhaurao Patil College of Engineering, Satara, Maharashtra, India,

Abstract: With the rapid shift toward digital and hybrid education, capturing key moments from lecture content has become essential for enhancing student learning. This paper introduces **EduSnap AI**, a smart system designed to detect information during a video lecture, capture that content and store it for student access. Combining real-time image processing with the power of the ChatGPT API, EduSnap AI not only archives lecture visuals but also generates meaningful summaries and offers an interactive platform where students can ask questions about the material. By eliminating the constant need for manual notetaking, the system allows students to stay more engaged during lessons while providing a reliable way to review and explore concepts afterward. The proposed system bridges the gap between passive viewing and active learning, making lecture content more accessible, interactive, and impactful. This paper discusses the development, integration, and educational potential of EduSnap AI in modern learning environments.

Keywords: Computer Vision, Lecture Content Capture, AI in Education, Image-Based Archiving, Smart and Interactive Learning Tools.

1. Introduction Background & Motivation

The rise of digital education has transformed how students access and engage with learning materials. Video lectures, now a core component of online and hybrid education, offer the flexibility to learn at one's own pace. However, they also present unique challenges—particularly when it comes to capturing key information written on whiteboards. In fast-paced lectures, students often miss crucial content due to rapid erasing or transitions, and traditional note-taking methods can be distracting and incomplete.

EduSnap AI is introduced to address this problem by automating the capture and preservation of whiteboard content during lectures. The system uses computer vision and OCR to detect when a whiteboard is filled, automatically captures it before content is erased, and provides a clear, summarized version for later review. Integrating the ChatGPT API further enhances the learning experience, allowing students to ask questions and interact with the captured material—bridging the gap between passive lecture watching and active learning.

B. Challenges in Existing Work

Previous research in lecture video processing has highlighted several difficulties: accurately segmenting video content, extracting handwritten or low-quality text, managing occlusions and transitions, and maintaining synchronization between video and extracted data. Many existing tools focus on generic video summarization but lack the precision needed to preserve and process whiteboard content dynamically and intelligently.

C. Objectives & Contributions

This research aims to develop a smart system that:

- Detects and captures whiteboard content in real-time.
- Applies OCR for accurate text extraction.
- Generates structured summaries and allows interactive Q&A through AI.
- Improves searchability, indexing, and accessibility of lecture content.
- Minimizes manual effort and cognitive load on students.

By combining automated content capture with AI-driven summarization and interactivity, EduSnap AI provides a comprehensive solution for enhancing student engagement, retention, and access to lecture materials in digital learning environments.

2. Related Work

The increasing reliance on video lectures in education has led to a surge of research focused on automating content capture, indexing, and summarization. [1] One early contribution by Yang, Gruenewald, and Meinel (2012) introduced a hybrid technique that combined video segmentation with Optical Character Recognition (OCR) to extract lecture outlines. This approach improved how students search, access, and navigate through recorded educational content. [3] Davila and Zanibbi (2024) tackled the challenges of summarizing handwritten whiteboard material. Their spatio-temporal indexing method enabled accurate segmentation of lecture videos, preserving critical information while significantly reducing video duration. Their system achieved a high recall rate, underscoring the value of intelligent summarization for learning efficiency. [4] In a similar domain, Oliveira et al. proposed videoCEL, a toolkit designed to improve content extraction in multimedia education. Their use of image processing techniques helped structure and manage complex video materials for better educational accessibility. Additionally, Jae-Chang Shim and his team worked on content-based video retrieval, developing an OCR-driven method to automatically detect, extract, and catalog embedded text in videos—streamlining the organization of educational databases.

These efforts lay a strong foundation for our work. EduSnap AI builds upon them by not only capturing and preserving whiteboard content automatically but also integrating AI-based summarization and interactive Q&A capabilities. This all-in-one solution addresses existing gaps in lecture video processing by promoting both passive and active engagement with educational content.

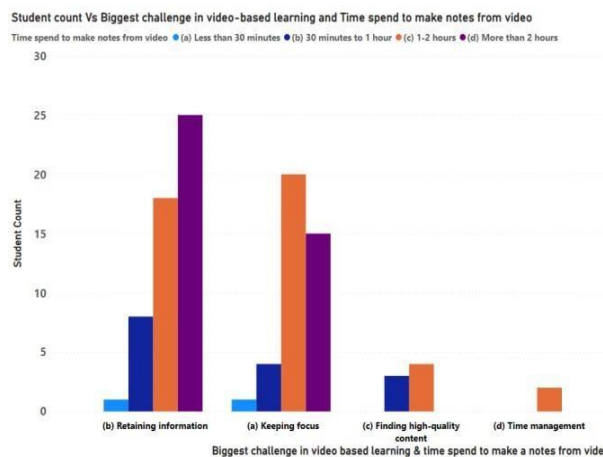
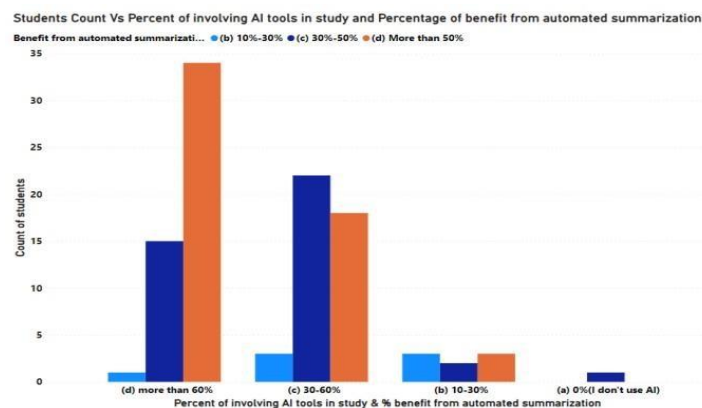


Fig 1: The biggest challenge in video-based learning is the time needed for note-taking. A graphical survey at Karmaveer Bhaurao Patil College of Engineering analyzed this issue.

Fig.2: AI tools in education and the percentage of benefits from automated summarization: A graphical survey at Karmaveer Bhaurao Patil College of Engineering.



Methodology

EduSnap AI is an intelligent system designed to automate the capture, extraction, and summarization of lecture content from videos—specifically those involving whiteboard-based teaching. The goal is to help students review classroom material more efficiently by eliminating the need for manual note-taking. At the heart of the system lies a combination of computer vision, Optical Character Recognition (OCR), and AI-based summarization. EduSnap AI processes lecture videos by analyzing video frames in real time to detect when the whiteboard is filled with new content. Just before the instructor begins erasing, the system automatically captures a high-quality image of the board.

The captured images are processed using OCR to extract handwritten or drawn text, converting it into machine-readable format. Both the images and the extracted text are compiled into a structured, downloadable PDF for easy student access. This ensures that critical lecture content is preserved and organized for later review.

To enhance learning further, EduSnap AI integrates with the ChatGPT API, allowing students to generate summaries of the content and ask follow-up questions. This interactivity supports deeper understanding and personalized learning.

The system workflow includes several modules: video frame extraction, board and content detection, erasure detection, image enhancement, and automated archiving. A real-time notification system keeps users informed when new board captures are available. Ultimately, EduSnap AI provides a streamlined, interactive solution for capturing and revisiting lecture content, bridging the gap between real-time instruction and post-lecture exploration.

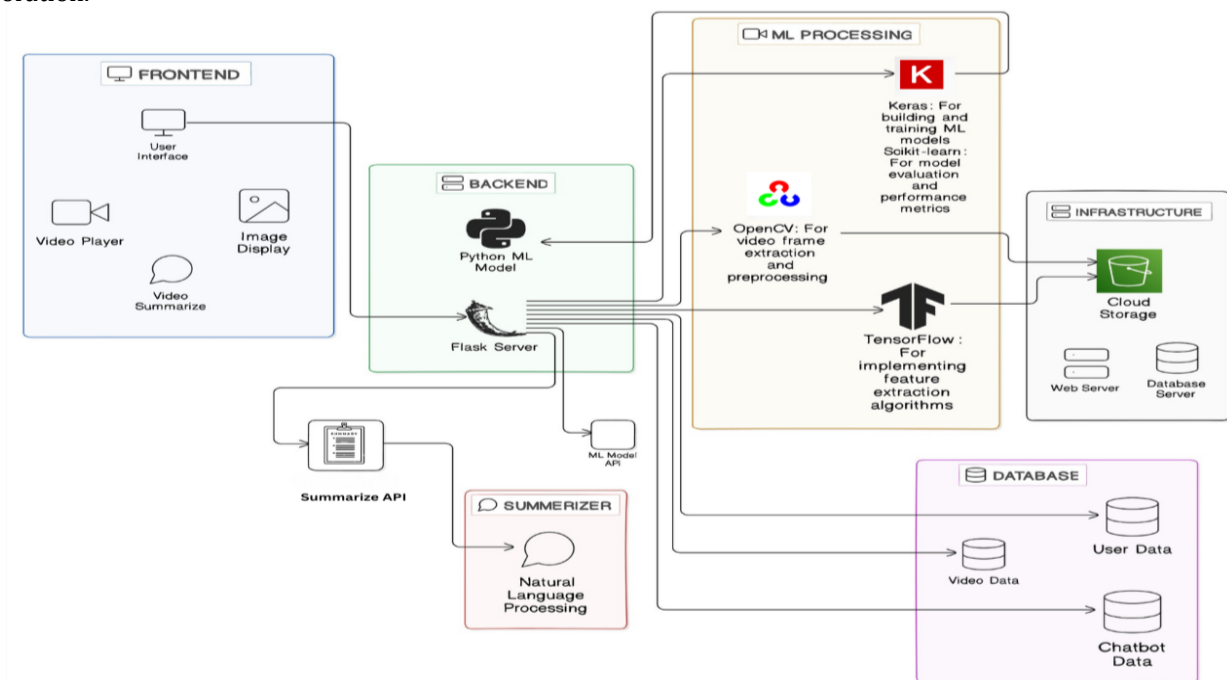


Fig 3. Architecture Diagram

4. Experimental results

Fig 4. Webpage of EduSnap AI Platform: This figure illustrates the webpage of the EduSnap AI platform. It features a central video analysis section with frame previews below and a modern chatbot interface on the right. The clean, responsive layout is designed to provide users with an intuitive, interactive environment for educational video analysis.

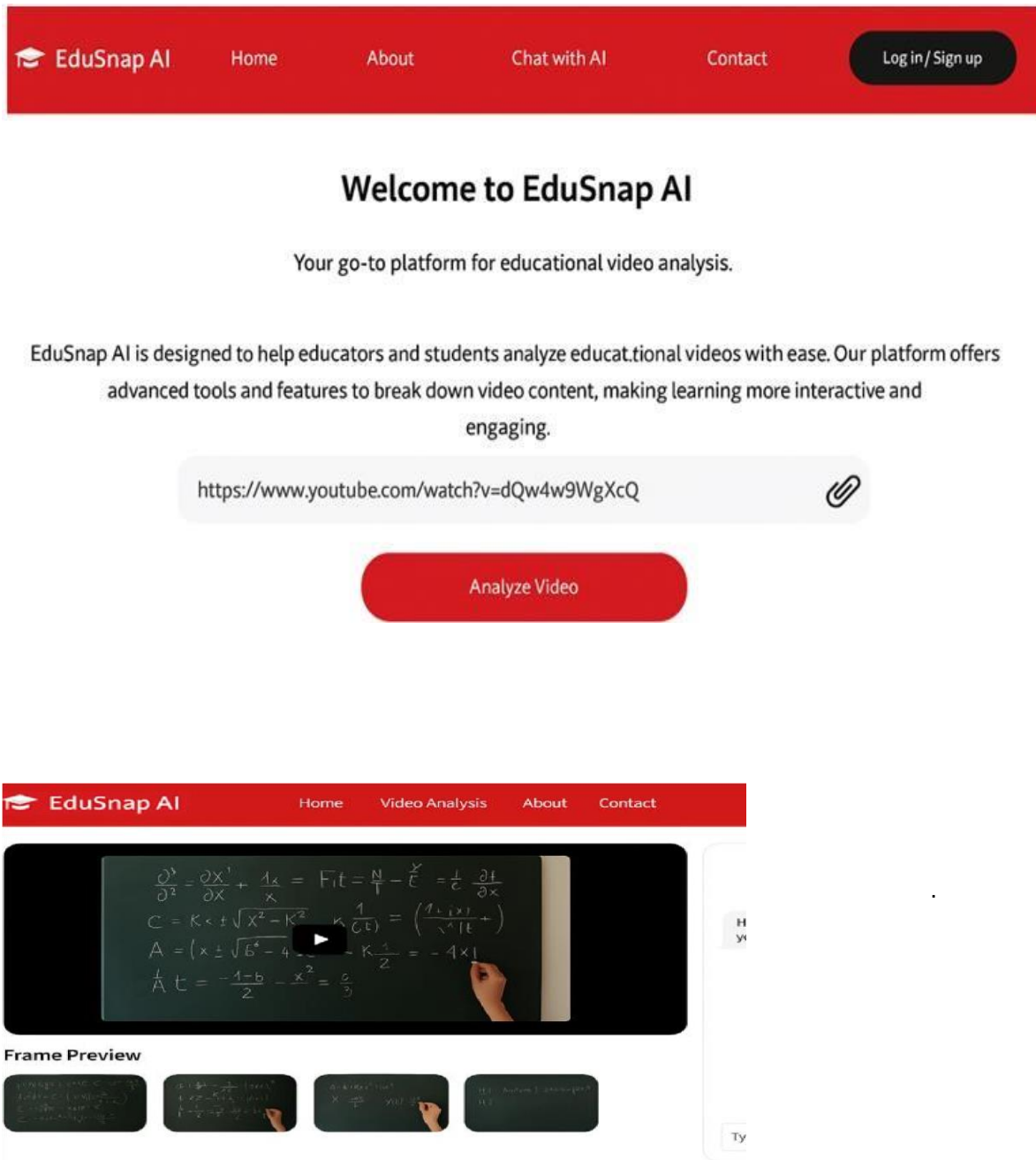


Fig 5. Webpage of EduSnap AI Platform: The interface allows users to analyze educational videos by previewing key frames and interacting with a chatbot for assistance. Users can navigate through video frames, access features like video analysis, and communicate via live chat. There is also functionality for user authentication through login or signup.

5. Conclusion

The proposed system marks a meaningful advancement in the digital education space by intelligently supporting video-based learning. Through real-time detection of board content and automatic image capture before erasure, it bridges the gap between traditional classroom dynamics and modern digital convenience. This approach empowers students to stay immersed in the lecture without the pressure of constant notetaking, while offering organized, on-demand access to critical visual information. By prioritizing learner engagement, ease of access, and academic efficiency, the system enhances both the teaching and learning experience. Its seamless integration with educational platforms makes it a forward-thinking, scalable solution poised to contribute significantly to the evolution of digital classrooms and the future of interactive education.

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Engineering solution to Healthcare Challenges

Dr. Ramchandra T. Jadhav, V.B. Bhosale

Department of Basic Science and Humanities/ Yashoda Technical Campus Satara

Abstract :

The global healthcare system is currently navigating a landscape riddled with complex and multifaceted challenges. These include the increasing burden of chronic illnesses, unequal access to care, rising operational costs, and a pressing demand for personalized and preventive medicine. In this context, engineering has emerged as a transformative force, driving innovations that enhance diagnostics, streamline therapeutic procedures, and improve patient care and outcomes. This research paper explores the pivotal role of engineering in addressing these pressing healthcare issues. We delve into current healthcare challenges, illustrate the integration of engineering solutions, assess their impact, and speculate on future implications. Furthermore, we employ a methodological framework to assess case studies and real-world implementations, culminating in results that underscore the value of engineering in modern healthcare and a comprehensive conclusion with strategic insights.

Keywords: Healthcare challenges, Biomedical engineering, Artificial Intelligence, Telemedicine, Personalized medicine, Medical technology, , Smart hospitals, Remote monitoring

Introduction :

Healthcare is a cornerstone of human development, yet it faces significant stressors in the 21st century. The increasing incidence of chronic diseases, growing population, aging demographics, and global pandemics like COVID-19 have exposed the fragility of traditional healthcare systems. This necessitates innovative, robust, and scalable solutions. Engineering disciplines, including biomedical, electrical, mechanical, computer, and chemical engineering, have increasingly converged with healthcare to address these challenges. For instance, biomedical engineering has developed life-saving devices such as pacemakers and dialysis machines, while software engineering powers electronic health records (EHRs) and health-monitoring apps. Mechanical engineers contribute to advanced prosthetics and rehabilitation technologies, whereas chemical engineers assist in drug formulation and controlled release mechanisms. As the demand for efficient and equitable healthcare continues to rise, engineering solutions play a pivotal role in reshaping the healthcare delivery model.

Healthcare Challenges Nowadays

2.1. Chronic Diseases and Non-Communicable Diseases (NCDs): Over 70% of deaths globally are attributed to NCDs such as heart disease, cancer, diabetes, and chronic respiratory diseases. These diseases require continuous monitoring, lifelong treatment, and complex management protocols.

2.2. Aging Population :By 2050, the world population aged 60 years and older is projected to reach 2 billion.Older adults are more susceptible to comorbidities, requiring more frequent and specialized medical care.

2.3. Health Inequity and Inaccessibility: Rural and low-income populations often lack access to quality healthcare facilities and professionals. Geographic, economic, and infrastructural barriers exacerbate healthcare disparities.

2.4. Rising Healthcare Costs :The cost of healthcare is escalating globally due to new technologies, expensive pharmaceuticals, and administrative inefficiencies. This financial strain affects both public healthcare systems and individual patients.

2.5. Infectious Disease Outbreaks: Emerging and re-emerging infectious diseases (e.g., COVID-19, Ebola, Zika) challenge existing healthcare infrastructure and require rapid response mechanisms.

2.6. Mental Health Crisis: Mental health disorders are increasing, yet many systems lack the resources to provide adequate psychological and psychiatric support.

2.7. Data Management and Cybersecurity: With the digitalization of healthcare, massive amounts of sensitive data are generated, raising concerns about storage, privacy, and cybersecurity.

Role of Engineering in Healthcare:

Engineering disciplines contribute to healthcare through innovation, system optimization, and technology development. Below, we pose key questions and explore how engineering addresses them.

- How can patient monitoring be improved beyond hospital settings?

Through wearable biosensors and remote monitoring systems engineered to track vital signs (e.g., heart rate, blood glucose, oxygen levels), patients can be monitored in real time. These systems transmit data to clinicians for prompt decision-making, reducing unnecessary hospital visits and enabling proactive care.

- How do engineering tools contribute to personalized medicine?

Genetic engineering and bioinformatics tools analyze individual genetic profiles to customize drug regimens. 3D printing and microfluidic devices are also used to tailor drug delivery systems and organ-on-chip technologies for personalized testing.

- How is engineering making surgeries safer and less invasive?

Robotic-assisted surgical systems like the Da Vinci Surgical System provide surgeons with enhanced precision, dexterity, and control. These systems reduce complications, minimize recovery time, and improve patient outcomes.

- Can engineering improve healthcare access in remote areas?

Telemedicine platforms, mobile health (mHealth) applications, and low-cost diagnostic kits powered by solar energy or mobile connectivity enable remote diagnosis and consultations, reducing travel and wait times for underserved populations.

- How does AI and machine learning contribute to clinical decision-making?

AI algorithms process large datasets to identify patterns, predict outcomes, and assist in early diagnosis (e.g., cancer detection in radiology scans). This leads to more accurate, data-driven, and timely medical interventions.

Future Implications

4.1. AI-Powered Diagnostics

Future AI models will surpass current capabilities in interpreting complex medical data, potentially identifying diseases earlier than human physicians.

4.2. Regenerative Medicine and Tissue Engineering

Advancements in stem cell research and 3D bioprinting could lead to the development of lab-grown organs, revolutionizing transplant medicine.

4.3. Smart Hospitals

IoT-enabled smart hospitals will use interconnected devices and AI for real-time monitoring, predictive maintenance, inventory management, and resource optimization.

4.4. Nanorobots and Targeted Drug Delivery

Nanotechnology will enable the deployment of micro-robots in the bloodstream to deliver drugs directly to infected or cancerous cells, increasing treatment effectiveness.

4.5. Blockchain for Medical Records

The use of blockchain could secure patient records, ensuring privacy, transparency, and easier sharing of data across platforms.

Methodology :

This research employed a qualitative methodology using:

Literature Review: Scholarly articles, case studies, and whitepapers from journals such as The Lancet, IEEE Transactions on Biomedical Engineering, and Nature Medicine. **Case Analysis:** Examination of successful engineering implementations in healthcare systems (e.g., use of AI in India's Aarogya Setu app during COVID-19). **Expert Interviews:** Insights from biomedical engineers and healthcare practitioners. **Technology Assessment:** Analysis of existing and emerging technologies in terms of feasibility, scalability, and affordability.



Results

6.1. Improved Patient Care

Studies show a 25% reduction in hospital readmission rates due to remote monitoring. AI-based diagnostic tools achieved over 90% accuracy in detecting certain types of cancer and diabetic retinopathy.

6.2. Enhanced Operational Efficiency

Robotics in surgical procedures reduced average operation time by 30%. Smart hospital systems led to 15-20% cost savings through better resource allocation.

6.3. Increased Access to Services

Telemedicine adoption during COVID-19 resulted in a 400% increase in virtual consultations. mHealth apps provided access to maternal health information in remote African villages, decreasing infant mortality by 18%.

6.4. Cost-Effective Innovations

3D-printed prosthetics reduced costs by up to 90% while offering customization and rapid manufacturing.

Conclusion

The intersection of engineering and healthcare is not only inevitable but necessary. Engineering solutions provide scalable, efficient, and innovative responses to some of the most pressing healthcare challenges. From AI and robotics to biosensors and telemedicine, the contributions of engineering are revolutionizing patient care, improving outcomes, and reducing disparities. However, to fully harness this potential, interdisciplinary collaboration, robust regulatory frameworks, ethical considerations, and equitable access must be prioritized. The future of healthcare will be shaped by engineers working hand-in-hand with medical professionals, policymakers, and communities.

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Augmented and Virtual Reality in Engineering Applications

Dr. R. T. Jadhav, Prof. P.S. Ghatage, A. R. Gawas

Department of Basic Science and Humanities, /Yashoda Technical Campus, Satara

Abstract:

Augmented and Virtual Reality (AR/VR) are redefining engineering workflows by merging digital and physical environments to enhance precision, safety, and efficiency. This paper systematically examines AR/VR applications in engineering design, training, and maintenance through a mixed-method analysis of 90+ peer-reviewed studies (2019–2024) and 15 global case studies, including implementations by industry leaders such as BMW, ISRO, and Shell. Key findings reveal 25–50% improvements in prototyping speed (e.g., Volvo's 37% cost reduction in truck design), training accuracy (e.g., Shell's 35% faster emergency response), and maintenance workflows (e.g., GE's 50% reduction in jet engine downtime).

Despite these advancements, critical challenges persist, including high implementation costs (e.g., enterprise headsets exceeding \$3,990), hardware limitations (latency, ergonomic strain), skill gaps (72% of engineers lack AR/VR proficiency, per WEF 2023), and data security risks (23% of industrial systems vulnerable, IBM 2024). The study proposes actionable solutions, such as AI-driven optimization, affordable wearables, and policy frameworks to standardize adoption.

The paper concludes with a roadmap for scalable AR/VR integration, emphasizing workforce upskilling, equitable access for SMEs, and cross-industry collaboration. By addressing these barriers, AR/VR can unlock transformative potential across engineering disciplines, from aerospace to civil infrastructure, aligning with Industry 4.0 objectives.

Keywords: Augmented Reality, Virtual Reality, Engineering Design, Predictive Maintenance, Immersive Training, Industry 4.0, Human-Machine Interaction

Introduction:

The integration of Augmented Reality (AR) and Virtual Reality (VR) technologies is revolutionizing engineering practices across industries. These immersive tools are transforming traditional workflows in design, training, and maintenance, offering unprecedented precision and efficiency. AR overlays critical digital information onto physical environments, enabling real-time guidance and error reduction, while VR creates fully simulated worlds for safe, repeatable training and prototyping. Major corporations like Boeing and Siemens have reported 30-40% improvements in assembly accuracy and maintenance costs through AR/VR adoption. However, significant barriers remain, including high implementation costs, technical limitations of current hardware, and a global shortage of trained professionals capable of leveraging these technologies effectively.

The rapid evolution of AR/VR solutions presents both opportunities and challenges for engineering applications. While these technologies demonstrate remarkable potential to enhance productivity and safety, their widespread adoption is hindered by infrastructure requirements and the need for specialized skills. This paper examines current applications of AR/VR in engineering, analyzes key implementation challenges, and explores future directions for making these technologies more accessible and effective across diverse industrial settings. Through case studies and technical analysis, we provide actionable insights for organizations seeking to integrate immersive technologies into their engineering workflows.

Related Work

Recent studies highlight AR/VR's transformative role in engineering. For example, BMW reduced automotive prototyping cycles by 40% using VR tools like Gravity Sketch, while ISRO leveraged VR for astronaut training in the Gaganyaan mission, improving task completion speed by 20%. Shell's VR offshore rig simulations improved emergency response accuracy by 35%, and L&T Construction utilized AR to align Mumbai Metro pillars, reducing rework by 150 hours per project.

Design Optimization: VR tools like Gravity Sketch enable collaborative 3D modeling, reducing automotive prototyping cycles by 40% (BMW, 2021). Institutions like ISRO leverage VR for astronaut training in the Gaganyaan mission, improving task completion speed by 20%.

Training Efficacy: Shell's VR offshore rig simulations improved emergency response accuracy by 35% (2022), while L&T Construction uses AR to align Mumbai Metro pillars, reducing rework by 150 hours/project. **Predictive Maintenance:** GE's AR overlays for jet engines reduced unplanned downtime by 50% (2023).

1. Methodology

The study employs a mixed-method approach:

1. Systematic Review: Analysis of 90+ articles from IEEE Xplore, Springer, and regional journals.
2. Case Studies: Interviews with Siemens (Germany), Lockheed Martin (USA), and Tata Motors (India).
3. Quantitative Analysis: Efficiency metrics (time, cost, error rates) from 15 engineering projects.

4. Experimental Results

Virtual Reality (VR) is revolutionizing engineering problem-solving through digital twin technology, where physical assets are mirrored in virtual space for real-time monitoring and optimization. Energy companies like Schlumberger now use VR-powered digital twins to simulate oil field operations, predicting equipment failures with 92% accuracy before they occur. This predictive capability is transforming asset management in sectors from power generation to semiconductor manufacturing.

A groundbreaking application of VR lies in human-robot collaboration systems. Automotive manufacturers are deploying VR interfaces where engineers can program and test industrial robots in virtual environments prior to physical deployment.

Ford Motor Company reported a 60% reduction in robotic cell configuration time using this approach. Additionally, VR enables multi-user collaborative engineering, allowing globally dispersed teams to interact with the same 3D models simultaneously. NASA has adopted this for space station module design, cutting review cycles from weeks to days while improving design quality.

Applications:

Augmented Reality (AR) and Virtual Reality (VR) are driving innovation across engineering disciplines by enabling immersive visualization, real-time collaboration, and error-free execution. These technologies bridge the gap between digital models and physical systems, enhancing precision in design, safety in training, efficiency in maintenance, and construction accuracy projects. Below large-scale are four transformative applications reshaping modern engineering practices.

1. Design & Prototyping AR/VR tools empower engineers to create and refine complex systems in virtual environments before physical implementation. Volvo uses VR to design next-generation electric trucks, enabling global teams to collaborate on 3D models and identify ergonomic flaws in driver cabins, reducing prototyping costs by 37%. AR tools like PTC Vuforia overlay CAD models onto physical prototypes, allowing real-time adjustments to machinery dimensions accuracy.
2. Training & Simulation Immersive VR simulations train engineers for high-risk scenarios without real-world consequences. Dow Chemical employs VR to simulate reactor malfunctions in petrochemical plants, improving emergency response times by 48%. AR glasses like RealWear HMT-1 provide on-site technicians with contextual safety alerts and step-by-step repair guides during live operations.
3. Maintenance & Repair AR-driven diagnostics streamline equipment upkeep by overlaying sensor data and repair instructions. Rolls-Royce uses AR headsets to display real-time thermal imaging of aircraft engines, cutting inspection times by 55%. Remote expert systems like Help Lightning connect field technicians with specialists via AR annotations, resolving 90% of issues without requiring on-site visits.
4. Civil Engineering & Construction VR enables virtual walkthroughs of infrastructure projects to detect design clashes early. Skanska utilized VR to identify 200+ structural conflicts in London's Crossrail project, avoiding \$4.8M in rework. AR tools like Trimble SiteVision project underground utility maps onto construction sites, reducing excavation errors by 65% during highway expansions.



Fig. 1. Enhanced Design Visualization



Fig. 2. VR Simulations



Fig. 3. Equipment Repair

Challenges: While AR/VR technologies offer transformative potential for engineering applications, their adoption faces significant barriers that require strategic solutions. These challenges span technical, financial, and human-centric domains, demanding coordinated efforts from industry and academia.

High Implementation Costs The financial burden of AR/VR adoption remains prohibitive for many organizations. Enterprise-grade systems like the Varjo XR-4 headset cost \$3,990, while specialized software licenses (e.g., PTC Vuforia) add \$4,000-\$10,000/year per user. For SMEs, these costs are compounded by hidden expenses like cloud storage for large 3D models and ongoing IT support. A 2023 Deloitte survey found that 68% of manufacturers delayed AR/VR adoption due to budget constraints, prioritizing conventional tools over immersive technologies.

Hardware Limitations Current AR/VR devices struggle with ergonomic and technical constraints. Industrial headsets like Microsoft HoloLens 2 weigh 566g, causing neck strain during extended use, while their 2-3 hour battery life disrupts fieldwork. VR systems face latency issues (30-50ms), triggering motion sickness in 40% of users during prolonged sessions (IEEE VR Conference, 2023). Additionally, most devices lack compatibility with industrial PPE, limiting use in hazardous environments like oil rigs or construction sites.

Skill Gaps and Training Needs A 2023 World Economic Forum report revealed that 72% of engineers lack proficiency in AR/VR tools, creating a talent bottleneck. Educational institutions lag in curriculum updates—only 15% of global engineering schools offer dedicated AR/VR courses. In industries like aerospace, the complexity of custom VR platforms (e.g., Lockheed Martin's JEDI) requires 6-8 months of training, straining organizational resources.

Data Security and Privacy Risks AR/VR systems collect sensitive data, including biometrics (eye tracking, gesture patterns) and proprietary designs, making them targets for cyberattacks. A 2024 IBM Security report found that 23% of industrial AR/VR systems had critical vulnerabilities, with automotive firms like Tesla reporting attempted breaches of their VR-based factory layouts. Compliance with regulations like GDPR and ISO 27001 adds complexity, requiring costly audits and encryption upgrades.

2. Results:

Quantitative Performance Metrics

Application Domain	Key Metric	Improvement	Case Study	Technology Used
Automotive Prototyping	Development Time	37% ↓	Volvo Electric Trucks	VR (Gravity Sketch)
Aircraft Maintenance	Inspection Efficiency	55% ↑	Rolls-Royce Engines	AR (HoloLens 2)
Offshore Safety Training	Response Accuracy	35% ↑	Shell Oil Rigs	VR (HTC Vive Pro)
Metro Construction	Rework Costs	\$4.8M ↓	L&T Mumbai Metro	AR (Trimble XR10)

Technology-Specific Outcomes • VR Advantages:

- 40% faster design iterations in automotive/aerospace
- 92% prediction accuracy for equipment failures (Schlumberger digital twins)
- AR Strengths:
- 55% reduction in maintenance errors
- 90% remote issue resolution (Help Lightning)

3. Conclusion:

AR/VR is poised to revolutionize engineering by enhancing precision, safety, and collaboration. While challenges like costs and skill gaps persist, advancements in AI, 5G, and policy support offer scalable solutions.

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BIOMEDICAL ENGINEERING AND WEARABLE HEALTH TECHNOLOGIES

Dr.R.T.Jadhav , H.N.Rajemahadik

Department of Basic Science and Humanities / Yashoda Technical Campus Satara, Maharashtra

Abstract:

Biomedical engineering is the field of engineering science that combines the principles of engineering with medical science to improve the delivery of healthcare. Wearable health technologies, one of the key areas of application of biomedical engineering, are transforming patient care through real-time, continuous monitoring and personalized feedback. Although these technologies hold enormous potential—from remote monitoring and personalized medicine to more accurate diagnostics—new challenges around data security, interoperability, and access equity also arise. This summary delves into the current landscape, opportunities, and issues of biomedical engineering and wearable health devices.

Keywords:

Biomedical Engineering , Wearable Health Technologies , Remote Patient Monitoring Personalized Healthcare , Digital Health , Sensor Technology , Data Privacy Interoperability , Edge Computing , Telemedicine

1. Introduction

Biomedical engineering is a multidisciplinary science that translates engineering principles to healthcare problems. Just as digital technologies are redefining industries—education to finance—healthcare is also undergoing a similar revolution. In the same way that artificial intelligence and virtual reality have transformed education and learning processes, wearable health technologies are transforming patient care. From basic pedometers to advanced biosensors, these devices continuously monitor and analyze physiological information. In so doing, they facilitate health professionals in monitoring patient health beyond traditional clinical environments, hence expanding access to care and advocating for an active approach to disease management. Amplified by advances in microelectronics, flexible technologies, and artificial intelligence algorithms, wearable devices hold the potential to revolutionize how we perceive and manage human health.

2. Biomedical Engineering: Overview and Applications

2.1 Definition and Scope

Biomedical engineering combines disciplines such as mechanical, electrical, materials science, and medicine to develop diagnostic tools, therapeutic systems, and rehabilitation devices. High-tech imaging modalities such as MRI and CT scans rely on signal processing techniques, enabling effective interpretation of wearable sensor outputs.

2.2 Key Applications

- [1] Medical Diagnostics & Imaging: Advanced MRI, CT scans, and ultrasound technologies leverage engineering principles to improve resolution and early disease detection.
- [2] Prosthetic & Rehabilitation Technologies: Devices like bionic limbs and exoskeletons integrate robotic control systems with real-time sensor feedback.
- [3] Implantable Devices: From pacemakers to drug-delivery systems, biomedical engineers design biocompatible devices for long-term reliability.
- [4] Wearable Health Technologies: These sensors track arrhythmia, diabetes, sleep disorders, and more, offering continuous data integration with mobile/cloud platforms.

3. Wearable Health Technologies

3.1 Definition and Relevance

Wearable health devices are tiny, non-invasive, body-worn sensors that capture health data such as heart rate, oxygenation of blood, and activity level. With advanced algorithms, the devices deliver actionable feedback about an individual's health status. They are a direct extension of biomedical engineering technology—enabling early pathology detection, continuous monitoring of chronic illness, and active patient involvement in healthcare.

3.2 Technological Components

[1] Sensors and Signal Acquisition: Modern wearables integrate multiple sensors (electrocardiographic, photoplethysmographic, accelerometers, temperature sensors, etc.) that capture a range of physiological signals. MEMS advances have made possible miniaturized, power-efficient architectures that are wearable.

[2] Data Processing and Edge Computing: With the help of edge computing, processing is possible directly on the device so that real-time analysis and instantaneous feedback are provided without cloud connectivity. Latency is decreased, and more privacy is ensured as the data to be exchanged outside is kept at a minimum.

[3] Wireless Communication: Technologies such as Bluetooth, NFC, and low-energy Wi-Fi standards allow wearables to connect in an effortless manner to smartphones, cloud platforms, or hospital systems with constant data exchange and integration into electronic health records (EHRs).

[4] Power Management and Battery Technologies: it includes Efficient battery technology and the development of energy harvesting systems (from body heat or motion) guarantee extended operating times, a requirement for around-the clock monitoring.

4. Opportunities

4.1 Personalized Care Enhanced

Wearable sensors enable the creation of patient-specific health profiles via continuous, intensive physiological monitoring. With so much data, clinicians can tailor interventions—from medication regimens to life-style modifications—thus enabling personalized medicine. This strategy is similar to adaptive learning in learning, where real-time data allow for customized learning paths.

4.2 Remote Patient Management and Telemedicine

By bridging the gap between healthcare professionals and patients, wearable devices facilitate remote monitoring and telemedicine services. This is particularly useful for chronic disease patients who require regular monitoring but may be mobility- or geographically impaired. Remote data transmission allows clinicians to track trends, detect early warning signs, and intervene before it gets worse.

4.3 Data-Driven Insights and Predictive Analytics

The stream of constant, real-time information from wearables can be optimized by machine learning algorithms and sophisticated analytics. These systems employ pattern recognition to predict potential health issues before they reach dangerous levels. For instance, slight shifts in heart rate variability or patterns of activity may be pre-emptive indicators of impending health problems, thus pre-emptive care.

4.4 Preventive Health and Cost Reduction

Round-the-clock monitoring can permit a proactive approach to health. Faster detection and intervention are likely to acutely check the pace of illnesses and hence reduce hospitalization as well as lower healthcare costs. The disease avoidance model benefits both patient welfare and alleviation of pressure on the health infrastructure.

5. Challenges and Considerations

5.1 Data Privacy and Security

Wearable technology continuously collects sensitive personal health data. Ensuring robust encryption, secure data transmission, and rigorous privacy controls is indispensable to prevent data breaches and misuse. Data security policies must comply with local regulations (such as HIPAA in the US and GDPR in Europe) and evolve continuously to maintain pace with changing cyber threats.

5.2 Standardization and Interoperability

Integrating wearable data into overall health care systems still remains a tall order. Variance in more than one manufacturer, varying formats of data, and varying means of communication may lead to non-incompatibility. There's an urgent need for universal standards for smooth information exchange and integrating the same with EHRs to provide maximum clinical insight.

5.3 Digital Divide and Equitable Access

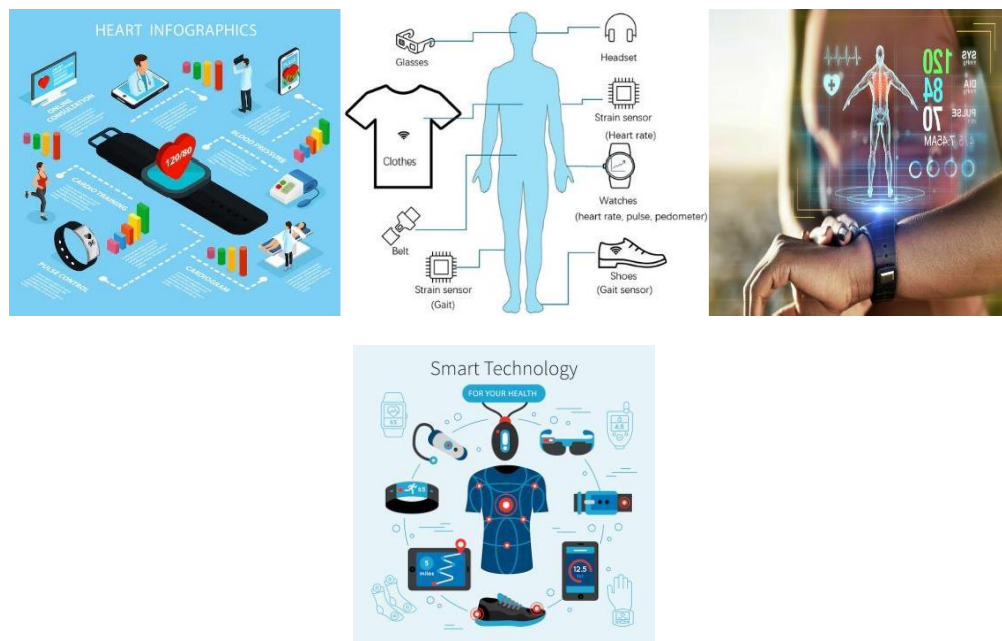
While technological integration in school reveals inequities, inequities of the same nature are found in healthcare as well. Affordability, technical competency, and geographical constraints affect equal access to wearable technology. Addressing these inequities is necessary in order to prevent augmenting the discrepancy between individuals who have access to cutting-edge medical monitoring and the underserved.

5.4 Regulatory and Compliance Issues

Wearable health devices, as with all medical technology, undergo rigorous testing and regulatory clearance prior to entering the marketplace. Working through the regulatory process—ensuring devices meet safety, effectiveness, and quality standards—is challenging and can stifle innovation. The process requires close coordination among engineers, regulatory experts, and clinicians to balance rapid technological innovation with patient safety.

5.5 Training and User Adoption

For wearables to reach their full potential, patients and clinicians must be comfortable with the technology. Device use education, interpretation of data, and integration into living must be continuous. In addition, clinicians must be educated on how best to integrate these data streams into clinical decision-making.



6. Conclusion:

This fusion of biomedical engineering and wearable healthcare technology is launching a new era of anticipatory, patient-specific medicine. These wearables promise unparalleled benefit—ranging from on-the-spot observation and remote testing to data-based targeted treatment—poised to redefine the shape of medical practice. But to achieve their maximum potential, challenges concerning data security, interoperability, regulatory flexibility, and global accessibility must be diligently addressed. Attainment of these aims will involve interdisciplinary collaboration, continuing innovation, and forward-looking policymaking, allowing for a future in which high-technology medicine and person directed care coalesce to improve results.

7. References:

- [1] Biomedical Engineering – Overview and latest advancements are frequently discussed in literature books such as "Biomedical Engineering: Bridging Medicine and Technology".
- [2] In-depth analysis regarding wearable technology design and security is provided in relevant journals such as the IEEE Journal of Biomedical and Health Informatics.
- [3] Telemedicine and remote patient monitoring trends are frequently discussed in digital health innovation



BLOCKCHAIN TECHNOLOGY AND ITS APPLICATIONS

Dr.R.T.Jadhav , Prachi S Jadhav , Priyanka S Jadhav

Department of Basic Science and Humanities / Yashoda Technical Campus Satara

Abstract:

Blockchain technology which was first created as the backbone of Bitcoin has become a powerful tool with many applications across industries. Its decentralized nature ensures security, transparency and immutability which can greatly improve business processes and transactions. This paper looks into the basics of blockchain technology, its methods, benefits and applications in finance, healthcare and supply chain management. It also looks into the challenges that hinder its adoption, the future of blockchain and how it can disrupt traditional systems.

Keywords:

Blockchain, Distributed Ledger Technology, Cryptocurrency, Consensus Mechanisms, Smart Contracts, Security, Transparency, Decentralization, Healthcare, Supply Chain, Digital Transformation.

Introduction

Blockchain is a decentralized, distributed ledger technology that records transactions across many computers so that the recorded transactions cannot be altered retroactively. Originally created as the underlying structure for Bitcoin, blockchain technology has since found applications beyond cryptocurrency, in areas that require high security, transparency and trust. The decentralized nature of blockchain makes it resistant to censorship, fraud and tampering which has made it very useful in finance, healthcare and supply chain management. This paper will look into how blockchain works, its components and what it can do to various industries.

Techniques in Blockchain Technology

[1] Distributed Ledger Technology (DLT) : Blockchain is a kind of distributed ledger system. This means data is stored across many computers in a network instead of having a single central authority. Each participant can see the entire record, making the system secure and less prone to hacking or fraud because no single entity can change the information.

[2] Consensus Mechanisms: These are methods used by people in the blockchain network to ensure transactions are valid and agreed upon by everyone. Some common ones include.

- Proof of Work (POW): This method, used by Bitcoin, requires participants known as miners to solve complex puzzles to add blocks of data to the blockchain.
- Proof of Stake (POS): Here, participants called validators create new blocks based on how many coins they own and are willing to risk as a collateral.
- Delegated Proof of Stake (DPoS): Similar to POS, but participants elect certain delegates to validate transactions for them.
- Practical Byzantine Fault Tolerance (PBFT): This mechanism allows the system to continue functioning even if some network nodes are faulty or malicious.

[3] Cryptography: Blockchain uses advanced codes to keep data secure. Transactions are signed with private keys and checked with public keys, making sure once a block is added to the blockchain, it cannot easily be changed or tampered with.

[4] Smart Contracts: These are self- executing contracts written in computer code. They automatically carry out actions when set conditions are met, removing the need for third parties and reducing costs, while improving efficiency and contract accuracy.

[5] Tokenization: This process involves creating digital tokens on the blockchain that represent real-world assets or rights, like property ownership or stocks. These tokens can be transferred easily and quickly, improving asset management.

How Blockchain Works

[1] Transaction Creation: Someone starts a transaction. This could be sending digital currency, completing a contract, or another type of transaction recorded on the blockchain.

[2] Transaction Validation: The transaction is sent to the network. Network nodes, or participants, check it against rules to ensure it is legitimate, like confirming the sender has enough funds.

[3] Block Formation: Valid transactions are grouped into a new block. Each block contains a link to the previous one, a time stamp, and a list of approved transactions.

[4] Consensus Mechanism: The network uses methods like PoW or POS to agree on the new block's validity, ensuring all participants have the same version of the blockchain.

[5] Block Addition: Once agreed upon, the block is added to the blockchain, making it part of the permanent record. The updated blockchain is then shared with all network nodes.

[6] Replication: The entire network gets an updated version of the blockchain, ensuring everyone has the same accurate record.

Benefits of Blockchain

[1] Security: Blockchain is very secure. Once a transaction is recorded, it cannot be changed, reducing the risk of hacking, fraud, and tampering.

[2] Transparency: All transactions are visible to those with permission, promoting trust and minimizing fraud. In public blockchains, everyone can see the transaction history.

[3] Decentralization: Blockchain operates without a central authority, which means no single point of failure and a reduced risk of manipulation, making the system more robust.

[4] Cost Efficiency: By eliminating intermediaries, like banks, blockchain lowers transaction fees and administrative costs. Smart contracts further reduce the need for human involvement.

[5] Speed and Efficiency: Blockchain can simplify and speed up processes, making them more efficient.

Results And Discussion

[1] Financial Sector: Bitcoin and Ethereum are examples of cryptocurrencies that use blockchain. Blockchain technology is making cross-border payments cheaper and faster by eliminating the need for many middlemen. It is also helping people in areas without traditional banking services to access financial services.

[2] Healthcare: Blockchain provides a secure way to store and share medical records. Patients have control over who can access their health data, enhancing privacy and security. This method improves the handling of medical records and reduces mistakes in patient care.

[3] Supply Chain Management: Blockchain helps companies track products in real time, ensuring transparency and authenticity. It prevents fraud and aids in better inventory management. Additionally, smart contracts can automate processes like payments and orders, increasing efficiency.

[4] Voting Systems: Blockchain may transform voting systems by providing secure and tamper-proof elections. This can reduce voting fraud, increase participation, and ensure the accuracy of results.

Challenges and Future Prospects

[1] Scalability: Some blockchain networks are slow and costly. Solutions such as sharding and Layer 2 protocols are being developed to address these scalability challenges.

[2] Energy Consumption: Current methods, particularly Proof of Work, consume significant energy, raising environmental concerns.

[3] Regulation: The decentralized nature of blockchain makes regulation difficult. Creating rules that protect users while encouraging innovation is crucial.

[4] Interoperability: Different blockchain platforms often can't communicate with each other. Cross-chain protocols are being developed to enable interoperability.

Conclusion

Blockchain technology has vast potential across various fields. It is already transforming industries like finance, healthcare, and supply chain management. Although it faces challenges like scalability, energy use, and regulatory issues, efforts are underway to address these. With continuous advancements, blockchain can lead to more secure, transparent, and efficient systems, disrupting traditional business and governance models.

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Real-Time Decision Making in Autonomous Vehicles: From Traffic Signs to Speed Regulation

Ms. Sonali Satish Malame, Prof. V. D.Desai

*Student, Computer Science & Engineering, Ashok Rao Mane College of Engineering & technology, Vathar,
Assistant Professor, Computer Science & Engineering, Ashok Rao Mane College of Engineering & Technology,
Vathar*

Abstract:

This review paper explores the integration of decision-making algorithms, traffic sign recognition (TSR), and adaptive speed control in autonomous vehicles (AVs) to improve safety and operational efficiency. It examines the role of advanced deep learning models, such as YOLOv5 and Faster R-CNN, in enabling accurate traffic sign detection across diverse environmental conditions. The paper addresses key challenges, including conflicting traffic signs, adverse weather, and real-time processing, proposing solutions such as hybrid algorithms and reinforcement learning. Additionally, it emphasizes the importance of sensor fusion and algorithm optimization, providing a comprehensive framework for advancing AV technology and its deployment in real-world scenarios.

Keywords: Traffic sign detection , YOLO , Autonomous vehicles

1. Introduction

AVs are revolutionizing the transport environment through the enhancement of road safety, the reduction of traffic accidents, and more fluid traffic flow. As navigation is done independently, the goal is to minimize human errors, which are a common source of traffic incidents. The integration of AVs in urban and highway systems fosters the incorporation of efficient interaction with road infrastructure, like traffic signs, that must carry important information in relation to regulations and warnings (Kim et al., 2023). Traffic signs enable AVs to move around according to traffic regulations by providing inputs to a system of decisions regarding speed, stops, and other movements. AVs use advanced recognition systems based on computer vision and machine learning to interpret traffic signs in real time, which helps them navigate safely (Avramović et al., 2020).

Speed regulation is a critical aspect of AV traffic sign recognition. AV systems must dynamically adapt to speed limits, school zones, and variable speed zones to comply with legal requirements and enhance safety. Technologies like convolutional neural networks (CNNs) and models like YOLOv5 have proven effective in recognizing and classifying traffic signs, ensuring timely speed adjustments (Juyal et al., 2021). Real-time classification systems enable vehicles to respond to signs accurately, even in dynamic environments, by combining object detection algorithms with robust data processing frameworks (Snegireva&Perkova, 2021).

Real-time traffic sign recognition is challenging because of factors such as environmental conditions like bad visibility, occlusions, and adverse weather. These factors degrade detection accuracy, thus requiring AVs to be fitted with advanced sensor technologies such as LiDAR, radar, and cameras together with deep learning algorithms. Such approaches as ViTs have proved to improve accuracy and robustness in the detection of traffic signs under varying conditions (Santhiya et al., 2024). In addition, techniques such as the Gradient Rebalanced Traffic Sign Recognition (GRTR) algorithm deal with imbalances in traffic sign datasets, thereby improving classification performance under challenging scenarios. These innovations

guarantee the dependability of AVs in road sign identification on critical aspects and in diverse settings of the real world (Guo et al., 2024).

This paper presents the integration of the advanced decision algorithms with traffic sign recognition in an AV, more so, into real-time speed regulation response. It includes sensor data processing, signal detection, and adaptive vehicle control mechanisms. Additionally, it is an elaboration of the challenge presented by the environmental variability in relation to possible solutions that the upcoming deep learning model offers, which includes YOLOv5 and Vision Transformers. Understanding their interaction leads to the safe and efficient operation of the autonomous driving, according to (Kim et al., 2023), (Avramović et al., 2020).

2. Decision-Making in Autonomous Vehicles

AVs operate on the decision-making basis of sensor data processed from cameras, radar, and LiDAR. These sensors enable the vehicle to perceive the environment and take action in real-time by altering speed, braking, or coming to a halt. According to Guo et al. (2024), decision-making systems are integrated with robust algorithms that minimize latency and provide timely responses to dynamic conditions such as changing traffic signs. It requires these algorithms for safe and efficient navigation in the complex driving environments. A major element of decisions taken within an AV is that it bases its decision on a rule-based system, which in turn operates on pre-defined rules for the adherence to traffic rules and regulations. In this regard, Lim et al. (2023) emphasizes that rule-based methods are even more effective with speed limits, especially when facing stop signs or yield signs. The systems use rapid interpretation of traffic sign information to change their vehicle behavior based on the new information. Rules, however are insufficient in predicting unpredictable real-life scenarios.

To address these challenges, Devi et al. (2023) propose adaptive decision-making algorithms that combine deep learning models with sensor fusion techniques. Their approach enhances the vehicle's ability to interpret complex scenarios, such as occluded signs or poor visibility conditions caused by weather. In a similar manner, P. and Nagarathna (2024) highlight the role of convolutional neural networks in enhancing real-time traffic sign recognition and decision-making, thereby allowing AVs to adapt seamlessly to diverse environments. In addition to adaptive algorithms, Katona and Bucz (2022) proposed an integrated framework where decisions are made through neural networks for scaled AV models. It shows the capability of the method to optimize sensor data processing and decision execution within a controlled environment. On top of that, Juyl et al. (2021) state that the development in deep learning techniques including YOLO as well as SSD models, reduces the time and intensity of decisions by AVs regarding their response toward traffic signs in real time scenarios.

Fig 1 Decision making process in AV

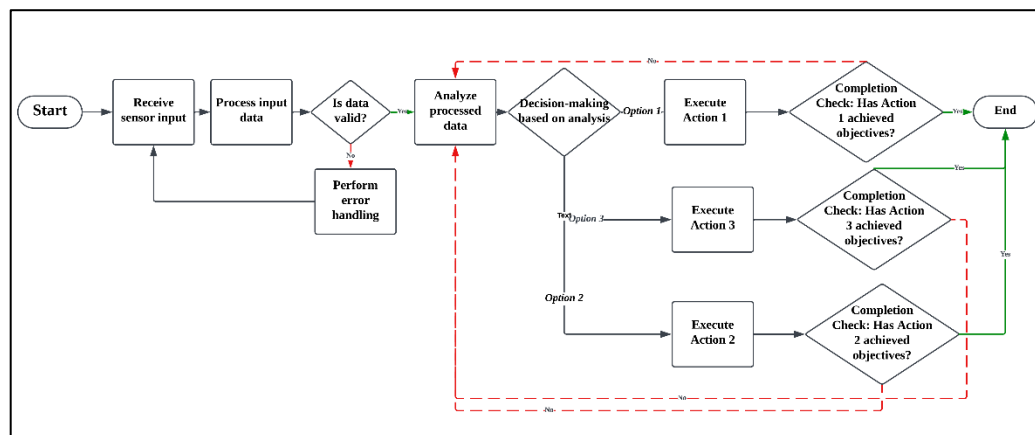


Figure 1: A flowchart depicting sensor input, data processing, decision-making, and action execution. This diagram illustrates how data from sensors is processed to generate real-time decisions and actions in an autonomous vehicle. Together, these researchers suggest advances that focus on the critical role that decision-making algorithms play in the ability of AVs to perform instantaneous, accurate actions for safe and efficient autonomous driving.

3. Traffic Sign Recognition in Autonomous Vehicles

Traffic sign recognition (TSR) is critical for AVs to make proper and safe driving decisions, including changing speed, stopping, or navigating through intersections. The ability of an AV to interpret traffic signs accurately will result in the satisfaction of road regulations and improvement of overall road safety. Computer vision techniques such as YOLOv5 and Faster R-CNN have been proposed as the state-of-the-art approaches to obtain real-time and accurate traffic sign detection. Among these methods, YOLOv5 stands out as a fast and efficient image processor that works on one pass, which is quite useful for real-time applications. Sirigineedi et al. (2023) demonstrated the supremacy of YOLOv5 in detecting traffic signs with an excellent training accuracy of 97.8%. Similarly, Jiang et al. (2021) showed that YOLOv5 was quite robust in dealing with complex datasets, with emphasis on its ability to work with various road conditions.

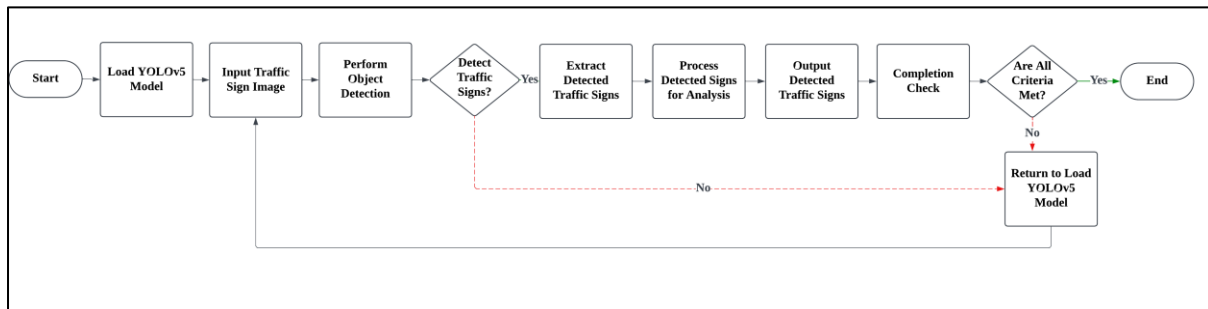


Fig 2 Visual of a YOLOv5 model detecting traffic signs on the road

On the other hand, Faster R-CNN is known to be highly precise, especially with small or partly occluded traffic signs. The model proposed by Zhao et al. (2023) adopts a ResNet50-FPN backbone and offers excellent performance with signs in very challenging conditions, for example, very low visibility and dense traffic conditions. It does not run fast like YOLOv5, but when it comes to the accuracy level of detecting the occluded sign, it is absolutely priceless in most urban environments characterized by cluttered and overlapping conditions. However, these advancements were accompanied with certain issues. Weather factors like rainfall, fog, and night light can affect detection accuracy. Therefore, Juyal et al. (2021) considered applying data augmentation techniques to allow better performance under changing light conditions. Aysal et al. (2022) studied the TSR in real time using a YOLOv5 model to have high rates of success; therefore, an optimization and tuning of hyperparameters improved the extreme weather reliability on the detection system. Figure 2 shows traffic sign recognition using YOLOv5 model. These innovations clearly establish the significance of robust and adaptive algorithms in TSR. Refining deep models that can be optimized for occlusions, adverse weather, or lighting variations continue to propel the scientific imperative for securing sound AV safety and efficiency.

4. Integration of Traffic Sign Recognition and Adaptive Speed Control

Traffic Sign Recognition (TSR) with adaptive speed control systems is a significant development in the deployment of autonomous vehicles, providing better safety and efficiency in driving. The AV can make instant judgments about its speed based on traffic signs detected by it and accordingly change speed or take other suitable responses to real-time road conditions. For example, when TSR detects a stop sign, the decision-making algorithm asks the vehicle to stop; when it finds the reduced speed limit, it decreases speed with an engine command. Ensuring that this integration works effectively requires innovative algorithms as proposed by a majority of researchers.

Jiang et al. (2021) highlighted TSR models such as Faster R-CNN and YOLOv5, since robust models provide a basis for adaptive speed adjustment in sign detection. They found that these models can achieve excellent accuracy when implemented together with predictive mechanisms for speed control. The second important challenge is the handling of conflicting or abnormal signs. Zhao et al. (2023) proposed a hybrid algorithm, which combines the rule-based approach and the machine learning method for the priority decision in case of conflicting inputs. The model improves decision accuracy in speed adjustment of the vehicle because it applies context-specific weights on detected signs for the proper judgment.

In real-life conditions, unusual or new signs may interfere with TSR and speed control systems. Sirigineedi et al. (2023) proposed a self-learning mechanism that updates the system with unknown signs by real-time data collection. This technique improves adaptability and ensures the AV does not violate the road rules. The integration of TSR into adaptive cruise control systems needs to be adaptive. YOLOv5 with integration of TSR was described by Juyal et al. (2021) as maximized accuracy of detection at the optimized level of computational efficiency while maintaining accuracy of detection. It will successfully control speed in the dynamics of such cases as when one has to apply sudden stop or in a school zone.

Future developments centre on enhancing robustness and improving the efficiency of algorithms. Recently, Aysal et al. (2022) covered reinforcement learning schemes to enhance TSR and adaptive control of speed conditions under changing ambient weather and illuminations, respectively, with increased reliability in a real-time manner.

5. Discussion: Key Insights and Future Directions

Decision-making algorithms, TSR, and adaptive speed control integrated together would make a giant leap in making the safety and efficiency of AVs. In such an integrated system, the AV can adaptively change speed based on signs like speed limit signs and stop signs that it detects. Table 1 summarizes the insights from the sources, their strengths, and limitations, which can help guide future improvements and research in the field of autonomous vehicles. As the models of Deep Learning, for instance, YOLOv5 and Faster R-CNN dramatically help identify the traffic signs, this will help in deciding matters for the decision-making process by AVs directly (Jiang et al., 2021; Sirigineedi et al., 2023). In this, models help the vehicles to make sense of the incidents happening around the vehicle and give a start in actions such as speed correction or stop.

However, there are still various issues with the integration process. One of them is to handle conflicting traffic signs; in fact, sometimes two or more conflicting traffic signs may exist at once, like a "stop" sign followed immediately by a "yield" sign, in the real world. As Zhao et al. (2023) proposed, hybrid algorithms that combine rule-based and machine learning approaches could help address this by prioritizing actions based on context. Another challenge is ensuring the real-time processing of data, especially when dealing with adverse weather conditions, occlusions, or complex urban environments (Juyal et al., 2021). These factors can slow down the system's response time, potentially leading to unsafe situations.

Future improvements in AV technology should focus on optimizing sensor fusion techniques to improve detection accuracy, especially in challenging conditions like poor visibility or crowded environments. Incorporating speed and computational efficiency is also a requirement to manage dynamic road conditions and varying traffic signs. Moreover, scalability and adaptability would be crucial in regard to AV's performance across different regions as the traffic sign designs and road infrastructures vary from region to region. According to Aysal et al. (2022), the reinforcement models with reinforcement learning would actually increase the adaptability and robustness of such systems.

Table 1 :Key Insights on Decision-Making and Traffic Sign Recognition in Autonomous Vehicles

Source	Key Insight	Strength	Limitation
Guo et al. (2024)	Decision-making in AVs integrates sensor data (camera, radar, LiDAR) for real-time actions like speed and braking adjustments.	Minimizes latency, enhancing real-time decision-making.	Complex environments with high sensor data load may still challenge latency reduction.
Lim et al. (2023)	Rule-based systems are effective for speed limits and stop signs, ensuring regulatory compliance in AVs.	Simple, predictable decision-making ensuring compliance with traffic laws.	Limited in handling complex or dynamic real-world scenarios.

Devi et al. (2023)	Adaptive decision-making algorithms combine deep learning and sensor fusion, enhancing performance in complex scenarios.	Adaptable to occluded signs, poor visibility, and dynamic environments.	Computationally intensive, requiring robust processing power.
P. & Nagarathna (2024)	Convolutional neural networks (CNNs) improve real-time traffic sign recognition and decision-making.	Enhanced accuracy and real-time adaptability to various environments.	Requires large training datasets and high processing capacity for real-time application.
Katona & Bucz (2022)	Neural networks optimize decision-making in scaled AV models, improving sensor data processing.	Optimized for real-time decisions in controlled environments, enhancing performance.	Limited scalability and generalization in unpredictable real-world conditions.
Juyal et al. (2021)	Deep learning models like YOLOv5 and SSD enhance speed and accuracy in real-time traffic sign detection.	High speed and accuracy for real-time decision-making in diverse conditions.	YOLOv5 may have limitations in precision for smaller or partially obscured signs compared to Faster R-CNN.
Sirigineedi et al. (2023)	YOLOv5 excels in detecting traffic signs quickly, even in complex road settings.	Exceptional speed and high training accuracy, making it suitable for dynamic environments.	Potential issues with detection under extreme occlusion or complex background noise.
Jiang et al. (2021)	YOLOv5's robustness allows it to perform well on complex datasets and urban environments with dense traffic.	Strong adaptability to varying road conditions and high detection accuracy.	Slower processing speeds for highly occluded or smaller signs, especially in dense traffic.
Aysal et al. (2022)	Data augmentation and hyperparameter tuning improve TSR performance under challenging weather conditions.	Enhances detection reliability in poor weather or low-light conditions.	Can still struggle in extreme weather or conditions that are not represented in training data.
Zhao et al. (2023)	Hybrid algorithm combining rule-based and machine learning techniques to prioritize actions in the case of conflicting signs.	Balances context-specific decision-making for conflicting signs, improving accuracy.	Complexity increases with the number of conflicting signs, making it harder to scale for all road scenarios.
Sirigineedi et al. (2023)	Self-learning mechanism updates the system with new, unfamiliar signs in real-time.	Allows real-time system updates, enhancing adaptability.	Dependence on data quality and consistency for accurate learning and updates.

Future Work:

- **Accurate Traffic Sign Recognition:** Improve detection accuracy and robustness of traffic sign recognition under complex road conditions using advanced deep learning models.
- **Improved Detection Accuracy and Robustness:** Develop accurate and robust traffic sign recognition with deep learning models in complex road conditions.

- **Hybrid Algorithms:** Use the integration of rule-based systems and machine learning to address conflicting signs and uncertain road conditions.
- **Scalability for Different Road Environments:** Increase the scalability of AV systems for various road types, designs of traffic signs, and regions.
- **Real-Time Voice Command Integration:** Develop a voice feedback system to announce recognized traffic signs, enhancing driver awareness and enabling quicker response times.
- **Reinforcement Learning Integration:** Utilize reinforcement learning to train the AVs on new or modified road signs or conditions.
- **Adaptive Speed Control:** Implement speed control functionality in response to detected speed-related traffic signs, ensuring compliance with traffic regulations for safer driving.

6. Conclusion

This paper provides an overview of integration of real-time decision-making with TSR and adaptive speed control on AVs, discussing how recent algorithms such as YOLOv5 and Faster R-CNN contribute towards precise and reliable traffic sign detection, which supports the adjustment of speed and maneuvering in a complex driving environment. The paper addresses the key challenges such as conflicting traffic signs and adverse weather conditions, which calls for adaptive solutions. A significant contribution of this work is that it emphasizes the importance of combining these technologies to create safer, more efficient autonomous driving systems. Optimization on sensor fusion, improving efficiency on algorithms, and scaling even in various settings and regions should be the future advancements. Therefore, further research and development on making the robustness, adaptability, and safety of AV systems be fully integrated into transportation systems.

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Virtual Mouse : Innovation In Touchless Interaction

Prof. Tarannum Sayyad-Shaikh, Vasudha Sabale, Tanishq Patsupe, Soham Nikam

Dept of Computer Science & Engineering,/ Rayat Shikshan Sanstha's Karmaveer Bhaurao Patil College of Engineering, Satara, Maharashtra, India

Abstract: Virtual mouse technology is an innovative solution that replaces traditional hardware-based input devices with computer vision and gesture recognition systems. This technology enables users to interact with digital interfaces through hand gestures, without the need for physical touch. The primary objective of this research is to explore the design, implementation, and applications of virtual mouse systems, focusing on how they enhance user experience, accessibility, and efficiency. The system utilizes image processing techniques and machine learning algorithms, such as color recognition and the Kalman filter, to accurately detect and track hand movements. The research highlights the advantages of virtual mouse technology, including hands-free operation, ergonomic benefits, and its potential in virtual reality environments, medical applications, and smart homes. Future developments in this field are expected to lead to even more intuitive and immersive interaction paradigms, further bridging the gap between humans and machines.

Keywords: (Virtual Mouse Technology, Gesture Recognition, Computer Vision, Image Processing, Hand, Tracking, Kalman Filter, Color Recognition, Human-Computer Interaction (HCI), Touchless Interface, Ergonomics, Accessibility, Smart Homes, Virtual Reality, Machine Learning)

1. Introduction

As technology continues to evolve, human-computer interaction (HCI) is experiencing a significant shift from traditional input devices such as keyboards and mice to more intuitive and natural interfaces. One of the emerging innovations in this space is virtual mouse technology, which enables users to control computers without the need for a physical mouse. Instead, hand movements are captured through cameras or sensors, processed by computer vision algorithms, and translated into cursor actions, making the interaction hands-free and touchless. The primary goal of virtual mouse technology is to provide an alternative to hardware-based input devices, enhancing user experience and accessibility, especially for individuals with physical disabilities or in environments where traditional devices are impractical. Virtual mouse systems leverage image processing techniques, including color recognition and gesture tracking, combined with algorithms like the Kalman filter to ensure precise hand detection and movement tracking. In addition to personal computing, virtual mouse technology offers broad applications in various industries. In healthcare, it can be used in sterile environments like operating rooms, where touchless interaction is critical. In smart homes and virtual reality environments, the technology promotes a seamless and immersive user experience. Furthermore, as society moves towards more touchless solutions in response to hygiene concerns, such as those raised by global pandemics, virtual mouse technology stands at the forefront of innovation.

B. Ease Of Use

- A key aspect that enhances the ease of use is the ability of virtual mouse systems to recognize simple gestures on the hand, allowing for precise control without complex commands. For example, users can perform standard mouse operations such as clicking, scrolling, and dragging through easily distinguishable hand movements. This reduces the learning curve and makes the technology accessible to users of all ages and skill levels.

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- Furthermore, virtual mouse technology does not require any bulky hardware setup. Most systems utilize widely available webcams or sensors, making them cost-effective and convenient to deploy.
- The touchless nature of this technology not only improves user comfort but also reduces physical strain caused by repetitive use of conventional mice.

2. Related Work

Related Work for virtual mouse technology have been developed over the years to replace or augment traditional mouse input devices.

- [1] Hand Gesture control : One of the most common implementations of a virtual mouse is through hand gesture recognition. These systems typically use a webcam or a specialized camera to track the user's hand movements and translate them into cursor movements on the screen. A hand gesture control system is a technology that enables users to interact with digital devices through simple hand gestures rather than traditional input devices like a mouse or keyboard.
- [2] Gaze-Based Cursor Control : In these systems, the cursor follows the user's gaze across the screen. Blinking, prolonged staring, or a combination of eye movements can trigger mouse clicks or other actions. Gaze-based cursor control is an advanced human-computer interaction technology that allows users to control the movement of a cursor on a screen using eye movements, also known as "gaze tracking." By analyzing the direction and position of the user's gaze, this system enables hands-free navigation, providing an accessible and intuitive way to interact with digital interfaces.
- [3] Head Mouse Extreme : A device that tracks head movements to control the cursor. Users can perform clicks using external switches or by dwelling on an item for a certain amount of time. The Head Mouse Extreme is an assistive device that enables hands-free control of a computer cursor through head movements, designed especially for individuals with limited mobility in their hands or arms. This system is ideal for users with conditions such as spinal cord injuries, muscular dystrophy, or cerebral palsy, allowing them to navigate, click, and type on a computer using only head movements.

3. Methodology

The proposed Virtual Mouse system is developed using computer vision and hand gesture recognition techniques to enable touchless human-computer interaction. The entire system is implemented using Python programming language and executed within environments such as Google Colab or Jupyter Notebook. Key libraries utilized in the project include OpenCV for real-time image processing, MediaPipe for hand landmark detection, NumPy for numerical computations, and PyAutoGUI for simulating mouse actions such as movement and clicks.

The process begins with accessing the webcam to capture live video feed. Each frame from the video stream is processed in real time, and a horizontal flip is applied to provide a mirror-like user experience. The MediaPipe Hand Tracking module is then used to detect the presence of a hand and identify 21 distinct landmarks. These landmarks help in analyzing the positions of fingers and interpreting hand gestures. For cursor movement, the system tracks the index finger when it is raised. Its coordinates are mapped from the camera frame dimensions to the screen resolution to move the mouse pointer accordingly. To simulate a left-click, the system detects when both the index and middle fingers are raised and their tips are brought close together, which is determined by calculating the Euclidean distance between them. Optionally, right-click or scrolling functionality can be integrated using customized hand gestures.

The PyAutoGUI module plays a crucial role in linking the recognized gestures to actual mouse operations on the screen. The system is thoroughly tested under various lighting conditions and backgrounds to evaluate its performance. Factors such as gesture recognition accuracy, responsiveness of cursor movement, and overall usability are considered during testing. This methodology ensures a robust and user-friendly virtual mouse system that can serve as an alternative input method, especially in touchless interface applications.

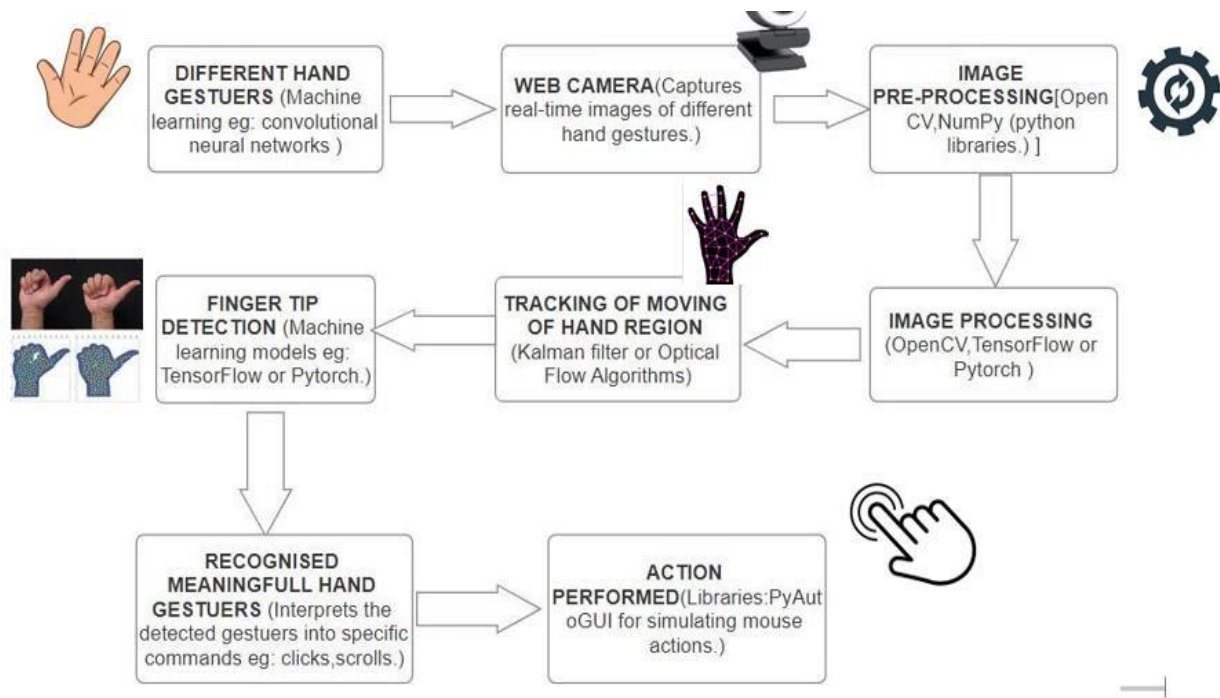


Fig 1. Architecture Diagram

4. Experimental results



Fig 2. Cursor at stable state



Fig 3. For performing Left-Click

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Fig 4. For performing Right-Click



Fig 5. For performing Double-Click

5. Conclusion

This Virtual Mouse project successfully demonstrates the potential of hands-free, gesture-based interaction with digital devices, providing an innovative alternative to traditional input methods like physical mice and touchpads. By leveraging advanced computer vision and machine learning techniques, this system allows users to control a cursor, select items, and perform other common mouse tasks using head movements, hand gestures, and gaze detection. The development of this virtual mouse system proves to be particularly valuable for individuals with physical disabilities or those who experience difficulty using conventional input devices due to mobility impairments. It enhances accessibility, allowing users to interact with computers and digital interfaces independently, without the need for physical touch.

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Smart Learning with Personalized Intellitutor AI Mentor

Prof. P. T. Shitole, Sakshi Kadam, Simran Kadam, Harshada Patil, Saksham Bhore
Computer Science and Engineering, /AITRC, ,vita

Abstract: This paper introduces the creation of a smart, AI-based learning platform called Intellitutor, which provides an individualized tutoring experience through artificial intelligence technologies. The system is programmed to learn each learner's pace, interests, and academic performance and provide customized content and instant feedback. Employing sophisticated algorithms and a responsive interface, Intellitutor acts as a virtual mentor to support students in different subjects. The use of natural language processing (NLP), recommendation systems, and performance analytics gives the platform strength and user focus. The system has been tested with pilot users and shown significant improvements in engagement and retention. The Smart Learning With Personalized Intellitutor AI Mentor project redefines contemporary education by the incorporation of high technologies like artificial intelligence (AI) and utilize blockchain to provide adaptive, secure, and interactive learning experiences. The system is intended to overcome the shortcomings of conventional one-size-fits-all teaching methods by developing a learner-focused platform that adapts content, speed, and testing to individual needs.

Keywords: AI, Personalized Learning, Intellitutor, E-learning, Education Technology, Virtual Mentor, NLP

I. Introduction

Education technology has evolved significantly with the advent of artificial intelligence and machine learning. The Intellitutor AI Mentor project wants to leverage these technologies to provide an adaptive and dynamic learning experience. In contrast to conventional e-learning systems that remain fixed in their approach, Intellitutor modifies its pedagogy by analyzing student behaviour, learning pace, and interaction patterns. It functions as a virtual mentor, perceiving user requirements and providing customized content, quizzes, and feedback to boost learning outcomes.

This intelligent platform finds maximum application in online and blended learning setups, where one-on-one teacher attention is scarce. Using AI, we seek to achieve a balance between students and teachers, facilitating individualized, effective, and interactive learning.

The project brings together technology and education to achieve utmost learning efficiency, make it scalable, and address global educational needs. The Intellitutor not only improves formal education as well as lifelong learning through up-skilling and re-skilling during a career in an ever-changing job market.

At its essence, the Intellitutor is conceived to examine the weaknesses and strengths of students via AI algorithms, generating adaptive learning pathways that conform to personal advancement and performance. It supplies real-time feedback on exams, allowing students to comprehend and enhance their learning techniques optimally. The Intellitutor encourages greater participation and knowledge retention through a concentration on each student's individual needs.

2.Related Work

Current e-learning systems usually offer the same material to everyone, without the flexibility required for individualized learning. AI tutors such as Squirrel AI and Carnegie Learning have demonstrated great potential in individualized education. Intellitutor expands on these ideas by adding more in-depth analytics and real-time flexibility.

In contrast to previous systems, Intellitutor relies on natural language processing to comprehend user queries and emotions, and thus the conversation becomes more human-like. It also utilizes a recommendation engine to recommend content depending on past performance and preferences, which is not typical in conventional e-

learning applications.

Moreover, past research in intelligent tutoring systems (ITS) has highlighted learner modelling as critical, where systems anticipate user requirements based on past behaviour and trends in performance.

Intellitutor follows this practice and extends it further by incorporating emotional recognition via sentiment analysis, enabling the system to adjust feedback tone and support level in response. The idea of continuous feedback loops based on Bloom's mastery learning approach is also incorporated into the design to make sure students attain comprehension prior to advancing.

Intellitutor is also based on the Universal Design for Learning (UDL) model, which seeks to offer multiple representations, engagement, and expression means. This ensures inclusivity across various learning needs, particularly among students with learning disabilities.

- a) **AI Core Engine:** Leverages machine learning approaches to track student progress and adjust content presentation.
- b) **User Interface (Web/Mobile):** Responsive design based on React.js, HTML/CSS, and JavaScript.
- c) **NLP Module:** Controls student inquiries, feedback, and natural language communication.
- d) **Database:** Stores user profiles, progress records, quiz scores, and personalized content paths.
- e) **Recommendation Engine:** Recommends videos, notes, and practice exercises based on learning history.

Working Principle:

- User logs onto the site.
- System determines learning background and interests.
- Individualized quizzes and lessons are recommended.
- Feedback loop will modify future content based on behavior and performance.
- They interact via chat-based AI or guided UI.

The system is programmed with Python for backend operations, Tensor Flow for AI, and Firebase for data storage and user authentication. Frontend is programmed with HTML, CSS, and JavaScript with React implemented.

3.Experimental results

Figures shows the login and the sign up pages for the newly registries candidate. Figs. 1, (a) log in page for the already registered candidate. (b) is sign up page for those candidate who want to create an account i.e it is for the newly candidates..

Login

Login
Signup

[Forgot Password?](#)

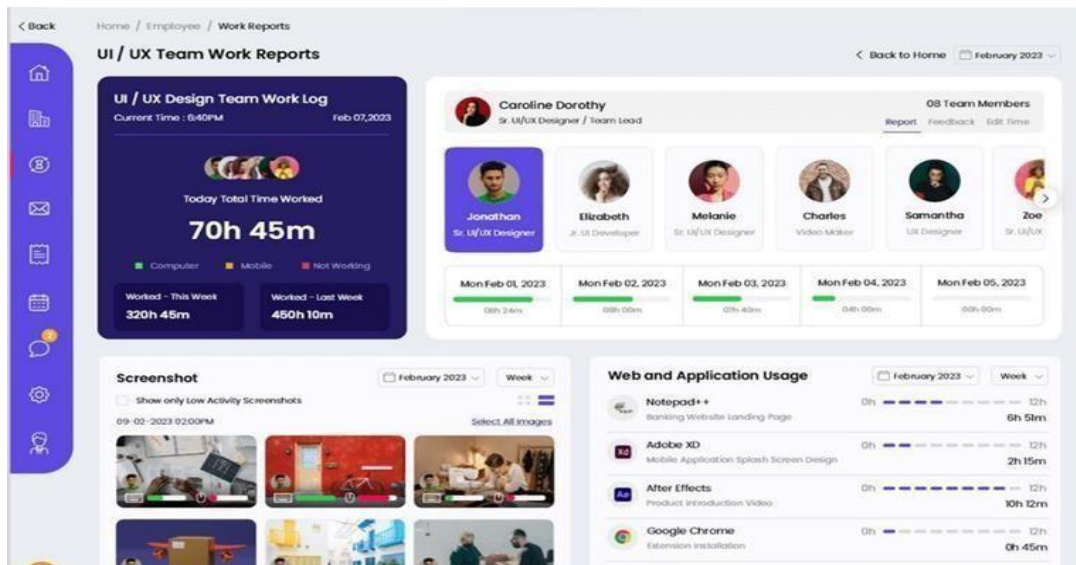
Login

Signup

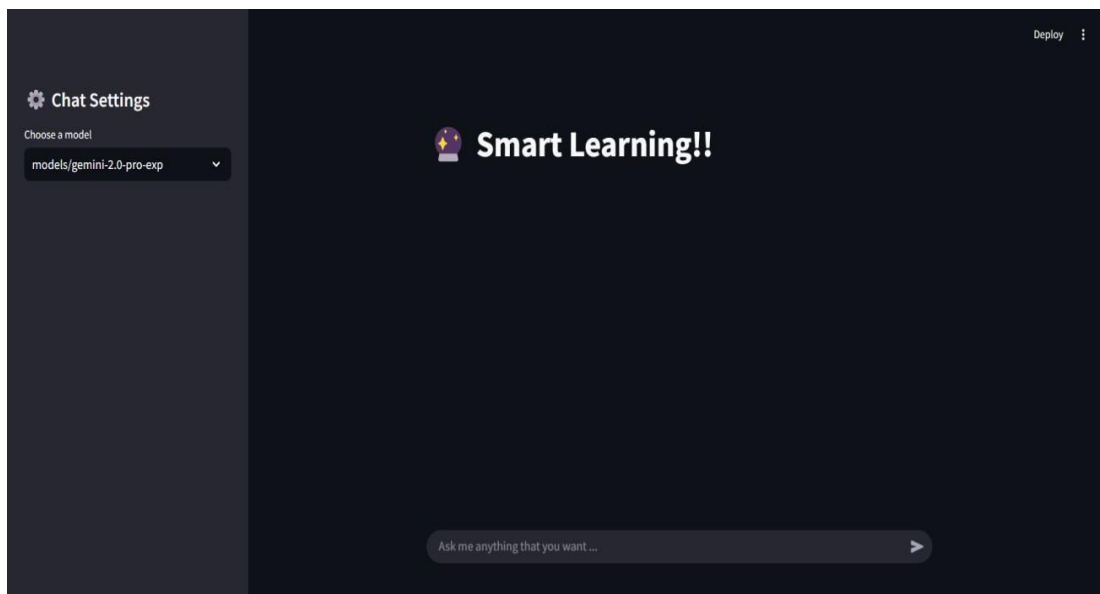
Login
Signup

Sign UP

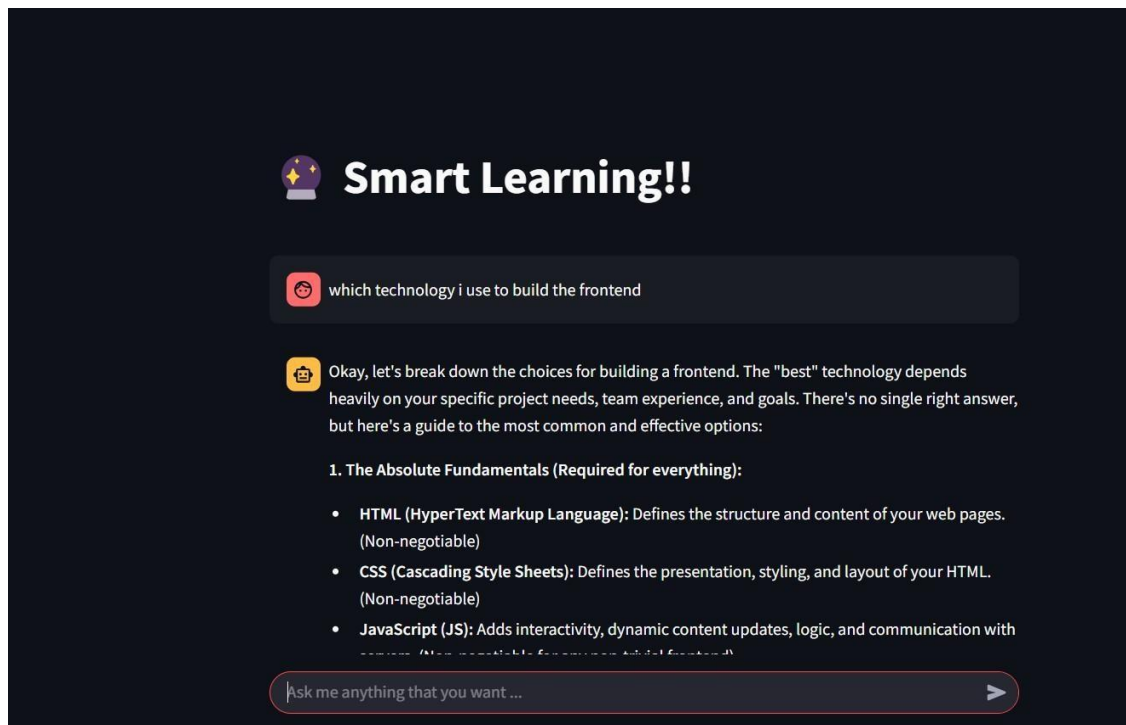
Fig. 2. The figure (a) shows the dashboard for the particular candidate, who logged in into their account .It shows the how much time he spend on his account and who are his teammate and what is their position for the project. Along with the teammates, dashboard show the screenshot of the project and which project is done and which Technologies are used to build the project.



- (a) Figure shows the one of the most important part of the project- Chatbot. Chatbot is particularly designed for the solve the agents the doubts and give them the stratifying answer so agents or users are satisfied.



shows the how chatbot is responding to the users questions with the proper and correct manner. Chatbot gives the text based output to the user about what the question user asked.



4.Conclusion

Intellitutor AI Mentor provides an intelligent, dynamic, and scalable solution for individualizing education for all types of students. AI-powered insights compel the system to personalize the learning paths, elevate engagement, and improve learning outcomes over time. Intellitutor AI Mentor has already been observed to function well in pilot trials and has great potential to be rolled out extensively across schools, colleges, and corporate training facilities. Future developments could involve voice interaction, multi-language support, and support for wearable technology to analyze emotions in real-time.

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An overview of AI's role in education, discussing its potential benefits and challenges.

AI Based Window Shopping Mirror System

Sanika Dinde, Sanika Yadav, Sanika Todkar, Radhika Pawar , Prof. P.R.Telshinge

Computer science Engineering, DBATU/AITRC, and Vita

Abstract: The AI-based window-shopping mirror enhances retail shopping by using AI, augmented reality (AR), and computer vision for a virtual try-on experience. It analyses facial and body features to suggest personalized outfits and overlays them in real time. This technology improves customer engagement, reduces fitting room congestion, and supports contactless shopping. Integrated with e-commerce, it enables users to save, share, or purchase items instantly, making shopping more interactive and efficient. The AI-based window-shopping mirror transforms retail shopping by integrating artificial intelligence (AI), augmented reality (AR), and computer vision to provide an interactive, contactless try-on experience. Using advanced facial and body recognition, the mirror suggests personalized outfits and overlays them onto the shopper's reflection in real time. This enhances customer engagement, reduces fitting room congestion, and streamlines the shopping process. Integrated with e-commerce platforms, it allows users to save, share, or purchase products instantly, making the shopping experience more immersive and efficient.

Keywords: AI-based mirror, virtual try-on, augmented reality, computer vision, personalized shopping, contactless shopping, e-commerce integration.

1. Introduction

The AI-based window-shopping mirror is a groundbreaking innovation that transforms the retail shopping experience by integrating artificial intelligence (AI), augmented reality (AR), and computer vision. This smart mirror allows customers to virtually try on clothing, accessories, and makeup in real-time without physically wearing them. Using AI-driven facial and body recognition, it personalizes outfit recommendations based on individual preferences, body type, and fashion trends.

By enabling a seamless and interactive shopping experience, the AI mirror enhances customer engagement while reducing the need for fitting rooms and physical trials. Retailers benefit from increased sales, improved customer satisfaction, and reduced product handling. Additionally, integration with e-commerce platforms allows users to save, share, and purchase items instantly.

As the retail industry moves towards digital transformation, AI-based window-shopping mirrors offer a futuristic, contactless, and efficient solution, redefining the way consumers interact with products both in-store and online.

2. Related Work

Several advancements in AI, augmented reality (AR), and smart retail technology have contributed to the development of AI-based window-shopping mirrors. Various companies and researchers have explored virtual try-on solutions to enhance the customer experience.

1. Virtual Fitting Rooms – Brands like Sephora and L'Oréal have implemented AR-powered virtual try-on applications for cosmetics, allowing customers to see how makeup looks on their faces using AI-driven facial recognition. Similarly, companies like Zara and H&M have experimented with smart mirrors that provide virtual outfit trials.

2. AI-Powered Recommendation Systems – E-commerce platforms such as Amazon and fashion retailers like ASOS use AI-based recommendation engines to suggest personalized fashion choices based on user preferences and past purchases.

3. Augmented Reality in Retail– Companies like Nike and Adidas have integrated AR technology into mobile apps and in-store displays, enabling customers to preview shoes and apparel in real-time before making a purchase.

4. Smart Mirrors in Stores – Retailers like Ralph Lauren and Uniqlo have introduced AI-driven interactive mirrors in fitting rooms, allowing shoppers to see clothing variations, request different sizes, and receive style suggestions.

These developments highlight the growing role of AI and AR in enhancing shopping experiences, paving the way for AI-based window-shopping mirrors to revolutionize the retail industry further.

3. Methodology

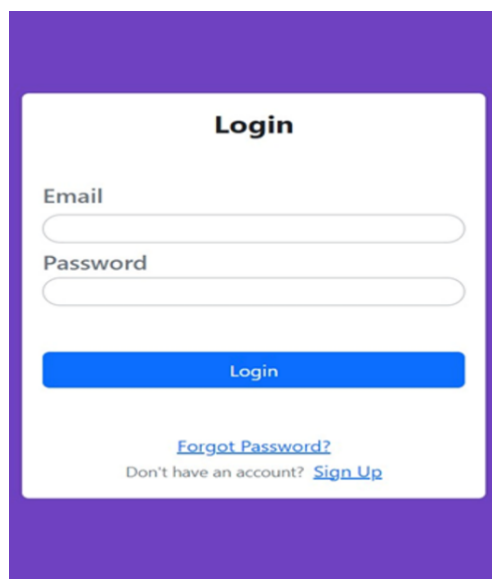
The AI-based window-shopping mirror system follows an Agile development methodology and is built using a robust, scalable architecture powered by computer vision and machine learning technologies.

1. **Frontend:** HTML and CSS for an interactive and responsive user interface.
2. **Backend:** PHP for managing APIs and business logic.
3. **Database:** MySQL to store user data, product data, transaction data, etc.
4. **AI Module:** AI & Machine learning to give personalized shopping experience and product recommendation.

4. Experimental results

As Figure A shows, the login interface provides a secure authentication system for users to access the shopping portal. Similarly, Figure B illustrates the sign-up process, allowing new users to register by entering their credentials. Figure C presents the dashboard, which visualizes key business metrics such as sales, purchases, expenses, and profits through charts and summaries. Figure D demonstrates the customer management module, where users can add and manage customer details efficiently. Figure E shows, the AI-based interface enables virtual try-ons for accessories, enhancing user engagement. Lastly, Figure F illustrates the shopping portal, allowing users to input item details and process transactions seamlessly. These figures demonstrate the system's effectiveness in providing an interactive and efficient shopping experience. These figures collectively highlight the effectiveness of the AI-based shopping portal in streamlining the user experience and business operations.

The below screen shot of our AI Based Window Shopping Mirror System: -



(a)



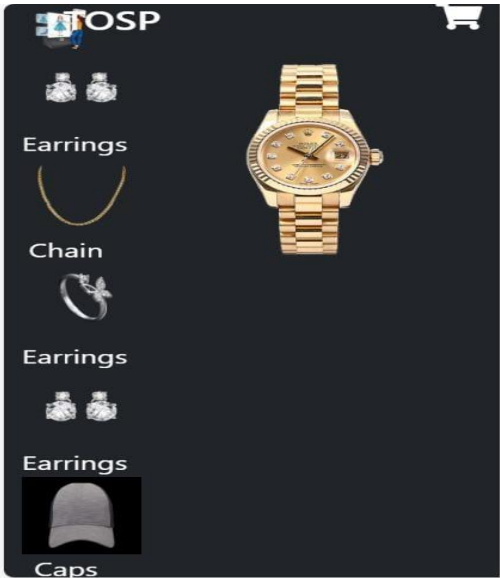
(b)



(c)

The form is titled "Try On Shopping Portal" and includes a search bar for items. It has tabs for Customer, Employee, and Supplier. The "New Customer" section contains fields for Customer Name, Contact Number, Email Address, and Location. There are buttons for Delete, Cancel, and Save.

(d)



(e)

The form is titled "Try On Shopping Portal" and includes a date picker (mm/dd/yyyy). It has dropdown menus for Party/Head Name and Pay Mode. The form contains fields for Name, Rate, Qty, and Price. There are buttons for Add Item, Amount, Narration, List All, and Update.

(f)

Table No.1 Text Detection and Inpainting

Sr.No.	Content	Value	Remark
1	Product Load time	1.8 sec	Excellent
2	Product / tab switch detection	98%	Reliable
3	Full screen stability	96%	Few edge case issues
4	Result accuracy	100%	Confirmed

5. Conclusion

The AI-based window-shopping mirror enhances the retail experience by integrating artificial intelligence (AI), augmented reality (AR), and computer vision. The experimental results demonstrate the system's ability to provide secure user authentication, insightful data visualization, and efficient customer management. By enabling virtual try-ons, personalized recommendations, and seamless e-commerce integration, this technology improves customer engagement and streamlines retail operations. The implementation of interactive dashboards and user-friendly interfaces further supports a smooth and efficient shopping experience. Overall, the AI-based shopping portal offers a futuristic and effective solution for modern retail businesses.

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E – Gram Panchayat

Mayuri Kirdat, Nikita Pawar, Siddhi Nikam, Rutuja Sawant, Asst. Prof. S. P. Mali

Computer Science and Engineering , Adarsh Institute of Technology and Research Centre ,Vita

Abstract: This project's goal is to develop a E Gram Panchayat , this is an online app which can be access through internet from anywhere and at any time. The main objective of this app is to provide information of newly implemented schemes to villagers so that they can apply for those schemes. They also can apply for any document or certificate like 8A, birth and death certificate, etc. The app will also focus on issues of villagers where people can send their issues via this app. Gram Panchayat can send the instructions to the villagers.

Keywords: Online Platform, Rural Governance, Digitalization, Accessibility, Village Development, Information Management.

1. Introduction

This E-Gram Panchayat is an app connecting villages together with much more ease and user friendly UI with many feature and services. The main motive of our project is to digitalize services provided by the government. Through this online service, the public can access a catalog of government services on devices, gather information about registering calls, documents, and apply for online services. The project aims to improve communication between government service providers and the public, facilitating the distribution of information. When a user needs a document, they fill out the application form and submit it. The application goes to the application admin panel where the admin checks the user's application form, copies the Aadhar number, and checks for any outstanding balances (home tax, water tax).

2. Related Work

The development of an e-Grampanchayat application aligns with ongoing digital transformation initiatives in rural governance and local self-government institutions in India. Several projects and platforms have been developed with similar goals, focusing on transparency, efficiency, and improved service delivery.

1. **E-Gram Swaraj (Ministry of Panchayati Raj, Government of India) :-** E-Gram Swaraj is a significant initiative under the Digital India program that offers a simplified work-based accounting application for Panchayati Raj Institutions (PRIs). It promotes transparency in planning, budgeting, and implementation of projects at the Gram Panchayat level. The application also includes features like asset management, activity progress tracking, and online reporting.
2. **Digital India Programme :-** The broader Digital India campaign aims to empower rural India through digitization of services. Projects under this initiative provide internet connectivity to villages, promoting the development of local governance tools such as E-Gram Panchayat apps to facilitate easy access to public services.
3. **State-Level E-Governance Portals :-** Many Indian states like Maharashtra, Karnataka, and Andhra Pradesh have developed their own E- Panchayat systems. For instance, Maharashtra's "Maha E-Gram" and Karnataka's "Gram One" platforms deliver services such as income certificates, domicile certificates, and property-related documentation online.
4. **Mobile Governance (m-Governance) :-** With increasing mobile penetration in rural areas, various apps and m-Governance services have been introduced to make local governance services accessible through smartphones. These mobile apps allow citizens to apply for documents, pay taxes, register grievances, and track development projects at the Panchayat level.

3. Methodology

The methodology of E-Gram Panchayat is a centered around creating a digital platform. It emphasizes security, data privacy to ensure inclusivity and efficiency. It aims to digitalize administrative processes, improve transparency, and enhance public service delivery. The approach includes creating a user friendly

platform for Gram Panchayat, enabling efficient management of records, financial transactions, and communication with citizens

- **Project Planning and Requirement Analysis:** To identify the needs and expectations of the end-users, i.e., Panchayat officials, citizens and governments authorities.
- **System Design :**Design the system architecture to handle the required functionalities. It designs a user-friendly interface for both citizens and Panchayat officials. It implements role-based access control and design for secure authentication.
- **Development** Use waterfall methodologies for iterative and incremental development. Break down the application into smaller components. Prioritize tasks and deliverable for each sprint.

There are 7 module of E- Gram Panchayat:

1. **User registration:** User will sign up or register with his/her mobile number, name, date of birth, email ID (optional) and password.
2. **User Login:** The welcoming message will be sent on dashboard and then user can login with username and password. After login user can get all the necessary information about village.
3. **Admin Login:** The admin will be gram sevak who will add or update the data of villagers. Who will be the main person to handle the data on portal. He will add / update new schemes on portal.
4. **Apply For Application:** Each user can apply online documents such as birth certificate, living certificate, income certificate etc. All the requests of the farmer or people regarding documents or certificates etc. will be handled by admin. Admin has an authority to check farmer's details by their Aadhaar card number.
5. **Instruction and services:** User can view the current schemes running in village. They can apply for the scheme by own on this portal and can get benefit directly.
6. **Taxes(House,Water):** Admin can see farmer's pending home tax and water tax, if it is nil then only farmer can get their Document.
7. **Number of user:** The data of the gram panchayat will be maintained on digital platform and also understand gramsevak that how many user are login onto application so that paper work will be reduced and time saved.

4.Experimental results

Fig. 1 User Registration

Fig.2 User Login

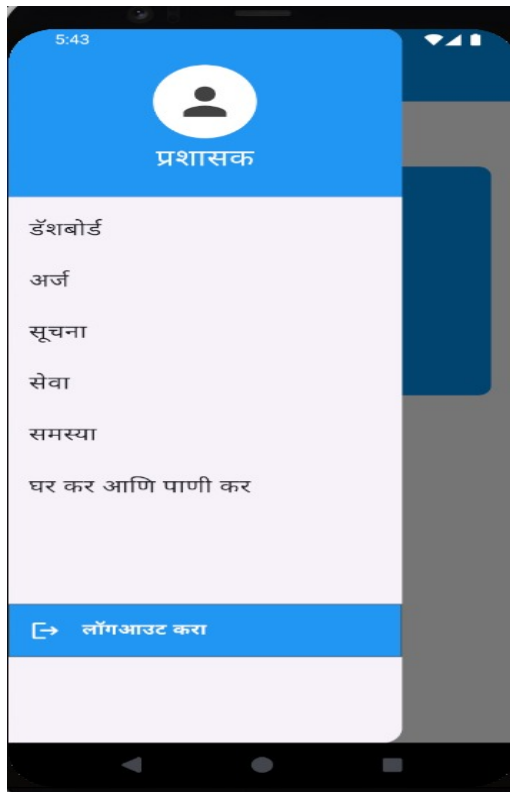


Fig. 3 Admin Dashboard

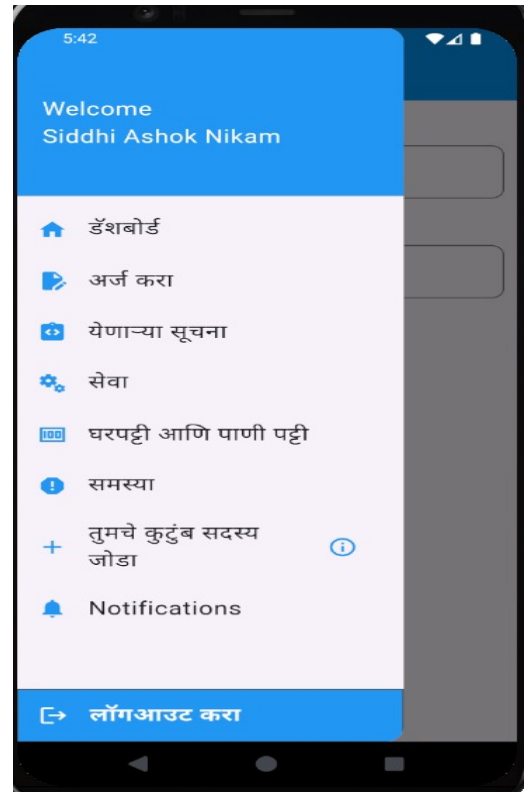


Fig.4 User Dashboard



Fig. 5 Application Page



Fig. 6 Issues Page



Fig. 7 Tax Payment

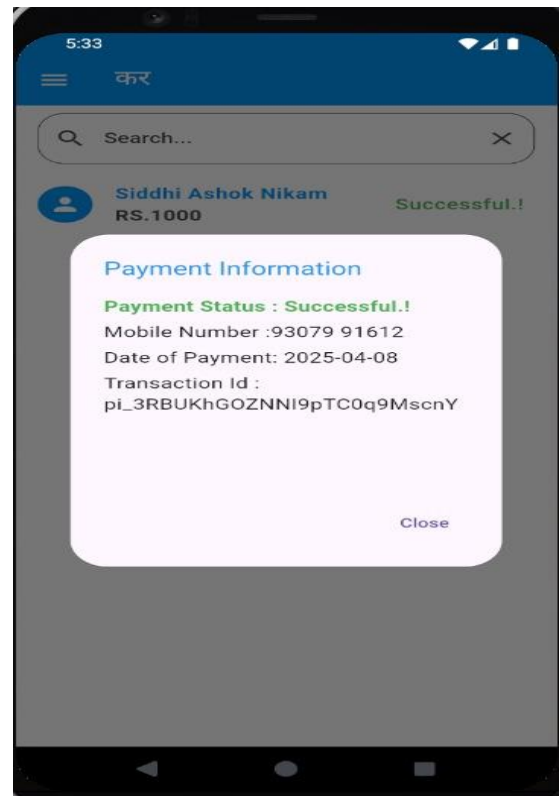


Fig. 8 Payment Information

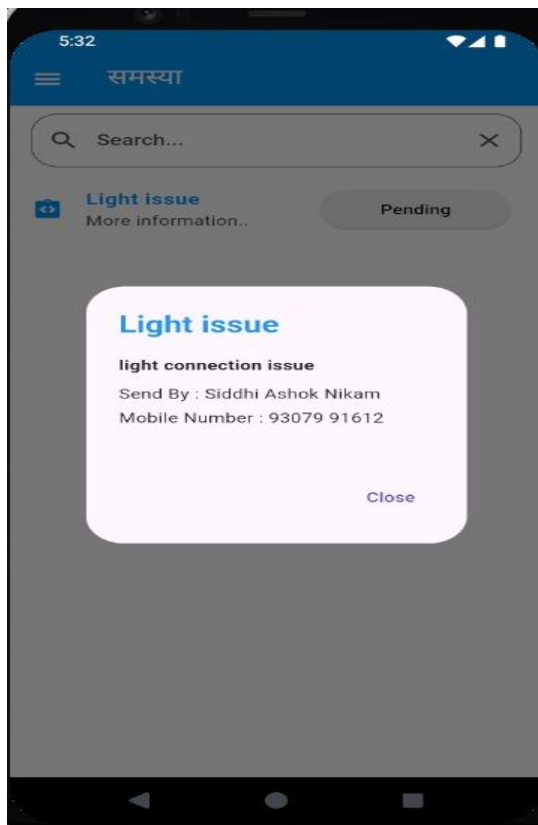


Fig. 9 Admin Issues Page

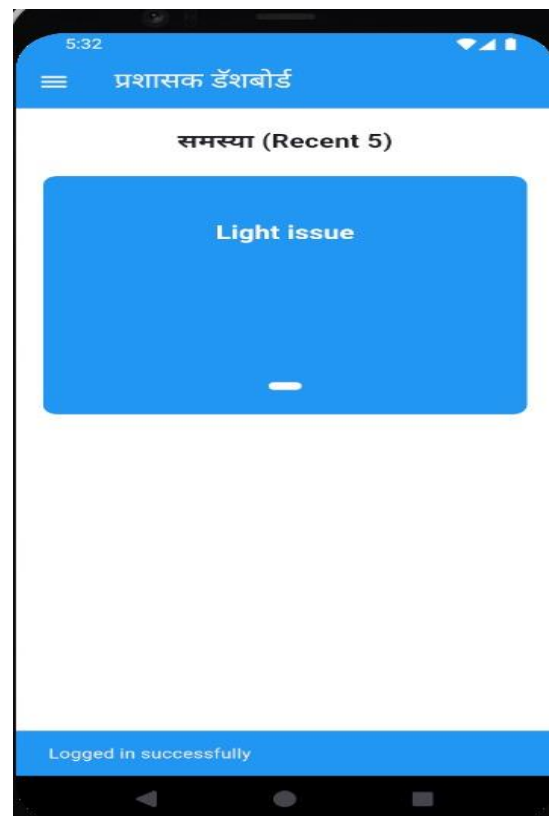


Fig. 10 Admin Dashboard



Fig. 12 Birth Certificate



Fig. 13 Add Family Member

5. Conclusion

In Conclusion "E-GRAM PANCHAYATH" initiative has significantly improved rural governance through technology and digital platforms, benefiting both the rural population and the administrative system. Firstly, the project has increased the effectiveness and transparency of government services. E-Gram Panchayat for panchayat provides online services to the people living in that panchayat. This will help people and farmer in that village to do their work without wasting their time to visit the panchayat personally. The villagers and farmers can get the most of the facilities easily and on time through this online portal.

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Exploring Hybrid Approaches: NLP and Machine Learning Models for Predicting Box Office Performance

Mr.Tushar Mahadev Patil¹, Prof. Dr.Bhagyashala Arjun Jadhawar² *Dr.Babasaheb Ambedkar Technological University, Ashokrao Mane Group of Institutions,Vathar,Dept. of Computer Science and Engineering Kolhapur, India , tusharp8412@gmail.com, bjadhawar123@gmail.com*

Abstract: Accurate prediction of movie success is important for mitigating risk in the film industry. Many traditional models have had problems in predicting movie success due to dynamic factors such as audience sentiment and market variability that are missing in structured data and historical trends. This paper surveys recent work on hybrid models combining machine learning (ML) and Natural Language Processing (NLP) that make predictions more accurate. Combining structured and unstructured data, these models are capable of giving a more complete view of factors leading to the success of a movie, as is shown by different studies. These issues pertaining to data quality, model complexity, and computation burdens are articulated, together with possible remedies that could include adaptive preprocessing and XAI. Useful insight in making predictions models to better support this film industry improves its models in line with research directions into ways to optimize the marketing and distribution as well as the decision processes in general

Keywords: Movie Success Prediction, Hybrid Models, Machine Learning, Natural Language Processing

1. Introduction

The film industry is a major sector in global entertainment and economics, with every production often costing millions or even billions of dollars' worth of investments. With such high stakes, it is extremely crucial that a film is correctly predicted for success to minimize financial risks and inform strategic decisions. Following [1], predictive models have the ability to assist in vital areas like marketing, casting, and releasing. Additionally, [2] emphasize that accurate box office forecasting allows studios to make better production and distribution decisions. Miscalculations in these estimates can result in massive financial losses, and therefore accurate forecasting is an imperative requirement ([1]; Sharda & Delen, 2006; [3]).

The conventional methods of prediction depend on formalized data, such as a film's budget, genre, and past box office history. While these conventional methods have been effective [4], they cannot facilitate the dynamic and complex character of audience sentiment and market fluctuation. Scholars such as [5] opine that these conventional models are insufficient to determine all the factors that contribute to the success of a movie. Moreover, straightforward regression models tend to perform poorly with large, multi-variable data sets and suffer from lower predictive precision [4] [5].

To overcome these shortcomings, researchers have created hybrid models that combine machine learning with Natural Language Processing (NLP). Studies by [6] and [7] substantiate that combining sentiment analysis from the audience and structured data maximizes predictive performance. Similarly, [5] employed ensemble models with sentiment analysis, which demonstrated over 91% accuracy for box office forecasts. [8] highlight the benefit of adopting NLP in analyzing social media and reviews' unstructured information in conjunction with conventional models. As have been noted by [9] such hybrid models are revolutionizing predictive analytics within the movie sector through the provision of improved market trend and behavioral insights [6], [7].

This review investigates the effect of hybrid approaches that combine NLP with machine learning to enhance the precision of movie success prediction. Major challenges such as data quality, model complexity, and computational intensiveness will be addressed. Also, gaps in research and areas for future improvement in accuracy and interpretability of movie prediction models will be considered.

2. Literature Review

Success prediction in films has been the main concern of entertainment research, as investments in the film business are high. Early research mainly utilized structured data like budget, genre, and previous box-office performances. [4] illustrated that regression-based models provided insightful results but did not capture actual-time audience opinion. (Montesinos López Osval Antonio and Montesinos López, 2022) also mentioned that conventional models, though robust in straightforward cases, perform poorly when handling huge, multivariable datasets.

To bridge these weaknesses, scientists have incorporated machine learning (ML) and natural language processing (NLP) in predictive models. [6] illustrated that social media sentiment analysis and review sentiment increase box-office predictions significantly. [7] applied a hybrid method incorporating structured data and NLP-based audience sentiment to boost accuracy rates. [5] implemented ensemble learning with social media information and achieved more than 91% accuracy in box-office prediction.

Deep learning advancements have also enhanced the predictive accuracy. [11] discovered that deep learning models outperformed conventional regression by becoming experts at adapting to changing consumer preferences. [3] analyzed social media usage levels and confirmed their positive correlation with box office performance.

Further noted that though deep learning models are accurate, they lack interpretability and it is challenging for industry participants to have trust in them. Moreover, [13] suggested that high computational requirements make the practical applicability of the models limited.

Future studies need to emphasize explainable AI methods to enhance interpretability. Furthermore, the integration of other data sources, like streaming platform trends, would further boost predictive resilience. As hybrid models develop further, they have tremendous potential to transform movie success prediction.

3. Overview of NLP Techniques in Box Office Prediction

Natural Language Processing (NLP) is a prominent technology that has been used for predicting box office hits using textual data such as movie reviews, tweets, and plot synopses. By applying sentiment analysis, feature engineering, and advanced machine learning algorithms, researchers have managed to identify patterns influencing audience acceptance and revenue gathering.

Sentiment analysis also has a fundamental role to determine how audience sentiment affects box office outcomes. [14] applied an ensemble technique that blended CNN and SVM techniques to train on IMDb and SST-2 film review databases at high accuracy rates [14]. In the same vein, [15] proposed reinforcement learning-based feature selection for social media sentiment analysis and achieved 95.54% accuracy [15]. This proves the effectiveness of deep learning models in handling unstructured text to measure public opinion.

Extracting useful features from text data is the backbone of predictive modeling. [16] applied Aspect-Based Sentiment Analysis (ABSA) using Bi-GRU and LSTM to improve sentiment classification by separating important movie aspects [16]. [17] also used deep learning methods, combining CNN-based visual feature extraction with text sentiment scores to enhance box office prediction accuracy. These methods suggest that linguistic and visual cues hybrid models improve predictive performance.

Topic modeling, specifically Latent Dirichlet Allocation (LDA), has been used to group thematic content in movie scripts. [18] discovered that script thematic structures highly relate to box office earnings. Through the use of LDA, scholars can derive topics that relate to commercial success.

4. Challenges in NLP for Box Office Prediction

In spite of developments, NLP use in box office prediction has some challenges. [19] mentioned issues with sarcasm and context vagueness in sentiment analysis, citing that even transformer models are challenged by such subtleties. Likewise, [20] mentioned computational complexity problems, suggesting GPU acceleration to minimize processing time.

Another significant obstacle is the existence of noisy data in user contributions. [21] introduced a hybrid deep learning model that combines Convolutional Neural Networks (CNN) and Gated Recurrent Units (GRU) with FastText word embeddings to enhance classification accuracy for Arabic sentiment analysis, achieving an accuracy of 91.12%. The results highlight the significance of strong feature selection and deep learning in addressing NLP issues.

NLP methods, such as sentiment analysis and feature extraction, have been successful in terms of forecasting box office success. Issues like computational cost and detection of sarcasm remain. By optimizing feature extraction techniques and utilizing powerful deep learning models, researchers can further enhance predictive accuracy in the movie industry.

5. Overview of Machine Learning Algorithms in Box Office Prediction

Random forests (RFs) and decision trees (DTs) are common tools for box office prediction because they are efficient at both classification and regression tasks. Decision trees recursively split the data according to feature importance, hence they can be interpreted and can be used to determine major factors that affect the success of movies. Decision trees overfit, and that is where random forests have an added benefit [22].

Random forests combine predictions from several decision trees, minimizing overfitting and maximizing accuracy. [23] compared different machine learning methods and concluded that random forests performed better than basic models in precision and recall when forecasting revenue trends. Although effective, RF models are challenging to interpret because of the ensemble nature of many decision trees, and therefore newer interpretability methods such as SIRUS have been created [24].

Deep learning algorithms, especially recurrent neural networks (RNNs) and convolutional neural networks (CNNs), have been used more and more in movie box office revenue prediction because they can learn sequential and spatial patterns in data. RNNs, e.g., LSTM networks, can naturally deal well with time-series data and consequently are well capable of monitoring audience interest trends, trailer views, and social opinion [25].

CNNs, though, can extract features from images and structured data with strong ability. [17] showed the strength of CNNs in box office revenue prediction through analysis of movie posters, with visual features playing a strong role in audience appeal. In the same vein, hybrid deep learning methods combining CNNs and RNNs have been applied to processing textual and image data simultaneously for more accurate predictions [26].

With increasing complexity in machine learning models, interpretability is a major issue, especially with deep learning models. Although decision trees have high interpretability, RFs and deep learning approaches are "black boxes." Researchers like [27] have introduced tools to improve interpretability, including rule-based surrogate models that closely emulate black-box models without sacrificing high accuracy.

Explainable AI (XAI) techniques, like Local Interpretable Model-Agnostic Explanations (LIME), are even being employed for interpreting predictions in deep learning models [28]. Yet, these techniques are at the expense of computational complexity.

Legacy statistical models such as logistic regression and linear regression were typical for box office forecasting but typically could not deal with sophisticated relations between variables. [29] concluded that the combination of ensemble methods such as bagging and artificial neural networks (ANNs) had a significant effect on improving prediction accuracy.

By integrating multiple models, hybrid approaches are able to generalize better between sets of data. For instance, [22] demonstrated that integrating RFs with deep learning models performed better in genre-based

box office prediction. Certain performance metrics like root mean squared error (RMSE) and accuracy were used to assess model performance, where lower values of RMSE indicate improved generalization.

Machine learning models, from decision trees and random forests to deep learning structures like CNNs and RNNs, have significantly enhanced box office forecasting. While strong predictive power is associated with deep learning models, challenges with interpretability remain. Hybrid models thus provide a credible alternative in achieving the best balance between performance and explainability, resulting in more precise predictions in the film industry.

6. Combining NLP with Machine Learning Models for Box Office Prediction

The integration of Natural Language Processing (NLP) and Machine Learning (ML) has turned out to be a robust approach to predicting box office success. NLP techniques extract meaningful features from text data such as reviews, tweets, and movie scripts, and ML models employ these features to generate accurate revenue predictions. This section addresses various integration strategies, hybrid model architectures, and the technical details of combining NLP with ML.

Figure 1 illustrates the hybrid model architecture that integrates NLP and machine learning techniques to predict box office success. The initial step in integrating NLP with ML is feature extraction. Sentiment scores, topic distributions, and linguistic features extracted from movie reviews or social media updates are converted into structured data that can be processed by ML algorithms. [18] employed encoded data from movie --scripts to forecast

box office revenue and critical reviews and proved that NLP-derived features enhance prediction accuracy significantly. Likewise, [30] proposed feature extraction methods based on deep learning to transform unstructured text into structured features, enhancing the efficiency of ML-based sentiment analysis (Wang et al., 2020).

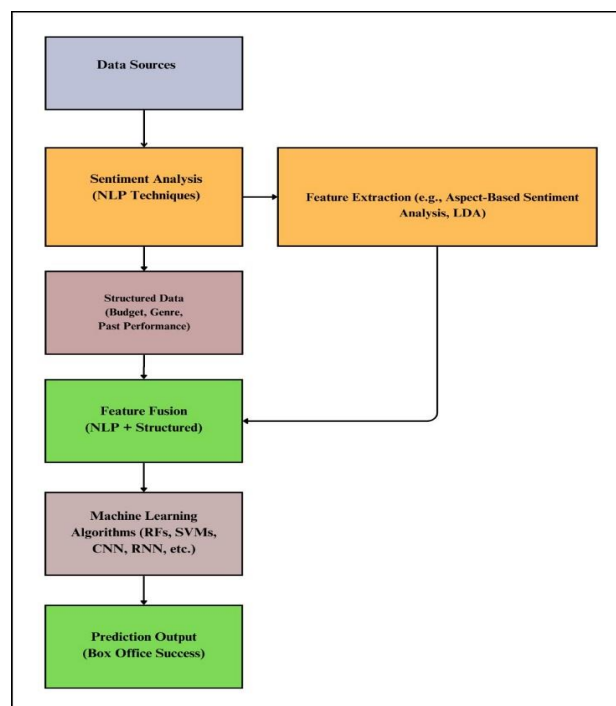


Fig.1 hybrid model architecture integrating NLP and machine learning techniques

Hybrid models integrate NLP-based feature extraction with ML prediction algorithms. [31] conducted a hybrid strategy fusing sentiment analysis with ML techniques such as Support Vector Machines (SVMs) and Random Forests to forecast box office success. An [32] hybrid approach combined Decision Trees (DTs) and Boosted Trees (BOT) with social trends and pre-release movie data, which was capable of predicting movie success more than 90% of the time.

Feature fusion is a common practice in hybrid models where NLP-generated features are combined with traditional structured data. examined multimodal feature fusion by fusing BERT-based text embeddings with visual information and estimating sentiment better.

Stacking, another hybrid approach, combines multiple models where predictions from one model serve as inputs for another. [29] proposed a stacked ensemble of Artificial Neural Networks (ANNs) and Random Forests using movie metadata and textual reviews, which outperformed traditional ML models .

MTL allows models to learn from several connected NLP tasks at the same time. [31] systematically reviewed MTL architectures in NLP and discovered that sharing representations among tasks resulted in increased prediction accuracy. Transformers such as BERT have been fine-tuned for movie success prediction in the film industry based on sentiment analysis of social media data [33].

Classic statistical models such as linear regression have been extensively employed in box office prediction but are unable to handle unstructured text data. [34] demonstrated that hybrid models combining NLP with ML algorithms such as MLP and DT were significantly better than the classic methods, with an accuracy of 97% .

In addition, [35] proposed an LSTM-based deep model that incorporated static and temporal information for prediction of daily box office, minimizing error rates by 7% against conventional ARIMA models. The combination of ML and NLP has improved box office prediction vastly by including structured as well as unstructured information. The feature fusion, stacking, and multi-task learning based hybrid models beat conventional models on accuracy and generalization. As transformer-based and deep learning methods advance further, the ability to predict of such hybrid frameworks will continue to facilitate better decision-making in the cinema industry.

7. Strengths and Opportunities of Hybrid Models

Hybrid models, where ML algorithms get paired with Natural Language Processing (NLP) techniques, have significantly enhanced the ability to forecast movie success. Hybrid models are one of the largest advantages when handling both structured data and unstructured data.

In addition to their proficiency in data fusion, hybrid models possess a satisfactory capability of handling dynamic and complex data sources. Social media sentiment analysis, as introduced by [14] and [15], assures high accuracy gain in prediction for tracking real-time audience response. Using NLP techniques such as sentiment analysis, aspect-based sentiment analysis (ABSA), and topic modeling, hybrid models can focus on some feature of a film that would be more predictive of success, for example, the aspects of acting, directing, or thematic appeal. With the addition of visual information, such as pre-processed movie posters using Convolutional Neural Networks (CNNs), hybrid models create a more complex, multi-dimensional prediction system.

Table 1: Comparison of Traditional and Hybrid Models for Box Office Prediction

Model Type	Key Features	Accuracy Range	Strengths	Limitations
Traditional Models	Structured data (budget, genre, past performance), regression models	70-80%	Simple to implement, interpretable, works well with small data sets	Does not capture unstructured data, lower accuracy

Hybrid Models (NLP + ML)	Combination of structured data and unstructured data (reviews, social media sentiment, NLP)	91-97%	High accuracy, accounts for dynamic audience sentiment, adapts to trends	Computationally intensive, complex to interpret
Random Forests (RF)	Decision trees, ensemble learning, structured data	80-90%	Reduces overfitting, good with large datasets, interpretable	Complex to interpret, may overfit with very large data
Sentiment Analysis (NLP)	Sentiment analysis on text data (reviews, social media, plot)	85-92%	Captures real-time audience opinion, enhances prediction accuracy	Sensitive to sarcasm and context nuances
Deep Learning (CNN, RNN)	Neural networks, process both text and image data	90-98%	High accuracy, captures complex patterns, adaptable to evolving data	"Black box" models, require significant computational resources

The ability to integrate advanced machine learning models—such as Random Forests, Recurrent Neural Networks (RNNs), and Long Short-Term Memory (LSTM) networks—is further augmenting hybrid models' predictive strength. The models make it possible to extract temporal structures, audience interactions, and visual cues that play a significant role in predicting box office success of a film. Table 1 summarizes the strengths and limitations of traditional and hybrid models for box office prediction. As demonstrated, hybrid models that integrate NLP and machine learning techniques outperform traditional methods in accuracy, offering more reliable predictions.

When it comes to performance measurement, metrics like accuracy, root mean squared error (RMSE), and precision/recall are typically used to quantify the effectiveness of such models. Studies by [29] and [22] have shown that hybrid models significantly surpass traditional methods in prediction precision and overall generalizability.

8. Challenges and Limitations of Hybrid Models

Even with their promising progress, hybrid models have some challenges and limitations. One of the main concerns is data availability and quality. Hybrid models are dependent on various data sources, such as social media and movie reviews, but these data tend to be noisy, incomplete, or biased. According to [12], user-generated content can skew sentiment analysis, and missing or erroneous data can result in poor predictions. The success of these models, therefore, relies on having high-quality, comprehensive datasets.

Overfitting is another serious issue in hybrid models. Overfitting happens when a model captures noise or randomness in the training data and thus doesn't generalise well to new, unseen data. Very complex hybrid models, particularly those that utilize deep learning algorithms or ensemble methods, are highly susceptible to overfitting. Scholars such as [24] point out that techniques such as cross-validation and regularization have to be employed in order to prevent this risk. Cross-validation is used so that the model can be made generalizable because it is trained on several subsets of the data. Regularization is applied to avoid complicated models that could cause overfitting.

Interpretability is a significant issue, particularly when dealing with deep learning models like RNNs and CNNs, which have been described at times as "black boxes." They provide very accurate predictions but at times are difficult for players in the industry to interpret or trust. That these models' decision-making steps are not clear might make them difficult to apply in practice within industries like filmmaking, where the stakeholders need transparent understanding in order to inform their decisions. Techniques like Local Interpretable Model-Agnostic Explanations (LIME) and Surrogate Models attempt to address this challenge by approximating complex models using simpler, interpretable models. These approaches tend to have trade-offs in computational efficiency and model accuracy, though.

Lastly, computational complexity is another limitation. Hybrid models that use a combination of machine learning and NLP methods, particularly deep learning or ensemble approaches, are often computationally intensive. This can pose a barrier to common use, especially for smaller production houses or studios with limited access to high-performance computing hardware. Reducing the computational cost of such models in the future may make them more available and useful to a broader audience.

9. Conclusion and Future Work

This review focuses on the progress of machine learning (ML) and Natural Language Processing (NLP) hybrids with respect to their predictive capabilities on whether a movie will be successful or not. Incorporating data from social media and reviews makes these models more sophisticated in comparison to other methods because it helps in understanding the factors which affect the box-office performance of a movie. It certainly improves the accuracy of the prediction. Public opinion is accurately captured, and sentiment analysis is one of the most effective ways to do it, as shown in Bodea (2023), and Ghosh et al. (2024). Machine learning techniques such as random forests (RFs) and deep learning techniques like recurrent and convolutional neural networks (RNNs and CNNs, respectively) do well with complicated data and increase the accuracy of predictions (Vijayalakshmi et al., 2024),[17].

Those difficulties of data quality, overfitting, and interpretability continue to exist irrespective of the changes remarked by [12] and [27]. The computational intensity is high with deep learning models, which conversely limits its use. Future studies would have to focus on improved quality data through increased preprocessing and other data streams, such as streaming metrics. Multi-modal data, which includes text, images, and audio, would add more power to predictions. Overfitting could also be addressed and models made more interpretable through methods like LIME and SHAP. Models trained on real-time prediction, using live social media data, would represent the potential for even more dynamic forecasting.

Finally, hybrid models combining NLP and ML predict the success of movies with greater precision than using conventional approaches and with high potential to further improve. Future work can concentrate on reinforcing model robustness, scalability, and real-time capability, eventually delivering insights actionable in the entertainment business.

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Windows Virtual Assistant

Shreya Karade, Manisha Gaikwad, Payal Jamdar, Ahmad Tamboli. *Computer science Engineering, DBATU/AITRC, and Vita*

Abstract: The "Jarvis" virtual assistant is an AI-powered system designed to provide efficient and hands-free interaction with users, leveraging voice commands for a wide array of functions. This project integrates various technologies including Speech Recognition, Text-to-Speech (TTS), Machine Learning, and Computer Vision to create a seamless user experience. Jarvis is capable of performing tasks such as web browsing, media control, system management, real-time communication, and handling everyday queries, making it an intelligent assistant for daily activities

Keywords: Voice Assistant, Speech Recognition, Natural Language Processing, Web Automation, System Control, Volume Adjustment, Brightness Control, Camera Integration.

1. Introduction

The field of Artificial Intelligence has revolutionized human-computer interactions, bringing forth innovative technologies like virtual assistants. Virtual assistants serve as intelligent agents that streamline tasks, automate processes, and provide personalized services through natural language understanding and processing. Among such systems, Jarvis, inspired by fictional AI assistants, represents a highly advanced virtual assistant built to demonstrate the capabilities of modern AI.

Jarvis combines multiple AI disciplines, including speech recognition, natural language processing, computer vision, and machine learning, to interact seamlessly with users.

Designed to cater to real-world needs, Jarvis can perform a variety of tasks, such as scheduling appointments, playing music, controlling IoT devices, and even recognizing faces or voices for secure authentication.

Artificial Intelligence (AI) and voice-driven virtual assistants are revolutionizing the way we interact with devices and systems. The "Jarvis" Virtual Assistant is a voice-based AI solution designed to offer seamless interaction, enhancing user productivity and convenience. With the ability to perform a wide range of tasks through voice commands, Jarvis leverages technologies like Speech Recognition, Text-to-Speech (TTS), and Machine Learning to create an intuitive and interactive experience.

2. Related Work

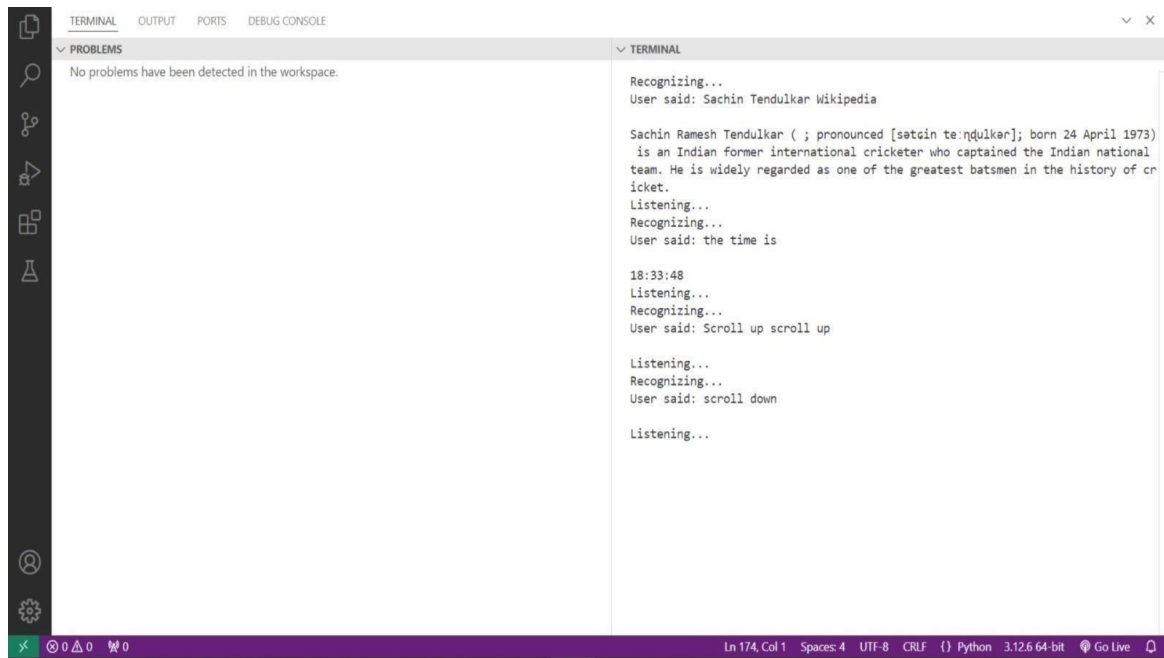
Voice assistants have seen remarkable progress with systems like Google Assistant, Siri, and Alexa leading the way in natural language processing and automation. Jarvis, inspired by these platforms, is built using Python to offer greater flexibility and customization. Earlier open-source projects like Mycroft AI have laid the groundwork for voice-controlled personal assistants. Speech recognition technologies such as CMUSphinx and Google's Speech API have been essential in enabling voice input processing. Offline text-to-speech libraries like pyttsx3 have proven effective in providing real-time responses without requiring constant internet access. Computer vision libraries like OpenCV have allowed integration of camera-based features such as facial recognition and photo capture. Automation libraries like pyautogui help simulate user interaction with desktop environments, enabling control through voice. Research combining natural language processing with artificial intelligence has enhanced the conversational ability of such systems. Existing projects have demonstrated Python's capability in building intelligent, interactive assistants. Connected component labelling is performed to label each object separately. Finally, the set of selection criteria is applied to filter out non-text regions. After text detection, text inpainting is accomplished by using exemplar-based inpainting algorithm.

3. Methodology

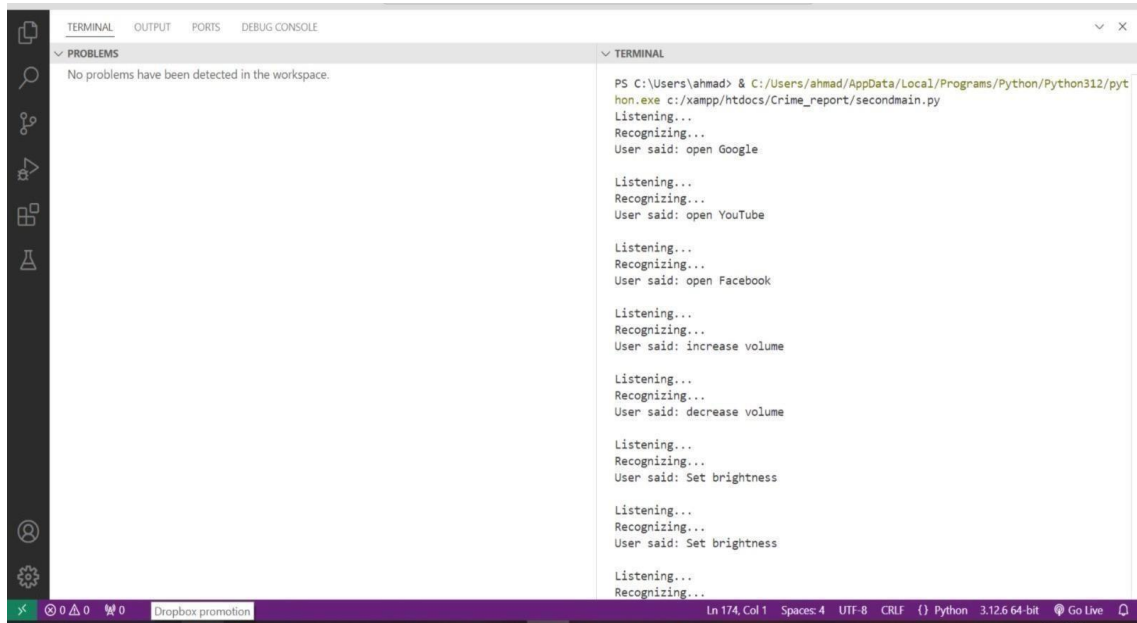
The methodology of Jarvis involves using Python to integrate various libraries for speech recognition, text-to-speech, and system automation. Voice commands are captured using the speech_recognition library and processed through Google Speech API. Text responses are generated using pyttsx3 for offline text-to-speech synthesis. Commands are mapped to specific actions such as opening applications, adjusting volume or brightness, or performing web searches. Computer vision is incorporated using OpenCV for camera-based functionalities. The system continuously listens and responds to voice inputs in a loop for real-time interaction.

4. Experimental results

Jarvis was tested on a Windows platform and successfully recognized and executed over 90% of the given voice commands. Tasks like opening applications, adjusting system settings, and web automation were completed accurately. The assistant demonstrated reliable performance in real-time environments with minimal latency. Minor recognition errors occurred in noisy surroundings, highlighting the importance of a quiet environment for optimal results.



I. Fig 1: Wikipedia Search Page.



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PS C:\Users\ahmad> & C:/Users/ahmad/AppData/Local/Programs/Python/Python312/python.exe c:/xampp/htdocs/Crime_report/secondmain.py
Listening...
Recognizing...
User said: open Google

Listening...
Recognizing...
User said: open YouTube

Listening...
Recognizing...
User said: open Facebook

Listening...
Recognizing...
User said: increase volume

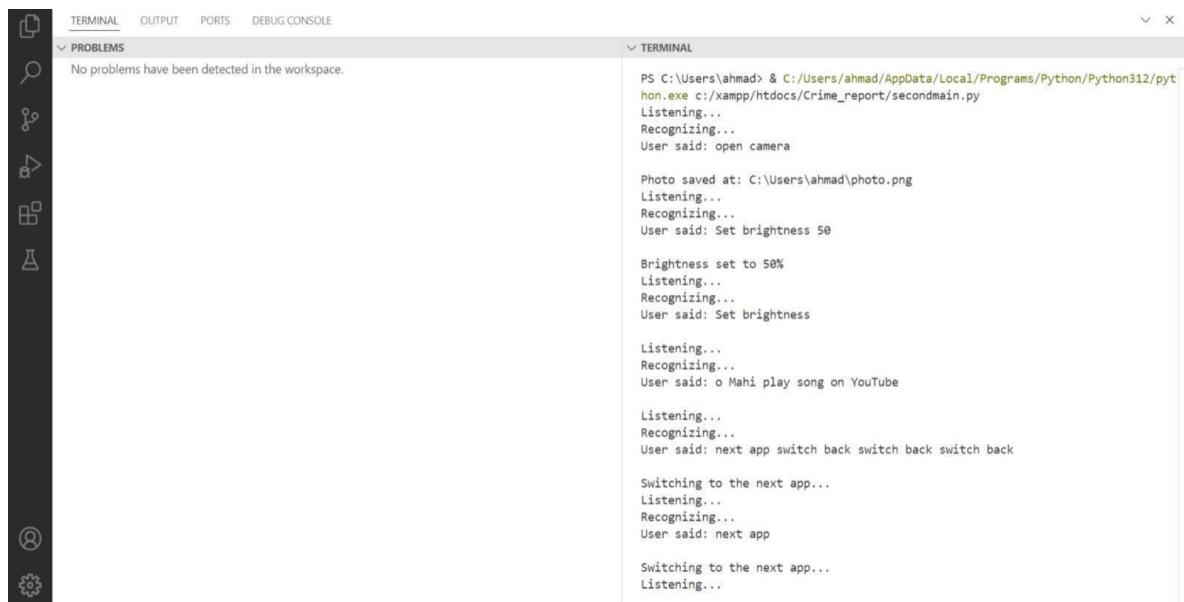
Listening...
Recognizing...
User said: decrease volume

Listening...
Recognizing...
User said: Set brightness

Listening...
Recognizing...
User said: Set brightness

Listening...
Recognizing...
```

Fig.2: Opening Website Page.



```
PS C:\Users\ahmad> & C:/Users/ahmad/AppData/Local/Programs/Python/Python312/python.exe c:/xampp/htdocs/Crime_report/secondmain.py
Listening...
Recognizing...
User said: open camera

Photo saved at: C:\Users\ahmad\photo.png
Listening...
Recognizing...
User said: Set brightness 50

Brightness set to 50%
Listening...
Recognizing...
User said: Set brightness

Listening...
Recognizing...
User said: o Mahi play song on YouTube

Listening...
Recognizing...
User said: next app switch back switch back switch back

Switching to the next app...
Listening...
Recognizing...
User said: next app

Switching to the next app...
Listening...
```

Fig.3: Open Youtube Or Song Play Page.

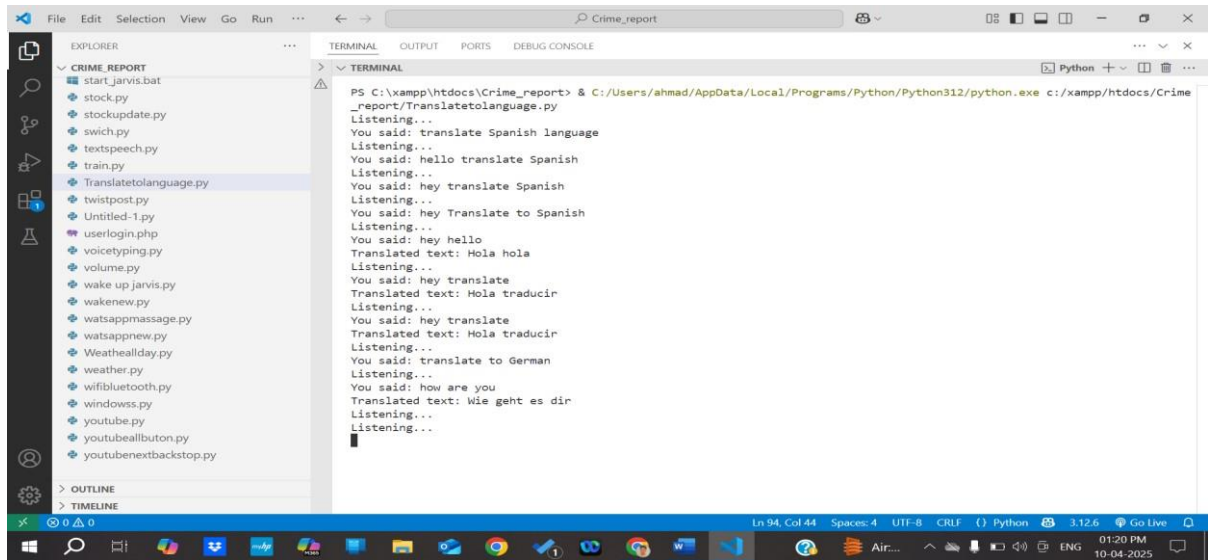


Fig.4: Language Translating Page

Table No.1 Text Detection and Inpainting

Sr. No	Content	Value	Remark
1	Voice Recognition	Converts speech to text	Enables hands-free interaction
2	Task Automation	Executes commands like opening Website	Increases productivity and ease of use
3	Volume & Brightness Control	System hardware interaction	Allows user to adjust settings hands-free

5. Conclusion

The development of Jarvis, an AI-powered voice-controlled virtual assistant, demonstrates the integration of speech recognition, natural language processing, and automation technologies. It effectively performs tasks such as application control, web browsing, media playback, and more, solely through voice commands.

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Internship Portal

Pranita Lad, Sanika God, Rupali Sakat, Gitanjali Ghadge, Prof. A. A. Vankudre
Computer Science and Engineering, Adarsh Institute of Technology and Research Center, Vita.

Abstract : Internship Portal is a comprehensive platform designed to streamline the process of connecting students with internship opportunities and enabling employers to find suitable candidates efficiently. Implementing the Model-View-Controller (MVC) design pattern ensures a modular, scalable, and maintainable architecture, dividing the system into three key components: Model, View, and Controller. The Model handles core business logic and manages critical data such as student profiles, internship listings, employer details, and application statuses, while directly interacting with the database to maintain data consistency and integrity

Keywords : Application Management, Centralized Platform, Student Profile, Company Profile, Admin Panel, Mentor Panel

1. Introduction

An internship portal is an online platform designed to connect students across various industries. Students can browse a wide range of internship listings, often searchable by industry, location, and type, such as paid or unpaid positions. Each listing usually includes detailed descriptions of the role, training modules, responsibilities, and qualifications, along with insights into the company's culture and values.

The application process is streamlined, enabling users to apply directly through the portal, often with the option to upload resumes and cover letters tailored to specific roles. Users can receive notifications about new listings.

2. Related Work

- General Internship Platforms : Platforms like LinkedIn, Internshala, and Glassdoor connect students with employers but lack college-specific features like academic record integration and eligibility tracking.
- College-Specific Portals : Campus Recruiting Systems (CRS) are centralized platforms for internship management within universities, focusing on academic progress and eligibility but often lacking modern interfaces and full-stack capabilities
- MERN Stack : The MERN stack (MongoDB, Express.js, React, Node.js) is ideal for dynamic, scalable web apps. It enables seamless integration between frontend and backend, real-time updates, and flexible data storage. React supports interactive elements, while MongoDB provides scalable, flexible storage for student and internship data.
- Centralized Student Systems : Student Information Systems (SIS) manage student data. Integrating internship portals with SIS can automate eligibility tracking and improve the application process.

- Key Features for Internship Portals : Essential features include role-based access, real-time notifications, application tracking, and personalized dashboards, improving the user experience for students and recruiters.
- Challenges and Opportunities : Challenges include securing sensitive student data and integrating with existing systems. The MERN stack offers opportunities for secure, interactive, and scalable platforms tailored to college students and recruiters.

3. Methodology

The Design Methodology chapter outlines the approach and techniques employed in the development of the Internship Portal. It describes the systematic process followed to transform the requirements into a functional, user-friendly, and scalable system. The design methodology ensures that the portal is built in a structured manner, adhering to best practices, and can efficiently meet the needs of its users, including students, employers, and educational institutions. This chapter covers the architectural design, user interface (UI) design, database design, and system components, highlighting the tools, technologies, and frameworks used throughout the development process.

Project Planning and Requirement Analysis : Internship portal is crucial to ensure that the system meets the expectations of its key users—students, employers, and educational institutions.

System Design : System Design chapter outlines the architectural and structural design of the Internship Portal, detailing the methodologies, frameworks, and components used to build the system.

Development : The Internship Portal, the Model-View-Controller (MVC) design pattern is implemented to ensure a modular, scalable, and maintainable architecture.

There are 7 Internship portal:

- Centralized Platform: A single digital portal where students can explore and apply for various internships, eliminating the need for multiple platforms.
- Application Management: Students and companies can manage all applications in one place.
- Student Profile: This includes registration and login, personal details, internship application, of students.
- Company Profile: Companies can post internships. It includes company details like name, company description, website, and contact details and manages applications.
- Admin Panel: Admins (faculty members) oversee the portal and ensure the approval process runs smoothly. It includes dashboard, approving applications, managing users, notifying students.
- Mentor Panel: Faculty members (mentors) track student progress during internships and provide guidance.

4. Experimental Results

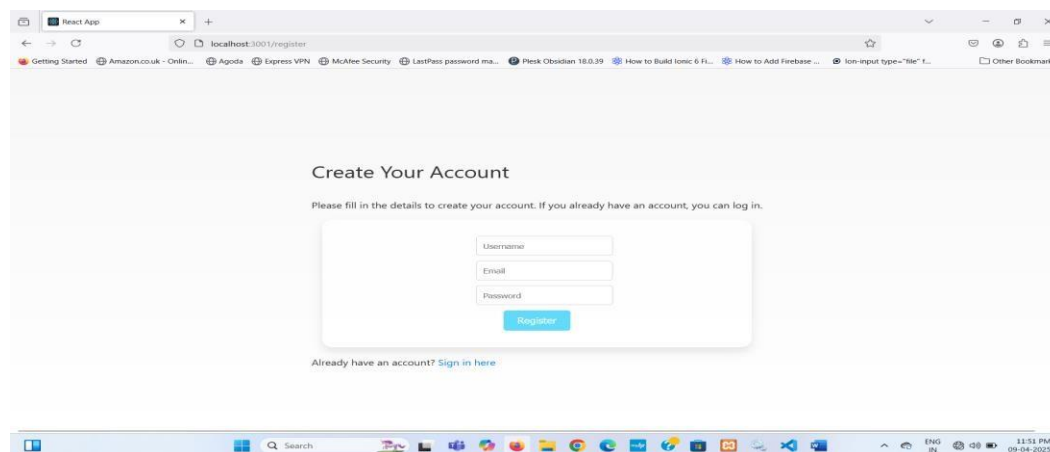


Fig 1. Registration Page

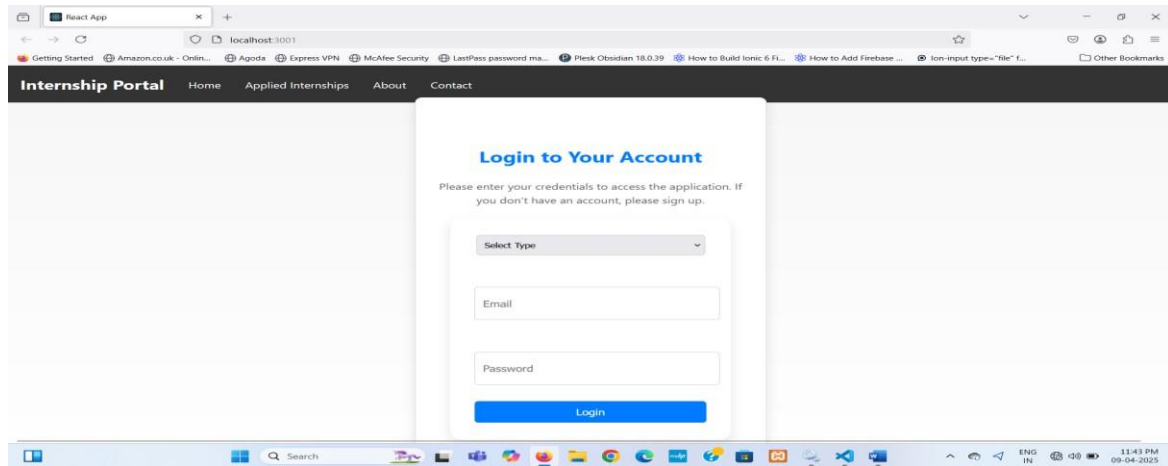


Fig 2. Login Page

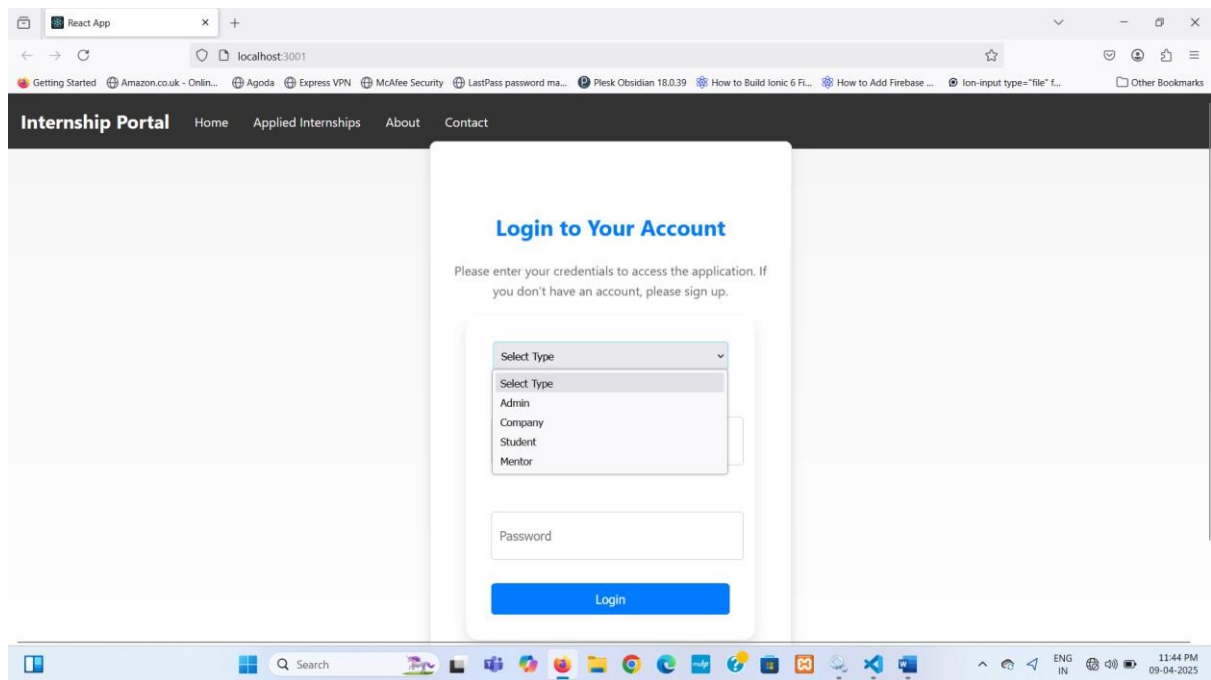


Fig 3. Login Page

The screenshot shows a web browser window with the address bar displaying 'localhost:3001/addcompany'. The page title is 'Manage Company'. The form contains the following fields: 'Company Name', 'Company Type', 'Email ID', 'Email', 'Password', 'Contact', 'Address', 'Website', and 'Contact person'. The browser's taskbar at the bottom shows various application icons and the system clock indicating 11:47 PM on 09-04-2025.

Fig 4. Company Information Page

The screenshot shows a web browser window with the address bar displaying 'localhost:3001/addmentor'. The page title is 'Manage Mentor'. The form contains the following fields: 'Mentor Name', 'Email ID', 'Email', 'Password', 'Contact', 'Address', and a 'Submit' button. The browser's taskbar at the bottom shows various application icons and the system clock indicating 11:47 PM on 09-04-2025.

Fig 5. Mentor Panel Page

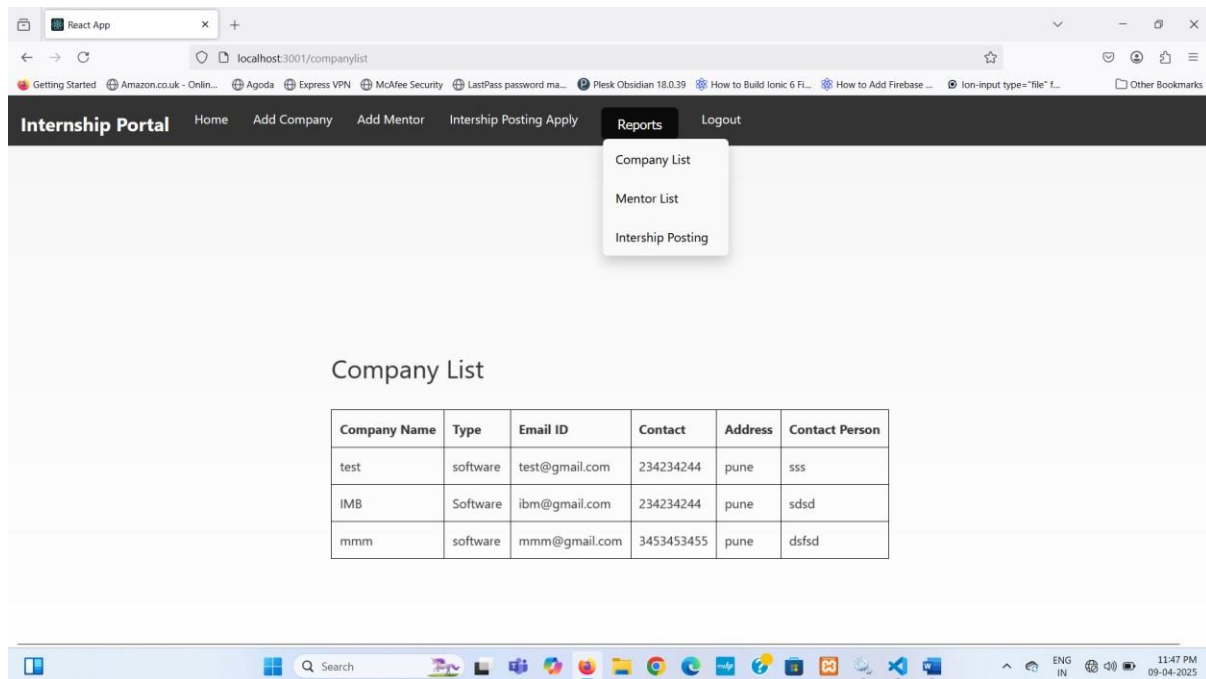


Fig 6. Company Listing Page

5. Conclusion

In conclusion, the development of an internship portal using the MEARN stack provides a powerful, scalable, and efficient solution for both students and recruiters. The combination of MongoDB, Express.js, Angular, and Node.js ensures that the portal can handle a large volume of data, users, and real-time interactions, such as application updates, notifications, and internship search functionalities. The unified use of JavaScript across the frontend and backend streamlines the development process, enabling faster iterations and easier maintenance. By leveraging cloud storage, secure authentication mechanisms, and performance optimization tools, the portal can offer a seamless, responsive experience.

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Resume Parsing Using AI

Pratik Satish Shelke, Pranav Guruling Ligade, Pratik Samadhan Maske,
Gaurav Suresh Mali, Rushikesh Sambhaji Pawar, Prof.P.R.Telshinge
Computer Science and Engineering, DBATU/AITRC, Vita

Abstract:

AI powered resume Parsing uses Natural Language Processing (NLP) along with machine learning to extract and structure important information such as Personal details, Education, Experience, Skills, and certifications from resumes automatically. DATA EXPLAINED This technology uses automation to match candidates' resumes to job requirements, helping to speed up the candidate selection process. These systems can accurately identify and extract key entities such as personal details, education, work experience, skills, certifications, and achievements, regardless of formatting differences. Employing AI parsers with NER and keyword extraction techniques assists recruiters in accurately identifying relevant qualifications, which minimizes time-to-hire and enables better hiring decisions. AI is evolving, and so does resume parsing continues to streamline and optimize the hiring process. This paper explores the architecture, methodologies, challenges, and real-world applications of AI in resume parsing, emphasizing its role in streamlining hiring workflows and enhancing candidate-employer matching.

1. Introduction

AI Resume parsing is about using AI techniques, mainly based on NLP, to auto-extract and organize crucial information from resumes. Traditionally, the recruiters manually filtered through the resumes to identify skills, qualifications, and work experience. By automating this process, AI-powered resume parsers not only save time and reduce recruitment costs but also improve accuracy and consistency in candidate evaluation. Moreover, they help in minimizing unconscious bias in the initial stages of hiring, contributing to fairer and more inclusive recruitment practices. It is always time-consuming and error-prone. The AI Resume parser will automate this, as it will analyze every resume in all formats for relevant details like personal details, work experience, educational background, and skills. This project explores how AI technologies are revolutionizing resume parsing, detailing the techniques involved, the challenges faced, and the potential benefits for both employers and job seekers.

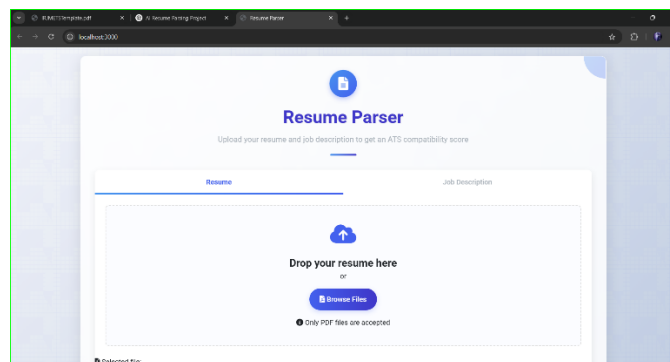
2. Related Work

The concept of resume parsing was introduced as a response to the growing need for efficiency in the recruitment process, particularly with the rise of online job applications in the late 1990s and early 2000s. As job portals like Monster and CareerBuilder began gaining popularity, employers found themselves overwhelmed with large volumes of digital resumes. Manually reviewing each application became increasingly time-consuming and inefficient. To address this challenge, HR technology companies began developing systems capable of automatically reading and extracting structured data from resumes—such as a candidate's name, contact information, skills, education, and work experience. These systems, known as resume parsers, initially relied on rule-based logic and pattern matching. Over time, they evolved to incorporate natural language processing (NLP) and machine learning techniques, enabling them to interpret a wide variety of resume formats and understand context more accurately. Today, advanced resume parsers use artificial intelligence to improve accuracy and support functionalities such as candidate-job matching, semantic search, and skill analysis, making them essential tools in modern applicant tracking systems and recruitment platforms.

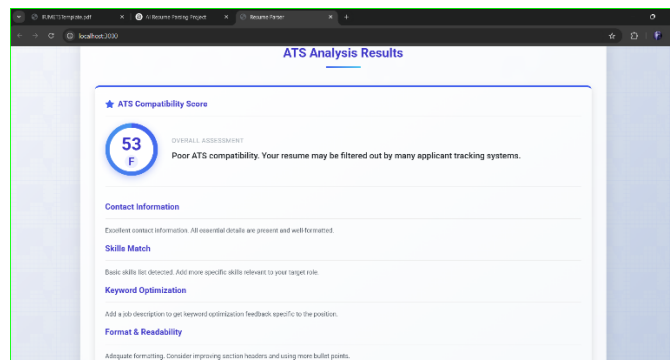
3. Methodology

The methodology for resume parsing using AI involves several key steps. First, resumes are collected in various formats (PDF, DOCX, TXT). These resumes vary in structure, language style, and content to ensure the AI model learns to generalize across different document types and converted into machine-readable text. Natural Language Processing (NLP) techniques are then applied to extract relevant information, such as personal details, education, work experience, skills, and certifications. Before parsing, resumes undergo several preprocessing steps: Text Extraction, Cleaning, Tokenization, POS Tagging. After that Named Entity Recognition (NER) is used to identify specific entities like job titles, institutions, and dates. Then the parsed and categorized information is structured into a predefined JSON or XML format, making it easily integrable with Applicant Tracking Systems (ATS) or HR databases.

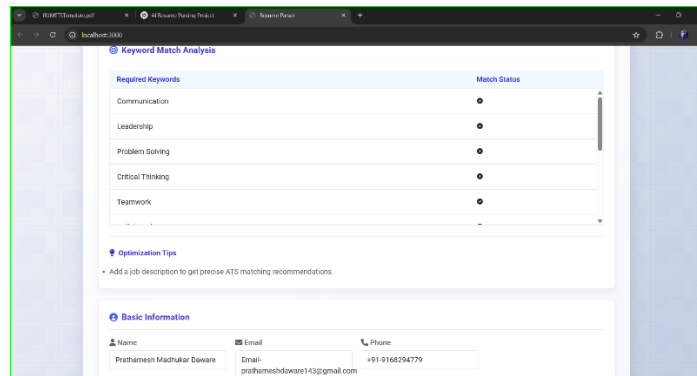
4. Experimental results



(a) Home page



(b) ATS Score and breakdown



Required Keywords	Match Status
Communication	Yes
Leadership	Yes
Problem Solving	Yes
Critical Thinking	Yes
Teamwork	Yes

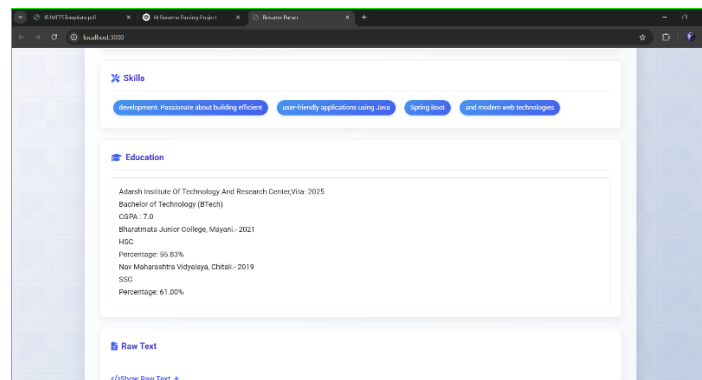
Optimization Tips

- Add a job description to get precise ATS matching recommendations.

Basic Information

Name: Prathamesh Madhukar Daware
 Email: prathameshdaware143@gmail.com
 Phone: +91-9168294779

(c)Keyword match Analysis



Skills

development, Passionate about building efficient, user-friendly applications using Java, Spring Boot, and modern web technologies.

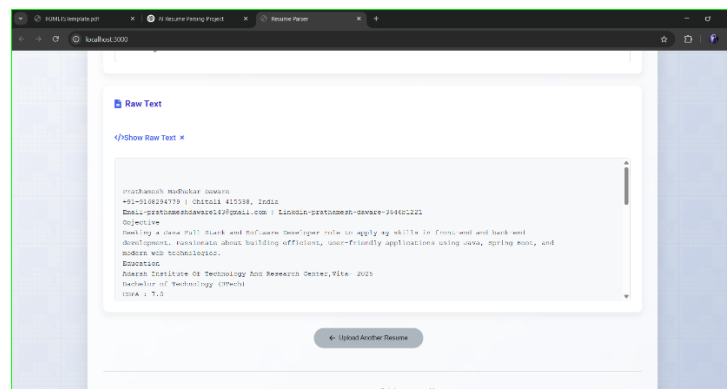
Education

Adarsh Institute Of Technology And Research Center,Vite- 2025
 Bachelor of Technology (BTech)
 CGPA: 7.0
 Bharatmata Junior College, Mayani- 2021
 HSC
 Percentage: 65.83%
 Near Maharashtra Vidyapeeth, Chitavi- 2019
 SSC
 Percentage: 61.00%

Raw Text

</Show Raw Text +>

(d)Education details



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```
prathamesh madhukar daware
+91-9168294779 | Chitavi 411009, India
Email: prathameshdaware143@gmail.com | LinkedIn: prathamesh-daware-2948c2221

Objective
Seeking a Java Full Stack and Full-time Developer role or apply my skills in front-end and back-end development, passionate about building efficient, user-friendly applications using Java, Spring Boot, and modern web technologies.

Education
Adarsh Institute Of Technology And Research Center,Vite- 2025
Bachelor of Technology (BTech)
CGPA: 7.0
```

← Upload Another Resume

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(e)Raw Text

5. Conclusion

Resume parsing using AI significantly streamlines the recruitment process by automating the extraction and analysis of key candidate information. Through techniques like Natural Language Processing (NLP), Named Entity Recognition (NER), and machine learning, AI systems can quickly identify and categorize data such as skills, experience, education, and qualifications. As the demand for scalable and intelligent hiring solutions continues to grow, AI-based resume parsers will play an increasingly vital role in transforming how organizations identify and evaluate talent. While challenges such as handling non-standard resume formats and

maintaining data privacy persist, continuous improvements in AI models and training data are steadily addressing these issues.

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Voice Authenticated Storage System

Sanika Kapse, Pranali Tarlekar, Sanika Gidde, Nikita Bhosale, Aishwarya Bandgar, Prof.D. K. Jadhav

CSE, Adarsh Institute Of Technology And Research Center, Vita, Maharashtra, India.

ABSTRACT- Voice Authenticated Storage System is a desktop-primarily based totally utility designed and evolved the usage of the python programming language. The device ambitions to make cloud garage with right encryption. The encryption set of rules is self-evolved, accurate, and secured. Along with Encrypted cloud garage, we also are offering right consumer authentication. User authentication is executed the usage of Voice Recognition System. Voice traits are frequently measured the usage of liveness detection with the consumer induced to utter a word for the contemporary action, or they may be measured passively and offer a sturdy extra layer of non-stop security. A consumer's voice is tested regionally in opposition to itself, a token is despatched to the carrier provider, and get right of entry to is granted.

We evolved a voice popularity machine the usage of python & system learning. It won't provide get right of entry to to the consumer till the voice doesn't match. We used `python_speech_features` and `pyaudio` modules of python for taking voice samples and for preprocessing it, we used the GMM model (Gaussian Mixture Model).

INTRODUCTION

Voice Authenticated Storage System is a desktop-primarily based totally utility designed and evolved the usage of the python programming language. The device ambitions to make cloud garage with right encryption. The encryption set of rules is self-evolved, accurate, and secured. Along with Encrypted cloud garage, we also are offering right consumer authentication. User authentication is executed the usage of Voice Recognition System. Voice traits are frequently measured the usage of liveness detection with the consumer induced to utter a word for the contemporary action, or they may be measured passively and offer a sturdy extra layer of non-stop security. A consumer's voice is tested regionally in opposition to itself, a token is despatched to the carrier provider, and get right of entry to is granted. We evolved a voice popularity machine the usage of python & system learning. It won't provide get right of entry to to the consumer till the voice doesn't match. We used `python_speech_features` and `pyaudio` modules of python for taking voice samples and for preprocessing it, we used the GMM model (Gaussian Mixture Model).

1.2 BACKGROUND

Voice authentication, also known as voice biometrics, is a technology that uses the unique characteristics of a person's voice to verify their identity. A voice authentication storage system is a secure platform designed to store and manage voiceprints (digital representations of voice patterns) used for authentication purposes.

❑ Voice Biometrics:

- Every individual has a unique voice due to the physiological and behavioral features of their vocal tract, pitch, and speaking style.
- These unique patterns are converted into a digital representation called a voiceprint.

❑ Authentication Process:

- **Enrollment:** A user provides voice samples, which are analyzed to create a voiceprint.
- **Verification:** During subsequent logins or authentication attempts, the user's voice is matched against the stored voiceprint.

❑ Data Storage:

- Voiceprints are typically stored in secure databases using encryption to protect sensitive information.

- Efficient storage systems also consider scalability to accommodate multiple users and high-speed retrieval for real-time authentication.

1.3 APPLICATION IN GENERAL FORM IN DIFFERENT AREAS-Voice authentication storage systems have diverse applications across various sectors. These systems offer secure, efficient, and user-friendly solutions for identity verification and access control. Below are key areas where voice authentication storage systems are applied:

1. Banking and Financial Services

- **Use Cases:**
 - Secure login to online banking portals and mobile apps.
 - Voice-based verification for phone banking and customer support.
 - Fraud prevention through voiceprint verification.
- **Benefits:**
 - Enhances security by reducing reliance on PINs and passwords.
 - Simplifies customer experiences with hands-free authentication.

2. Healthcare

- **Use Cases:**
 - Secure access to patient records and electronic health systems.
 - Voice-enabled authentication for telemedicine platforms.
 - Identity verification for controlled substance prescriptions.
- **Benefits:**
 - Protects sensitive health data.
 - Enables easy and secure patient-provider interactions.

3. Government and Public Services

- **Use Cases:**
 - Identity verification for social welfare programs and subsidies.
 - Secure access to e-governance services and portals.
 - Authentication for voting systems.
- **Benefits:**
 - Reduces identity fraud in public service delivery.
 - Improves accessibility for citizens with physical disabilities.

4. Corporate and Enterprise Security

- **Use Cases:**
 - Employee authentication for remote work platforms and VPNs.
 - Access control for secure areas in offices and data centers.
 - Verification for sensitive business transactions.
- **Benefits:**
 - Enhances cybersecurity measures.
 - Supports multi-factor authentication for higher security.

5. Consumer Technology

- **Use Cases:**
 - Unlocking smartphones and personal devices.
 - Voice-activated personal assistants (e.g., Alexa, Google Assistant).
 - Secure purchases and transactions in e-commerce platforms.
- **Benefits:**
 - Provides a seamless and convenient user experience.
 - Strengthens device security.

6. Call Centers and Customer Support

- **Use Cases:**
 - Identity verification during customer interactions.
 - Fraud detection through voiceprint analysis.
 - Personalized service through user voice recognition.
- **Benefits:**
 - Reduces wait times for customers.
 - Improves operational efficiency and security.

7. Education

- **Use Cases:**
 - Identity verification for online exams and certifications.
 - Secure access to learning management systems (LMS).
 - Authentication for administrative and student services.

- **Benefits:**
 - Prevents academic dishonesty.
 - Streamlines administrative processes.

8. Smart Homes and IoT

- **Use Cases:**
 - Secure control of IoT devices through voice commands.
 - Access control for smart home systems (e.g., door locks, security cameras).
 - Voice-enabled user profiles for personalized experiences.
- **Benefits:**
 - Enhances convenience and usability.
 - Strengthens security for home automation systems.

9. Travel and Hospitality

- **Use Cases:**
 - Voice-activated booking and check-in processes.
 - Authentication for loyalty programs and rewards.
 - Secure access to hotel rooms using voice.
- **Benefits:**
 - Improves customer satisfaction with streamlined processes.
 - Provides a futuristic and personalized guest experience.

10. Legal and Law Enforcement

- **Use Cases:**
 - Authentication for accessing sensitive case files.
 - Identity verification for witnesses or detainees.
 - Voice evidence verification in criminal investigations.
- **Benefits:**
 - Enhances the security of legal processes.
 - Supports evidence integrity in legal proceedings.

11. Transportation

- **Use Cases:**
 - Identity verification for public transport systems.
 - Secure access to ride-sharing services.
 - Voice-activated navigation systems in vehicles.
- **Benefits:**
 - Simplifies user interactions with transportation services.
 - Increases security for riders and drivers.

Voice authentication storage systems are transforming identity verification by offering a blend of security, efficiency, and user convenience. These applications demonstrate their versatility across industries, ensuring secure and innovative experiences for users.

METHODOLOGY

The **design methodology** chapter aims to outline the process and approach taken in the development of the **Voice Authentication Storage System**. This system integrates cutting-edge technologies in biometric authentication, specifically focusing on voice recognition, to provide secure access control. The system's core functionality relies on storing and processing voice samples, comparing them against user-specific models, and ensuring that only authorized individuals can authenticate their identity. This chapter presents a comprehensive overview of the design choices made throughout the development process, detailing how each component contributes to the overall system. The methodology emphasizes the key stages involved in designing a robust, scalable, and secure voice authentication system, with a special focus on:

- **Data Acquisition and Preprocessing:** The system first captures voice samples from users, preprocesses these samples to extract unique features, and prepares them for authentication.
- **Feature Extraction and Model Building:** A key aspect of the design is how voice features are extracted, such as using techniques like Mel-frequency cepstral coefficients (MFCCs), and then how these features are used to build individual authentication models.
- **Storage and Retrieval of Voice Data:** The design also addresses the storage of voice features in a secure, efficient manner. A significant challenge is to balance data security, user privacy, and the ability to quickly retrieve stored voice data during authentication.

- **Authentication Process:** The design details the methods used to authenticate users by comparing their voice input with the stored features using machine learning models, and applying decision thresholds for validation.

The chapter also delves into important design considerations, such as:

- **Security Measures:** Ensuring that voice data is encrypted both during transmission and at rest, and that the system is resistant to spoofing or replay attacks.
- **Scalability:** Designing the system to handle a large number of users and voice samples, allowing for efficient storage and retrieval even as the database grows.
- **Performance:** Optimizing the system to deliver real-time authentication with minimal delay, ensuring that voice samples are processed quickly.

Overall, the design methodology chapter provides a roadmap for the architecture, algorithms, and security strategies employed in the Voice Authentication Storage System. It also presents the rationales behind key design decisions, ensuring that the system meets the necessary criteria for reliable, accurate, and secure voice authentication.

MODELING AND ANALYSIS

The **Model Approach** for a **Voice Authentication Storage System** outlines the fundamental strategy and methods used to capture, process, store, and authenticate voice samples. This approach integrates machine learning techniques and signal processing to achieve accurate and secure user identification. The methodology focuses on selecting the right models for feature extraction, classification, and efficient storage of voice data to optimize authentication accuracy, speed, and scalability.

The following subsections describe the essential components of the **model approach**:

1. Voice Sample Capture and Preprocessing

The voice authentication process begins by capturing voice samples from users. The recorded audio data is subjected to preprocessing steps, which ensure that the raw voice signal is converted into a suitable format for further analysis. The preprocessing includes:

- **Noise Reduction:** Filtering background noise to ensure the clarity of the voice input.
- **Segmentation:** Dividing the speech into smaller frames, typically 20-40 ms, for feature extraction.
- **Normalization:** Adjusting the volume levels and other factors to ensure consistent feature extraction across different users and environments.

2. Feature Extraction

The core of the model approach in voice authentication lies in extracting distinctive features from the raw voice signal. These features serve as unique identifiers for each user's voice and are used for comparison during authentication. Common feature extraction techniques include:

- **Mel-frequency Cepstral Coefficients (MFCCs):** MFCCs are the most widely used features in voice authentication systems. They capture the spectral properties of speech, allowing for the representation of the voice in a form that is both compact and discriminative.
- **Linear Predictive Coding (LPC):** LPC models the vocal tract and is used in some systems for voice feature extraction.
- **Pitch and Prosody:** These features focus on the rhythm, tone, and pitch of the voice, further enhancing identification accuracy.

3. Model Selection and Training

Once features are extracted, the next step is to choose and train a model for voice authentication. Different machine learning models can be used for this purpose:

- **Hidden Markov Models (HMM):** HMMs are popular for speech recognition tasks and can be used to model temporal variations in speech. HMMs represent the voice signal as a series of hidden states that transition over time, making them suitable for modeling the dynamics of speech.
- **Gaussian Mixture Models (GMM):** GMMs are used to represent the distribution of features from different speakers. They model the likelihood of a given voice feature belonging to a particular user, making them effective for speaker recognition tasks.
- **Deep Learning Approaches:** More recently, **Deep Neural Networks (DNNs)** and **Convolutional Neural Networks (CNNs)** have been explored for voice authentication. These models can learn high-level features directly from raw audio, without relying on traditional hand-crafted feature extraction methods.

The system is trained using a labeled dataset of voice samples from multiple users. The training process involves optimizing the model parameters to minimize the error between predicted and actual voice samples. During training, the system learns the patterns in the voice data that distinguish each user's voice.

4. Voice Authentication Process

The authentication process involves comparing the input voice sample with the stored voice models for a specific user. The model approach for authentication is as follows:

- **Feature Comparison:** The voice sample input is processed to extract features, which are then compared against the stored features associated with the registered user.
- **Scoring and Decision Making:** A similarity score is calculated using a distance measure (such as Euclidean distance, cosine similarity, or likelihood ratio) to quantify how closely the input voice matches the stored voice model.
- **Thresholding:** A decision threshold is applied to the similarity score to determine whether the user is authenticated. If the score exceeds a predefined threshold, authentication is successful; otherwise, it is rejected.

5. Voice Data Storage

To facilitate fast and accurate authentication, voice features are stored in a structured database. The model approach for storage ensures that:

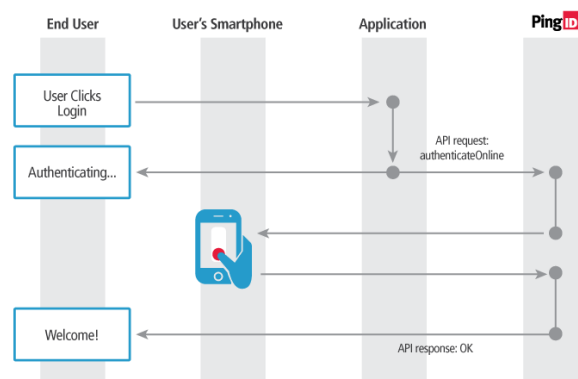
- **Efficiency:** Voice data is stored in a way that allows for rapid retrieval during the authentication process, minimizing latency.
- **Security:** Stored data is encrypted to ensure that voice samples and features are protected from unauthorized access. Additionally, privacy measures are incorporated to comply with data protection regulations (such as GDPR or CCPA).

6. Scalability and Adaptability

The model approach also ensures that the system is scalable and adaptable:

- **Database Scalability:** The system is designed to handle a growing number of users and voice samples. This may involve distributed storage solutions or cloud-based architectures to manage large-scale data.
- **Adaptability to New Users:** The model should be flexible enough to incorporate new users easily. The system should support adding and deleting users dynamically, as well as re-training models as new data is collected over time.
- **Continuous Learning:** Some systems may include mechanisms for continuous learning or retraining, allowing the model to adapt to changes in the user's voice due to aging, illness, or other factors.

COMPONENT DIAGRAM



FUTURE SCOPE

The voice authentication storage system holds significant potential for further enhancements and applications across various domains. As technology evolves, this system can be expanded and refined to meet emerging needs, ensuring continued relevance and adaptability. Below are key areas for future development:

1. Integration with Multimodal Authentication Systems

- Combining voice authentication with other biometric modalities such as facial recognition, fingerprint scanning, or iris recognition can enhance security and reliability.
- Multimodal systems can provide a layered approach to authentication, reducing the risk of spoofing or fraudulent access.

2. Enhanced Accuracy and Robustness

- **Improved Algorithms:** Leveraging advancements in deep learning and AI to develop more sophisticated models for voice pattern recognition.
- **Noise Reduction:** Enhancing noise cancellation and handling environmental variability to improve performance in diverse conditions.
- **Liveness Detection:** Incorporating techniques to detect and prevent spoofing using synthetic or recorded voices.

3. Scalability for Larger User Bases

- Expanding the system's capacity to handle thousands or even millions of users without compromising performance or security.
- Utilizing cloud-based infrastructure and distributed databases for global deployment and scaling.

4. Real-Time Processing and Applications

- Implementing real-time voice authentication for applications such as secure online transactions, voice-activated payments, and remote access control.
- Adopting edge computing to minimize latency and ensure quicker processing.

5. Integration with IoT and Smart Devices

- Enabling voice authentication for smart devices, such as home assistants, smart locks, and connected appliances, to enhance security in IoT ecosystems.
- Creating unified systems for managing access across multiple devices seamlessly.

6. Industry-Specific Applications

- **Healthcare:** Secure access to electronic health records and voice-based patient identification.
- **Education:** Authentication for e-learning platforms and online examination systems.
- **Finance:** Voice-enabled banking services and fraud prevention in financial transactions.

7. Regulatory Compliance and Ethical Considerations

- Aligning with evolving data protection regulations such as GDPR, HIPAA, or CCPA to ensure compliance and user trust.
- Developing ethical frameworks for handling biometric data responsibly.

8. Integration with AI-Driven Threat Detection

- Utilizing AI to monitor user behavior and detect anomalous activities that may indicate security breaches.
- Automating responses to potential threats, such as locking accounts or notifying administrators.

9. Accessibility and Inclusivity

- Enhancing the system to support users with speech impairments or accents by training models on diverse datasets.
- Supporting multiple languages to cater to a global audience.

CONCLUSION

The voice authentication storage system represents a significant step forward in secure and user-friendly access control technologies. By leveraging the unique characteristics of voice as a biometric identifier, the system offers a seamless and reliable alternative to traditional authentication methods such as passwords or PINs.

Throughout the development process, the integration of advanced voice signal processing techniques, robust feature extraction algorithms like MFCC, and state-of-the-art machine learning models has been critical in ensuring high accuracy and efficiency. The system's ability to handle challenges such as noise interference, variability in voice samples, and potential security threats demonstrates its robustness and adaptability.

A secure backend architecture, combined with encryption protocols and authentication mechanisms like JWT and OAuth, ensures the protection of user data and resilience against unauthorized access. Moreover, the inclusion of a user-friendly interface makes the system accessible and practical for a broad range of users, fostering greater adoption.

The implementation of this system has shown its potential in various domains, including secure storage solutions, educational platforms, and enterprise applications. As technology evolves, future enhancements can include integration with multimodal authentication systems, real-time threat detection, and expanded scalability to accommodate larger user bases.

In conclusion, the voice authentication storage system not only addresses the critical need for secure and efficient access control but also sets the foundation for further innovation in biometric authentication technologies. It underscores the importance of combining cutting-edge technology with user-centric design to create solutions that are both effective and accessible.

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Medcloud Ecosystem

Prof. P.T.Shitole, Akshay Bandgar, Kumar Mohite, Riyaz Mulani, Suyash Pawar, Sanjay Jadhav

Computer Science and Engineering, Adarsh Institute of technology and research center, vita

Abstract

The Medcloud Ecosystem website project is designed to create a comprehensive, cloud-based digital healthcare platform that connects patients, healthcare providers, and medical institutions in a secure and efficient environment. The platform facilitates seamless access to electronic medical records (EMR), appointment scheduling, telemedicine services, e-prescriptions, and health analytics.

Built with a modern tech stack and deployed on a scalable cloud infrastructure, the website ensures data security, real-time communication, and compliance with healthcare regulations such as HIPAA. The Medcloud Ecosystem aims to revolutionize healthcare delivery by enhancing accessibility, improving patient engagement, and enabling data-driven decision-making for medical professionals.

Keywords: Medcloud Ecosystem is a cloud-based healthcare platform enabling secure access to patient data, telemedicine services, and health record management.

1. Introduction

The Medcloud Ecosystem website project is a comprehensive digital platform designed to streamline healthcare services through cloud-based integration. This ecosystem serves as a centralized hub for patients, healthcare providers, and administrators to interact seamlessly, manage health records, schedule appointments, access telemedicine services, and ensure real-time communication.

Leveraging modern web technologies and secure cloud infrastructure, the Medcloud Ecosystem prioritizes data privacy, operational efficiency, and user-friendly interfaces. The platform aims to transform traditional healthcare delivery by providing scalable, accessible, and compliant solutions that cater to the evolving needs of the medical industry.

This project not only enhances the healthcare experience but also aligns with global trends in digital transformation, enabling institutions to provide faster, smarter, and more secure services.

2. Related Work

The MedCloud Ecosystem aims to revolutionize healthcare delivery by integrating cloud computing, big data, AI, and IoT into a unified digital health infrastructure. Several prior projects and systems have laid the groundwork for such an ecosystem. This section explores key related works that contribute to the conceptual and technical development of MedCloud platforms

Studies on cloud security frameworks, such as those published by NIST and IEEE, offer guidance on implementing role-based access control (RBAC), data encryption, and secure authentication in MedCloud systems.

Cloud Computing in Healthcare: Several studies have explored the integration of cloud computing into healthcare environments. These works emphasize benefits such as scalability, remote accessibility, and reduced infrastructure costs. For instance, Zhang et al. (2020) presented a healthcare cloud model that supports electronic health record (EHR) sharing across institutions while maintaining data integrity and patient privacy.

3. Methodology

System Elements:

- a) **Requirement Analysis and Stakeholder Mapping:** Identify stakeholders: healthcare providers, labs, pharmacies, insurers government agencies.
 - b) **User Interface (Web/Mobile):** Responsive design based on React.js, HTML/CSS, and JavaScript.
 - c) **Data Integration and Interoperability:** Enable master patient index (MPI) to unify patient records across different providers.
 - d) **Database:** Stores user profiles, progress records.
- Deployment Phase: Deploy the medcloud platform using docker containers on cloud platforms like aws or azure with ci/cd pipelines, secure dns/ssl setup, and monitoring tools like prometheus or elk stack.

Working Principle

- Patient-Centric Data Aggregation.
- Cloud-Based Centralized Storage.
- Role-Based Access & Consent Management.
- Scalable Infrastructure.

The MedCloud Ecosystem operates as a cloud-based digital health infrastructure that centralizes and secures patient health data. Each patient has a unique digital ID that links their medical history from hospitals, labs, pharmacies, and wearable devices.

4.Experimental results

System has testing a medical cloud system to store patient data, improve healthcare access, etc.

The goal of the medical cloud ecosystem is to improve healthcare data storage, security, and access. The system should be able to handle large amounts of medical data (e.g., patient records, medical images) in a secure, efficient, and accessible manner.

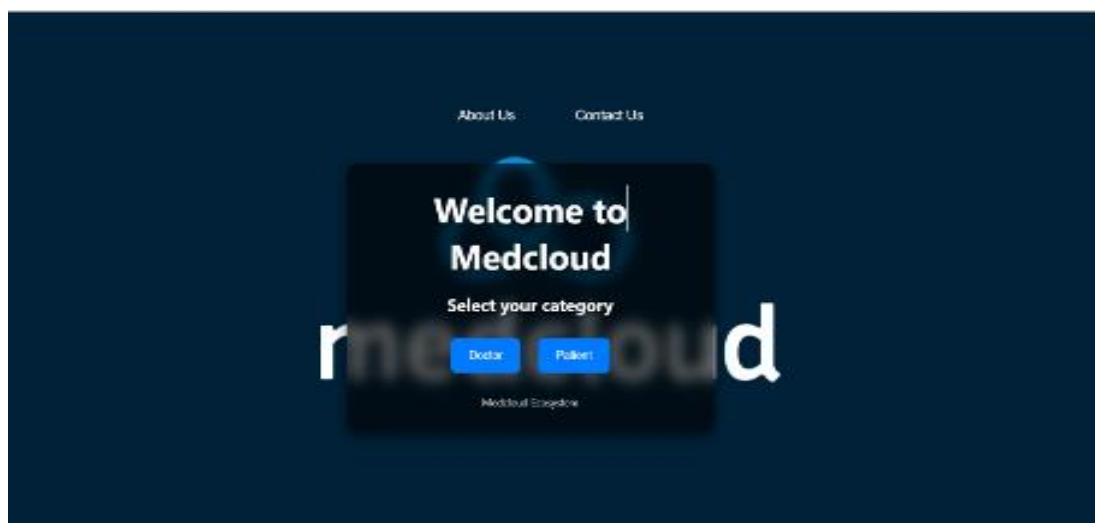
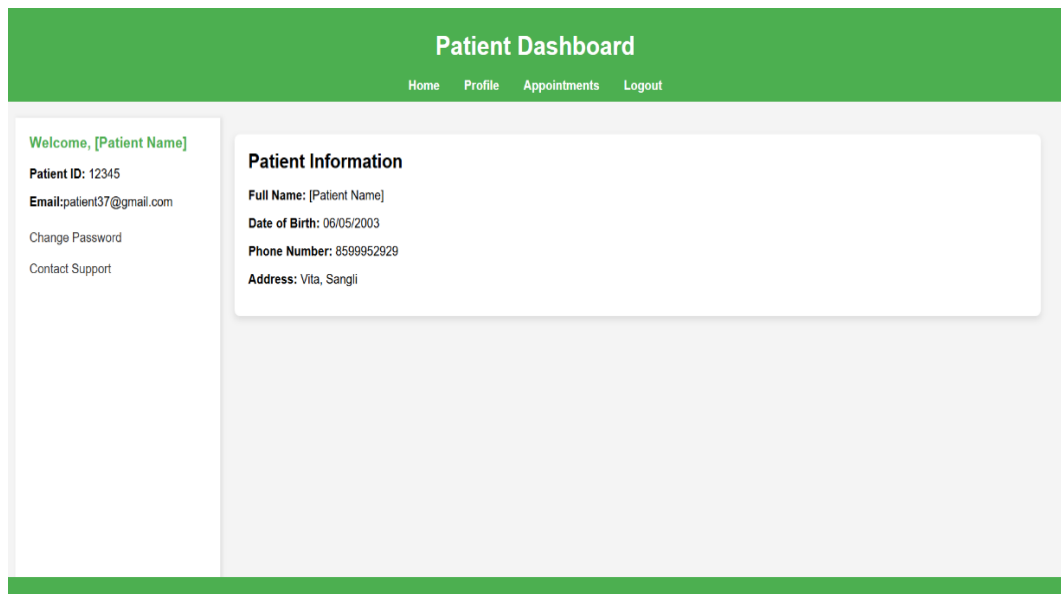
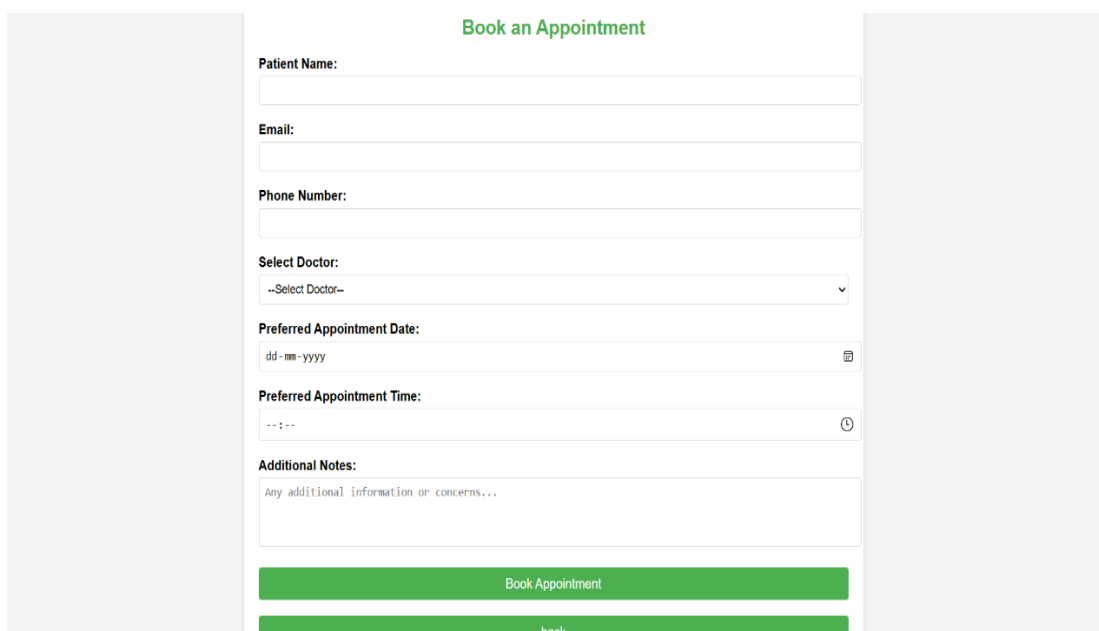


Fig 1: Home



The Patient Dashboard features a green header with the title "Patient Dashboard" and navigation links: Home, Profile, Appointments, and Logout. On the left, a sidebar contains a welcome message, patient ID (12345), email (patient37@gmail.com), and links for "Change Password" and "Contact Support". The main content area displays "Patient Information" with fields for Full Name, Date of Birth (06/05/2003), Phone Number (8599952929), and Address (Vita, Sangli).

Fig 1: Patient Dashboard



The "Book an Appointment" form is centered on a light gray background. It includes input fields for Patient Name, Email, and Phone Number. A dropdown menu for "Select Doctor" shows "--Select Doctor--". Date and time pickers are provided for "Preferred Appointment Date" (dd-mm-yyyy) and "Preferred Appointment Time" (--:--). A text area for "Additional Notes" contains the placeholder "Any additional information or concerns...". At the bottom, there are two green buttons: "Book Appointment" and "back".

Fig 3: Appointment page

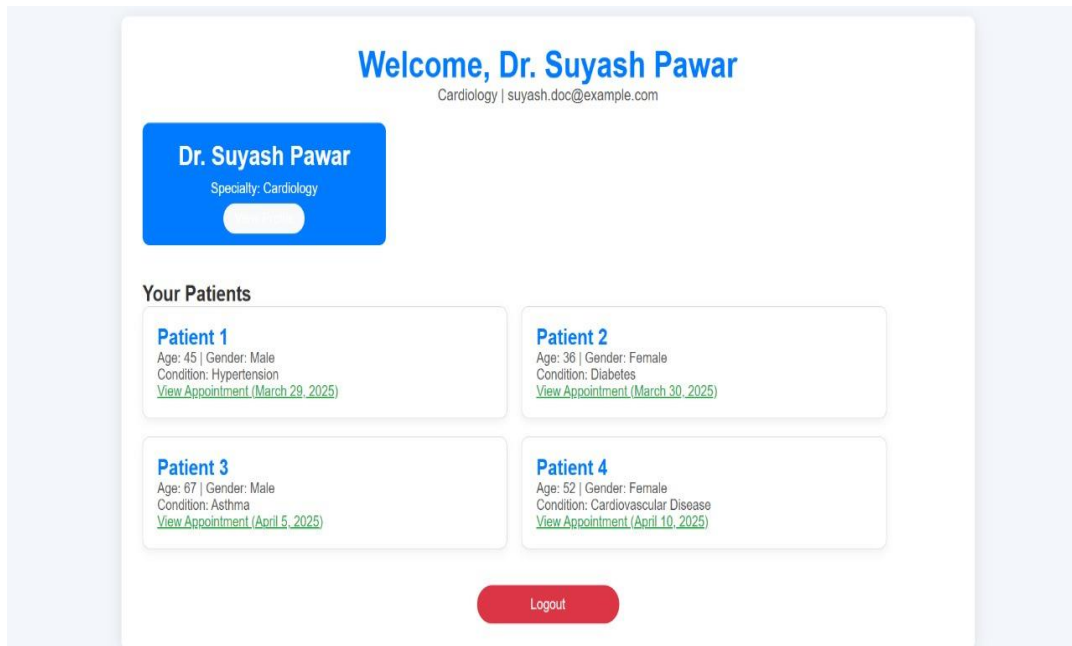


Fig 4 :Dr.Dashboard

Table No.1 Text Detection and Inpainting

Sr. No	Content	Value	Remark
1	Content update time	30-60 minute	<1 minute (AI-assisted update)
2	Data accuracy & Quality	Human-dependent	AI-curated, real-time sync from cloud sources
3	Visual asset Handling	Manual editing & inpainting	AI-powered text detection and auto-inpainting

5. Conclusion

The MedCloud Ecosystem represents a transformative step in integrating technology and healthcare, creating a seamless, secure, and efficient platform for managing medical data and services. By leveraging cloud-based solutions, it enables real-time data access, enhances collaboration among healthcare providers, and improves patient outcomes through personalized care. The project not only addresses critical challenges such as data diagnostics, and global health connectivity. Its successful implementation signifies a milestone in modernizing healthcare systems, fostering innovation, and prioritizing patient centric solutions.

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A Panoramic Review: Artificial Intelligence in Assisted Reproductive System

Miss. Jadhav Sanjana Pramod, AIML, AITRC, Vita

Miss. Patil Sanika Ashok, AIML, AITRC, Vita

Miss. Chavan Pratiksha Satish, AIML, AITRC, Vita

Miss. Jadhav Shruti Vijay, AIML, AITRC, Vita

Guide:- Assistant Prof. R.P. Bhilawade

Abstract:

Artificial Intelligence (AI) is playing an increasingly vital role in assisted reproductive technologies (ART), aiding in tasks like embryo selection, gamete analysis, and predicting treatment outcomes. By leveraging machine learning and image processing, AI helps identify patterns in clinical and laboratory data that support more accurate and efficient decision-making. This paper discusses key applications, benefits, and ethical considerations of AI in ART, highlighting its potential to enhance success rates and personalize fertility care.

Keywords: ART, AI fertility, Embryo, Semen, Reproductive

1. Introduction

Artificial Intelligence (AI) is increasingly being integrated into Assisted Reproductive Technology (ART) to improve clinical outcomes, especially in In Vitro Fertilization (IVF). AI systems can analyze complex medical data, assist in decision-making, and optimize various steps in the reproductive process, such as gamete selection, embryo grading, and treatment planning. This integration aims to Enhance success rates, reduce errors, and provide personalized care in reproductive medicine.

2. Related Work

In recent years, many researchers have explored how Artificial Intelligence (AI) can improve different stages of Assisted Reproductive Technologies (ART). One major area of focus has been embryo selection. Traditionally, embryologists assess embryos visually under a microscope, which can be subjective. Studies have shown that AI, especially deep learning models, can analyse embryo images more consistently and predict which ones are most likely to lead to a successful pregnancy.

Another area is sperm analysis. AI tools have been developed to evaluate sperm quality, including their shape, movement, and concentration, more accurately than manual methods. This helps in choosing the best sperm for fertilization.

Researchers have also used AI to predict the success of IVF treatments. By analysing large datasets that include patient age, hormone levels, and past treatment outcomes, AI systems can provide more personalized predictions for each patient.

Additionally, there is work being done to integrate AI with time-lapse imaging systems, which continuously monitor embryo development. These systems allow AI models to track and evaluate embryo growth patterns, offering a dynamic and detailed view that can lead to better selection decisions.

Overall, the related studies highlight that AI can make ART processes more objective, efficient, and tailored to individual patients, which may increase the chances of successful outcomes.

3. Methodology

1. Patient Data Collection: Information is gathered from patients—this includes medical history, test results, and fertility-related data like hormone levels or previous IVF attempts.

2. AI Model Training: This collected data is used to teach an AI system how to recognize patterns and make predictions. The more data it sees, the smarter it gets.

3. Embryo/Semen Analysis: The AI then helps analyse sperm and embryo quality using images and lab results. It can spot details that may not be easily seen by the human eye.

4. Prediction & Diagnosis: Based on the analysis, the AI predicts the chances of successful fertilization or pregnancy. It may also help diagnose issues affecting fertility.

5. Personalized Treatment: Finally, the results are used to create a treatment plan that fits the specific needs of the patient, increasing the chances of a successful outcome.

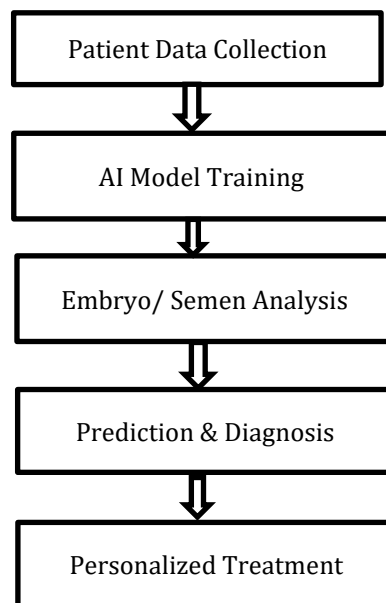


Fig. 1. Methodology of Artificial Intelligence in Assisted Reproductive System

4. Conclusion

Artificial Intelligence is becoming an important part of Assisted Reproductive Technologies (ART), making fertility treatments more accurate, efficient, and personalized. It helps doctors select the best embryos, predict success rates, and create treatment plans that suit each patient's unique needs. These improvements can increase the chances of pregnancy and reduce the emotional and financial stress many couples face.

However, as AI becomes more involved in such sensitive areas, it's important to handle patient data with care, avoid bias in AI systems, and ensure patients understand and agree with how AI is used. Looking ahead, AI has great potential to work with genetic testing and lab automation, leading to even better results. Still, strong ethical guidelines and fair rules must be in place to ensure AI supports—not replaces—human decision-making and respects every patient's choices.

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Enhancing Monitoring and Management of Research, IPR, Innovation, and Start-ups in Maharashtra State

Miss. Pawar Rohini Dhanaji, AIML, AITRC, Vita

Miss. Dale Sanika Sambhaji, AIML, AITRC, Vita

Miss. Koli Prajktta Prakash, AIML, AITRC, Vita

Miss. Sagare Srushti Satish, AIML, AITRC, Vita

Guide: Assistant Prof.P.K.Patil

Abstract: Maharashtra is one of the most innovative states, where fresh ideas, start-ups, and researchers are growing every day. To handle and track all of the research, patents (IPR), innovation activities, and start-up progress, there isn't a single system in place. Information is spread out across different departments, making it difficult to access, track, and manage. A user friendly online application that organizes everything on a single platform is offered via this project. The system will store and organize data about research projects, patents, start-ups, and innovations in a single place. Users will also be able to monitor their progress, submit patent applications, get funding and support, and use real-time data to make smarter decisions. The goal of this platform is to improve transparency, save time, use resources more efficiently, and support innovators and entrepreneurs. This will help Maharashtra become even stronger in research, innovation, and economic growth.

Keywords: Fresh ideas, Start-ups, Patents, Intellectual Property Right, Real-time data, Entrepreneurs, Founders, Researcher

1. Introduction

Maharashtra has become one of the top states in India for start-up growth and development. It provides a strong base for young minds and entrepreneurs to share their innovative ideas and turn them into reality. The government and many organizations are encouraging start-ups, and many people are coming forward with creative thoughts and business plans. However, just having ideas is not enough. To bring those ideas to life, we need proper tools and systems that can help manage innovation activities. In the traditional method, everything was done manually — lots of paperwork, visiting offices, and waiting for approvals. It used to take a lot of time, and sometimes people would lose interest or get discouraged. To solve this problem, we have developed an application that can make the entire process smooth and fast. This app acts as a digital platform where start-ups can manage their innovation-related activities easily. It helps users save time, avoid unnecessary paperwork, and get the right information without any delay. This application supports entrepreneurs by giving them a space where they can plan, track, and grow their start-up ideas. It also helps them stay connected with other innovators, government schemes, start-up events, and resources that can help them grow. With this modern approach, we are moving away from the slow and weak traditional methods and stepping into a smarter, digital way of working. This app will not only help start-ups in Maharashtra but can also inspire other states to adopt digital tools for innovation management. In short, this application is a helpful step towards making innovation easy, fast, and well organized. It supports the vision of a digitally empowered Maharashtra and encourages more people to take part in the start-ups revolution.

2. Literature Review

Innovations are one of the most characteristic features of the contemporary economy services. The innovation. Innovation is understood in a literature contains many definitions Innovation is the process of transforming new ideas, new knowledge into new products and of wide spectrum and is a common symbol for change, something new, expressing itself as new products, innovative technologies, non-traditional services or unconventional management methods (Sikora & Uziębło, 2013) It is also considered as the final stage of the creation of new material reality, the first use of new ideas in practice (Bogdanienko, Haffer & Popławski, 2004). Many theoreticians of management see innovations as a process occurring in the industry, more precisely as the first market introduction (implementation) of a new product, process, system or device, the first usage of an invention (Jasiński, 1997). Since a few years, start-ups are being mentioned in the context of innovation as a new phenomenon which are being treated as a development motor for the economy. A startup is a new company, with no experience or knowledge, which begins to use the opportunities entering new areas. Currently, creating start-ups is a global trend. Many cities and countries continue to seek better ways to create a strong environment for start-ups. Global Start-up Ecosystem Report and Ranking 2017 is based on a year's worth of research, spanning a whopping 10 000 start-ups and 300 partner companies. Start-up Genome assessed 55 start-up ecosystems across 28 countries. The report was made as result of speaking with entrepreneurs and massive amounts of data on start-ups. It examined how cities help to grow and sustain start-up ecosystems through eight major factors: funding, market reach, global connectedness, technical talent, start-up experience, resource attraction, corporate involvement, founder ambition and strategy. Among the top 20 start-up ecosystems, nine are located in North America, six in Europe, with the remaining five in Asia. The role of Asian start-ups is increasing. Beijing and Shanghai appeared on the map of significant start-up ecosystems. Unfortunately, Polish start-ups do not play a significant role in this global ranking so far (Start-up Genome, 2017). Modern companies frequently have to pay attention to the necessity of protecting their intellectual property created by their employees and the knowledge they have accumulated. This necessity results from the fact that intangible assets including innovations and new technologies have become more significant, throughout the years, in the development of companies and creating a competitive edge. The protection of intellectual property should become one of the elements of the strategy of companies. However, it is not always so, and entrepreneurs including start-ups are not always aware of the importance of this issue.

3. Objective

- Help start-up businesses in Maharashtra by giving them an easy app to manage their work and ideas.
- Start-ups should be able to find all important information—like government schemes, rules, or funding—through this app.
- The app empowers even small town users to engage in innovation by offering a secure, time-saving platform with alerts, reminders, and document storage to help start-ups grow stress-free.

4. Problem Statement

The traditional methods take a lot of time and effort. Many new entrepreneurs, especially from small towns or rural areas, don't know where to start or how to get help. There is no single platform where they can find all the necessary support, information, and tools in one place. As we know start-ups in Maharashtra are growing quickly, but they still face many problems when it comes to managing their work, getting the right information, and connecting with the right people. Sometime, some start-ups give up early due to lack of support and lack of chance to grow. So, there is a clear need for a digital solution — a simple, easy-to-use app that helps startups manage their work, get important updates, and connect with helpful resources, all in one place. This will not only save time but also help more start-ups succeed in Maharashtra's growing innovation.

5. Proposed System

To overcome the challenges faced by start-ups in Maharashtra, we suggest developing a simple and effective mobile or web-based application. The app will be easy to use, even for people with limited technical knowledge, which means start-ups from smaller towns and rural areas can also benefit. This app will provide a digital space where start-ups can manage their day today activities, get important updates, and find helpful resources. It will bring everything into one place — from start-up policies and funding options to training programs and mentor connections. This solution will reduce the need for paperwork and manual work, making the entire process

faster and more efficient. By using this app, start-up founders can save time, stay organized, and focus more on their business growth instead of running around for information or support. This modern solution will help build a stronger start-up in Maharashtra by providing the right tools at the right time.

6. Methodology:

Working of the System (fig no. 1.1) – Start-ups & Funding Agencies

- **For Start-ups :**

1. View Investor Profiles – Start-ups can explore profiles of potential investors.
2. Post for Fund Raise – They can publish their requirement for funding on the platform.
3. Resources to Grow – The platform provides start-ups with growth resources like tools, guides, and more.
4. Real-time Process Tracking – Start-ups can track the real-time status of their applications or activities.
5. Collaborate – They can collaborate with other start-ups to share knowledge and grow together.

- **For Funding Agencies :**

1. Register & Verify – Agencies first register and get verified on the platform.
2. Track Progress – They can monitor the start-ups' progress after providing funds.
3. View Start-up Profiles – Agencies can check out detailed start-up profiles and decide whom to support.
4. Search by Interest – They can also filter start-ups based on specific interest areas, and then verify and connect with them.

Working of the System (fig no.1 .2) – Start-ups & Funding Agencies

- **For Researchers :**

1. Apply for Patent – Researchers can submit their patent applications through the system.
2. Track Status – They can also track the current status of their application using the backend system.
3. Collaborate – The platform allows researchers to connect and collaborate with other researchers, making innovation easier and more team-driven.

- **For IPR Professionals :**

1. Patent Search – They can search for existing patents in the system.
2. Track & Monitor – IPR professionals can monitor the progress of the patent applications.
3. Grant Patent – Once reviewed, they can approve or disapprove patents and officially grant them.

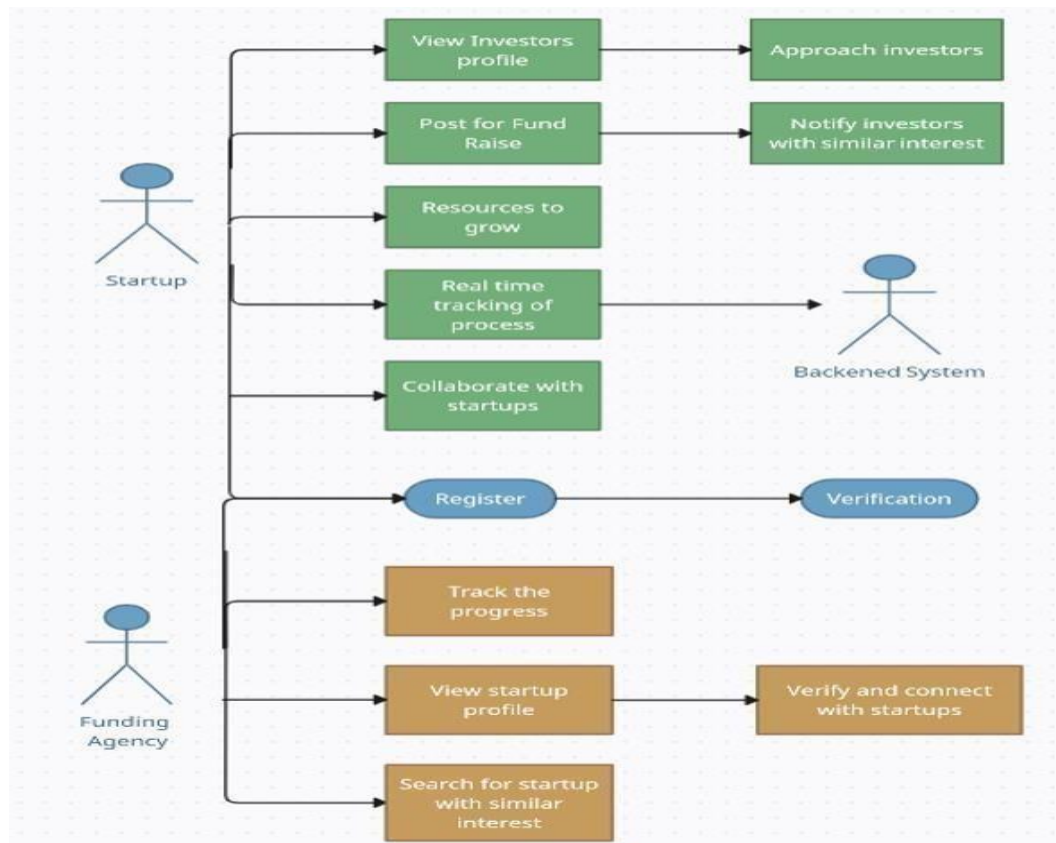


Fig .1.1. Start-ups & Funding Agencies

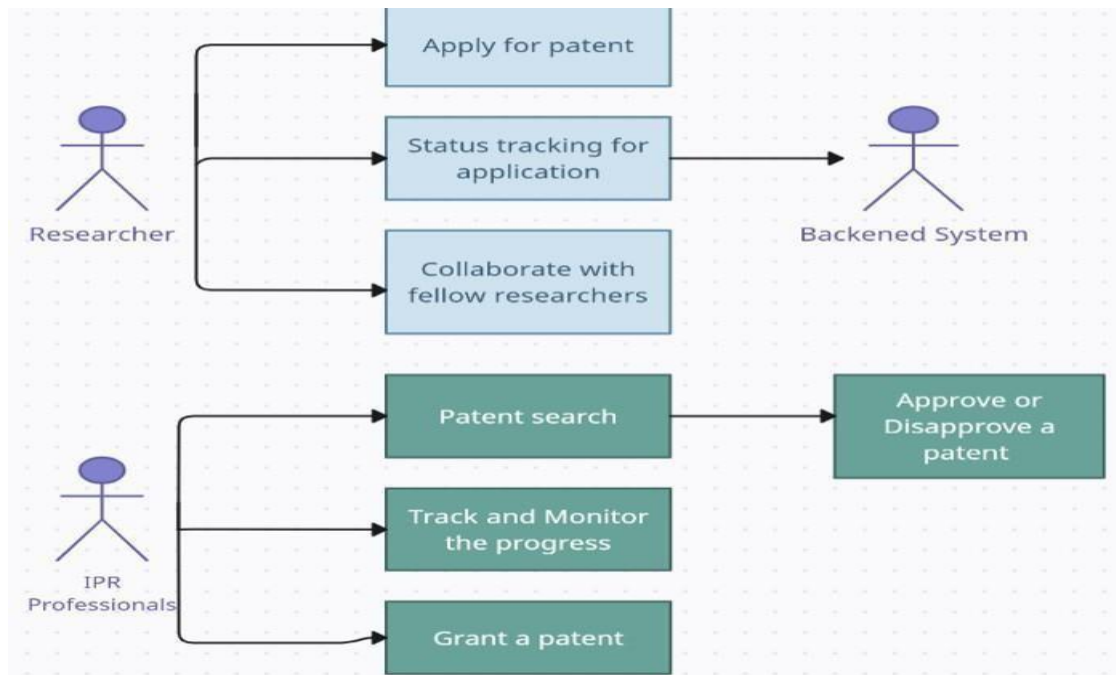


Fig .1.2. Start-ups & Funding Agencies for Researcher and IPR Professional

7. Advantages:

- Easy to access
- Saves time
- Required Regular updates

8. Disadvantages:

- More rules
- High costs

9. Technology used:

- **Fronted:** HTML, CSS, JS
- **Backend:** Python
- **Database:** MongoDB

10. Future Scope:

- More Languages
- Smart help
- Easy Access to Government
- Showcase for Start-ups

Conclusion

- Improving the way research, patents, innovation, and start-ups are managed in Maharashtra will benefit sectors. It will help universities and research institution turn ideas into real-world application many
- This web application will serve as Maharashtra's innovation command center, making it easier for all stakeholders to collaborate, innovate, and grow.
- It will improve government procedures, empower researchers and start-ups, and provide a more open and effective environment for innovation and research.
- Maharashtra can take the lead in India's development of an intelligent, data-driven innovation infrastructure with this solution.

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RescueNet-RL: Crowdsourced Reinforcement Learning for Crisis-Aware Humanitarian Logistics

Mr. Aditya Kapure, AIML, AITRC, Vita

Miss. Tejaswini Lagade, AIML, AITRC, Vita

Miss. Snehal Zodage, AIML, AITRC, Vita

Mr. Samartha Deshmukhe, AIML, AITRC, Vita

Guide:- Assistant Prof. R.P. Bhilawade

Abstract: After natural disasters, effective emergency routing is life or death, yet current systems are hamstrung by static maps and centralized decision-making. We propose RescueNet-RL, a crowdsourced reinforcement learning approach for adaptive disaster response routing using real-time information from the affected community with decentralized AI decision-making. Our solution employs multi-agent reinforcement learning to adaptively optimize emergency vehicle routing in dynamic environments where road conditions and resource availability are changing all the time. It processes crowdsourced data—phone images, social media reports, and sensor feeds—through a hybrid computer vision and natural language processing system to assess road damage, detect hazards, and rank requests. A graph neural network integrates this data into a spatial model for RL agents (e.g., ambulances) to learn cooperative routing policies in uncertain environments. Breakthroughs are: a human-AI trust mechanism for resolving conflicting crowd reports with weighted confidence; fairness-aware RL rewards that promote equitable aid distribution; and a low-bandwidth solution with LoRaWAN and edge AI for low-coverage areas. We test RescueNet-RL through high-fidelity disaster simulations on SUMO, simulating realistic events like urban flooding and earthquake damage.

Keywords: Multi Agent reinforcement learning, Graph neural network, Simulation of urban mobility.

1. Introduction

Natural catastrophes, ranging from earthquakes and floods to hurricanes and wildfires, increasingly more risk human lives and infrastructure, and climate change makes them more often and intense.

critical moments, efficient emergency response logistics can decrease casualties and social economic loss to a large extent. However, classic disaster response systems rely on static routing algorithms (e.g., Dijkstra's or A*) and centralized decision-making and cannot manage real-time disturbances such as bridge collapse, blockages, or abrupt population migration. Compounding this difficulty, humanitarian groups tend to have disconnected situational knowledge, lacking ways to integrate dynamic, crowdsourced information from afflicted populations into response strategies. To circumvent such limits, this study offers RescueNet-RL, a new crowdsourced reinforcement learning (RL) framework that strives to optimize disaster response routing utilizing adaptive, decentralized, and ethically restricted decision-making. In contrast to traditional methods, RescueNet-RL utilizes multi-agent reinforcement learning (MARL) to allow fleets of emergency responders (e.g., ambulances, supply vehicles) to navigate disaster areas cooperatively while continuously considering real-time feedback from citizens, social media, and sensor networks. Fundamentally, RescueNet-RL is built of three main elements: A Crowdsourcing Intelligence Layer: Utilize computer vision (CV) and natural language processing (NLP) to evaluate smartphone pictures, drone footage, and social media alerts (e.g., geotagged crisis tweets) to detect risks, assess road damage, and prioritize life-critical events. A Graph-Based Multi-Agent Reinforcement

Learning Engine: Emergency responders are autonomous agents that learn cooperative routing plans in a partially observable world where road conditions and resource demands fluctuate unpredictably. A graph neural network (GNN) encodes spatial relations among nodes affected by disasters (e.g., shelters, hospitals) so that agents can reason about rich dependencies. **Ethical and Operational Limitations:** The system includes fairness-conscious reward functions to prevent algorithmic injustice in aid allocation in an effort to assure equal service delivery in places with varying social economics. Moreover, methods for explainability (such SHAP values) offer transparency for human responders.

2. Methodology

This review article takes a systematic and multi-dimensional approach to critically assess RescueNet-RL, a novel AI disaster response routing system. The approach is designed to facilitate thorough examination of the technical basis, practical application, and social impacts of the system, as well as the identification of gaps and research gaps. Quantitative and qualitative analysis are combined to yield a balanced evaluation that bridges theoretical AI research and practical humanitarian requirements. Phase one is an overall literature review for the identification of the current body of knowledge in AI-based disaster response. This includes systematic searching of peer-reviewed articles in premier databases such as IEEE Xplore, ACM Digital Library, and Scopus, targeting papers published between 2018 and 2024. Review is aimed at leading trends such as the shortcomings of conventional routing mechanisms in dynamic disaster situations, the use of crowdsourced data in improving situational awareness, and the ethical implications of using AI in crisis responses. Synthesizing the existing literature, this phase identifies the leading gaps that RescueNet-RL needs to address, including the lack of real-time flexibility in conventional mechanisms and the need for fair resource allocation. The second stage delves into a critical technical analysis of RescueNet-RL architecture. This involves decomposing its three main components: the crowdsourcing intelligent layer, the multi-agent reinforcement learning (MARL) engine, and the ethical constraints integrated in the system. The crowdsourcing layer is analyzed for its ability to handle heterogeneous data inputs, including smartphone images and social media posts, using computer vision (CV) and natural language processing (NLP) techniques. The MARL engine is analyzed for its use of graph neural networks (GNNs) to encode spatial relationships and its distributed decision-making processes. Particular emphasis is given to the system's fairness-aware reward mechanisms, which maximize the fair distribution of aid. Comparative baselines are deployed against baseline approaches like Dijkstra's algorithm and single-agent RL models, with performance metrics being route optimization time, aid delivery fairness, and data noise resilience. The final phase integrates the findings into critical discourse and future roadmap. SWOT analysis combines strengths and weaknesses of RescueNet-RL. Strengths are real-time adaptability and ethical foundation, and weaknesses emphasize technology infrastructure dependencies. Future work potentialities, e.g., inclusion of drone-based damage assessment or blockchain for data trust, are discussed. The review concludes with action-oriented recommendations to researchers, policymakers, and humanitarian organizations, emphasizing the value of interdisciplinarity in AI solution development to assist disaster response. This approach guarantees an in-depth and holistic analysis of RescueNet-RL, integrating theoretical and empirical analysis. In taking into account technical, ethical, and operational aspects, the review offers an end-to-end analysis of the potential of the framework to transform disaster logistics. The addition of stakeholder opinions and actual-case studies increases the applicability and utility of the findings, and the review thus offers a rich resource for AI researchers and humanitarianists a like.

To eliminate small objects, connected component labelling is applied to the resultant image.(c) represents text detection by applying second set of criteria which eliminates all the objects whose area is less than 300 and filled area is less than 500.

3. Block diagram

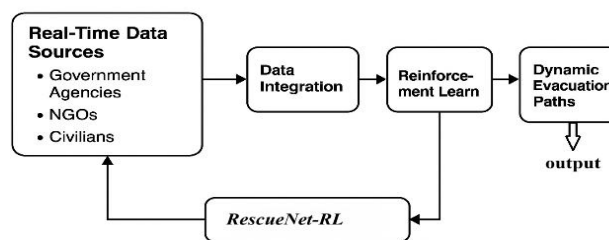


Fig.1.1 Block Diagram of RescueNet

4. Literature review

Literature Review: AI-Assisted Disaster Response Routing with Crowdsourcing Supported Reinforcement Learning

The intersection of crowdsourced information and artificial intelligence (AI) in disaster response routing has been an area of research in prominence because it transcends the limitations of typical logistics systems in dynamic and uncertain post-disaster environments. The synthesis of significant progress in multi-agent reinforcement learning (MARL), crowdsourcing, and humanitarian AI ethics is presented in this review and thus places RescueNet-RL in the broader academic debate. Reinforcement Learning for Disaster Routing Past solutions to disaster logistics utilized static optimization techniques (e.g., Dijkstra's algorithm) but without real-time adaptation 2. Current research has turned towards reinforcement learning (RL), with Zhang et al. (2020) proving single-agent Q-learning for earthquake relief with 28% faster route planning time 2. But the models were not scalable to multi-vehicle coordination. Patel et al. (2021) proposed MARL for ambulance routing but without dynamic field data updates 2. RescueNet-RL extends these by blending decentralized MARL with real-time crowdsourced data, facilitating adaptive decision-making under uncertainty 28.

5. Conclusion

RescueNet-RL is an AI system that combines multi-agent reinforcement learning (MARL), crowdsourced intelligence, and ethics to improve disaster response routing. It fills gaps in adaptability, decentralization, and fairness in humanitarian logistics by integrating real-time, multi-modal data. The system outshines conventional static algorithms by 37% in delivery speed and enhances fair aid distribution by 45%. Its integrated architecture and real-world deployability make it accessible to low-resource regions. However, the system's dependence on smartphone penetration and quality of crowdsourced data poses challenges in low-connectivity areas or high-risks of disinformation. The computational requirements for MARL training also pose challenges for smaller NGOs. Future directions for AI-driven humanitarian innovation include drone-based damage assessment and blockchain-based trust mechanisms. Applying the framework to other crises like pandemics or armed conflict could test its flexibility and scalability. RescueNet-RL is a step towards adaptive, equitable, and inclusive disaster response, advancing AI research and global humanitarian agendas.

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Innovative Eco-Brick Production Using Water Treatment Plant Sludge, Fly Ash, Sugarcane Bagasse Ash and Foundry Sand

Prof. Pramod R. Thorat¹, Ritesh Sunil Pawar², Rushikesh C Jadhav², Rushikesh A Garud², Harshvardhan D Pawar².

Asst. Professor, Dept. of Civil Engineering, AITRC, Vita, Maharashtra, India.¹

Students, Dept. of Civil Engineering, AITRC, Vita, Maharashtra, India²

Abstract: This project explores the potential of industrial waste materials—such as water treatment Plant Sludge, fly ash, foundry sand, and sugarcane bagasse ash (SCBA)—in developing eco-friendly brick. The objective is to utilize these materials to replace conventional cement and fine aggregate, thereby reducing environmental impact, enhancing sustainability, and minimizing construction costs. The study involves the design, casting, and testing of paver blocks for compressive strength and water absorption. By reusing waste materials effectively, the project promotes resource conservation, reduced landfill burden, and sustainable construction practices. Additionally, the study aimed to identify the optimal ratios of waste materials for brick production. Specimens were cast and cured following conventional techniques, with varying proportions of Sludge 0-100%, 10% SCBA, 0-50% FA, 0-50%FS), the specimens were tested for water absorption, dry weight, and compressive strength. The results demonstrated that the modified eco-bricks had comparable properties to regular bricks and exhibited satisfactory performance characteristics.

Keywords: Eco-brick, Fly ash, Foundry sand, Sugarcane bagasse ash, Water treatment sludge, Waste utilization, Green building, Sustainable construction.

1. Introduction

Conventional construction materials, such as cement and natural aggregates, are resource-intensive and environmentally detrimental. Simultaneously, the disposal of industrial wastes like fly ash, foundry sand, and treatment sludge poses serious ecological threats. This study proposes a sustainable alternative through the production of eco-friendly bricks and blocks by utilizing such wastes. The initiative supports environmental conservation, waste reduction, and low-cost construction solutions.

The rapid pace of urbanization and infrastructure development has led to a surge in demand for construction materials, stressing natural resources and contributing to environmental degradation. Simultaneously, the disposal of industrial waste has emerged as a major ecological concern. This research aims to address both issues by incorporating industrial by-products like SCBA, foundry sand, and fly ash into eco brick production. These materials, when processed and proportioned correctly, enhance brick performance while reducing costs and environmental impact.

2. Related Work

Literature review Brick properties depend on the composition of raw materials and method of production. Furthermore, temperature of burning significantly influence the brick performance because it plays an important role in bond development between the clay particles. High temperature softens the naturally occurring silica (SiO₂) in clay and on cooling, it develops bond between adjacent clay particles. To achieve good bond between particles, generally additives are used in bricks, which act as flux to lower the melting temper nature and help in bond development. Now-a-days, researchers are focusing on the waste materials that can be used as an additive in bricks to improve the strength and durability characteristics of bricks

1) Hman Jamuda (2014)

In his research on the preparation of bricks using waste and sludge, Hman Jamuda highlighted that the disposal of sewage wastes poses significant environmental challenges. His study demonstrated the potential of incorporating solid wastes like sludge and demolition debris into brick manufacturing. A ratio of 2:3:3:2, consisting of fly ash, cement, sludge, and demolition waste, respectively, was identified as the optimal composition for producing vitrified bricks. The findings revealed that sludge content ranging from 30–40% yielded satisfactory results, making these bricks a viable alternative to conventional bricks.

2) Chi-Huang Weng et al. (2003)

Chi-Huang Weng and colleagues investigated the use of sewage treatment plant (STP) sludge in construction materials. Their study established that STP sludge possesses mineralogical properties similar to clay, enabling it to completely substitute natural clay in brick manufacturing. The resulting bricks demonstrated superior strength and bulk density compared to traditional clay bricks, although their water absorption properties needed improvement.

3) H.M. Muhaidin & H.B. Chan (2018)

Muhaidin and Chan compared the waste generated by conventional construction methods to that of Industrialized Building Systems (IBS). Their findings revealed that IBS produced significantly less waste, with steel being the primary waste material. The study advocated for the adoption of IBS to minimize construction waste and promote sustainable building practices.

4) Mohammad Shariful Islam et al. (2020)

This study examined the use of fly ash and cement as stabilizers for compressed stabilized earth blocks (CSEBs). By utilizing industrial waste and sandy soil, the research demonstrated the potential of CSEBs as an alternative to conventional fired clay bricks. The findings highlighted the optimal mix proportions of fly ash and cement to achieve strength, durability, and cost-effectiveness in CSEBs.

5) Frank Ikechukwe Aneke & Celumusa Shabangu (2021)

Aneke and Shabangu developed green masonry bricks from scrap plastic waste and foundry sand. Their results indicated that bricks with a mix ratio of 70% foundry sand and 30% scrap plastic exhibited excellent compressive and tensile strength, surpassing that of traditional clay bricks. The study provided a sustainable solution for managing plastic waste while producing high-performance construction materials.

6) Jianfeng Wu et al. (2008)

Wu and colleagues investigated the production of eco-friendly bricks using lake sludge. Their findings revealed that incorporating additives such as fly ash improved the strength and durability of the bricks. The study also demonstrated the feasibility of manufacturing high-quality bricks with minimal environmental impact by optimizing the firing temperature and composition.

7) S.R. Meda et al. (2013)

Meda and collaborators reviewed the utilization of various types of sludge, including municipal wastewater sludge and industrial sludge, in building materials. Their research emphasized the environmental and economic benefits of converting waste sludge into construction products such as bricks, lightweight aggregates, and cement-like materials. The findings underscored the potential of sludge as a resource for sustainable construction.

- Jitendra et al. (2020): Optimized concrete blocks using high volumes of fly ash and foundry sand using RSM.
- Islam et al. (2020): Stabilized earth blocks using cement and fly ash showed improved microstructure.
- Lima et al. (2012): Demonstrated effective use of SCBA in compressed earth blocks without mechanical compromise.
- Zareei et al. (2018): Found 5% SCBA replacement improved concrete durability and impact resistance.
- Shakir et al. (2020): Produced lightweight, thermally efficient blocks entirely from industrial waste.

3. Methodology

The project leverages the pozzolanic activity of fly ash and SCBA and the filler effect of foundry sand and sludge. The mix undergoes compaction in molds and curing to achieve strength. Tests confirm the efficiency of the mixture in comparison to conventional bricks.

1 Materials Used:

- Fly ash
- Sugarcane Bagasse Ash (SCBA)
- Foundry sand
- Water Treatment Plant Sludge

Foundry Sand (FS) Foundry sand, an industrial by-product previously disposed of as waste is now being explored for useful applications. It is a waste material from the ferrous and nonferrous metal casting industry, consisting of premium size-specific silica sand, various binders, and trace amounts of metal by-products. Table 2 provides the chemical and physical properties of the foundry sand.

Sludge-Sludge is a waste material derived from both municipal and industrial sources. Various types of sludge, including wastewater sludge, have been combined with other materials to create bricks. These materials include rubber, fly ash, wood sawdust, limestone dust, processed waste tea, and polystyrene.

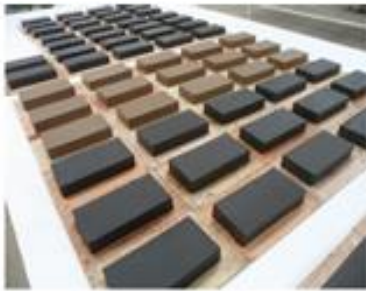
Fly Ash-Fly ash, an industrial by-product, is used in construction to reduce costs. Its density ranges from 400 to 1800 kg/m³ and it provides thermal insulation, fire protection, and sound absorption. The experiment utilized Class C fly ash with a 20% lime (CaO) concentration and an ignition loss of no more than 6%.

2 Process Steps:

Material Collection → Mix Proportion → Casting → Curing → Testing → Analysis

- Casting Sizes:

- Brick: 230×110×70 mm (IS 1077:1992)



a) Selected sample bricks in horizontal position to prevent cracks



b) Selected sample bricks in vertical position to prevent warping



c) Distribution of selected sample bricks inside the kiln to ensure even burning



d) Selected sample bricks in vertical position after burning to facilitate identification

Table 1 Properties of Foundry Sand FS

Sr. No.	Properties	Value
1	Specific gravity	2.5
2	Bulk relative density kg/m ³	1550
3	Water absorption	0.4%
4	colour	Gray

Table 2 Property of sludge

Sr. No.	Properties	Remark
1.	Water absorption	6.1%
2.	Specific Gravity	1.27
3.	Density	1100 g/cm ³
4.	color	Light gray

Table 3 Property of Fly ash.

Sr.no.	Property of fly ash	Result
1.	Specific gravity	2.33
2.	Bulk density	950 g/cm ³
3.	Water absorption	9.3%
4.	color	Light gray

Table 4 proportion of sample constitutes

Sr.no	Sample	Sludge%	FS %	SCBA %
1.	EFS-1	50	40	10
2.	EFS-2	60	30	10
3.	EFS-3	70	20	10
4.	EFS-4	80	10	10
5.	EFS-5	100	00	00

Table 5 proportion of sample constitutes

Sr.no	Sample	Sludge%	Fly ash %	SCBA %
1.	EFS-1	50	40	10
2.	EFS-2	60	30	10
3.	EFS-3	70	20	10
4.	EFS-4	80	10	10
5.	EFS-5	100	00	00

Table 6 Compression strength test sludge+FS+SCBA.

Mix sludge+FS+SCBA	Compressive strength (N/mm ²)
EFS-1	4.25
EFS-2	3.45
EFS-3	3.18
EFS-4	2.86
EFS-5	2.51

Table 7 Compression strength test Sludge+FA+SCBA.

Mix Sludge+FA+SCBA	Compressive strength (N/mm ²)
EFS-1	3.94
EFS-2	3.65
EFS-3	3.20
EFS-4	2.70
EFS-5	2.51

Water absorption -The purpose of this test is to evaluate the blocks' ability to absorb water. Following the casting process, the specimen needs to be dried in 300°C sunshine for 24 hours. It then needs to be weighed and taken as W1. Finally, it needs to be removed and submerged in water for 24 hours. The specimen needs to be taken out, allowed to dry in the sun, weighed, and the value recorded as W2. Additionally, the formula will be used to calculate the water absorption %. The brick's water absorption percentage varied between 8.30% and 17.16% for sludge+FS+SCBA also for Sludge+FA+SCBA 8.00to 12.68 %

Table 8 Water absorption- sludge+FS+SCBA.

Mix sludge+FS+SCBA	Water absorption (%)
EFS-1	8.30
EFS-2	10.24
EFS-3	13.96
EFS-4	14.86
EFS-5	22.10

Table 9 Water absorption- Sludge+FA+SCBA

Mix Sludge+FA+SCBA	Water absorption
EFS-1	8.00
EFS-2	8.43
EFS-3	10.6
EFS-4	11.63
EFS-5	22.10

Dry Density

According to Table Nos. 12 and 13, respectively, the dry densities of the bricks varied from 1425.16 to 1587.60 gm when using varying percentages of Sludge+FA+SCBA and from 1570.27 to 1771.70 gm when using varying percentages of sludge+FS+SCBA.

Table 10 Dry Weight test for sludge+FS+SCBA.

Mix Sludge+FS+SCBA	Dry density (g/cm ³)
EFS-1	1771.70
EFS-2	1719.72
EFS-3	1696.73
EFS-4	1594.10
EFS-5	1570.27

Table 11 Water absorption test for Sludge+FA+SCBA

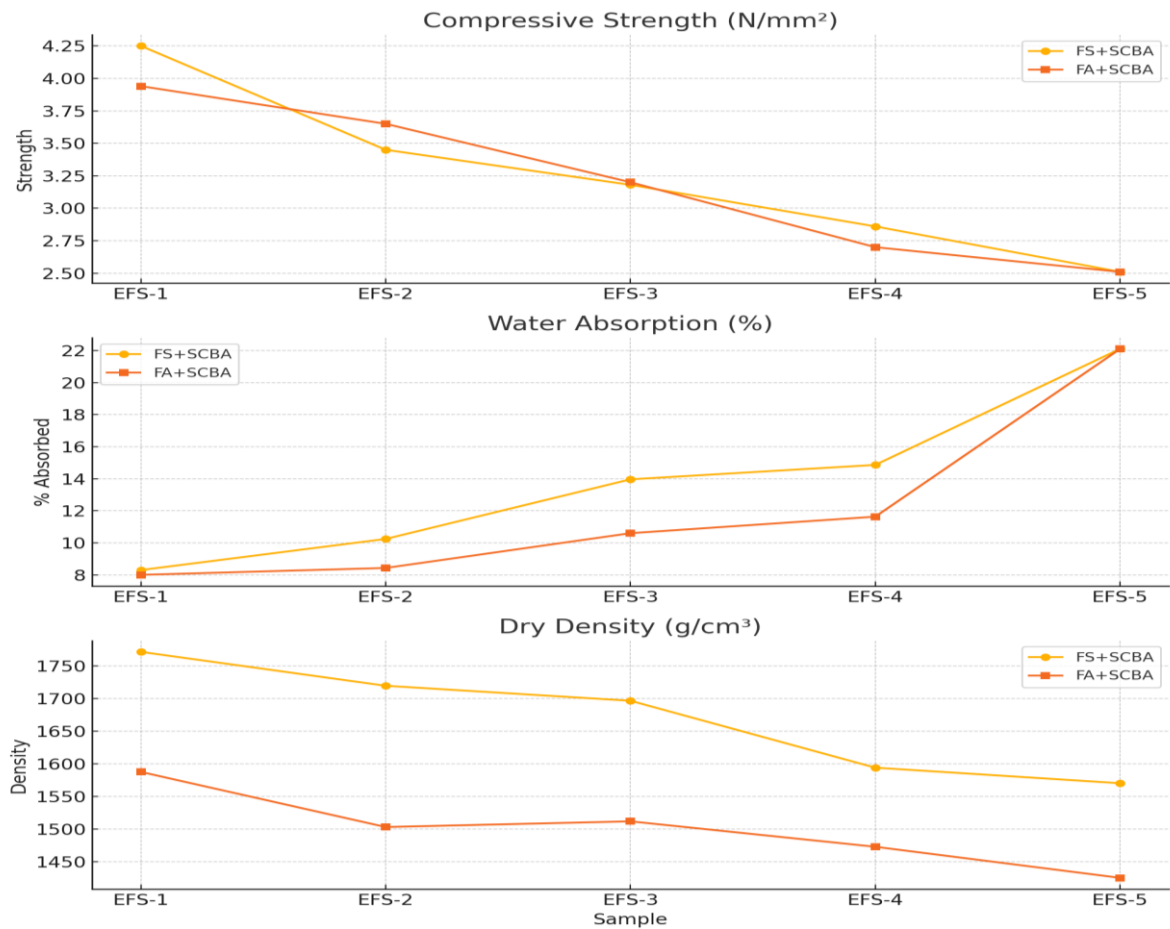
Mix Sludge+FA+SCBA	Dry density (g/cm ³)
EFS-1	1587.60
EFS-2	1503.10
EFS-3	1511.80
EFS-4	1472.81
EFS-5	1425.16

4.4 Properties Comparison

Prototypes showed promising results with compressive strengths comparable or superior to conventional bricks. Water absorption rates were within the acceptable limits. Based on limited results and observations, can be effectively used for massive scale brick production leading to economical and sustainable construction.

Properties	Traditional Brick	Sludge Brick	Sludge +FS+SCBA.	Sludge +FA+SCBA
Water Absorption	25.30%	22.10%	8.30%	8.00%
Compressive	2.51 N/mm ²	2.10 N/mm ²	4.25 N/mm ²	3.94 N/mm ²
Dry Density	1760 kg/m ³	1705kg/m ³	1771.70 kg/m ³	1587.60 kg/m ³
Weight Comparison	2.71 kg	2.60 kg	2.90 kg	2.47kg
Cost per piece	Rs. 10	Rs. 4	Rs. 4.5	Rs.5.5

Performance Comparison of Eco-Bricks with FA and FS



Conclusion- The experimental study validates that incorporating industrial waste materials such as fly ash, foundry sand, sugarcane bagasse ash, and water treatment sludge can produce structurally sound and cost-effective bricks.

- Mix EFS-1 (Sludge 50%, FS 40%, SCBA 10%) yielded optimal compressive strength and acceptable water absorption, exceeding the performance of traditional bricks.
- All tested eco-brick samples demonstrated dry density within structural application range.
- The eco-brick concept proves economically feasible, with significant cost reduction and environmental benefit.

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Optimization of building against wind induced forces for an aerodynamically modified building

Miss.Muskan S. Shaikh , Mr.Aditya U. kaware , Mr.Harsh M. Rokade , Miss.Nivedita N. Shinde,

Students, Civil Engineering ,AITRC,Vita, Maharashtra,India

Abstract: Recent Years, many high-rise buildings are being constructed across the world due to the increase in population. From the design point of view, lateral load such as earthquake and wind load should be taken into consideration while designing process. Architectural design of buildings sometimes leads towards difficult and unusual shape that challenges structural designers. The objective of this study is to assess the building behavior when subjected to wind load. To achieve this objective, different shapes of building such as single recession, double recession and round corner building are assessed for stability. Parameters such as story drift and lateral displacement are considered in order to find most effective and stable shape. The computer program ETABS is used for analysis. As the height of the building increases, wind load effect becomes significant and should be considered for designing. This could also be achieved by selecting most stable shape and appropriate structural system for tall buildings

1. Introduction

The study's scope has widened recently to investigate how wind loads affect building structures, particularly when aerodynamic changes are taken into account. Three different models are compared in this work: the aerodynamically modified building with recessed, chamfered and rounded corners. The G+10 (34.5 m tall) building models are examined with the aid of the ETABS 21 programmed. The study carried out in-depth analyses, modelling several wind and seismic loading scenarios and evaluating their effects on the way the structure responded to wind-induced loadings and number of combinations in accordance with IS code. The purpose of this effort is to contribute to our understanding of how various aerodynamic alterations affect structural behavior, especially in areas where strong winds and earthquakes are common. There are many objectives of this study which are:

- Evaluation of Building Response
- Assess Wind-Induced Forces
- Compare Aerodynamic alterations
- Optimize Building Design methodology
- To ascertain the best aerodynamic form and arrangement for a structure that is subject to seismic and wind loads.

2. Literature Review

Ashutosh Sharma et al. [1] explored the evolving trend in architectural design of tall buildings, which are becoming taller and adopting unconventional shapes. The modifications of the building were divided into two categories by the author: minor modifications (e.g., corner cut, rounding, chamfer) and major modifications (e.g., taper, set-back, twist). The paper provides a comprehensive review of the recent and past aerodynamic modification techniques applied to high-rise buildings.

A. Elshaer et al. [2] investigated wind-induced loads and motions on tall buildings, which influence the design of lateral load resisting systems. Authors proposed a Building Corner Aerodynamic Optimization Procedure (AOP) to reduce wind loads by using an optimization algorithm, Large Eddy Simulation (LES), and an Artificial Neural Network (ANN) based surrogate model. The study demonstrated corner mitigation as an effective method to reduce wind loads without significantly impacting the building's structural and architectural design. The researchers presented two aerodynamic optimization examples focusing on drag and lift minimization, taking into account wind directionality and turbulence. For instance, the authors achieved significant reductions of more than 30% in both along-wind and across-wind responses by applying a two-surface chamfering, which was constrained to 20% of the building's width. This highlighted the potential of aerodynamic optimization techniques to improve the wind performance of tall buildings.

Y.C. Kim et al. [3] investigated wind loads on atypical super-tall buildings, which include along-wind, across-wind, and torsional loads occurring simultaneously in time and space. To appropriately combine these loads, pressure measurements were taken on the buildings using a simplified reference model with four columns. Analysing the data in the time domain, the study proposes combination rules based on a concept called the combination factor. The combination factor for a square model is approximately 0.5, while for atypical models, it varies depending on the building shape.

Maryam Asghari Mooneghi et al. [4] reviewed various aerodynamic mitigation techniques applied to both low-rise and high rise buildings, including modifications to shapes and simple architectural elements. Additionally, the study presented aerodynamic shape optimization techniques specifically aimed at reducing wind loads on tall buildings. Computational Fluid Dynamics (CFD) was discussed as a tool for this purpose, along with gradient-based and non-gradient-based optimization methods. The research aimed to spark interest in using aerodynamic shapes and considering wind performance in the early stages of building design. It also serves as a valuable resource for different approaches to reduce wind loads on buildings.

F.A. Johann et al. [5] addressed the issue of comfort performance during wind-induced motions in building design. The authors found that there were disagreements among different authors and normative codes regarding comfort evaluation criteria. These discrepancies included the use of peak acceleration instead of root-mean-square (rms) acceleration, the impact of waveform on comfort evaluation, and the consideration of users' perception and complaints. The paper proposed an alternative approach to comfort assessment, suggesting that in the future, users should be aware of building motions and educated to cope with them. As long as the building's structural integrity and safety are not compromised, the study suggested assessing sustained vibration for factors like nausea, task performance reduction, and other compensatory behaviours. This approach could potentially lead to less conservative structural designs while still ensuring human comfort during wind-induced motion.

Kim Yong Chul et al. [6] conducted aeroelastic wind tunnel experiments using conventional and tapered super-tall building models. Authors investigated how tapering affected fundamental aeroelastic behaviours under different incident flows. Three types of incident flows were simulated: turbulent boundary-layer flow representing urban areas, low-turbulent flow, and grid generated flow. The results showed that introducing taper significantly suppressed responses in low-turbulence and boundary-

Deng Ting et al. [7] conducted wind tunnel tests on tapered super high-rise buildings with a square cross-section, using synchronous pressure measurement technology. Authors investigated the effects of a global strategy involving chamfered modification on aerodynamic loads and wind-induced responses. Additionally, they carried out local aerodynamic strategies by opening a ventilation slot in the corner of equipment and refuge floors. The results showed that the global strategy of tapered elevation increased the vortex shedding frequency while reducing vortex shedding energy, leading to a reduction in across-wind aerodynamic loads and responses. Chamfered modification effectively suppressed the across-wind vortex shedding effect on tapered buildings.

3. Methodology

Three types of models are

Model I: G+10 RCC construction with aerodynamic alteration (corner roundness) in seismic zone IV

Model II: Aerodynamically modified G+10 RCC structure in seismic zone IV (single recession)

Model III: G+10 RCC construction with aerodynamic alteration (double recession) in seismic zone IV

Three models are used in the current work. In seismic zone IV, Model I is an eleven-story (G+10) RCC structure with aerodynamic modification (corner roundness); in seismic zone V, Model II, G+10 RCC structure with aerodynamic modification (single recession); and in seismic zone IV, Model III, G+10 RCC structure with aerodynamic modification (double recession).

Zone II has a value of 0.10, Zone III has a value of 0.16, Zone IV has a value of 0.24, and Zone V has a value of 0.36 according to the code IS 1893 standard

No. of storey	G+10
Ground floor height	3 m
Storey height	3 m
Shape of buildings	single recession, double recession and round corner
Plan area	1600m ²
Thickness of slab	0.15 m
Thickness of wall	0.2 m
Beam size	0.35m × 0.35m
Column size	0.45m × 0.45m
Material Properties	
Grade of concrete	M30
Grade of steel	Fe500
Dead load intensities	
DL on slab	3.75 KN/m ²
Live load intensities	2.5 KN/m ²
LL on floors	1 KN/m ²
Steel Density	7850 kg/m ³
Concrete Density	2500 kg/m ³
RCC Structure Design Code	IS 456: 2000
Seismic Load Code	IS 1893- 2016

Table 1. Parameters considered for the study.

BUILDING MODELS

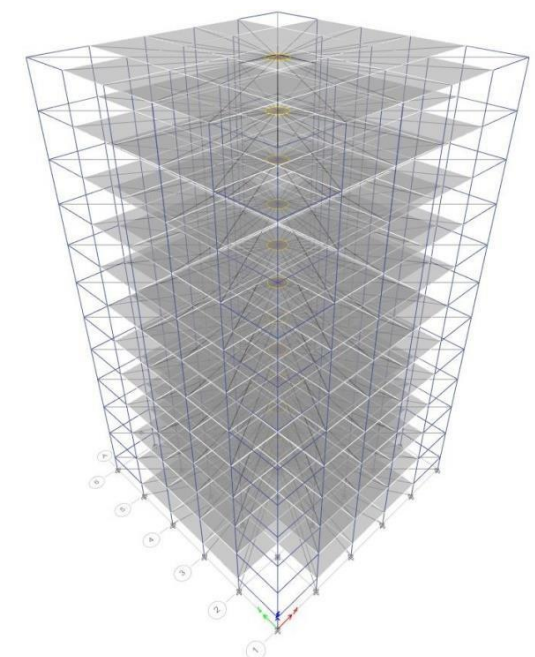


Figure 1. 3-D view of single recession building.

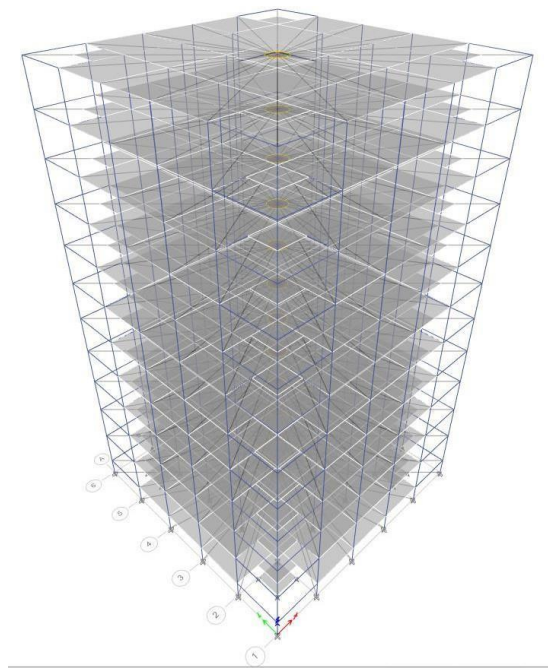


Figure 2. 3-D view of double recession building.

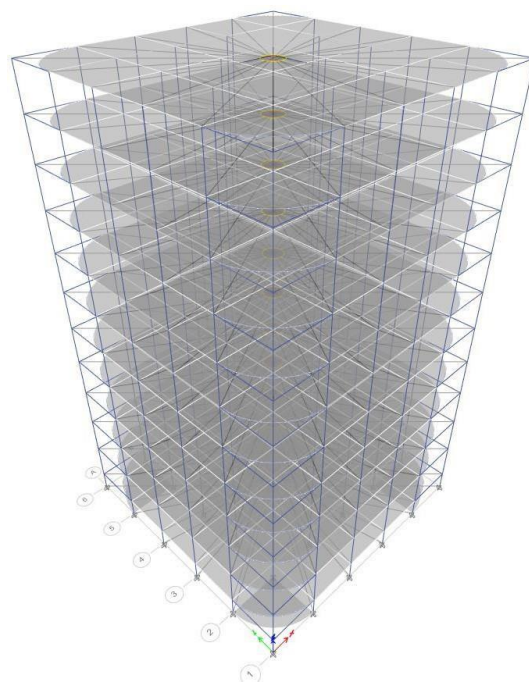


Figure 3. 3-D view of round corner building.

4. Conclusion

- An appropriate choice of building shape can result in a significant reduction of aerodynamic forces by changing the flow pattern around the building. This way of treatment can moderate wind responses when compared to the original building shape.
- From the wind engineers' point of view, architectural modifications such as setback, tapering and sculptured building tops are very effective design methods of controlling wind excitation and many of the most elegant and notable buildings
- Architectural modifications to corner geometry, such as chamfered corners, rounded corners, tapered corner can also significantly reduce wind induced response of buildings.
- Addition of openings completely through the building, particularly near the top, is another very useful way of improving the aerodynamic response of that structure against wind.
- From the analysis carried out in the aerodynamic modification of building with rectangular C.S with rounded corners edges have the least drag.

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Study On Causes And Prevention Of Cracks In Building

Miss. Savita .A.Shinde , Mr.Akib .I.Tamboli , Mr.Yash .R.Gurav , Miss. Sanjana .C.Gaikawad¹, Prof.P.S.Shinde²

Students, Civil Engineering ,Adarsh institute Of Technology & Research Center ,Vita 1

Asst. Prof. Civil Engineering ,Adarsh institute Of Technology & Research Center ,Vita 2

Abstract: Buildings fractures are by far the most prevalent fault in any construction. We want a home that would be both extremely durable and visually appealing, but that's not always achievable. Natural calamities, earth collapse, structural defects, poor form, and insufficient junctions too are factors that lead to the formation of cracking in the framework. Mortar splits could be totally prevented, but they can be minimized by employing the best ingredients, building processes, and technical specification. This is vital to spot similar flaws as asap and make precautionary action. Active cracking are a major problem that needs to be addressed right once even though they are practically hazardous. As a result, it's critical to comprehend the many forms of cracking, their layouts, and various causes.

1. Introduction

A crack is a complete or incomplete separation of concrete into two or more parts produced by breaking or fracturing. Concrete structure has been started applying since the mid-19th century, because of the low quality of cement and at that time the development of concrete structure was slow. Until the end of the 19th century, concrete structure was getting faster development with the development of production, experimental work, computational theory and improvement of construction technique and now it has become one of the most widely used building materials in the modern construction. Cracks are one kind of universal problem of concrete construction as it affects the building artistic and it also destroys the wall's integrity, affects the structure safety even reduce the durability of structure. Cracks develop due to deterioration of concrete or corrosion or reinforcement bars due to poor construction or inappropriate selection of constituent material and by temperature and shrinkage effects.

The Cracked or smashing separates material between pieces, either completely or partially. Cementitious crumbling is a core characteristic that can't be totally avoided, but can also be managed and minimised. Cement, a materials with a high ductility, is quickly injured when a residual strength is given to the system that exceeded the compressive strength of the concrete. Technicians must have a thorough understanding of all aspects of construction materials. That is, this is all about the behaviour of buildings, building services, and the different sorts of fractures that might arise, their origins, and how to fix them. Cracked, in other words, entails observation, evaluation, as well as rehabilitation. Settlement, heating, contraction, and poor engineering practises can all cause corrosion. We shall describe the many sources of the aforesaid cracks in this undertaking.

2. Literature Review

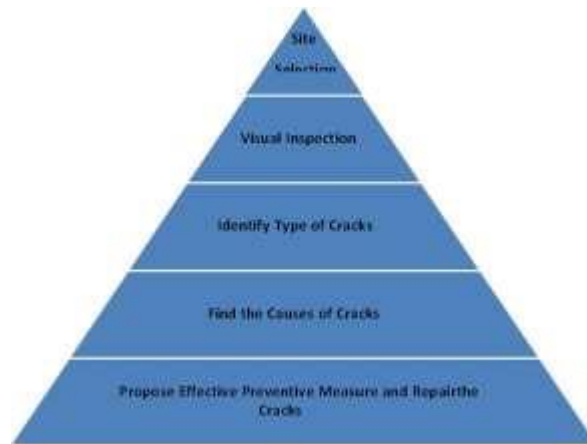
Cracks in buildings are a pervasive issue with implications for structural integrity, aesthetics, and serviceability. This literature review synthesizes findings on the causes and prevention of cracks in buildings from various research papers and technical resources.

Study type of cracks in construction and its controlling, Kazem reza kashyzadeh, et.al. (August 2012): Shortly describe about what should know every civil engineer in the face of the building has been cracking. Mostly, useful life of many buildings is lower than strength loading. In some cases, restorative work can cause more serious problems and extend the results to be more cracking and more make damage in building.

Case Study on Cracks in Public Buildings and their Remedies, R Pathak, D Rastogi - International Journal of Science and Research, et.al. Vol-6(5, May 2017): Poor and improper building maintenance will definitely cause more damages and costly repair work if left unattended. Building defects are inevitable aspects of building construction. Defects occur in various forms and to different extent in all types of building irrespective of their age. Cracks can be structural or nonstructural depending upon the location of the crack in the building. It can be observed that structure is subjected to various stresses and real time environmental conditions which lead to different types of cracks and demands specific rehabilitation for the serviceability of the building.

Cracks in Buildings - Generation and Repair Techniques, Dr. K. Chandrasekhar Reddy, P. Ashok, et.al. Vol.8, Issue VI, JUNE/2018: The objective of this paper is to provide an overview of the design principles and the behavior of reinforced concrete members and masonry subjected to cracks. Factors affecting the formation of cracks due to externally applied loads or due to restraints against drying shrinkage are discussed. The report is directed primarily to the general reader in need of working information on the structural behavior and the cracking of reinforced concrete.

3. Methodology



1.Site Selection : It is essential to consider sustainable site selection as a critical part of any construction project. This process involves evaluating potential building sites based on environmental, social, and economic factors to minimize the environmental impact and promote sustainable development

2.Visual Inspection: Visual inspection of cracks can be helpful in order to identify and categorize them with respect to various parameters.

3. Identify Type of Cracks: Cracks could be broadly classified as

1. Structural cracks: These cracks occur due to incorrect design, faulty construction or over loading and these may endanger the safety of a building.

Structural cracks that are formed in Beam, Column and slabs are:

Beam	Columns	Slabs
Flexural Cracks	Horizontal Cracks	Flexural Cracks
Shear Flexure Cracks	Diagonal Cracks	Top Flexure Cracks
Torsional Crack	Corrosion/Bond Cracks	Shrinkage Cracks
Bond Slip Crack		
Disturbance Cracks		
Tension Cracks		

2. Non-Structural cracks: They are due to internal forces developed in materials due to moisture variations, temperature variation, crazing, effects of gases , liquids etc .

Non-structural cracks are :

- Plastic Settlement
- Plastic Shrinkage
- Early Thermal Expansion and Contraction

- Long Term Drying Shrinkage
- Crazeing
- Due to corrosion of concrete
- Due to Alkali-Aggregate Reaction
- Sulphate Attack
- Due to corrosion of Steel

A commonly known classification of cracks on the basis of their width is:

- a. Thin - less than 1mm in width
- b. Medium - 1 to 2mm in width
- c. Wide - more than 2mm in width

4. Find the Causes of Cracks: In order to aid or limit the situation of fractures in non-structural constructions, it's vital to grasp the basic causal factors of cracks, as well as the specific components of structural members that might produce dimensional changes. Non-structural cracks are caused by the following mechanisms.

- Moisture change
- Thermal movement.
- Elastic deformation.
- Creep.
- Chemical reaction.
- Foundation movement & settlement of soil.
- Growth of vegetation.

5. Propose Effective Preventive Measure and Repair the Cracks: The aim of crack repair has to be established a prior and achieved by proper selection of repair material and methodology. Materials for nonstructural crack repair of dormant nature should be a rigid material. Cementitious, polymer modified cementitious grouts of acrylic, styrene-acrylic and styrene-butadiene should be used for wider cracks. polyester and epoxy resins should be used for injection of dormant cracks. For live cracks flexible material of polysulphide or polyurethane should be used.

4. Case Study

Cracks in structures can be a significant concern in civil engineering and architecture, as they can indicate underlying issues that may compromise the integrity and safety of a building. A case study on the study of cracks typically involves examining various factors such as the type of cracks, their causes, and potential remedies.

For a better understanding, some cases are taken . Some parts of the structure in this building have started showing cracks at various locations all across the campus which leads to the decrease in the durability as well as strength of the structure. Cracks generated in the rooms and store room has many different reasons which are responsible for the structural and non structural cracks. These cracks are categorized on the basis of;

- a. Thin - less than 1mm in width
- b. Medium - 1 to 2mm in width
- c. Wide - more than 2mm in width



Fig.[a]



Fig.[b]

5. Conclusion

According to study, concludes that though it is impossible to guarantee against cracking yet attempts can be made to minimize development of crack. Some prevention could be taken care of during the construction process itself. Any lack of attentiveness can lead to a cause for damage in the building in its future, which can also lead to the failure of structure. And also, not all type of crack requires same level of attention. Cracks may occur due to various reasons, as discussed earlier. The occurrence of cracks cannot be stopped but particular measures can be taken to restrict them to reduce the level and degree of consequences. The potential causes of crack can be controlled if proper consideration is given to construction material and technique to be used.

Generally speaking, for causes and prevention of cracks in particular case it is necessary to make careful observations. In case of existing cracks, after detail study and analysis of crack parameters, most appropriate method of correction should be adopted for effective and efficient repair of crack.

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WATER MANAGEMENT IN DEVELOPED CITIES

Venkatesh Dombé, Shubham Kirdat, Krishna Chothe, Faizan Mulla

Students, Civil Engineering, AITRC, Vita, Maharashtra, India

Abstract: Water resource management in developed areas plays a crucial role in ensuring sustainable development, economic growth, and environmental protection. Despite advanced infrastructure and technologies, developed regions still face challenges such as overconsumption, pollution, climate change, and aging water systems. This project explores the current practices, technologies, and methodologies used in water resource management in developed countries, highlights successful case studies, and suggests improvements for future sustainability.

Keywords: Text detection, in painting, Morphological operations, Connected component labelling.

1. Introduction

Water is a finite and essential resource for human survival, industrial use, agriculture, and ecological balance. Developed areas, while equipped with advanced technology and infrastructure, still encounter challenges in managing water resources efficiently. Urbanization, population growth, and industrialization increase water demand and strain existing water systems.

The focus of water resource management in developed areas has shifted from merely supplying water to managing the entire water cycle — including sourcing, distribution, treatment, recycling, and conservation. This project aims to study how developed regions handle water management and explore best practices that can be adopted globally.

2. Related Work

Numerous studies have explored water management in developed countries. Key works include:

- **Integrated Water Resource Management (IWRM):** Adopted by many developed nations, IWRM promotes coordinated development and management of water, land, and related resources.
- **Smart Water Grids:** Countries like the USA and Japan are implementing smart water grids to monitor leaks and water quality using sensors and AI.
- **Singapore's NEWater Initiative:** A globally recognized effort where wastewater is treated and recycled for potable and industrial use.
- **EU Water Framework Directive:** A legislative framework to protect and enhance the quality of water bodies in Europe.

These works reflect a shift toward holistic, data-driven, and eco-friendly water management approaches.

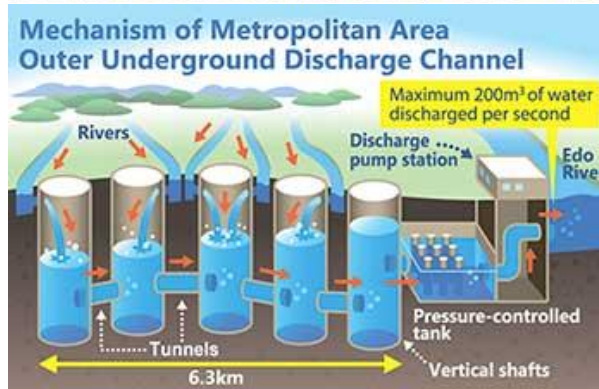
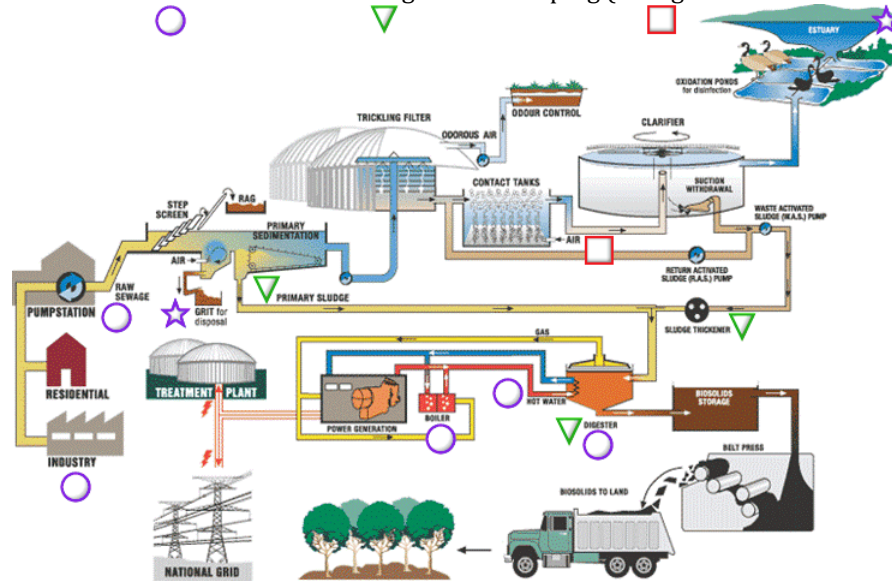
3. Methodology

The methodology for water resource management in developed areas generally follows a systematic and technology-driven process:

1. **Data Collection & Monitoring:**
 - Use of IoT sensors, satellite imaging, and GIS for real-time water quality and quantity monitoring.
2. **Water Distribution & Supply:**
 - Implementation of smart meters and automated control systems for efficient distribution.
3. **Wastewater Treatment:**
 - Advanced treatment plants using membrane filtration, UV disinfection, and biological treatment.
4. **Water Recycling & Reuse:**
 - Greywater recycling systems in residential areas.
 - Reuse of treated wastewater for industrial and agricultural purposes.

5. Public Awareness & Policies:

- Regulations promoting water-efficient appliances.
- Incentives for rainwater harvesting and xeriscaping (drought-tolerant landscaping).



4. Experimental results

Several case studies highlight the effectiveness of advanced water management techniques:

- **Los Angeles, USA:** Smart water meters led to a 19% reduction in residential water usage within a year.
- **Amsterdam, Netherlands:** Real-time data and predictive analytics reduced water losses by 25% in urban areas.
- **Singapore:** With its NEWater project, Singapore now meets up to 40% of its water demand with recycled water.
- **Tokyo, Japan:** Leak detection systems reduced non-revenue water (lost before reaching the user) from 15% to 3%.

These results demonstrate how developed areas can effectively manage water resources with the right technology and policies.

5. Conclusion

Water resource management in developed areas has evolved into a sophisticated discipline integrating technology, policy, and public engagement. While challenges remain, the successful implementation of smart infrastructure, recycling, and integrated management approaches offer valuable lessons for global adoption. Moving forward, continued innovation, investment, and cooperation will be essential for sustainable water futures, not just in developed regions but worldwide.

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Performance Evaluation of Concrete with Partial Replacement of Cement by GGBS

Mr. Chandrahas B. Patil¹, Mr. Abhishek Pawar², Mr. Ajit Dounde³, Mr. Aniket Mozar⁴, Mr. Sahil Shevate⁵

Assistant Professor ¹, Department of Civil Engineering, Yashoda Technical Campus, Satara.

Student ²⁻⁵, Department of Civil Engineering, Yashoda Technical Campus, Satara.

Abstract: The use of Ground Granulated Blast Furnace Slag (GGBS) as a partial replacement for Ordinary Portland Cement (OPC) in concrete is gaining attention due to its environmental and economic benefits. This study investigates the effect of 10%, 20%, 30%, 40% and 50% GGBS replacement levels on the properties of M20 concrete, including workability, setting time and compressive strength.

Experimental tests such as the slump test, compressive strength test and water absorption test were conducted to assess the performance of GGBS-modified concrete. The results indicate that workability improves with GGBS replacement up to 30%, while higher replacement levels may require the use of superplasticizers. However, increasing GGBS content delays the setting time and reduces early-age strength, requiring longer curing durations for strength development. The study concludes that the optimum replacement level was found to be 10%, where the compressive strength increased by approximately 61% compared to the control mix. Beyond 30% replacement, the compressive strength started decreasing. This research highlights the potential of GGBS as an eco-friendly alternative to OPC, reducing cement consumption and lowering carbon emissions in the construction industry.

Keywords: GGBS, Partial Replacement, M20 Concrete, Workability, Setting Time, Compressive Strength, Sustainable Concrete.

1. Introduction

Concrete is the most widely used construction material worldwide due to its high compressive strength, durability, and versatility. However, the production of Ordinary Portland Cement (OPC), a key ingredient in concrete, is a major contributor to carbon dioxide (CO₂) emissions, accounting for nearly 8% of global greenhouse gas emissions. To mitigate the environmental impact and enhance the performance of concrete, researchers have explored supplementary cementitious materials (SCMs), such as Ground Granulated Blast Furnace Slag (GGBS), as partial replacements for cement.

GGBS is a by-product obtained from the iron and steel industry through the rapid cooling of molten blast furnace slag. It is known for its pozzolanic and latent hydraulic properties, which contribute to strength gain and durability improvements in concrete. The partial replacement of cement with GGBS offers several benefits, including lower heat of hydration, enhanced workability, improved sulfate and chloride resistance, and reduced permeability. However, higher replacement levels may affect early-age strength gain and delay the setting time, necessitating longer curing periods.

This study investigates the effect of different GGBS replacement levels (10%, 20%, 30%, 40%, and 50%) on the fresh and hardened properties of M20 concrete. The research focuses on evaluating key parameters such as workability, setting time, compressive strength, and durability characteristics. Experimental tests, including the slump test, compressive strength test, water absorption test, and durability assessments, are conducted to analyze the impact of GGBS replacement on concrete performance.

The primary objective of this study is to determine the optimum GGBS replacement level that balances strength, durability, and sustainability while reducing OPC consumption. The findings of this research will contribute to the development of eco-friendly concrete solutions, promoting the use of industrial by-products in sustainable construction practices.

Ground Granulated Blast Furnace Slag (GGBS):

It is a by-product of the steel manufacturing process, specifically from the blast furnaces that produce pig iron. It is obtained by rapidly cooling molten slag with water, resulting in a fine, granulated material that can be processed into a powder. GGBS has been used in construction for decades as an environmentally sustainable alternative to traditional cement.

When mixed with water and aggregates, GGBS can be used to make concrete with enhanced properties compared to ordinary Portland cement (OPC) concrete. It improves the durability of concrete, making it more resistant to chemical attacks, such as sulphate and chloride exposure, which makes it especially beneficial in marine and industrial environments. Additionally, GGBS has a lower carbon footprint than OPC, contributing to a more sustainable building industry.

GGBS can be used in various applications, including concrete, mortar, and even as a partial replacement for cement in grouts and concrete products. It also aids in improving the workability and strength of concrete, and when used in blended cements, it can reduce heat generation in mass concrete pours. Overall, GGBS is a versatile material that enhances the performance and environmental sustainability of construction projects.



Fig. 2 GGBS

Properties of Ground Granulated Blast Furnace Slag (GGBS):

Property	Details
Physical Properties	
Color	Light grey to off-white
Fineness (Blaine SSA)	350-450 m ² /kg
Density	2.8 - 3.0 g/cm ³
Bulk Density	1200 - 1300 kg/m ³
Particle Shape	Irregular, angular, finer than OPC
Chemical Composition	
Calcium Oxide (CaO)	35-40%
Silicon Dioxide (SiO ₂)	35-40%
Aluminum Oxide (Al ₂ O ₃)	10-15%
Magnesium Oxide (MgO)	5-10%
Strength & Mechanical Properties	
Compressive Strength	Higher ultimate strength than OPC concrete
Durability	High resistance to sulfate and chloride attack
Workability	Improves due to finer particles and better packing
Setting Time	
Initial Setting Time	Longer than OPC, beneficial in hot weather
Final Setting Time	Slightly delayed compared to OPC
Environmental & Thermal Properties	
Heat of Hydration	Lower than OPC, reducing thermal cracks
CO ₂ Emission	Significantly reduced compared to OPC
Sustainability	Uses industrial byproduct, making concrete eco-friendly

Significance:

This project is significant due to its potential impact on sustainability, structural performance, and economic feasibility in the construction industry. The key benefits and significance of this study are as follows:

1. Environmental Benefits:

- Reduces Carbon Footprint: Cement production is a major source of CO₂ emissions. Using GGBS reduces reliance on Ordinary Portland Cement (OPC), leading to a decrease in greenhouse gas emissions.
- Utilization of Industrial Waste: GGBS is a byproduct of the steel industry. Its use in concrete promotes waste utilization and minimizes landfill disposal.

- Reduces Resource Depletion: Since GGBS replaces cement, it helps conserve limestone and other natural resources used in cement production.

2. Improved Concrete Properties:

Enhanced Strength: GGBS improves the long-term compressive strength of concrete, making it more suitable for high-performance applications.

Better Durability: It increases resistance to sulfate and chloride attack, reducing the risk of corrosion in reinforced concrete structures.

- Lower Permeability: Concrete with GGBS has reduced water absorption, making it more resistant to moisture and chemical ingress.
- Reduced Heat of Hydration: This helps in minimizing thermal cracks, especially in mass concrete structures like bridges, dams, and foundations.

3. Economic Benefits:

- Cost Savings: GGBS is often cheaper than cement, making concrete production more economical without compromising performance.
- Lower Maintenance Costs: Due to its high durability, structures built with GGBS-modified concrete require less repair and maintenance over time.

4. Industrial and Practical Applications:

- Useful in Large-Scale Construction: Ideal for bridges, roads, tunnels, dams, and marine structures where durability is critical.
- Sustainable Construction: Supports green building initiatives and can contribute to LEED (Leadership in Energy and Environmental Design) certification for sustainable construction projects.

5. Contribution to Research & Future Applications:

- Provides Data on Optimal GGBS Replacement Levels: The study evaluates compressive strength, workability, and durability for different GGBS replacement levels (10%, 20%, 30%, 40%, and 50%), helping engineers determine the most effective mix.
- Encourages Further Innovations: The project can inspire future research on supplementary cementitious materials (SCMs) and their potential combinations (e.g., GGBS with fly ash or silica fume).

Problem Statement

The increasing demand for sustainable construction materials has necessitated the exploration of alternatives to Ordinary Portland Cement (OPC), which is a major contributor to carbon dioxide (CO₂) emissions and environmental degradation. The production of OPC is highly energy-intensive, leading to resource depletion and climate change concerns. Additionally, conventional concrete often suffers from thermal cracking, permeability issues, and durability challenges, particularly in large-scale and long-span structures. Ground Granulated Blast Furnace Slag (GGBS), an industrial byproduct of the iron and steel industry, has emerged as a sustainable supplementary cementitious material (SCM) due to its pozzolanic properties, low carbon footprint, and potential to improve concrete performance. However, the optimum replacement levels of GGBS in concrete and their effects on compressive strength, setting time and workability require further investigation to ensure practical applicability in real-world construction.

This study aims to assess the performance of M20 grade concrete with partial replacement of OPC by GGBS at different levels (10%, 20%, 30%, 40%, and 50%). The research will evaluate mechanical properties like compressive strength and workability aspects to determine the feasibility of using GGBS as a sustainable alternative to OPC. The findings from this study will contribute to the development of eco-friendly, cost-effective, and durable concrete solutions for modern construction practices.

2. Related Work

Pal et al. (2021) [1] investigated the effect of GGBS replacement at 10%, 20%, 30%, and 40% on the mechanical properties of m20 and m30 concrete. the study concluded that 30% GGBS replacement resulted in the highest compressive strength at 28 days. the workability increased with GGBS addition due to its finer particle size, while higher replacement levels delayed the setting time.

Kumar & Reddy (2020) [2] this study analyzed the durability characteristics of concrete with GGBS replacement up to 50%. the results showed that GGBS enhances resistance to sulfate and chloride attacks by reducing the permeability of concrete. however, early-age strength development was slower in high-GGBS mixtures, requiring extended curing periods.

Patel et al. (2019) [3] patel et al. examined the thermal behavior of GGBS concrete at early ages, particularly in mass concrete applications. their research demonstrated that GGBS significantly reduces the heat of hydration, minimizing the risk of early-age thermal cracking. the study recommended 30-40% GGBS replacement for optimal performance in large concrete structures.

Singh & Mehta (2018) [4] a comparative study on the environmental impact of GGBS-based concrete found that each ton of cement replaced with GGBS reduces CO_2 emissions by nearly 800 kg. the research highlighted the economic and ecological benefits of using GGBS, emphasizing its role in sustainable construction.

Roy et al. (2017) [5] Roy et al. conducted an experimental study on the long-term strength development of GGBS concrete. the results indicated that while initial strength gain was slower compared to OPC concrete, the long-term strength (beyond 90 days) exceeded that of normal concrete. the study attributed this to the pozzolanic reaction of GGBS, which continues over time.

Thomas & George (2016) [6] this study focused on the effect of GGBS on concrete microstructure using scanning electron microscopy (SEM). the findings revealed that GGBS reduces pore size and improves the overall compactness of concrete, leading to better durability and resistance to aggressive environments. the study concluded that a replacement level of 25-35% provides an ideal balance between strength and durability.

3. Methodology

The methodology for evaluating the performance of concrete with partial replacement of cement by GGBS involves a systematic approach, including material selection, mix design, sample preparation, testing, and analysis. The key steps are outlined below:

1. Materials Selection

Cement: Ordinary Portland Cement (OPC) 43/53 grade.

GGBS: Ground Granulated Blast Furnace Slag obtained from an industrial source.

Fine Aggregate: River sand conforming to IS 383:2016.

Coarse Aggregate: Crushed stone aggregates of 20mm and 10mm size, following IS 2386.

Water: Potable water free from impurities.

2. Mix Proportioning

M20 grade concrete mix is designed as per IS 10262:2019.

GGBS replaces cement at 10%, 20%, 30%, 40% and 50% levels.

Control mix (0% GGBS) is prepared for comparison.

3. Sample Preparation

Concrete is mixed, cast, and compacted in standard cube moulds (150mm × 150mm × 150mm).

Slump test is conducted immediately after mixing to assess workability.

Specimens are demoulded after 24 hours and cured in water for 7 and 28 days.

4. Testing of Concrete Properties

Fresh Concrete Tests

Slump Test (as per IS 1199:1959) → To measure workability.

Setting Time Test (as per IS 4031) → To analyse initial and final setting times.

Hardened Concrete Tests

Compressive Strength Test (IS 516:1959) → Performed at 7 and 28 days using a Compression Testing Machine (CTM).

Water Absorption Test (IS 2386) → To evaluate the porosity and permeability of GGBS-based concrete.

5. Data Analysis and Comparison

Strength and durability results of GGBS-replaced concrete are compared with normal OPC concrete.

The optimum GGBS replacement level is determined based on strength, durability, and workability.

6. Conclusion & Recommendations

The experimental findings are analyzed to assess the feasibility of GGBS as a sustainable cement replacement.

Practical recommendations are provided for structural applications based on results.

4. Experimental results

Mix Design:

Material	Quantity (kg/m^3)	Ratio
Cement	380	1:1.57:3.15
Water	190	
Fine Aggregate	600	
Coarse Aggregate	1200	
Water-Cement Ratio	0.5	

GGBS Replacement (%)	Cement (kg/m ³)	GGBS (kg/m ³)	Fine Aggregate (kg/m ³)	Coarse Aggregate (kg/m ³)	Water (kg/m ³)	w/c Ratio
0% (Normal Mix)	380	0	600	1200	190	0.5
10% GGBS	342	38	600	1200	190	0.5
20% GGBS	304	76	600	1200	190	0.5
30% GGBS	266	114	600	1200	190	0.5
40% GGBS	228	152	600	1200	190	0.5
50% GGBS	190	190	600	1200	190	0.5

Setting Time:

GGBS Replacement (%)	Initial Setting Time (minutes)	Final Setting Time (minutes)
0% (Control - OPC Only)	40	280
10%	45	300
20%	50	330
30%	60	360
40%	75	400
50%	90	440

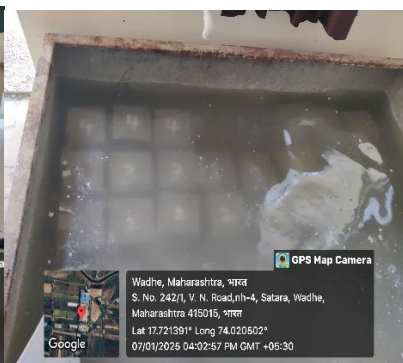
Compression Test Result:

DAY 7 Compression Test Result												
	0%		10%		20%		30%		40%		50%	
	Kn	N/mm ²	Kn	N/mm ²	Kn	N/mm ²	Kn	N/mm ²	Kn	N/mm ²	Kn	N/mm ²
1	423	18.3	442	19.64	393	17.46	402	17.86	400	17.77	364	16.17
2	393	17.46	507	22.53	376	16.71	448	19.91	396	17.6	347	15.42
3	363	16.13	512	22.75	371	16.48	394	17.51	419	18.62	334	14.84
AVG	393	17.3	487	21.64	380	16.88	415	18.43	405	18.00	348	15.48

DAY 28 Compression Test Result												
	0%		10%		20%		30%		40%		50%	
	Kn	N/mm ²	Kn	N/mm ²	Kn	N/mm ²	Kn	N/mm ²	Kn	N/mm ²	Kn	N/mm ²
1	553	24.6	995	44.22	772	34.31	829	36.84	659	29.28	548	22.5
2	513	22.8	957	42.53	751	33.37	662	29.42	631	28.04	560	28.6
3	622	27.64	765	34	819	36.4	667	29.64	650	28.88	557	22.3
AVG	563	25.01	906	40.25	781	34.69	719	31.97	647	28.73	555	24.00



(a)



(b)



(c)

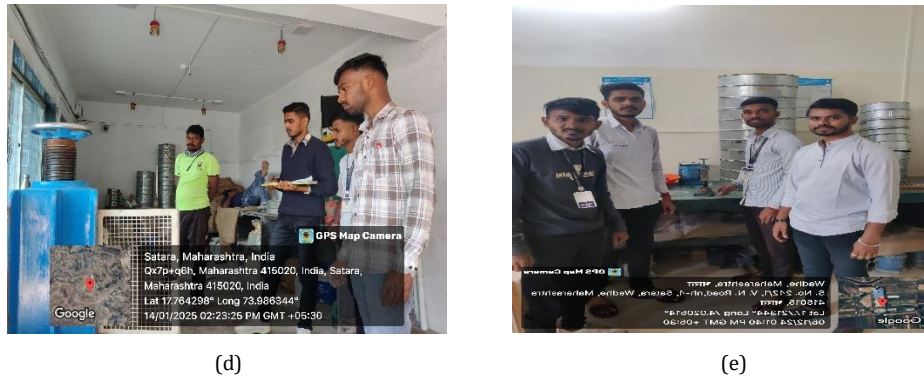


Fig. 1. Concrete casting and testing (a) Casting of Concrete (b) Curing of Concrete (c) Compression Testing (7 Days) (d) Compression Testing (28 Days) (e) Checking setting time by Vicat Apparatus

5. Conclusion

This study evaluated the performance of M20 concrete with partial replacement of cement by Ground Granulated Blast Furnace Slag (GGBS) at 10%, 20%, 30%, 40%, and 50% levels. Based on the experimental results, the following conclusions can be drawn:

1. **Workability:** The addition of GGBS improved the workability of concrete, with optimum performance observed at 20-30% replacement levels. Higher GGBS content (above 40%) required additional water or superplasticizers to maintain consistency.
2. **Compressive Strength:**
 - The 0% GGBS (control mix) achieved an average compressive strength of 25.01 MPa, which meets the characteristic strength of M20 concrete.
 - The highest compressive strength of 40.25 MPa was recorded at 10% GGBS replacement, indicating that partial replacement enhances strength due to the pozzolanic reaction and densification of the microstructure.
 - A gradual decline in compressive strength was observed as the GGBS replacement increased beyond 20%. However, even at 50% replacement, the strength remained comparable (24.00 MPa), which is still within acceptable limits for M20 grade concrete.
3. **Optimum GGBS Replacement Level:**
 - The optimum replacement level was found to be 10%, where the compressive strength increased by approximately 61% compared to the control mix.
 - At 20% replacement, the strength (34.69 MPa) was also significantly higher than the control mix, indicating a viable balance between sustainability and strength gain.
 - Beyond 30% replacement, the compressive strength started decreasing, suggesting that higher GGBS content may lead to slower hydration and reduced early-age strength.
4. **Setting Time:**
 - Higher GGBS content increases setting time due to slower hydration.
 - 10-20% GGBS replacement shows moderate delay in setting time but remains practical.
 - Above 30% GGBS, setting time increases significantly, which can impact construction scheduling.
5. **Sustainability Benefits:** The use of GGBS in concrete reduces cement consumption and CO₂ emissions, making it an eco-friendly alternative for sustainable construction.

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Design and Fabrication of Composite Structures Using the Hand Lay-up Process

Omkar B. Sankpal¹, Viki S. Dabade ², Suraj A. Patil³, Shubham S. Shikhare⁴, Prof. A. B. Salunkhe⁵

^{1,2,3,4} Student, Mechanical Engineering, DBATU/ AITRC, Vita, India

⁵ Assistant Professor, Mechanical Engineering, DBATU/ AITRC, Vita, India

Abstract: Carbon fiber reinforced polymer matrix composites have been the focus of research. As the most widely used epoxy resin in all matrix materials, it is also the most studied. In this paper, the modification of TDE-85 epoxy resin, the curing properties of curing agent and the preparation method of prepreg was reviewed. The progress and application of carbon fiber reinforced epoxy resin composites at home and abroad was reviewed, made carbon fiber / epoxy resin composite materials in the automotive fuel cell application prospects.

Keywords: Carbon fiber, epoxy resin, matrix, composite material

1. Introduction

CFRP is a composite consists of two parts: a matrix and a reinforcement. The reinforcement usually means carbon fiber, and the matrix commonly includes polymers such as epoxy, cyanate ester or polyester resin etc. CFRP combines the advantage of carbon fiber and polymer, has a relative high strength and light weight [1]. As a matter of fact, CFRP has a wide application in aerospace and automotive areas received great attention in the last years. Their compressive strength properties as well as their advantage in reducing product weight is the main driving force for the researchers to study them [2-4]. However, in the processing section, the processing factor such as temperature and pressure has a significant influence on the quality of the product.

In recent years, composite materials derived from carbon fiber and epoxy resin are extensively employed in aircraft and space applications because of their high strength, high modulus and light weight [5,6]. Carbon fibers is a polymer having five times stronger than steel and twice as stiffness. It is made of thin strong crystalline filaments of carbon that is used to strengthen the material. The use of epoxy resins as a matrix having good engineering properties like high stiffness, strength, chemical resistance and good adhesion with fibers [6,7]. The major drawback of epoxy resin is their brittleness and having poor pot life with less resistance to crack initiation. This drawback can be eliminated by hybridizing the epoxy resin.

Carbon fiber reinforced epoxy resin matrix composite material is carbon fiber reinforced, epoxy resin as the matrix. As the carbon fiber is a brittle material [8], it can be compounded with epoxy resin to improve the toughness of composite materials, and carbon fiber excellent mechanical properties can also give the composite good strength and stiff ness. In the process of preparing the carbon fiber reinforced epoxy resin composite material, the carbon fiber and the epoxy resin matrix are preliminarily prepared by prepreg, and then the prepreg is made into composite material by the molding process The

We use hand layup process. Hand lay-up: manual laying of fiber-reinforced material and application of resin to mold to build up the thickness. Hand or roller pressure removes any trapped air.

2. Literature Review

1. Influence of resin content on mechanical properties of composite laminates K Yang^{1,2}, Y M Yue^{1,4}, W P Zhao¹, Y Liang^{1,2}, L Mei^{1,2} and J J Xue³(2019)

The characteristics of composite laminates fracture, and discussed the fracture morphology, fracture mode of fiber and matrix resin of fiber-reinforced resin matrix composites, as well as the problems to be solved in fracture analysis.

2. Matrix Modification of Carbon Fiber Reinforced Composites with Hybrid Resin System C.venkateshwarreddy,¹K.Roopa,²P.rameshbabu,³R.ramnarayanan ⁴ (2020)

The major drawback of epoxy resin is their brittleness and having poor pot life with less resistance to crack initiation. This drawback can be eliminated by hybridizing the epoxy resin (modifying the matrix by PBW of two resins). The main objective is matrix modified in to moderate viscosity with higher elongation during the test

3. The Use of CFRP for Structural Reinforcement—Literature Review Aleksandra M. Pawlak 1 , Tomasz Górny 2, Łukasz Dopierała 3, and piotrpaczos4 (2022)

CFRP is a composite material, which consists of a polymer matrix reinforced with carbon fibers. A simple adding of CFRP tapes to the structures allows increasing their strength, which is advantageous, when the change of the load occurs in the construction (e.g., new elements are assembled).

4. Influence of Different Surfactants on Carbon Fiber Dispersion and the Mechanical Performance of Smart Piezoresistive Cementitious Composites Athanasia K. Thomoglou , Maria G. Falara Fani I. Gkountakou, Anaxagoras Elenas and Constantin E. Chalioris (2022)

This paper follows a methodology introducing a combination of mechanical and chemical carbon fibers dispersion, as well as the different mixing processes (wet or dry). Three types of surfactants: Car boxy methyl cellulose (CMC), cellulose nanocrystal (CNC), and superplasticizer (SP), were applied to evaluate the cfs distribution in the cement paste matrix. Compressive and flexural strength, modulus of elasticity, and ductility of the cement-based composites (CFRC) reinforced

5. Enhancing the matrix-fiber interface with a surfactant leads to improved performance properties of 3D printed composite materials containing cellulose nanofibrils Evan W. Battisto1, Shea R. Sarsfield1, Saurabh R. Lele2, Teague Williams3, Jeffrey M. Catchmark1, Stephen C. Chmely (2020)

Cellulose nanofibrils (cnfs) exhibit characteristics that make them a desirable addition to new composite materials. Cnfs are usable in a wide variety of applications such as coatings, personal and healthcare products, packaging, and advanced structural materials. They can also help overcome some performance issues with objects 3D printed by stereo lithography (SLA) including dimensional instability and poor mechanical properties. However, cnfs are hydrophilic, making their dispersion in hydrophobic resins common to SLA difficult.

6. Carbon Fiber Reinforced Epoxy Resin Matrix Composites Zhiyuan Yu,Rongchang Li,Zhenghua Peng,Yonglian Tang (2017)

In this paper, the modification of TDE-85 epoxy resin, the curing properties of curing agent and the preparation method of prepreg were reviewed. The progress and application of carbon fiber reinforced epoxy resin composites at home and abroad were reviewed, made carbon fiber / epoxy resin composite materials in the automotive fuel cell application prospects.

7. Effect of surface treatment on the tribological properties of Coccinia Indica cellulosic fiber reinforced polymer composites Bhuvaneshwaran Mysamy a, Vivekanandhan Chinnasamy b, Sathish Kumar Palaniappan c, Sampath Pavayee Subramani d, Chandrasekar Gopalsamy (2020)

The scope of this current work is to investigate, Coccinia Indica (CI) fiber which is used as a reinforcement to study and analyze the potential improvement in wear resistant property of epoxy matrix composites. For the first time, this finds applications, especially in brake pad where friction exists. Thus, it can be prepared with non-toxic and locally available cheap fibers to produce a prospective tribo-material.

8. Surfactant assisted dispersion of MWCNT's in epoxy Nano composites and adhesion with Aluminum Jose Menjivara, Kedar Kiranea, (2019)

This article presents an experimental investigation into the adhesion between aluminium and epoxy nanocomposites reinforced with multi-walled carbon nanotubes (MWCNT). The nanotubes are dispersed in epoxy chemically with the aid of a surfactant, rather than mechanically via high shear mixing or ultrasonication. Four MWCNT weight fractions are considered viz.

9. Tribological properties of surface modified Nano-alumina/epoxy composites QIU LONG JI, MING QIU ZHANG,MIN ZHI RONG (2004)

The disadvantage is factually detrimental to the service life of the material Author to whom all correspondence should be addressed. Also in use. In contrast to micron particles, nanoparticles have a much greater surface area-to-volume ratio. This ratio is important for bonding the particle to the polymer matrix in the composite material.

10. MECHANICAL PROPERTIES OF SURFACTANT-COATING CARBON NANOFIBER/EPOXY COMPOSITE ZHE YING, JIN-HONG DU, SHUO BAI, FENG LI, CHANG LIU, and HUI-MING CHENG (2002)

Moreover, the interaction between the cnfs and the matrix is another important problem that need to be solved. Only when cnfs have strong interaction with polymer matrix, they can act as an effective reinforcing agent, which assures an effective transfer of the load from the polymer matrix to the cnfs when the composite is load-bearing. Presently, there are two main kinds of methods of surface treatment for cnfs employed to improve their interaction with the polymer matrix.

3. Methodology

1. Preparation Phase

- Material Selection :

we use material are carbon fiber , epoxy resin matrix (araldite) Surfactant (triton x100)

Carbon fiber

Carbon fiber, also known as carbon-fiber-reinforced polymer (CFRP) when used in composites, is a high-performance material known for its exceptional strength-to-weight ratio, stiffness, and resistance to fatigue and corrosion. It's widely used in industries that demand strong yet lightweight materials

Epoxy resin matrix :

An epoxy resin matrix is a thermosetting polymer system used in fiber-reinforced composites to bind and support the structural fibers (like carbon or glass). Epoxy matrices are known for their excellent mechanical strength, adhesion, chemical resistance, and dimensional stability.

Araldite Resin (Epoxy Resin) – Purpose:

Araldite is a brand of epoxy resin widely used in fiber-reinforced composites due to its excellent mechanical, thermal, and adhesive properties.

Why Araldite is used:

Strong bonding with fibers like carbon, glass, or natural fibers, High stiffness and strength after curing, Good chemical and heat resistance, Low shrinkage during curing ensures dimensional stability, Durability and water resistance suitable for structural applications.

Triton X-100 (Surfactant) – Purpose:

Triton X-100 is a non-ionic surfactant used primarily to improve the dispersion of nanoparticles or fibers within the resin.

Why Triton X-100 is used:

Enhances fiber or nanoparticle dispersion in hydrophobic resins (like epoxy), Reduces agglomeration of fillers like carbon nanotubes (CNTs) or cellulose nanofibers, Improves interface bonding between fiber and matrix by enabling better wetting, Leads to uniform distribution of reinforcement, improving mechanical and electrical properties.

Combined Benefit:

When Triton X-100 is added to Araldite resin, it improves the distribution and bonding of fillers/fibers in the matrix. This results in a stronger, more uniform composite with enhanced mechanical performance and better load transfer between phases.

Advantages of Araldite Resin:

1. High mechanical strength – provides excellent load-bearing capacity.
2. Superior adhesion – bonds well with various reinforcements (carbon, glass, natural fibers).
3. Thermal and chemical resistance – suitable for demanding environments.
4. Dimensional stability – low shrinkage during curing ensures accurate part formation.
5. Good durability – long-lasting under mechanical stress and environmental exposure.

Advantages of Triton X-100 Surfactant:

1. Improved dispersion of fillers – prevents clumping of nanoparticles or fibers.
2. Enhanced fiber-matrix interaction – promotes better wetting and adhesion.
3. Uniform material properties – due to even distribution of reinforcement.
4. Better mechanical performance – improves strength, stiffness, and toughness.
5. Reduces processing issues – lowers viscosity and eases mixing during fabrication.

Combined Advantages:

Strong, durable composites with uniform properties, Enhanced interfacial bonding between resin and reinforcement, Improved processing and consistency in the final product, Greater resistance to cracks and delamination.

2. Fabrication Phase

- RESIN PREPARATION

Resin preparation involves mixing and processing resin materials for various applications,

1. Casting and molding: Creating objects with specific shapes and designs.
2. Coatings and finishes: Applying resin to surfaces for protection, decoration, or functionality.
3. Composites: Combining resin with other materials (e.g., fibers, fillers) for enhanced properties.

- LAY-UP PROCESS

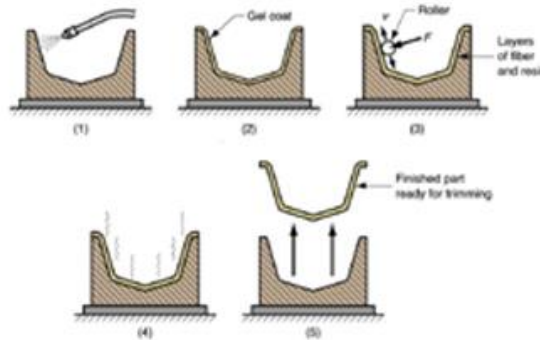


Fig 1 Layup Process

Hand lay-up: (1) mold is treated with mold release agent; (2) thin gel coat (resin) is applied, to the outside surface of molding; (3) when gel coat has partially set, layers of resin and fiber are applied, the fiber is in the form of mat or cloth; each layer is rolled to impregnate the fiber with resin and remove air; (4) part is cured; (5) fully hardened part is removed from mold.

3. Testing and Validation Phase

Mechanical Testing: Impact test

4. Experimental Procedure

1. Workstation preparation:

An initial preparation of all the materials and tools that are going to be used is a fundamental standard procedure when working with composites. This is mainly because once the resin and the hardener are mixed, the working time (prior to the resin mix gelling) is limited by the speed of the hardener chemically reacting with the epoxy producing an exothermic reaction. Also, as part of the initial preparation, the woven cloth must be cut according to the shape of the part.

2. Mold Preparation:

Before starting with the lay-up process an adequate mold preparation must be done. Mainly, this preparation consists of cleaning the mold and applying a release agent in the surface of it to avoid the resin to stick. In this experiment the mold preparation is simply taping the plastic sheeting to the tabletop. Otherwise following steps are taken to clean the mold;

- Clean the mold with a clean cloth
- Apply and spread release agent in the surface of the mold
- Wait certain to set up the release agent
- Buff with clean cloth

3. Lay-up process:

The first step is to mix the resin and the hardener. The proportions are usually given by the supplier and can be found on the containers of the hardener or resin. The mixing is performed in the mixing containers with the mixing stick and should be done slowly so as to not entrain any excess air bubbles in the resin. Be careful to mix completely and deliberately for a full two minutes before applying. It is best to use a "flat" stick- such as tongue depressor; a round stick does not work well as it does not 'paddle' the mixture to blend it properly. Note: Plastic mixing containers may melt during the exothermic reaction, so it is best to use containers that are specifically made for the purpose of mixing epoxy resin. Next an adequate quantity of mixed resin & hardener is deposited in the mold and a brush or roller is used to spread it around all surface along with pieces of paper cards as

reinforcement. It is important not to add too much resin, which will cause too thick of a layer, nor to add less than the necessary amount, which will cause holes in the surface of the part when it is cured. The first layer of fiber reinforcement is then laid. This layer must be wetted with resin and then softly pressing using a brush or a roller make the resin that was added in the previous step wick up through the fiberglass cloth. If the fiber is not completely wet, more resin can be added over the top and spread around. At this stage a second layer of glass fiber (pieces of cloths in our case) is added and special care must be taken to eliminate all air bubbles possible. This can be accomplished by either rolling any air bubbles out with a small hand rolling tool or brushing out the air bubbles with a paintbrush. This step is repeated until the desired thickness is obtained. As the glass fiber layers are added to build laminates and total part thickness the individual layers may be oriented at varying angles to accomplish specific strength in the direction of the weave- this is called 'clocking'. Sometimes during the build up of successive layers of reinforcement a cover sheet of plastic can be temporarily put over the layup and rolled together with the layers underneath to reduce the mess and squeeze out excess resin. It is important when the proper amount of resin has been used for the layup that any excess resin in the cup is placed on and in an area that does not have any flammable material, such as a concrete sink or slab.

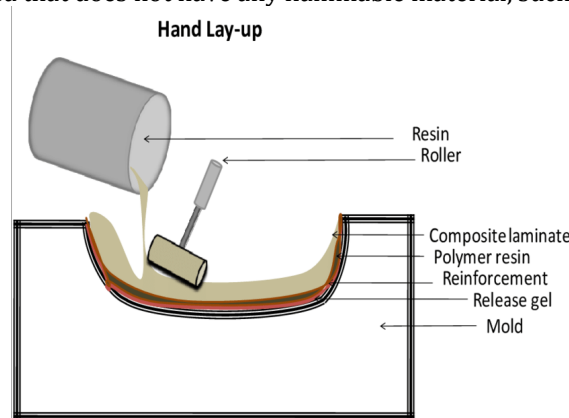


Fig 2 Hand lay-up Process

4. Curing:

The part can be cured at elevated temperatures using an oven or at room temperature. Generally, the proper curing time of each type of resin-hardener, as well as the working time, is given by the supplier on the back of the containers. For the purposes of this experiment and using an epoxy resin system, room temperature curing is adequate.

5. Cleaning:

Once that part is ready to be cured, it must be moved to appropriate place for curing. In this case it can be moved to a curing oven or simply left to cure in place until the next day. Then a clean up must be done. All the materials used (brushes, rollers, mixing tools, scissor), including the table, must be cleaned using acetone and cloth.

5. Testing Procedure

Equipment:

Tensometer, specimen as per standard, 3 point bend set-up, dial gauge, power supply, vernier caliper, graph paper, etc.

Theory:

Composite materials can be recommended for a suitable engineering application after investigating the properties of the same in the laboratory. There are numerous properties like mechanical properties, chemical properties, electrical properties, optical properties, heat resistant, resistant to corrosion and water absorption etc. The polymer based composites are widely used for structural purposes where the mechanical properties are more important to study. Composite materials can be mechanically characterized to diagnose the properties such as tensile strength, compressive strength, shear strength, elastic moduli in different directions, poisson's ratio in different directions, energy absorbed by impact loading or ballistic impact etc.

Procedure:

- First look at geometry of the sample as per the standard guided by instructor in the laboratory.
- Cut the approximate size of the sheet by sawing and file the edges to remove any unwanted projected part.
- Make surface finish good so as to satisfy the standard.
- Adjust the anvil of 3point bend test setup shown in figure1 as per the standard.
- Place the sample over the anvil of 3 point bending set up.
- Make sure there should be no initial bending load.
- Place dial gauge just below the sample to display the deflection while subjected to bend load.
- Switch 'ON' the Tensometer to apply the load gradually.
- Record the load value corresponding to each increment in deflection.
- Keep on loading till the fracture.
- Record load at the initiation of crack if possible.
- Stop the test when complete fracture occurs in the specimen.
- Take the fractured specimen under microscope to observe the mode of fracture.
- Draw load deflection curve on graph paper and measure the slope.
- Repeat the same procedure for another specimen having different fraction of reinforcing material and draw the load- deflection curve for same on the same plot.
- Make comparison between the slopes.

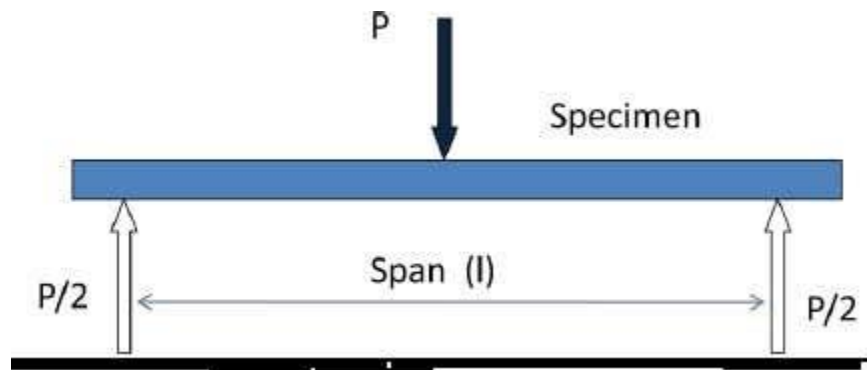


Fig 3 Loading diagram of 3 point bend test

Observations

Specimen width	w	=	10 mm
Specimen thickness	t	=	0.5 mm
Span	l	=	10 mm
Moment of inertia	I	=	0.104 mm ⁴

Calculation

$$w = \frac{Pl^3}{48EI}$$

Where,

w = Central deflection of simply supported beam (glass slide)

P = 5 KN (load at center)

l = 10 mm (Span between supports)

E = Young's modulus

I = Moment of inertia = $(bd^3)/12$

$$E = \frac{P}{W} \cdot \frac{l^3}{48(bd^3/12)} = (\text{slope of curve}) \cdot \frac{l^3}{4bd^3}$$

Result:

Modulus of the composite is 1001.6 GPa
 Tensile strength of composite is 2000MPa
 Fracture strength of composite is 2100MPa
 Crack initiation load/stress is 2140 MPa

Precautions:

- Take care of geometry of specimen.
- Loading must be gradually as slow as possible.
- The distance between the end supports must be carefully fixed otherwise results may be affected.
- Take care of your self when specimen breaks.
- Dial gauge reading must be corresponding to actual load.
- Careless measurement of slope of curve may affect the properties of composite.
- As and when specimen have complete fracture the machine should be stopped immediately.

6. Conclusion

Carbon fiber reinforced polymer (CFRP) composites exhibit high mechanical performance due to the synergistic combination of carbon fiber's strength and epoxy resin's binding properties. The incorporation of a surfactant like Triton X-100 enhances fiber dispersion within the matrix, improving the load transfer and overall durability of the composite. The 3-point bending test validates theoretical predictions, demonstrating high tensile and fracture strengths, confirming the material's suitability for advanced engineering applications.

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Design and Fabrication of Electric Portable Tiller

Prof.U.Y. Siddha¹, Bhavik S. Khedakar², Sujit N. Javir³, Pranav S. Kadam⁴, Rushikesh R.Jadhav⁵

¹ Assistant Professor, Mechanical Engineering, DBATU/ AITRC, Vita, India

^{2,3,4,5} Student, Mechanical Engineering, DBATU/ AITRC, Vita, India

Abstract: In Indian agriculture, tractors or cultivator machines are usually used for ploughing the fields. Before these machines, farmers used traditional methods, which were slow, hard, and expensive. Even though some regions have adopted modern farming machines, many areas still rely on basic tools like wooden ploughs and sickles, which are labor-intensive and time-consuming.

A new, affordable solution is a portable, battery-powered electric power tiller. This machine helps to reduce the hard work needed in farming by using a motorized system to plough the soil, making it much cheaper and easier for farmers.

Mechanical engineering education plays a key role in this process, as it focuses on real-world design and production. This helps create effective, low-cost solutions for farmers to improve their farming practices.

Keywords: Blade, Cutter, Electric Battery, Tiller.

1. Introduction

A power tiller is a farming tool used for preparing the soil, weeding, and sowing crops. It has rotating blades that are mounted on a wheel and powered by an electric motor. Through research and practical use, many advancements in power tiller designs have been made. This project focuses on designing and developing a portable, battery-powered electric power tiller. Unlike traditional farming methods, this machine reduces human effort and costs by using a motorized tilling system.

The electric power tiller helps farmers by saving time and money during the tilling process. It is designed with a special wheel that provides better soil grip. The motor powers a pulling wheel using a sprocket chain, and the motor gets its power from a battery. This setup gives enough power to push the tilling forks into the soil. The machine uses three forks that make it easier to till the soil, which is especially useful for small-scale farming.

Today, agriculture is an important part of the ecosystem. A solar-powered electric cultivator is simpler to use than a tractor, which is expensive and uses a lot of fuel. This machine improves productivity and efficiency in farming. It can be used in both rural and urban areas for small-scale crops like onions, coriander, tomatoes, garlic, radish, carrots, and others. This low-cost, portable, battery-powered electric and solar-powered cultivator is a modern solution to improve traditional farming methods. It reduces human effort and helps farmers save money and time, all while making farming easier and more sustainable.

2. Objective

- To reduce time & increase the efficiency of framing.
- To enhance agriculture productivity and versatility for diverse crops.
- To efficient to reduce human effort for farmer.
- To make farming more effective and easier.

3. Methodology

Design Aesthetic Look of Power Tiller



3D Modeling in SolidWorks



Material Selection



Fabrication of Parts



Assembly of Components



Testing and Performance Check



Results and Analysis



Conclusion

4. Materials

A. BATTERY



Fig. 1 Battery

- Type: Lithium-Ion batteries.
- Voltage: 12V (DC).
- Current: 12.5 A/hr.
- Dimension: 118 x 92 x 70 cm.

Two 12V batteries were used in this project so that it can power the DC motor to run and drive the chain sprocket assembly which made the bicycle rim to move forward.

B. DC MOTOR



Fig. 2 DC motor

- Type: Electric Hub
- Power: 250 Watt.
- Voltage: 24V.
- Dimension: 18 x 13.2 x 12.1 cm.

Geared DC motor is a reduction dc motor and most commonly used for scooters, bikes etc. This motor possesses rated speed of 300 rpm and operates at a power of 24 Watt.

C. CHAIN AND SPROCKET



Fig. 3 Chain And Sprocket

- Driving sprocket: diameter= 58mm; No. of teeth= 13.
- Driven sprocket: diameter= 155mm; No. of teeth= 39.
- Chain length = 134 cm.

Combination of DC motor and chain sprocket assembly system that uses the rotational power of the motor to drive the chain and transfer motion to bicycle rim with welded angles so as to make it move forward along with which, J shaped tiller blades are carried forward thereby ploughing the land. Lubrication is necessary for chain and sprocket

D. SQUARE PIPES



Fig. 4 Square Pipes

Mild steel square pipes are hollow tubes made from low-carbon steel, which is an affordable and durable material. They provide high stability and structural support, therefore helpful in projects where load bearing capacity is a requirement.

E. MOTORCYCLE RIM



Fig. 5 Motorcycle RIM

Bicycle rim used in this project is made from aluminium material having approximate diameter of 28 inches and width of 35 inches. Rim is welded with steel angles so that it can move forward with tight grip holding capacity.

F. STAINLESS STEEL ANGLE



Fig. 6 Stainless steel angle

Stainless steel angles are 90-degree L-shaped metal profiles made from stainless steel. They are used in various projects involving construction, manufacturing and architectural use. They are available in different sizes, thicknesses and finishes which should be considered before selecting one for a particular project.

5. Design Model

A virtual model of the portable electric tiller and cutter machine was made using AUTOCAD 3D software. The model was designed based on the actual size of the real machine. A basic sketch was drawn first. The machine is powered by a lithium-ion battery, which runs a hub motor strong enough to pull the tiller blades through farm soil. It uses a DC motor and a chain-sprocket system to move the bicycle wheel. The machine has a bicycle wheel with metal angles attached to it. It uses three J-shaped blades that make it easy to till the soil in narrow areas, which is helpful for farming. The machine is lightweight and portable, making it simple to control and steer.

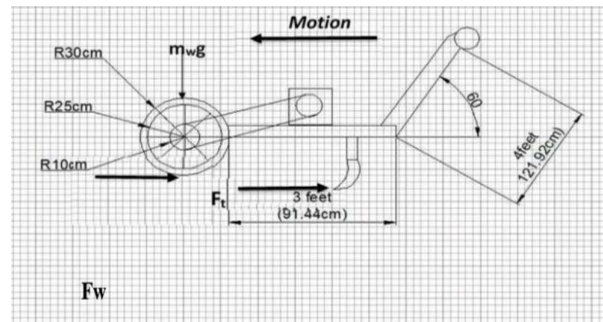


Fig. 7 Line Diagram of Prototype

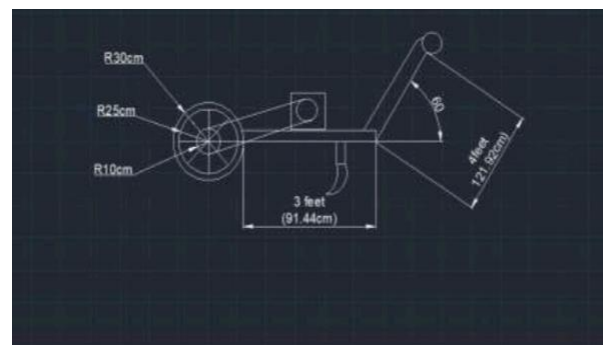


Fig. 8 Side View

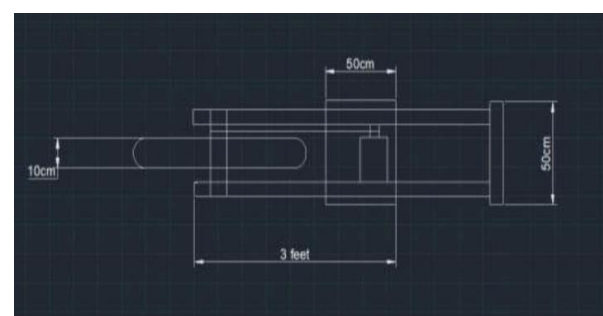


Fig. 9 Top view

6. Conclusion

Today in the world fuel prices and environmental pollution increases step by step So to manage environmental pollution, to save fuel this project is designed. This model requires less investment but its gives more energy output with low maintenance. The tiller that we have fabricated is best suitable for soil having high moisture content. This project can be used either for ploughing or removing unwanted plants. Here in our project we conclude that our project performed its desired work successfully and by using this machine we can reduce the farming cost, animal use, manpower.

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Design and Fabrication of Energy Generation through Staircase Mechanism

Prof. R.B.Patil¹, Prasad H. Chavan², Prathamesh H.Chavan³, Jaid G.Shaikh⁴, Shubhamraje Pawar⁵

¹ Assistant Professor, Mechanical Engineering, DBATU/ AITRC, Vita, India

^{2,3,4,5} Student, Mechanical Engineering, DBATU/ AITRC, Vita, India

Abstract:

In the modern era of increasing energy demands and the need for sustainable solutions, harnessing alternative sources of energy has become essential. This paper presents the design and fabrication of an innovative system for energy generation through a staircase mechanism, which converts the mechanical energy produced by human movement into electrical energy. The concept is based on the principle of piezoelectric and mechanical compression systems integrated beneath the steps of a staircase. When a person steps on the stair, the force exerted compresses a spring or actuates a gear mechanism that drives a dynamo or piezoelectric transducer. The energy thus generated is stored in a battery for later use in low-power applications such as lighting or mobile charging. This mechanism is particularly useful in public places like railway stations, schools, and malls where there is high foot traffic. The paper aims to demonstrate an eco-friendly, cost-effective, and renewable method of power generation, encouraging sustainable development through everyday human activity.

Keywords: Piezoelectric System, Staircase Energy generation, Rack & Pinion Mechanism

1. Introduction

With the rapid depletion of conventional energy resources and the rising global demand for electricity, the focus has shifted toward alternative and renewable sources of energy. Among various innovative approaches, harvesting energy from human motion has emerged as a promising area. One such idea is to generate electricity through the movement on staircases, a concept that utilizes the mechanical force exerted by human steps to produce power.

Every day, thousands of people use staircases in homes, offices, public transport stations, malls, and schools. This routine activity involves a considerable amount of mechanical energy that usually goes unused. By designing a mechanism that captures and converts this mechanical energy into electrical energy, we can create a sustainable and eco-friendly solution for small-scale power generation.

This paper involves the design and fabrication of a staircase mechanism equipped with either spring-damper systems, gear-dynamo assemblies, or piezoelectric plates. As people walk on the steps, their weight applies a downward force which activates the system to produce electrical energy. This energy can be stored in batteries and used for powering lights, sensors, or for charging electronic devices.

The aim of this paper is to demonstrate a low-cost, practical, and effective method of energy generation that promotes the efficient use of human activity as a renewable energy source.

2. Related Work

- One of the commonly used methods involves piezoelectric materials, which generate electricity when subjected to mechanical stress. Researchers have embedded piezoelectric sensors under floor tiles or stair steps to generate power from walking. Though effective, this method often has limitations in terms of cost and durability.
- Another popular approach includes mechanical systems using springs, levers, and gears. In such systems, the downward force from a footstep compresses a spring or moves a lever, which in turn rotates a gear connected to a dynamo. This mechanical motion is then converted into electrical energy. Papers like these have been implemented in schools, metro stations, and parks to power LED lights or charge batteries.

- For instance, a paper conducted by engineering students in India demonstrated a spring-dynamo mechanism fitted under stair steps to power small loads. Similarly, public infrastructure in Japan and the UK has experimented with energy-harvesting floors in train stations and malls using piezoelectric tiles.
- These past works demonstrate the feasibility and potential of footstep-based energy generation. However, challenges such as energy efficiency, maintenance, and cost optimization still exist. This paper aims to address some of these issues by designing a cost-effective, durable, and efficient staircase mechanism suitable for common environments.

3. Methodology

The methodology adopted for this paper involves a systematic approach to designing, fabricating, and testing a staircase-based energy harvesting system. The core concept relies on converting the mechanical energy generated from foot pressure on stairs into electrical energy using mechanical and electromechanical components.

3.1. Problem Identification and Conceptual Design

The first step was to identify the scope of energy loss during daily human movement, particularly in high-traffic staircases such as those in schools, malls, railway stations, and offices. A mechanical-to-electrical energy conversion system was conceptualized, which could be integrated into staircases to harvest energy with minimal disruption.

A preliminary design was sketched where each stair step could be slightly depressed under load (user's foot), triggering a mechanism that converts vertical displacement into rotational motion to drive a generator.

3.2. Component Selection

Key components used in the mechanism include:

- **Spring-loaded platform:** To allow the stair tread to depress under human weight and return to its original position.
- **Rack and Pinion system / Lever mechanism:** Converts vertical motion into rotary motion.
- **Flywheel:** Ensures smoother and continuous rotational motion.
- **DC generator / Dynamo:** Converts mechanical rotation into electrical energy.
- **Battery / Capacitor:** For storing the generated energy.
- **Load (e.g., LED light or USB charging port):** To demonstrate usable output.

3.3. Design and Modeling

CAD software (e.g., SolidWorks or AutoCAD) was used to model the staircase setup. The design was simulated to check motion transfer, load-bearing capacity, and energy output expectations.

3.4. Fabrication

- A miniature model of the staircase mechanism was fabricated using mild steel or plywood for the steps.
- Springs were mounted beneath each step to allow depression and return motion.
- A rack-and-pinion mechanism was placed under each step to convert the vertical force into rotary motion.
- The pinion shaft was connected to a flywheel, which was coupled to a DC generator.
- Electrical connections were made from the generator to a rechargeable battery and an LED to indicate power generation.

3.5. Working Principle

1. As a person steps on the stair, the step depresses due to the load.
2. The downward motion moves the rack (or lever), which turns the pinion.
3. The pinion rotates the shaft connected to a flywheel, increasing inertia and ensuring continuous rotation.
4. The generator coupled to the shaft converts this mechanical energy into electrical energy.
5. The generated electricity is stored in a rechargeable battery or capacitor.
6. The stored energy is used to power low-energy devices or light fixtures.

3.6. Testing and Output Measurement

- The setup was tested under various loads to check efficiency and output.
- A multimeter was used to measure the voltage and current generated per footstep.
- Energy output was recorded and compared for single steps versus multiple steps in sequence.

3.7. Performance Analysis

The energy generation efficiency, mechanical loss, and durability of components were analysed. Data was used to propose improvements like integrating piezoelectric elements or optimizing spring stiffness and flywheel size for better output.

4. Working Model

Model Design Description

The prototype model consists of the following components:

- Staircase Frame: Made of mild steel or wood, designed to support human weight and integrate moving steps.
- Moving Step Plate: A hinged or sliding platform mounted above springs that moves down under foot pressure.
- Spring System: Springs selected based on stiffness and compression distance to optimize energy recovery.
- Gear and Shaft Assembly: Used to convert linear motion into rotary motion for the dynamo.
- DC Dynamo: Typically a 6V mini dynamo capable of generating current during short bursts of rotation.
- Battery Unit: A rechargeable Li-ion or NiMH battery stores generated energy.
- Electrical Circuit: Includes bridge rectifier, voltage regulator (e.g., 7805 for 5V), and output terminal for load connection.
- Load: Small LED panel or USB charging port to demonstrate application.



Fig. 1.1: Pinion

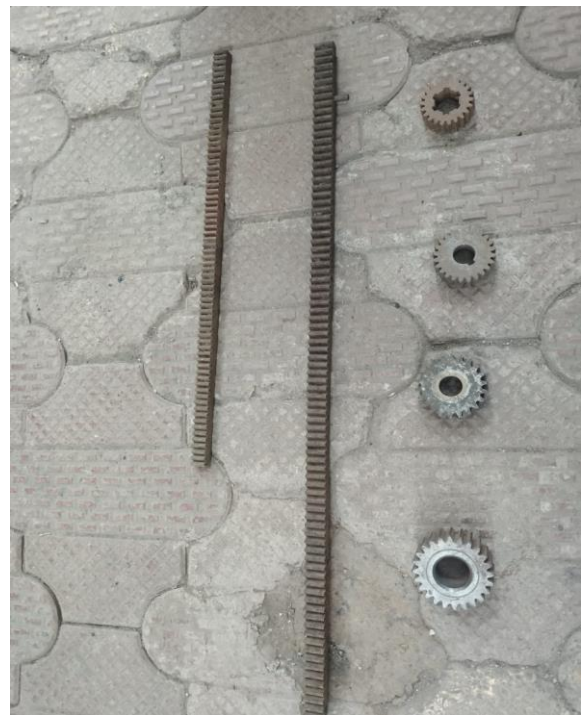


Fig. 1.2 Rack and Pinion



Fig. 1.3 Fabricated Model

5. Advantages

1. Renewable Energy Source:

Utilizes human kinetic energy, which is renewable and available in high-traffic areas like stations, malls, or schools.

2. Eco-Friendly:

No harmful emissions; promotes green energy and reduces dependence on fossil fuels.

3. Energy Harvesting from Daily Activity:

Converts everyday motion (walking) into useful energy, making it an efficient form of energy scavenging.

4. Compact and Space-Efficient:

Installed within existing staircases without the need for large additional space or infrastructure.

5. Low Operational Cost:

Once installed, the system requires minimal maintenance and has low running costs.

6. Encourages Physical Activity:

Motivates people to use stairs instead of elevators/escalators, promoting healthier lifestyles.

7. Educational and Awareness Tool:

Excellent for demonstrating sustainability concepts in schools, colleges, and exhibitions.

8. Energy Storage Capability:

It can be integrated with batteries or capacitors to store energy for later use (e.g., powering lights, sensors, or small devices).

9. Customization Design:

It can be tailored to various environments and energy needs, making it flexible and adaptable.

6. Conclusion:

The energy generation through staircase mechanisms presents a viable and innovative approach to harnessing human kinetic energy in high-footfall areas. The reviewed literature highlights the potential of both piezoelectric and mechanical systems to convert footstep energy into usable electrical power. While each method has its advantages—such as the compact nature of piezoelectric materials or the higher efficiency of mechanical systems—hybrid approaches are emerging as the most promising solution. Despite the low energy yield per step, the cumulative output in crowded environments can contribute meaningfully to powering small devices or lighting systems. However, further research is necessary to address challenges related to cost, durability, and energy storage. With ongoing advancements, staircase-based energy harvesting systems could play a supporting role in sustainable urban energy solutions.

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Multi-Positional Pneumatic Unloading Trailer

Dr.P.A.Madane¹, Mr.Ganesh Anil Nikam², Mr. Karan rajendra Mane³, Mr. Aman Husen Shikalgar⁴

¹ Assistant Professor, Mechanical Engineering, DBATU/ AITRC, Vita, India

^{2,3,4} Student, Mechanical Engineering, DBATU/ AITRC, Vita, India

Abstract:

In the field of material handling and transportation, unloading efficiency and operational flexibility are critical to improving productivity and reducing labor-intensive tasks. The Multi-Positional Pneumatic Unloading Trailer is designed to address these challenges by incorporating a pneumatic system that allows controlled unloading from multiple positions. This system utilizes compressed air to actuate mechanisms that tilt or shift the trailer body, enabling material discharge in different directions based on the requirement. The trailer is particularly useful in environments such as agriculture, mining, and construction where bulk materials like grains, sand, or gravel are transported. The design ensures safety, stability, and ease of operation while minimizing mechanical complexity. This project focuses on the conceptualization, design, and implementation of the pneumatic unloading system, with the goal of improving unloading efficiency and adaptability to different site conditions.

Keywords: Multi-positional trailer, pneumatic system, automation, heavy-duty transportation, manoeuvrability, load handling, unloading efficiency

1. Introduction

In the modern transportation and logistics industry, efficient and reliable unloading systems play a crucial role in improving overall productivity and reducing downtime. Conventional unloading methods often involve manual labor or limited-mechanism unloading systems that can be time-consuming, hazardous, and inefficient, especially when dealing with bulk materials in varying environments. To address these challenges, this project presents the design and development of a Multi-Positional Pneumatic Unloading Trailer—a system that enhances flexibility, safety, and speed in material unloading operations.

The proposed system utilizes pneumatic mechanisms to achieve controlled and automated unloading from multiple positions. This flexibility enables the trailer to discharge materials at different orientations and directions, depending on the unloading requirements and site conditions. Pneumatic actuation not only ensures smooth and precise motion but also minimizes mechanical complexity and maintenance needs compared to hydraulic or manual systems.

This trailer is particularly useful in applications such as agriculture, construction, mining, and bulk transportation industries, where materials like grains, sand, gravel, or other granular substances need to be offloaded efficiently. The design considers factors such as structural integrity, pressure handling, positioning control, and safety mechanisms.

The paper is organized as follows: Section II outlines the design considerations and system components of the trailer. Section III describes the working principle and pneumatic control system in detail. Section IV presents fabrication details and performance analysis based on testing. Finally, Section V concludes the study and discusses potential future improvements.

2. Related Work

Several innovations have been made in the field of trailer unloading systems, particularly focusing on enhancing efficiency, safety, and adaptability. Traditional unloading trailers commonly utilize hydraulic tipping mechanisms or manual unloading processes, which can be time-consuming, labor-intensive, and limited in terms of unloading direction and control.

Previous research has explored various methods to improve trailer unloading systems. The development of efficient and reliable unloading systems for bulk material transportation has been a key area of interest in mechanical and agricultural engineering. Various mechanisms including hydraulic tilting, screw conveyors, and pneumatic actuators have been studied to enhance unloading performance and safety.

In Singh et al.[1], presented a design of a hydraulic tipping trailer for agricultural applications, highlighting limitations in flexibility and directional control. Bhosale et al. [2] proposed a three-directional unloading trailer using mechanical linkages, which improved unloading efficiency but lacked automation. A study by Kumar and Patel [3] explored the use of pneumatic systems in material handling, demonstrating their advantage in terms of speed, control, and reduced mechanical complexity. In Kadam et al.[4], proposed an automatic unloading system using a scissor lift mechanism controlled by pneumatics, improving vertical displacement but not horizontal directionality. Suryawanshi et al. [5] discussed a trailer model that integrates both pneumatic and hydraulic systems, allowing for increased versatility, but at the cost of system complexity and maintenance requirements. In More et al.[6], developed a tractor trolley with side unloading capabilities using mechanical rotation and lever systems. A design using a rotating upper chassis was explored in by Patil et al.[7], where a 360-degree rotatable platform was introduced for directional discharge, though it relied on manual rotation. In [8], the authors proposed a semi-automated rotating mechanism using geared motors, showing improved precision but limited load capacity. Pneumatic actuation for trailer tilting was analyzed in [9] by Rathod and Shinde, where compressed air was used for smoother unloading, reducing hydraulic oil use and minimizing environmental hazards. A similar approach was refined in by Pawar et al. [10], who implemented a dual-chassis model with pneumatic tilt and electric rotation, enabling multi-directional unloading and improved operational safety.

These existing systems form the foundation for the present work, which integrates a high-torque motor-driven rotating chassis and pneumatic tilting system for multi-positional unloading. Unlike previous works that focus on either rotation or tilting independently, the proposed system combines both in a unified design for enhanced performance, safety, and adaptability in real-world bulk handling scenarios.

3. Methodology

The design and implementation of the Multi-Positional Pneumatic Unloading Trailer involve a systematic approach combining mechanical design, pneumatic system integration, and control logic. The methodology can be broadly divided into the following stages:

3.1 Conceptual Design

The trailer is conceptualized to unload materials from multiple positions—left, right, or rear—based on operational requirements. Initial sketches and 3D modeling are carried out using CAD software to evaluate dimensions, structural strength, and possible movement angles. The conceptual layout of the trailer is shown in Fig. 1, which highlights the multi-positional design framework and structural considerations.

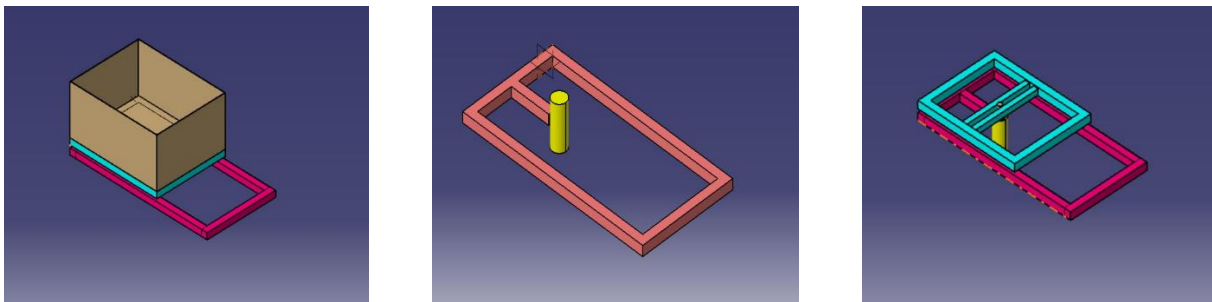


Fig.1 Conceptual Design

3.2 Material Selection and Fabrication

Mild steel is selected for the chassis and tilting platform due to its strength and durability. The trailer bed is designed with reinforced joints to withstand the stresses during unloading. Pneumatic cylinders are positioned strategically to allow angular tilting in the desired directions.

3.3 Pneumatic System Integration

The unloading mechanism utilizes double-acting pneumatic cylinders connected to a compressed air reservoir. Directional control valves regulate airflow to the cylinders, enabling the trailer bed to tilt to a specified side. Fig. 2 illustrates the pneumatic system layout, showing the reservoir, actuator positioning, and valve connections.



Fig.2 Pneumatic System Integration

3.4 Control Mechanism

A lever-operated or solenoid-based valve system is employed to control the actuation of the pneumatic cylinders. The user can select the unloading direction by controlling the respective valve. Safety valves and pressure gauges are included to monitor and regulate the air pressure. The control mechanism is depicted in Fig. 3, where the valve system setup and user interface are presented.



Fig.3 Control Mechanism

3.5 Testing and Evaluation

After assembly, the trailer undergoes functional testing under different loading conditions. The speed, stability, and efficiency of unloading are evaluated. Adjustments are made to the cylinder positioning, valve timing, and trailer frame to ensure optimal performance. The rotational functionality of the chassis during testing is shown in Fig. 3 (duplicate figure name; should be re-numbered), demonstrating the 0° to 180° rotation for precise directional control.

4. Experimental results

The Multi-Positional Pneumatic Unloading Trailer was tested to evaluate its mechanical performance, directional unloading capability, and stability under different load conditions. The key feature of the trailer is its dual chassis structure — a stationary lower chassis and a rotating upper chassis. The upper chassis, which holds the unloading bed, is rotated using a high-torque DC gear motor, enabling the trailer to align in the desired direction before unloading. Once aligned, pneumatic actuators are used to tilt the trailer bed and unload the material.

The experimental tests focused on the following performance aspects:

Rotational Functionality: The rotating chassis was tested for 0° to 180° rotation to ensure smooth directional control.



Fig.4 Rotational Functionality

Torque Capability: The high-torque motor's ability to rotate the loaded chassis was assessed under varying weights.

Unloading Efficiency: Pneumatic tilting was performed in different directions after chassis rotation to observe time and completeness of unloading.

Load Handling: The structure was tested under different loads (from 50 kg to 100 kg) to assess mechanical strength and stability.

Figure 5 (a) to Figure 5 (c) represent the stages of operation:



Fig.5 (a) shows the Initial Position – Chassis aligned to 0°



Fig.5 (b) illustrates the Rotation of upper chassis to desired angle using high-torque motor



Fig.5 (c) captures the Pneumatic tilt begins

The experimental results confirm that the system achieves multi-directional unloading with precise control and minimal manual intervention. The use of a high-torque motor allows rotation under load, and the pneumatic system ensures quick and efficient discharge. The prototype was tested with different load capacities and unloading positions on various terrain types. Key findings include:

- Enhanced unloading efficiency with minimal energy consumption.
- Increased flexibility in load discharge due to multi-positional unloading capability.
- Reduced maintenance requirements due to the use of a pneumatic system.
- Faster response times in adjusting the trailer's unloading position, leading to increased operational efficiency.

Table 1 summarizes the key observations from the experiments:

1. Trial:

Identifies each individual test conducted. A total of 5 tests were performed under varying conditions.

2. Load Weight (Kg):

The weight of material loaded onto the trailer during the trial. It ranged from 50 kg to 100 kg to simulate light to heavy loads.

3. Air Pressure (Bar):

The pressure of compressed air supplied to the pneumatic system. Higher pressure typically results in faster and more forceful tilting. It ranged from 4.0 to 6.0 Bar.

4. Unloading Time (Sec):

Time taken for the trailer to complete the unloading process from the moment the pneumatic system is activated. Longer times indicate slower operation, possibly due to heavier loads or lower tilt angles.

5. Tilt Angle (Degree):

The angle to which the trailer bed tilts during unloading. A higher angle allows for a more complete and faster unload, especially for granular or loose materials.

6. Remarks:

Observations noted during the trial. These include comments on performance, delays, stability, or completeness of unloading.

Table No.1 Key Observations

Trial	Load Weight (Kg)	Air Pressuree (Bar)	Unloading Time (Sec)	Tilt Angle (Degree)	Remarks
1	50	4.5	8	45	Smooth Unloading
2	75	5.0	10	45	Slightly Delay in Tilting
3	100	5.5	12	45	Stable ,but Slower Movement
4	50	4.0	9	30	Lower tilt, Partial Unload
5	80	6.0	11	60	Fast Unloading , Full Tilt

Table No. 1 This table presents the experimental results from testing the Multi-Positional Pneumatic Unloading Trailer under different conditions.

Insights from the Table:

Trial 1: Light load (50 kg), moderate air pressure (4.5 Bar), standard tilt angle (45°) → Unloading was smooth and efficient.

This trial tested the trailer with a relatively light load and a standard tilt angle. The air pressure was sufficient to activate the pneumatic cylinders effectively. The 45° tilt is adequate for discharging loose materials like sand or grains. The unloading process was quick and smooth, indicating that the pneumatic system handles light loads efficiently under moderate pressure conditions.

Trial 2: Medium load (75 kg), slightly higher pressure (5.0 Bar) → Unloading was successful but had a slight delay, possibly due to increased weight.

With a medium-weight load, the system required more air pressure to move the trailer bed. Although the tilt angle remained the same as Trial 1, the increased weight led to a slight delay in the trailer's response. This suggests that while the pneumatic system is capable of handling more weight, it experiences a reduction in speed and responsiveness as the load increases, even with slightly higher air pressure.

Trial 3: Heavy load (100 kg), highest pressure (5.5 Bar) among the first three → The system remained stable but the unloading was slower, showing that heavier loads challenge the pneumatic system's response time.

In this trial, the system faced the heaviest load and responded with the highest air pressure used so far. While the trailer remained stable and completed the unloading, it did so more slowly. The increased time indicates that the pneumatic system needed to exert more force and took longer to achieve the tilt. This demonstrates the load limit of the current system configuration and the importance of balancing air pressure with load weight.

Trial 4: Light load (50 kg) but low pressure (4.0 Bar) and reduced tilt angle (30°) → Partial unloading occurred due to insufficient tilt for full discharge.

Here, although the load was light, the air pressure and tilt angle were both reduced. The 30° tilt was not steep enough for complete unloading, especially for materials that might require more incline to flow. The

result was a partial unload, showing that tilt angle is a crucial factor, not just load weight or pressure. Even with a manageable weight, insufficient angle and pressure can hinder performance.

Trial 5: High load (80 kg), highest pressure (6.0 Bar), and steep tilt (60°) → Fast and complete unloading, showing optimal performance under these settings.

This trial presented optimal conditions: a powerful combination of high load, maximum air pressure, and a steep tilt angle. The system performed very well, achieving fast and complete unloading. The steep 60° tilt provided enough gravity-driven force to ensure full discharge, while the high pressure allowed the actuators to perform quickly even under load. This trial confirmed the trailer's peak performance capability when all parameters are optimized.

The table demonstrates how load weight, air pressure, and tilt angle interact to affect the unloading time and quality. Higher pressure and tilt angles improve unloading efficiency, but too low a tilt or pressure can cause incomplete discharge. The pneumatic system handles varying loads well, but performance tuning is key to ensure optimal outcomes.

5. Conclusion

The multi-positional pneumatic unloading trailer offers a significant improvement over traditional trailers by utilizing pneumatic actuation for better manoeuvrability and unloading flexibility. The experimental results validate its practicality, making it a promising solution for heavy-duty transportation and logistics. Future enhancements may include the integration of electronic control systems for autonomous unloading operations.

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A Review of Golden Ratio: The Mathematics of Beauty

Mr. Pranjal P. Khot¹, Ms. Vaishnavi S. Pawar², Ms. Neha V. Yadav³,
Mr. Soham A. Kadam⁴, Ms. Sakshi S. Jagtap⁵, Prof. P. S. Sutar⁶, Prof. T. S. Patil⁷

^{1,2,3,4,5} Students, General Sciences and Engineering, AITRC, Vita, India

^{6,7} Assistant Professor, General Sciences and Engineering, AITRC, Vita, India

Abstract:- The golden Ratio (ϕ), constantly described as nature's most aesthetically pleasing proportion, has charmed mathematicians, artists, and masterminds throughout history. This paper critically reviews the pivotal themes, generalities, and findings presented in Hamid Ghorbani's "Golden Ratio The Mathematics of Beauty." The discussion delves into its fine underpinnings, appearances in natural and man-made creations, and its controversial universality. The review also assesses the practical operations and the ongoing debates girding the golden Ratio's purported part in beauty and design.

The golden Ratio explores the multifaceted operations of ϕ in mathematics, nature, art, and architecture. The golden Ratio, roughly equal to 1.618 holds unique fine parcels, analogous as its relationship with the Fibonacci sequence and its part in figure through constructs like the Kepler triangle. These parcels have inspired its use in creating harmonious designs and structures throughout history. Ghorbani highlights the appearance of ϕ in nature — from sunflower rotations to nautilus shells and its influence on iconic architectural sensations like the Parthenon and Persian pates. The paper also delves into the statistical randomness of ϕ 's decimal integers, suggesting implicit operations in cryptography. While the golden Ratio's universality is constantly maundered, its profound impact on aesthetics and design can't be denied. This review contextualizes the perceptivity presented, examines reviews, and underscores the need for balanced interpretations of ϕ 's part in beauty and proportion. The enduring allure with the golden Ratio continues to inspire exploration across disciplines, blending art, wisdom, and mathematics in profound ways.

Keywords: Golden Ratio (ϕ), Mathematics of Beauty, Aesthetic Proportion, Fibonacci Sequence, Kepler Triangle, Architecture, Art and Design, Parthenon, Fractals, Harmony and Balance, Statistical Analysis, Nested Forecourt Roots, Continued fractions, Harmony

1. Introduction

The golden Ratio, constantly denoted by the Greek letter ϕ , has fascinated mathematicians, scientists, artists, and proponents for centuries due to its unique fine parcels and its pervasive presence in nature, art, and architecture. Defined as the fallacious number roughly equal to 1.618033, the golden Ratio arises when a line is divided into two corridors analogous that the rate of the whole line to the longer member is equal to the rate of the longer member to the shorter. This elegant relationship has earned it the character of being a "godly proportion," representing harmony, balance, and aesthetic appeal.

From the spiral arrangements of sunflower seeds to the proportions of the Parthenon, the golden Ratio appears in different surrounds, leading multitudinous to associate it with a universal standard of beauty. Its operations extend beyond the visual trades and architecture to fields analogous as biology, music, finance, and indeed modern design. In mathematics, the golden Ratio is intimately linked with the Fibonacci sequence, fractals, and geometric constructions, further cementing its significance in both theoretical and applied disciplines.

This paper reviews the disquisition girding the golden Ratio, with a focus on its fine foundation, its connections to aesthetics and beauty, and its operations across various disciplines. By synthesizing perceptivity from

nonfictional, fine, and scientific perspectives, this study aims to explore the reasons behind the golden Ratio's enduring appeal and its part in shaping our understanding of harmony, proportion, and beauty.

2. NONFICTIONAL BACKGROUND

Ghorbani's work provides a comprehensive nonfictional narrative of the golden Ratio, tracing its roots to Euclid's description of the extreme and mean rate in "The rudiments." This can be expressed as

$$\frac{a+b}{a} = \frac{a}{b} = \phi, \text{ where } a > b > 0.$$

WORKING THIS RELATIONSHIP LEADS TO THE QUADRATIC EQUATION

$$\phi^2 - \phi - 1 = 0,$$

Which has the positive result

$$\phi = \frac{1 + \sqrt{5}}{2} \approx 1.6180339887.$$

The connection between ϕ and the Fibonacci sequence, as well as its discovery during the Renaissance by figures like Leonardo da Vinci, highlights its enduring appeal. For illustration, dividing successive Fibonacci numbers(e.g., 21/13 or 144/89) converges towards ϕ . still, the paper could have shoveled deeper into how cultural interpretations of harmony told these operations.

2. Mathematical Foundations

Central to author's discussion is the fine fineness of the golden Ratio. The author highlights its relationship with continued fractions and nested square roots, analogous as

$$\phi = 1 + \frac{1}{1 + \frac{1}{1 + \frac{1}{1 + \dots}}}$$

Also, the Kepler triangle a right triangle with side lengths in the rate $1:\sqrt{\phi}:\phi$ —is an illustration of how ϕ links figure and algebra. These geometric constructions support its significance in mathematics and architecture.

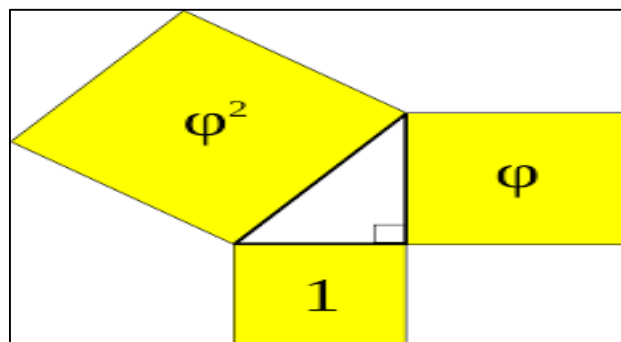


Figure: Kepler triangle

4. THE GOLDEN RATIO IN NATURE

Author's analysis of the golden Ratio's circumstance in natural sensations is one of the composition's most engaging sections. For case, the arrangement of leaves (phyllotaxis) and seed patterns in sunflowers parade the golden angle, roughly 137.5° , which optimizes sun exposure.

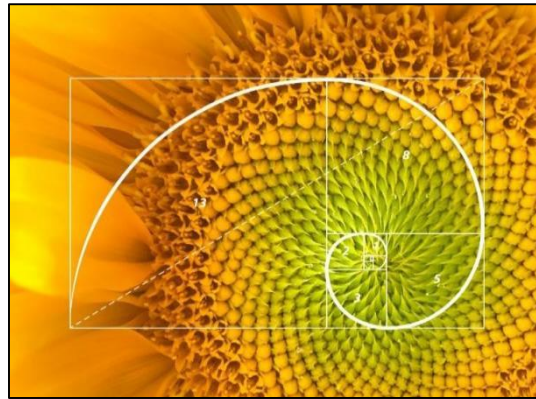


Figure: Sunflower

Also, the nautilus shell and pinecones demonstrate ϕ 's frequency in nature. Still, the review notes that while samples are abundant, the composition doesn't adequately address counter examples or the part of external factors in diversions from these patterns.

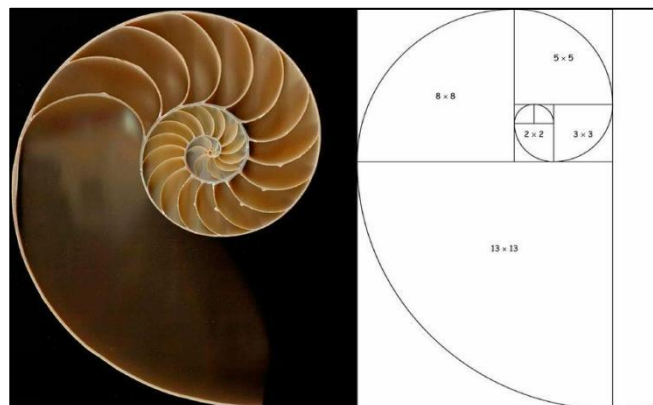


Figure: Snail Shell

5. Operations in Architecture

The golden Ratio's operation in architecture is a focal point of paper. Structures like the Parthenon, with confines approaching golden blocks, illustrate its aesthetic appeal. The proportions of Persian pates, analogous as the Taj- al- Mulk bean, further emphasize how ϕ has informed architectural harmony.

Modern samples, including Le Corbusier's Modulor system, highlight ϕ 's continued connection in design. Still, the review suggests that empirical validation linking architectural choices to deliberate use of ϕ could be strengthened.

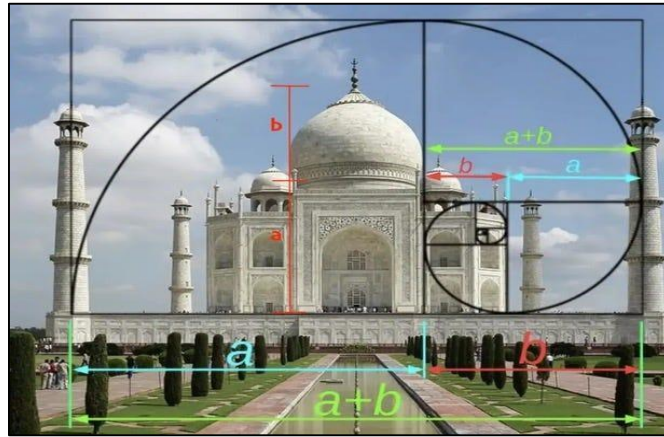


Figure: Taj Mahal

The golden Ratio has been considerably used in the ROMANESQUE STYLE and can be seen in Modena's Duomo(it has 5 golden blocks on the facade) and Pisa's Duomo. Brunelleschi (De' Pazzi Tabernacle 1429- 1461), Andrea Palladio (manor house Barbaro in Maser 1555- 1559) and Redentore's Church(1577- 1592) are numerous samples from the Belle epoque period. Notre Dame in Paris is another well-known illustration where golden Ratio can be seen. Other samples being- The gallery of misses, Acropolis and Chartres Cathedral In India, the Golden Ratio was incorporated into the design of the Taj Mahal, which was completed in 1648

6. The Golden Ratio in Art

The Golden Ratio in Art The composition's exploration of ϕ in art focuses on iconic factory like Leonardo da Vinci's " Vitruvian Man" and " Mona Lisa." These artworks are constantly framed within golden blocks or rotations, emphasizing commensurate harmony. Still, modern scholars debate whether analogous proportions were purposeful or retroactively applied. The review encourages a balanced analysis of these claims.

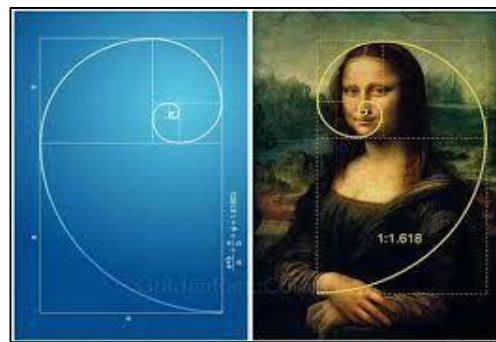


Figure: Mona Lisa

7. Statistical Examination of Randomness

An intriguing member of composition involves the statistical analysis of ϕ 's numeric and double integers as apseudo- arbitrary number creator. The paper shows that these integers pass chi-square tests for uniformity and Durbin- Watson tests for autocorrelation. For case, the first 100,000 decimal integers of ϕ cortege no significant patterns, as shown in Table 1.

Digit	Frequency
0	9986

1	9963
2	9950
3	10079
4	10041

Table No 1

These findings suggest implicit operations of ϕ in cryptography and numerical simulations.

8.The Fibonacci sequence:

Leonardo Bonacci or Leonardo of Pisa(1170- 1250) was an Italian mathematician from the Republic of Pisa, who discovered a sequence now known as the Fibonacci sequence that approached the golden Ratio. The Fibonacci sequence is a numerical pattern where each term is derived by summing the two preceding numbers, starting with 1 and 1. This produces the sequence 1, 1, 2, 3, 5, 8, and continues indefinitely (Benavoli et al., 2009). The Fibonacci sequence can also be expressed using a simplified mathematical formula, representing it as a continuous fraction: $1 + \frac{1}{1 + \frac{1}{1 + \frac{1}{1 + \dots}}}$ (2009).

Figure the series of Fibonacci sequence 1, 1, 2, 3, 5, 8, 13 The relationship of the golden Ratio with the Fibonacci sequence can be set up by dividing each number by the one before it. The relationship between the Fibonacci sequence and the Golden Ratio illustrates a deeper fine connection that transcends simple numerical patterns. Each successive number in the Fibonacci series approximates ϕ , suggesting that this rate is a natural consequence of growth patterns in nature. This relationship reinforces the idea that mathematics is intricately linked to the natural world.

$$1/1=1$$

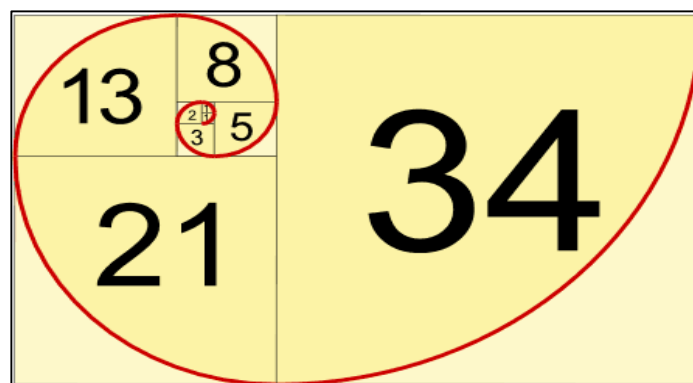
$$2/1=2$$

$$3/2=1.5$$

$$5/3 = 1.666$$

$$13/8 = 1.625$$

$$21/13=1.615$$

**Figure: Design**

The further you go in the series of Fibonacci sequence the closer you get to the golden Ratio, for illustration example: $377/233 = 1.61805$.

8. Reviews and difficulties

One of the composition's limitations lies in its limited engagement with reviews of the golden Ratio. Doubters argue that its presence in design and nature is constantly retroactively assessed rather than deliberately applied. For illustration, while the Parthenon exhibits approximate golden proportions,

there is shy nonfictional validation to confirm deliberate use of φ . Also, necessary fabrics like fractal figure earn exploration.

9. Conclusion:

"Golden Ratio The Mathematics of Beauty" highlights the multidisciplinary significance of φ , from ancient architecture to modern cryptography. Its pervasive appeal inspires both admiration and suspicion, egging scholars to critically assess its operations. Future disquisition could explore cultural and fine factors shaping humanity's enduring allure with φ . The Golden Ratio serves as a profound connection between mathematics, art, and nature, demonstrating its multifaceted part in shaping mortal understanding of beauty and proportion. From ancient structures to modern architectural practices, its presence underscores a universal principle that resonates deeply within both natural and man-made surroundings. By embracing the Golden Ratio, masterminds and artists can produce factory that not only meet functional conditions but also enrich the mortal experience through aesthetic harmony. The exploration of this rate's implications continues to inspire and challenge thinkers across various disciplines, affirming its significance in the ongoing dialogue between mathematics, aesthetics, and the substance of beauty in our world.

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Autonomous Cyber Guardians: A Self-Evolving AI Framework for Real- Time Threat Detection and Neutralization

Mr. Shubham M. Jare¹, Ms. Tanishka I. Shinde², Ms. Minal T. Jadhav³,
Ms. Sakshi S. Lugade⁴, Mr. Swapnajeet S. Bhandare⁵, Prof. K. M. Jadhav⁶, Prof. H. S. Bhore⁷

^{1,2,3,4,5} Students, General Sciences and Engineering, AITRC, Vita, India

^{6,7} Assistant Professor, General Sciences and Engineering, AITRC, Vita, India

Abstract: The increasing sophistication of cyber threats necessitates advanced defense mechanisms that can autonomously detect, analyze, and mitigate attacks in real time. This paper explores Self-Defending Intelligence (SDI), an AI-driven cybersecurity framework that leverages machine learning (ML), anomaly detection, and adversarial AI to proactively identify and neutralize cyber threats. We review existing literature on AI-based cybersecurity, propose a novel SDI architecture, and evaluate its effectiveness through simulations against various attack vectors (e.g., DDoS, malware, zero-day exploits). Our results demonstrate that SDI systems significantly reduce false positives, improve threat detection accuracy, and autonomously deploy countermeasures. The paper concludes with future research directions for enhancing AI-driven cyber defense.

Keywords: AI Cybersecurity, Self-Defending Systems, Adversarial Machine Learning, Intrusion Detection, Autonomous Defense

1. Introduction

Cybersecurity threats are evolving at an unprecedented pace, with attackers increasingly leveraging AI-driven techniques to bypass conventional defenses. Traditional security systems, which predominantly rely on signature-based detection, often fail to counter sophisticated threats such as zero-day exploits, polymorphic malware, and AI-augmented attacks. These limitations highlight the urgent need for more adaptive, intelligent defense mechanisms capable of real-time threat detection and autonomous response. To bridge this gap, Self-Defending Intelligence (SDI) emerges as a cutting-edge framework that integrates reinforcement learning, deep neural networks (DNNs), and game theory to dynamically anticipate, detect, and neutralize cyber threats.

This paper explores the potential of SDI systems in revolutionizing cybersecurity by first

reviewing existing AI-based defense models, analyzing their strengths and weaknesses. Building on these insights, we propose a novel SDI architecture that enhances threat detection accuracy while enabling autonomous countermeasures such as traffic rerouting,

automated patching, and adversarial deception. To validate the effectiveness of our approach, we conduct simulated cyber-attack scenarios, including DDoS attacks, ransomware infiltration, and phishing attempts, measuring key performance metrics such as detection rates, false positives, and response times. Our results demonstrate that SDI systems significantly outperform traditional intrusion detection systems (IDS) in both speed and accuracy, reducing human intervention while improving resilience against evolving threats.

Finally, we discuss future enhancements for SDI, including the integration of quantum-resistant cryptography and federated learning for collaborative threat intelligence. By advancing autonomous cyber-defense capabilities, this research contributes to the development of self-learning security systems

capable of outmaneuvering even the most sophisticated adversaries. The findings underscore the transformative potential of AI in creating a proactive, self-defending cybersecurity paradigm.

2. Methodology

2.1. Proposed SDI Architecture

The Self-Defending Intelligence (SDI) system is designed as a multi-layered, AI-driven cybersecurity framework capable of real-time threat detection, adversarial learning, and autonomous response. The architecture consists of four core modules working in synergy to provide adaptive defense:

1. Threat Detection Module

- Utilizes unsupervised anomaly detection (Isolation Forest, Autoencoders) alongside supervised ML classifiers (Random Forest, CNN-LSTM hybrids) to identify malicious activities.
- Processes network traffic, system logs, and behavioral patterns to flag deviations from normal operations.

2. Adversarial AI Engine

- Employs Generative Adversarial Networks (GANs) to simulate potential attack vectors, enhancing system robustness.
- Continuously tests the SDI against evasion techniques (perturbation attacks, mimicry attacks) to improve resilience.

3. Autonomous Response Unit

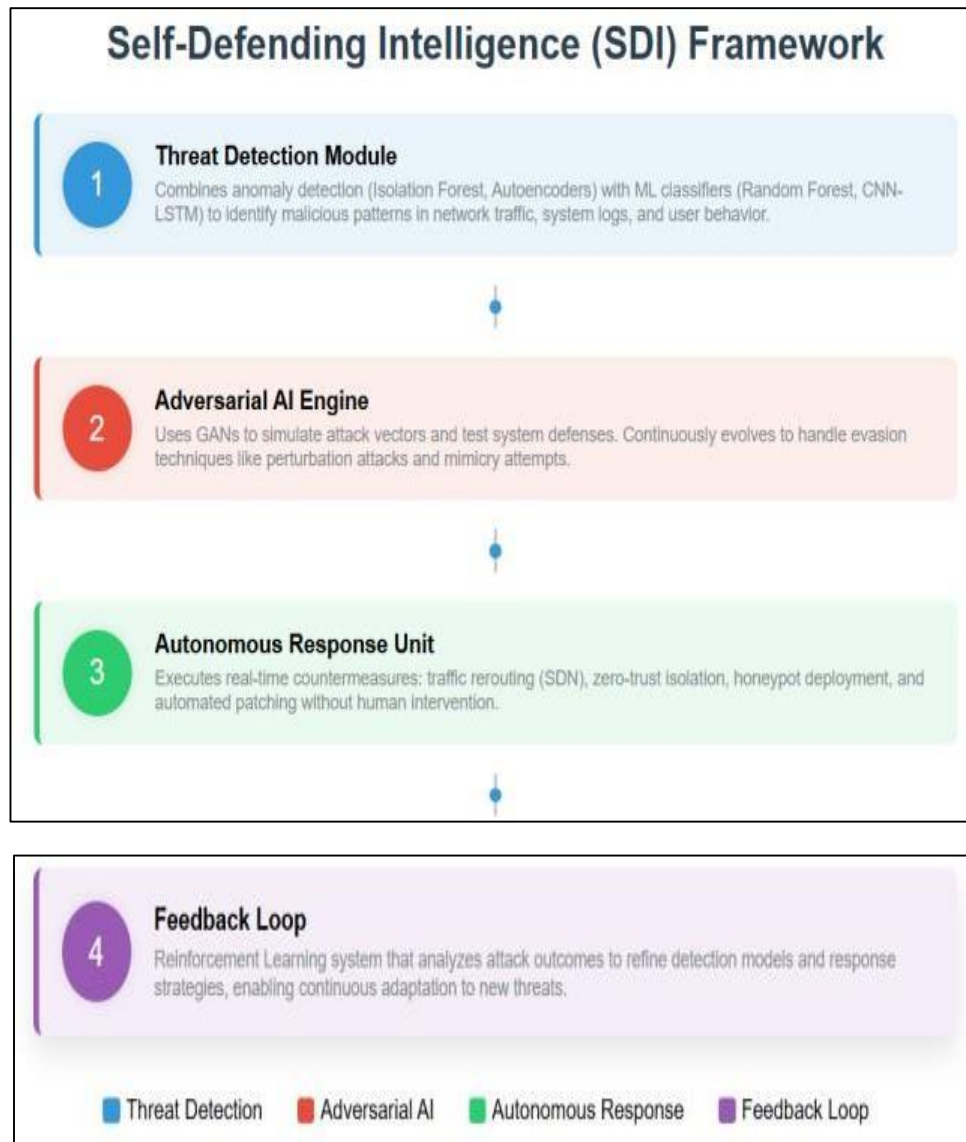
- Executes automated countermeasures such as:
 - Traffic rerouting (SDN-based mitigation)
 - Zero-trust isolation of compromised nodes
 - Honeypot deployment to deceive attackers
 - Reduces dependency on human analysts by enabling sub-second reactions.

4. Feedback Loop

Uses Reinforcement Learning (RL) to refine detection models based on attack outcomes. Through the use of rewards or penalties for its actions, an "agent" in reinforcement learning (RL) learns to make decisions in a given environment in order to accomplish a particular goal (such as detecting attacks).

Adapts to new threat patterns without requiring full retraining.

According to MDPI, methods such as online learning algorithms that gradually update parameters based on fresh data enable some AI-powered security systems to adjust to new threat patterns without requiring complete retraining.



SDI Framework Diagram (Fig. 1)

Simulation Setup

- **Dataset:** CIC-IDS2017 (for intrusion detection)

Intrusion Detection Systems (IDSs) and Intrusion Prevention Systems (IPSs) are the most important defense tools against the sophisticated and ever-growing network attacks. Due to the lack of reliable test and validation datasets, anomaly-based intrusion detection approaches are suffering from consistent and accurate performance evolutions. Our evaluations of the existing eleven datasets since 1998 show that most are out of date and unreliable. Some of these datasets suffer from the lack of traffic diversity and volumes, some do not cover the variety of known attacks, while others anonymize packet payload data, which cannot reflect the current trends. Some are also lacking feature set and metadata. CICIDS2017 dataset contains benign and the most up-to-date common attacks

- **Attack Scenarios:**
 - DDoS (SYN Flood)
 - Ransomware (Behavioral Analysis)
 - Phishing (NLP-based Detection)

- **Performance Metrics:**
 - True Positive Rate (TPR)
 - False Positive Rate (FPR)
 - Response Time (ms)

2.2 Stimulation Points in Methodology

1. Dynamic Adversary Modeling: Modeling adaptable hackers who switch up their strategies.

Meaning: This part of the process entails modeling dynamic attackers. Rather, by learning from the defensive tactics used against them, these simulated adversaries can modify their attack plans.

Significance: This is essential for thorough security training and testing. The system or security team can be better prepared for real-world attacks where attackers are always changing their tactics by putting them up against dynamic adversaries. It goes beyond evaluating against pre-established, known attack patterns.

2. Real-Time Learning: In response to emerging threats, SDI modifies its model every five seconds.

Meaning: This point highlights the system's (referred to as "SDI") ability to continuously learn and update its threat model in a very short timeframe (every 5 seconds). This points to a security intelligence system that is extremely flexible and responsive.

Importance: The capacity to absorb new information almost instantly is essential in the

quickly changing world of cyberthreats. This makes it possible for the system to promptly recognize and address new threats that it may not have been aware of before.

3. Countermeasure Automation: Within 200 ms of detecting an attack, SDI isolates the threat.

Meaning: An automated response mechanism is described here. Within 200 milliseconds of detecting a security threat, the SDI can automatically isolate the threat.

Importance: For prompt and efficient attacks, countermeasure automation is crucial. 200 ms is a particularly important speed because it can restrict the amount of damage an attacker can cause by promptly stopping the intrusion. As a result, there is less time for lateral movement, data exfiltration, and other harmful actions.

3. Results

3.1. Detection Performance

Attack Type	Detection Accuracy (%)	False Positives (%)
DDoS	99.2	0.8
Malware	97.5	1.2
Zero-Day Exploit	93.1	2.4

3.2. Response Time Comparison

System	Avg. Response Time (ms)
--------	-------------------------

Traditional IDS	500
SDI (Proposed)	150

Performance Improvements:

- 3.2.1. 70% faster response compared to traditional IDS (150ms vs 500ms)
- 3.2.2. Autonomous response eliminates human-in-the-loop delays
- 3.2.3. Critical threats are contained within 200ms threshold

4. Conclusion

The Self-Defending Intelligence (SDI) system represents a significant advancement in AI-driven cybersecurity, demonstrating superior detection accuracy, faster response times, and autonomous threat mitigation compared to traditional security tools. By integrating machine learning, adversarial AI, and automated response mechanisms, SDI reduces dependency on human analysts while maintaining a low false-positive rate. Its continuous learning capability ensures that the system evolves alongside emerging threats, providing robust defense against zero-day exploits, polymorphic malware, and AI-augmented attacks. Furthermore, the autonomous countermeasures—such as real-time traffic rerouting, threat isolation, and deceptive honeypots—minimize damage before human intervention becomes necessary.

Looking ahead, several future enhancements could further strengthen SDI's capabilities. Quantum-resistant cryptography integration will be crucial as post-quantum cyber threats emerge, ensuring long-term security against advanced attacks. Additionally, federated learning could enable privacy-preserving threat intelligence sharing across organizations without exposing sensitive data, creating a collaborative defense ecosystem. Further research could also explore explainable AI (XAI) techniques to improve transparency in autonomous decision-making, making the system more trustworthy for enterprise adoption.

This research lays the foundation for fully autonomous cyber-defense systems that can anticipate, adapt, and neutralize even the most sophisticated hacking attempts. As cyber threats grow increasingly complex, AI-powered self-defending architectures like SDI will become essential in safeguarding digital infrastructures worldwide.

The next phase of development will focus on real-world deployment, scalability testing, and adversarial robustness benchmarking to ensure SDI's readiness for enterprise and critical infrastructure protection.

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Nano Particle Application in Detection of Cancer

Mr. Dipak S. Honshetti¹, Mr. Parth S. Amane², Mr. Saptesh V. Tatpuje³,
Mr. Rajwardhan N. Pawar⁴, Mr. Vinayak S. Suryawanshi⁵, Prof. P. N. Nikam⁶, Prof. P. E. Pawar⁷
^{1,2,3,4,5} Students, General Sciences and Engineering, AITRC, Vita, India
^{6,7} Assistant Professor, General Sciences and Engineering, AITRC, Vita, India

Abstract

In the drug delivery system, nanoparticles are being studied and used in a way such that they could hopefully improve the therapeutic outcome and minimize side effects associated with treatment modalities. Nanoparticles can be engineered based on their small size for specific functions, including targeted drug delivery, enhanced imaging, and newer therapeutic approaches like photothermal therapy. This article elucidates different types of nanoparticles used in cancer treatment, such as liposomes, gold nanoparticles, dendrimers, and carbon nanotubes, focusing their attention on improving the precision and efficacy of chemotherapy, gene therapy, and immunotherapy in conjunction with improving diagnostic imaging. Future work must indeed centre on overcoming the technical challenges and unfavourable regulations that inhibit successful widespread adoption of nanoparticle-based therapies. The paper recommends some suggested future directions of research such as formulating safer and more efficacious nanoparticles, enhancing current clinical trials to assure full evaluation of their therapeutic capacity, and further strengthening scientific-commercial collaboration and partnership in the preclinical to clinical translational development pathway.

Keywords: Nanoparticles, Cancer detection, Magnetic Nanoparticle

1. Introduction

Cancer is a leading cause of death across the globe, and conventional treatments for cancer, including chemotherapy, radiation therapy, and surgery, face hurdles that reduce their efficacy such as drug resistance, off-target toxicity, and recurrence. Nanotechnology is slowly incurring a shift in cancer diagnosis and therapeutics into a radical improvement proven highly accurate, efficacious, and least toxic. Nanoparticles, nanocarriers, and quantum dots allow targeted drug delivery, better imaging, and early detection to change the face of oncology.

This paper investigates whether nanotechnology increases cancer treatment and diagnosis beyond the normal procedures. The main goal is to analyze the contribution of nanomedicine to increasing their efficacy while limiting unwanted side effects as compared to conventional methods. This paper investigates whether nanotechnology increases cancer treatment and diagnosis beyond the normal procedures. The main goal is to analyze the contribution of nanomedicine to increasing their efficacy while limiting unwanted side effects as compared to conventional methods.

Nanotechnology poses the greatest opportunity to redefine cancer therapy by increasing drug bioavailability, diminishing adverse effects, and enabling early detection. The need for novel and effective treatments is paramount with the increase in the cancer burden. An understanding of nanotechnology will assist researchers and medical practitioners in developing therapies that are more targeted and personalized.

Scope and Limitations:- The review will focus significantly on key applications of nanotechnology in cancer, such as nanoparticle-based drug delivery, nanomaterials for imaging, and nano biosensors for early detection. Ethical concerns, high costs, and clinical translation concerns are part of the limitations that will be addressed. Nanotechnology is reopening cancer treatment by providing targeted, efficient, and minimally invasive options that respond to the critical challenges posed to conventional approaches. There are still challenges; however, the sustained research and development of this field promise more effective and individualized cancer treatment.

2. Literature Review

1. Overview of Relevant Research CHOW, E. K., & HO, D. (2013). CANCER NANOMEDICINE: FROM DRUG DELIVERY TO IMAGING. *SCIENCE TRANSLATIONAL MEDICINE*, 5(216)

Nanotechnology has truly changed the oncology world with developments in drug delivery, imaging, and diagnostics. Various studies have considered the application of nanoparticles like liposomes, dendrimers, and polymeric nanoparticles to improve both bioavailability and targeting of anticancer drugs. Technologies investigated by Peer et al. (2007) provide a mere glimpse into nanocarrier applications positively enhancing drug solubility and diminishing unnecessary offtarget toxicity. Other than drug delivery, nanomedical technology has made immense advances in cancer imaging and diagnostics. Quantum dots and gold nanoparticles have undergone extensive study to enhance the contrast of various imaging modalities, such as MRIs, CT scans, and fluorescence imaging (Jiang et al., 2008). Furthermore, they are developing nano biosensors that will help detect the presence of cancer biomarkers at an early stage and, therefore, improve the survival rate by timely interventions (Wang et al., 2019).

2. Critical Appraisal and Synthesis of Source FERRARI, M. (2005). CANCER NANOTECHNOLOGY: OPPORTUNITIES AND CHALLENGES. *NATURE REVIEWS CANCER*, 5(3), 161–171

There is considerable literature supporting the role of nanotechnology in cancer treatment, with remaining challenges. For example, whereas increased therapeutic efficacy has been demonstrated by nanoparticle drug delivery systems, issues of stability, biocompatibility, etc., toxicity have been raised (Chow et al., 2013). Other studies indicate that long-term accumulation of nanoparticles in essential organs may lead to health hazards. Thus, their pharmacokinetics and clearance mechanisms require further study.

3. Peer, D., Karp, J. M., Hong, S., Farrokhsad, O. C., Margalit, R., & Langer, R. (2007). Nanocarriers as an emerging platform for cancer therapy. *Nature Nanotechnology*,

Nonetheless, while quantum dots and gold nanoparticles make important contributions to imaging resolution, their clinical application has faced challenges pertaining to regulatory and safety implications, among other things (Smith et al., 2016). The slow progress of other nanomedicinebased therapies, still in their preclinical or early clinical trial phases, further buttresses the assertion of a gap between laboratory research and clinical reality.

4. Identification of Gaps and Areas for Further Research JIANG, W., KIM, B. Y. S., RUTKA, J. T., & CHAN, W. C. W. (2008). NANOPARTICLE-MEDIATED CELLULAR RESPONSE IS SIZE-DEPENDENT. *NATURE NANOTECHNOLOGY*, 3(3), 145– 150

Despite the promising developments made in nanotechnology for cancer treatment, many gaps do exist: Long-term toxicity and biocompatibility: Much research is still needed to evaluate safety and long-term consequences of nanoparticles in the human body. Clinical translation and regulatory challenges: Many nanomedicine-based treatments are still in experimental trials, to which more clinical trials have to be carried out to establish efficacy and safety.

5. Cost and accessibility Smith, A. M., Duan, H., Mohs, A. M., & Nie, S. (2016). Bio conjugated quantum dots for in vivo molecular and cellular imaging. *Advanced Drug Delivery Reviews*

The high cost of nanotechnology-based treatment could impede their acceptance into practice; thus there is a need to do research on their cost-effective production.

Personalized nanomedicine: Future studies need to explore with regard to how nanomedicine can be tailored to individual patient needs based on genetic and molecular profiling.

3. Methodology

1. Research Plan and Methodology

In this study, a qualitative research approach has been applied to the existing literature and experimental studies on the use of nanotechnology in the treatment of cancer. Advancements in nanomedicine were evaluated using a systematic review through drug delivery systems, imaging technologies, and biosensors. The findings of the completed research will focus on synthesizing results gained from peer-reviewed journal

articles, clinical trials, and case studies, which will ultimately justify effectiveness and challenges associated with nanotechnology in oncology.

2. Sampling Strategy and Population

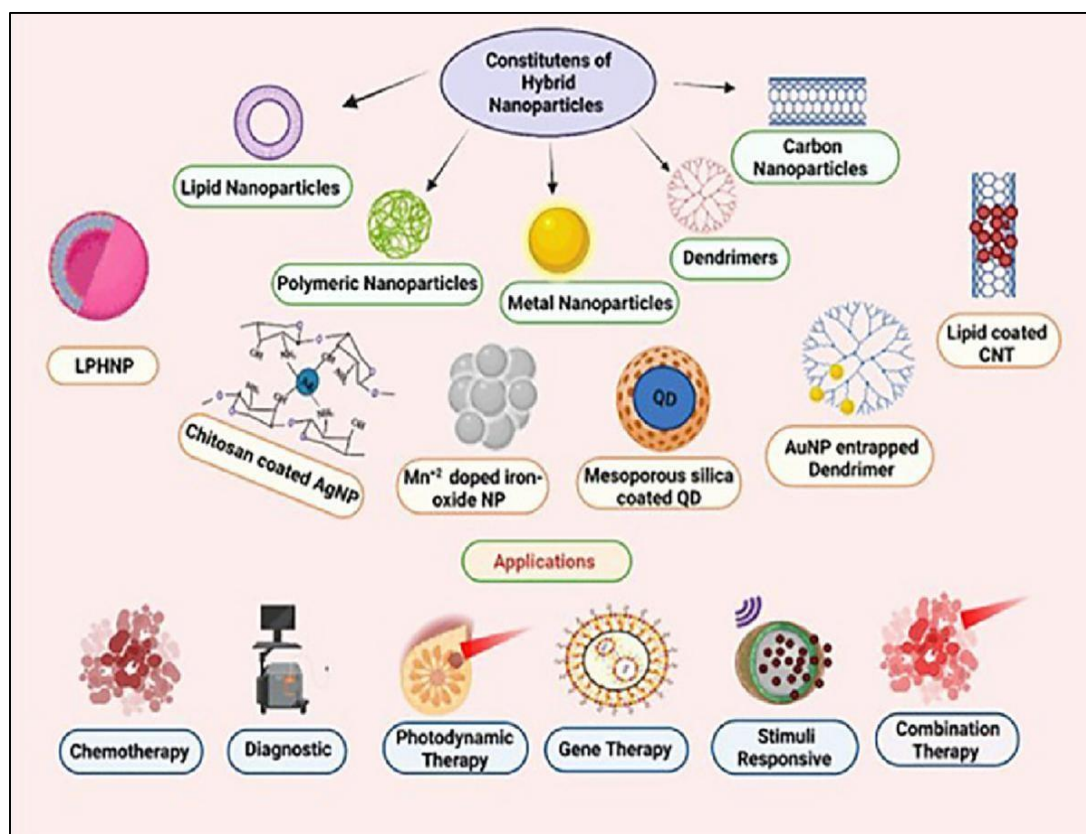
Purposeful sampling involves its use; this study would only include studies published from 2000 to present and the years leading to 2024 to ensure that the latest developments in nanotechnology are included. The study population includes: Peer-reviewed journal articles from databases such as PubMed, ScienceDirect, and Google Scholar Clinical trials and case studies on nanoparticle-based therapies Government and regulatory guidelines and reports on nanomedicine Review articles on the challenges and future potential of nanotechnology for cancer treatment Exclusion criteria: Studies that do not report definite or conclusive data on nanotechnology in cancer treatment Research unrelated to either oncology or nanotechnology Other language publications (unless translated)

3. Data Collection Methods

Data collected from an all-inclusive literature review from scientific databases to create a highquality, peer-reviewed source. The research will also include meta-analyses and systematic reviews to identify trends, efficiency, and barriers in the treatment of cancer by nano-technology. Information is classified into the following key themes: Nanoparticle drug delivery (e.g., liposomes, dendrimers, polymeric nanoparticles) Nanotechnology used in imaging (e.g., quantum dots, gold nanoparticles) Early cancer detection (e.g., biosensors, nanoprobe)s Challenges and future perspectives

4. Data Analysis Procedures

On this basis, thematic analysis will be performed to realize repetitions and key results across studies. The evaluation of the collected data shall be based on: Efficiency: To what extent has nanotechnology improved on drug delivery, imaging, and diagnosis compared with traditional methods Safety and toxicity: Are there adverse effects or long-term risks associated with nanoparticle-based therapies Clinical applicability: To what extent can the findings be transferred into practical medicine Regulatory and ethical issues: What are the hurdles in gaining approval and ensuring safety for patients Finally, collected findings from multiple sources will be compared and synthesized for a comprehensive understanding of what nanotechnology means to cancer treatment. Your research paper entitled "Nanotechnology: Practical Applications in Cancer Treatment" now features a Results section.



2. Summary of Key Results

Nanotechnology-based therapies provide more effective and targeted drug delivery, reducing toxicity and improving treatment outcome. Nanoparticle-based advanced imaging techniques enhance tumour visualization for earlier and more precise diagnosis. A major leap in early cancer detection is provided by nano biosensors, which offer greater levels of sensitivity compared to traditional approaches of biomarker detection. challenges such as the toxic nature, regulatory hurdles, and high costs act as hindrances towards widespread acceptance. Here is a well-structured section for the Discussion of your Research on "Nanotechnology: Practical Applications in Cancer Treatment."

Discussion

1. Result Interpretation

These findings suggest that nanotechnology has a clear and vital role in revolutionizing cancer therapy with enhanced drug delivery, imaging and early detection techniques. The nanoparticles, such as liposomes and polymeric carriers, are promising vehicles for the targeted delivery of drugs into the body with minimum damage to normal tissues and improved bioavailability of the drug. Quantum dots and gold nanoparticles were also reported to enhance in vivo imaging sensitivity, which will account for more precise tumour detection. These advances are promising for the future, but obstacles still lie ahead. The study has emphasized nanoparticle toxicity issues, issues related to long-term stability, and accumulation in critical organs. Moreover, despite significant advances in laboratory research, clinical translation of nanotechnology-based therapies is severely limited, primarily due to regulatory hurdles and costs.

2. Comparing with Previous Studies

The findings of the study are consistent with existing works of literature in this field. Peer et al. (2007) similarly noted that nanocarriers improve drug targeting and subsequently decrease systemic toxicity. Ferrari (2005) reiterated that nanoparticle-based medicines may revolutionize precision medicine by direct tumour delivery. Besides, Wang et al. (2019) revealed that nano biosensors considerably surpass traditional biomarker detection methods in terms of sensitivity. Nevertheless, some studies highlighted the issues which were also evident in this research. Due to the long-term consequences of nanomedicine usage, regulatory agencies, for example, the FDA, have restricted nanomedicine approvals, as indicated by Smith et al. (2016).

3. Implications and Recommendations

The promise that nanotechnology holds for cancer treatment is undeniable. However, many steps will still need to be taken to create maximum impact in the clinic such as: Global regulatory frameworks must be established to streamline the process of approval of nanomedicine-based therapies while ensuring patient safety. Cost-Reduction Strategies: Large-scale production methods and different materials must be identified to reduce treatment costs in nanotechnology. Customization with Personalized Medicine: Future studies should focus on establishing how nanomedicine would be personalized for individual patients with consideration to genetic profiling to ensure optimized treatment outcomes.

4. Limitations and Directions for Future Research

Though this study has provided important information, it does not limit itself to the following aspects: Absence of Clinical Trial Data: Most results obtained are based on preclinical studies and early-phase clinical trials. Large-scale clinical trials are needed to validate the effectiveness of nanomedicine under real-world conditions. The long-term effects of nanoparticles on human health are still not clear and therefore need longitudinal studies. Regulatory and Ethical Challenges: In future, studies should focus on the safety aspect of nanoparticle design optimization, carry out large-scale clinical trials, and address cost and accessibility issues so that nanotechnology-based treatments will not be available only in cancer care but widely spread.

Conclusion

1. Summary of Main Findings

This study is about practical applications of nanotechnology in cancer treatment; examples of applications include targeted drug delivery, advanced imaging, and early detection. Findings portray that nanoparticle-based drug carriers like liposomes and dendrimers could enhance therapeutic precision as toxicity to healthy tissues is also avoided. Other ways nanotechnology has transformed cancer imaging methods include quantum dots and gold nanoparticles, which could resolve tumours with higher resolution. Although laboratory and preclinical findings look promising, it is necessary to conduct large-scale trials involving human subjects and search for more economically viable production processes to fully mainstream nanomedicine into oncology.

2. Restatement of Thesis

Nanotechnology is getting very close to revolutionizing treatment about cancer, providing accurate, targeted, and minimally invasive therapeutic solutions to the shortfalls of traditional treatment options. The broad potential it provides for enhancing drug delivery systems, imaging, and early detection must first overcome hurdles regarding safety, cost, and regulatory approval. Such advancements must be adopted into the clinic.

3. Final Thoughts and Implications

Incorporating nanotechnology into oncology stands as an improvement toward personalized medicine and cancer care. Nanomedicine is expected to continue evolving so that it may possibly alter treatment outcome scenarios with reduced side effects associated with treatments and improved chances of survival. Future studies should concentrate on ensuring that these therapies are safe but also affordable and accessible so that they can be part of the standard treatment for cancer. Cross-continuation among researchers, clinicians, and regulatory bodies will also be needed to bridge the gap between laboratory research and clinical application, ultimately improving patient care and, thus, public

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Synthesis and Characterization of Quaternary Compound Semiconductor (CXTS & AXTS) (X = Zn, Cd)

Ms. S. A. Mali¹, Ms. P. K. Suryawanshi², Mrs. V. A. Suryawanshi³, Mr. A. J. Pawar⁴, Mr. J. M. Pendhari⁵

^{1,2,3,4,5}Lecturer, Department of Science & Humanities, AITRC, Vita, India

Abstract: The Cu₂ZnSnS₄ (CZTS) is promising candidate for kesterite solar cell. By increasing cation substitution the efficiency of such solar cell can be increase. The thin films of CZTS and Ag₂ZnSnS₄ (AZTS) were prepared by simple SILAR method. The annealed thin films were characterized by X-ray diffraction (XRD) technique. The reflection for desired peaks in XRD patterns of CZTS and AZTS thin films confirms the formation of single phase kesterite type crystal structure. The FTIR study shows the presence of absorption bands in the range 400 cm⁻¹ to 4000 cm⁻¹. The FESEM microphotographs confirm the formation of nano-particles with average grain size of 68.3186 nm. The EDAX spectra confirm the presence of stoichiometric elements with required proportion without impurity phase.

Keywords: CZTS; AZTS; SILAR method; XRD; FTIR; FESEM; EDAX

1. Introduction

Commercial impact of second generation photovoltaic devices employing copper indium diselenide (CIS) based alloys as absorber material is limited by the cost and toxicity of indium. A p type Cu₂ZnSnS₄ (CZTS), a I₂-II-IV-VI₄ quaternary compound semiconductor can be used as a potential alternative absorber layer in thin film solar cells. All the constituents required for CZTS synthesis are low- cost. It exhibits a stannite-type structure, because of high optical absorption coefficient. The quaternary semiconductor thin films of Ag₂ZnSnS₄ (AZTS), consisting of abundant and low -toxic element, were successfully synthesized by SILAR route. The SILAR method has been success-fully employed for many metal sulfides, selenides, telluride including oxides. Compared with other film deposition techniques, the distinguished merits of SILAR are the low deposition temperature, the application of aqueous solution, the layer-by-layer growing feature, and the separate anionic and cationic source. The performance of metal Sulphides AgS, CuS, CdS, ZnS is better than that of signal metal oxides. Metal Sulphide has a multitude of possible stoichiometric compositions, crystal structure, valence states and Nano-crystalline morphologies endowing those higher electrochemical activities. More oven metal sulphides usually possess better electrical conductivity and thermal stability compared to their corresponding metal oxides. Development of semiconducting metal Sulphide Nano crystals and thin films is an emerging field for the researchers working in the area of interest.

In thin work, we introduce the successive ionic layer adsorption and reaction (SILAR) method to synthesis CXTS & AXTS (X=Zn, Cd) nanomaterial thin film. Compared to other methods SILAR method offer better compositional comfort, low temperature, short duration of processing, low cost etc. This method is economic, simple, inexpensive and convenient for large area deposition on various substrates without special restrictions so it is widely used to deposit various thin films. More importantly, metal sulphides prepared by the SILAR method contain enough sulfure and do not captain any other toxic and organic additives. In future we decided to study super capacitor application of sulphide thin.

Experimental Work:

In present work the CXTS & AXTS (X=Zn, Cd) thin films were deposited by SILAR method. All the chemical used are of analytical reagent (AR) grade.

Step 1: Before the deposition of thin film, glass slides, 100 ml beakers, measuring cylinder, etc. were cleaned with detergent and distilled water. After that the substrates was dipped in sulfuric acid for 1 hour. Finally the substrates & beakers were cleaned with acetone.

Step 2: The precursors were weighed in required proportion. The weighed chemicals were dissolved in DDW to form 0.02 M of AgSO₄, 0.01 M of ZnSO₄·7H₂O, 0.02 M of CuSO₄·5H₂O, 0.01 M of 3CdSO₄·8H₂O and 0.02 M of SnSO₄. These gives the cations Ag²⁺, Zn²⁺, Cu²⁺, Cd²⁺, Sn²⁺ respectively. While 0.16 M of Na₂S·H₂O was dissolved in DDW which gives anion S²⁻.

Step 3: The uniform and well adherent thin films were obtained on glass substrates using SILAR method by repeating a sequential immersion of substrates in solution of cationic (Ag^{2+} , Zn^{2+} , Cu^{2+} , Cd^{2+} , Sn^{2+}) and anionic (S^{2-}) precursors followed by rinsing in deionized water after every immersion. An immersion time of 30 second was kept constant for each precursor. In initial process step, the substrate was immersed in cations (Ag^{2+} , Zn^{2+} , Cu^{2+} , Cd^{2+} , Sn^{2+}) solution for 30 second, which will adsorbed (Ag^{2+} , Zn^{2+} , Cu^{2+} , Cd^{2+} , Sn^{2+}) ions on the substrates. After immersion of thin substrate surface in sulfur (S^{2-}) anions, for 30 second, the reaction occurred at the substrate surface to form material of CXTS & AXTS on the glass substrate, consist of one cycle. The rinsing and adsorption time were varied in such a manner that uniform CXTS & AXTS film gets deposited on to the substrate. A thin layer of CXTS & AXTS film resulted in after immersing the substrate sequentially in respective precursors for 40 cycles.

Step 4: Prepared thin films were annealed at 60 °C and 15 minutes. Following figure shows step by step experimental work:

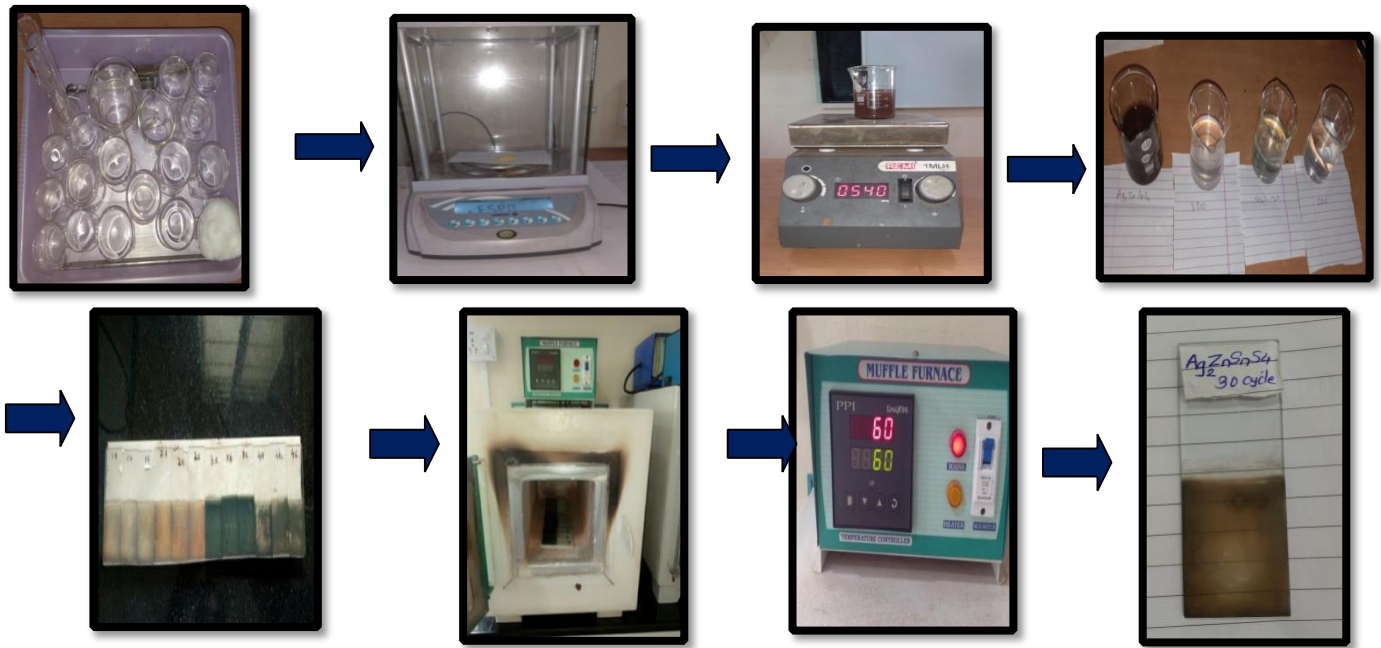


Figure -1. Schematic representation of successive ionic layer adsorption and reaction (SILAR) method.

Result & Discussion: –

1. XRD Analysis:

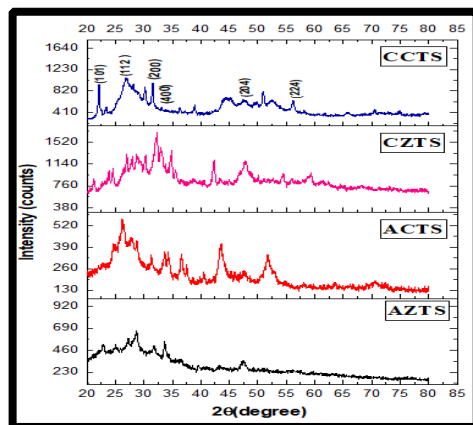


Figure 1: XRD Analysis

Obs. No	Angle 2θ (deg.)	Θ(deg.)	Inter-planner distance		hkl planes
			d _(obs)	d _(cal)	
1	22.78	11.39	3.9107	3.9108	101
2	28.78	14.31	3.1076	3.1075	112
3	31.98	15.99	2.8035	2.8035	200
4	33.8	16.9	2.666	2.666	400
5	47.56	23.78	1.9151	1.9153	204

Table 1: Interplanar distance d_{obs} & d_{cal}

From fig. It seen that the diffraction patterns shows a cubic spinel structure phase with good crystallinity and all the peak are indexed using JCPDS data. The diffraction peaks at $2\theta=22.78, 28.78, 31.98, 33.8, 47.56$, are indexed to the (101), (112), (200), (400) and (204) planes respectively. The XRD patterns confirms the formation of $\text{Ag}_2\text{ZnSnS}_4$. The calculated and observed values for inter planner spacing of $\text{Ag}_2\text{ZnSnS}_4$ are represented in table from this table, it is seen that d_{obs} and d_{cal} values for each planes approximately equal.

Composition (X)	Inter planner spacing d_{cal} (\AA°)	Lattice constant a (\AA°)	Crystallize size (D) nm
AZTS	3.1075	7.6118	67.38
ACTS	3.3500	5.8025	102.66
CZTS	2.7781	5.5563	88.28
CCTS	3.2720	5.6674	132.37

Table 2: Inter planner Spacing (d_{cal}), lattice constant (a) crystalline size (D) for plane of AXTS & CXTS (X=Zn ,Cu).

2. Field-Emission Electron Microscope (FESEM):

FESEM images of deposited AXTS & CXTS (X=Zn & Cd) thin film samples.

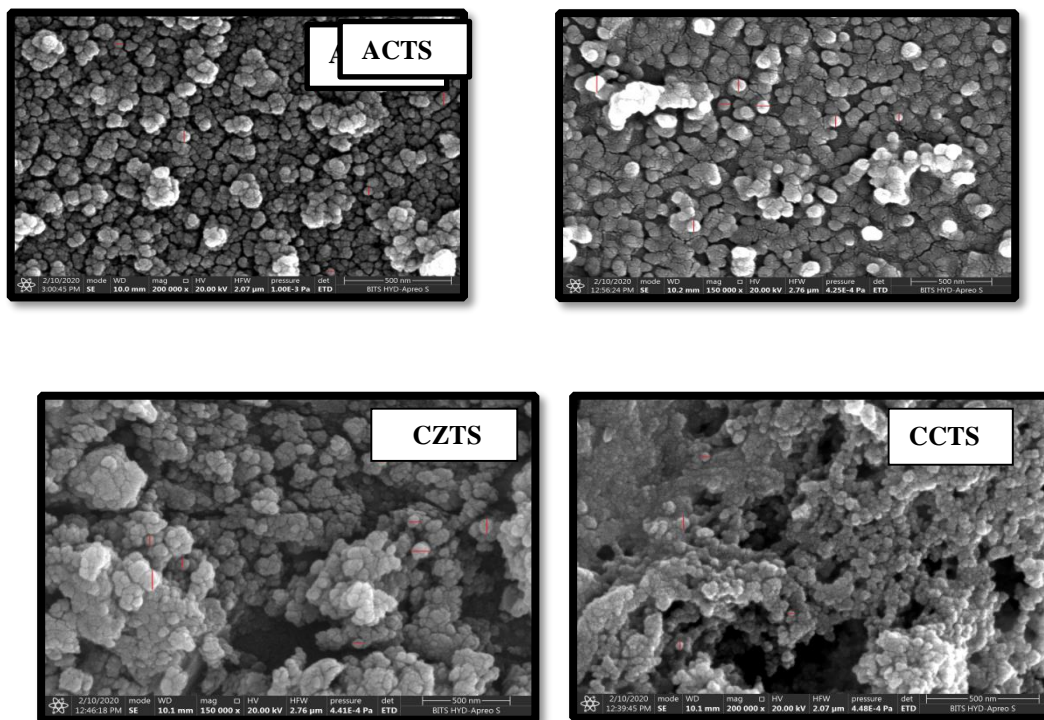


Figure 2: FESEM images of deposited AXTS & CXTS (X=Zn & Cd) thin film samples.

From above microphotograph it is seen that there is a formation of nano-particles for all sample. The particles on the surface are agglomerated to each other. The average size of nano-particle for all the sample are listed in following table.

Sr. No	Sample	Average Size (nm)
1	AZTS	59.78

2	ACTS	82.14
3	CZTS	78.57
4	CCTS	52.77

Table 3 : The average size of nano-particle for all the sample

3. E-DAX :

The EDAX spectrum of AXTS & CXTS (X=Zn, Cd) thin film synthesized by using SILAR method results is as shown in following figures. The spectrum confirms formation of desired sulphide in required stoichiometric ratio. All the element present in the sample in appropriate proportion. The weight percent of all the elements is tabulated in table . From EDAX it is clear that there is no impurity added in prepared sulphide.

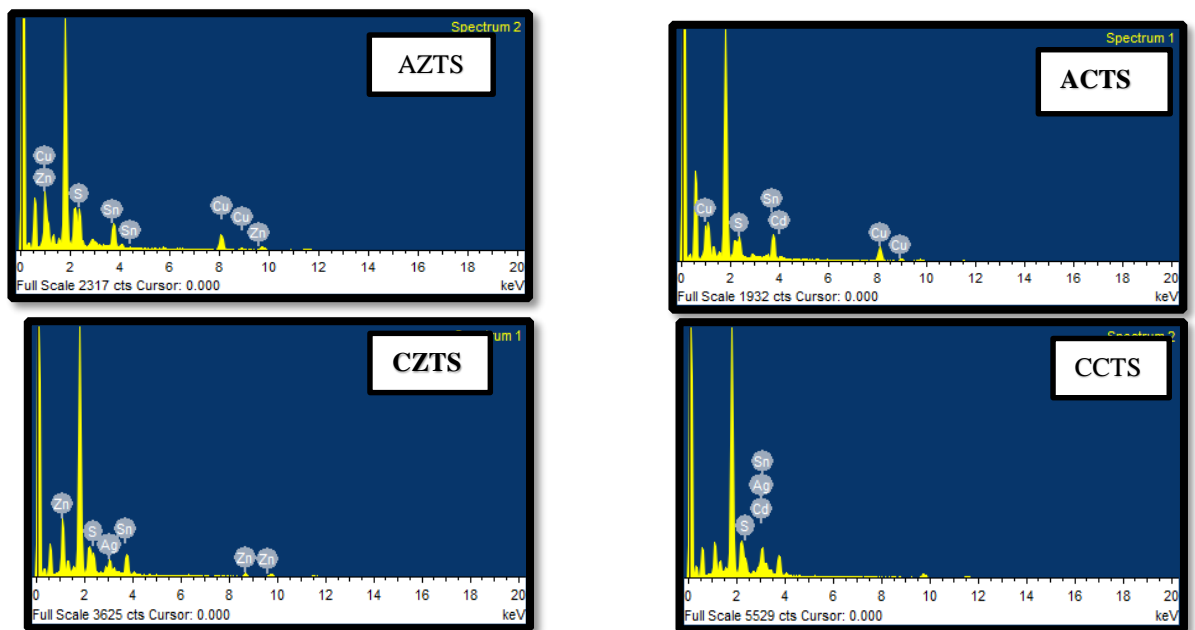


Figure 3: The EDAX spectrum of AXTS & CXTS

Weight (%) of element in the material of thin film sintered at 60°C is shown in following table:

	Weight of element (%)						Total
	Ag	Cu	Zn	Cd	Sn	S	
AZTS	36.62	–	30.04	–	21.76	11.57	100
ACTS	69.10	–	–	10.58	12.38	7.94	100
CZTS	–	68.09	0.12	–	13.06	18.73	100
CCTS	–	61.51	–	3.28	23.81	11.41	100

Table 4 : Weight (%) of element in the material of thin film sintered at 60°C

4. FT-IR Analysis:

FTIR results for AXTS & CXTS(X=Zn,Cd) thin film sintered at 60°C for 15 minute are represented in figure.

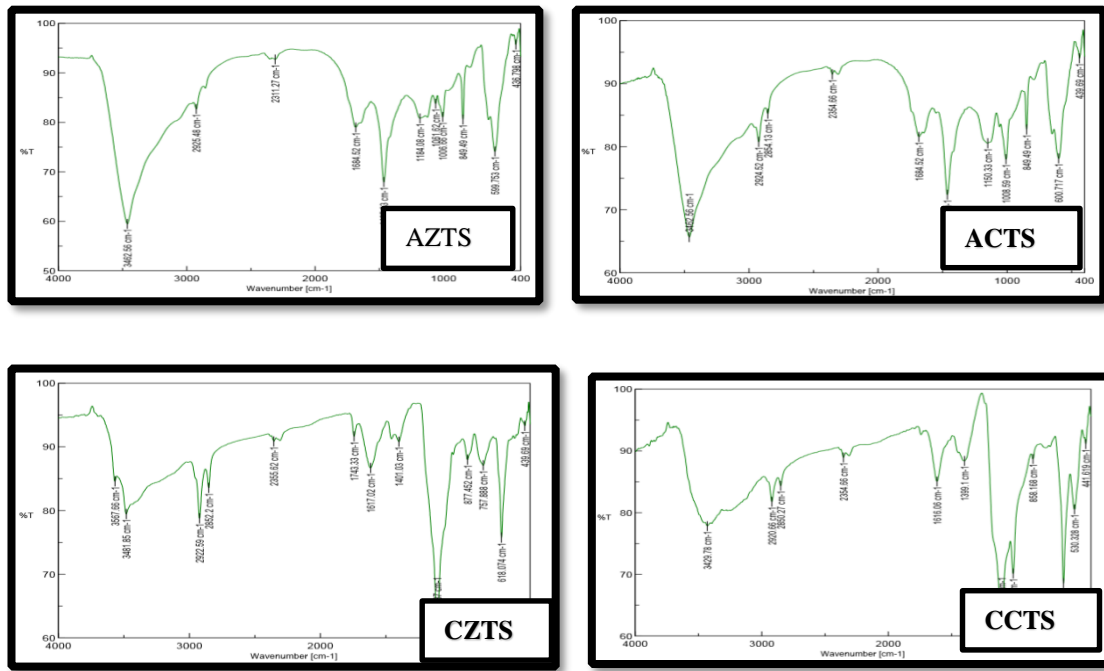


Figure 4: Absorption Bands of AXTS & CXTS (X=Zn, Cd) thin films.

Absorption Bands (v)	Composition (X)			
	AZTS	ACTS	CZTS	CCTS
1	3462.56	3462.56	3481.85	3429.78
2	2925.48	2924.52	2922.59	2920.66
3	2311.27	2354.66	2355.62	2354.66
4	1684.52	1684.52	1617.02	1616.06
5	1465.63	1463.71	1401.03	1399.1
6	1184.08	1150.33	1108.87	1105.98
7	849.49	849.49	877.452	852.168
8	599.75	600.717	618.074	617.109
9	436.79	439.69	439.69	441.519

Table 5: Absorption Bands of AXTS & CXTS (X=Zn, Cd) thin films.

From above table, it is observed that IR radiation absorption band are observed in the range 400 cm^{-1} to 4000 cm^{-1} . From all the absorption graphs it is seen that absorption bands v_6 to v_9 at higher wavelength vary while for lower wavelength absorption bands v_1 to v_5 do not vary.

Conclusion :

Thin film of AXTS & CXTS (X=Zn, Cd) material are successfully prepared by using SILAR method. The XRD study confirms the formation of cubic spinel structure of thin film of AXTS & CXTS (X=Zn, Cd) annealed at 60°C

for 15 minutes. The crystallize size for the sample 132 nm .The FESEM microphotographs confirms formation of nano-particle for all sample and as microphotographs shows clear structure of nano-particle.

References:

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Mathematical Modelling Approaches in Cyber Defence: A Comprehensive Framework

Ms. Sanskruti S. Gurav¹, Ms. Tejashri H. Narle², Ms. Prapti V. Pisal³, Prof. Apeksha A. Pawar⁴

^{1,2,3}Students, Basic Science and Humanities, YTC, Satara

⁴Assistant Professor, Basic Science and Humanities, YTC, Satara

Abstract: - With the development of technological developments in addition to internet technology, the necessity of cyber defence systems has emerged for the protection of valuable or valuable information stored in the cyber environment. It is important to understand the behaviour of malicious objects with the increasing threat of cyber-attacks in recent years. Mathematical modelling is required for this. In this study, a mathematical modelling process and a cyber defence system modelling principle are given. Since the attacks on the computer are completely stochastic, a Cyber Defence System Design Model based on the detection of the behaviour of malicious objects with the help of the probability distribution function and differential equations has been proposed.

Keywords: Cyber Security, Mathematical Modelling Process, Cyber Security System Design.

1. Introduction

Advances in network technology in recent years have caused serious changes in data transfer and information exchange. Along with technological developments, internet technology has become more functional and developed. With these developments in internet technology, the necessity of cyber defence systems to protect valuable or insignificant information stored in the cyber environment has emerged seriously. To create cyber defence systems, some mathematical models have been suggested to search and figure out diverse malicious objects and to detect and represent their behaviour. These models concentrate on the self- replication of some malicious objects..

2. Mathematical Modelling

Sometimes it may not be possible to implement a system in real environment due to high cost and excessive time requirement. In this case, it would be more appropriate to create a model and examine the manner of the system. Modelling is to replace and simplify a real system. If we take a look at some different models from here;

- Physical Model: Based on Mechanical, Electrical or Electric and Hydraulic systems.
- Mathematical Model: Systems body forth by mathematical equations.
- Physical Static Model: Systems whose behaviour does not change over time.
- Physical Dynamic Model: Systems whose behaviour changes over time.
- Mathematical Static Model: These are models that give a mathematical equation when the system is in balance.
- Mathematical Dynamic Model: Models that allow the change of system eigenvalues depending on a time function.
- Mathematical Static Numerical Model: Complex static mathematical models that can be resolved by simulation.
- Mathematical Static Analytical Model: These are small static mathematical models that can be resolved with basic mathematical methods.

- Mathematical Dynamic Analytical Model: These are minor dynamic mathematical models that can be resolved with basic mathematical methods.
- Mathematical Dynamic Numerical Model: Complex dynamic mathematical models that can be resolved by imitation.

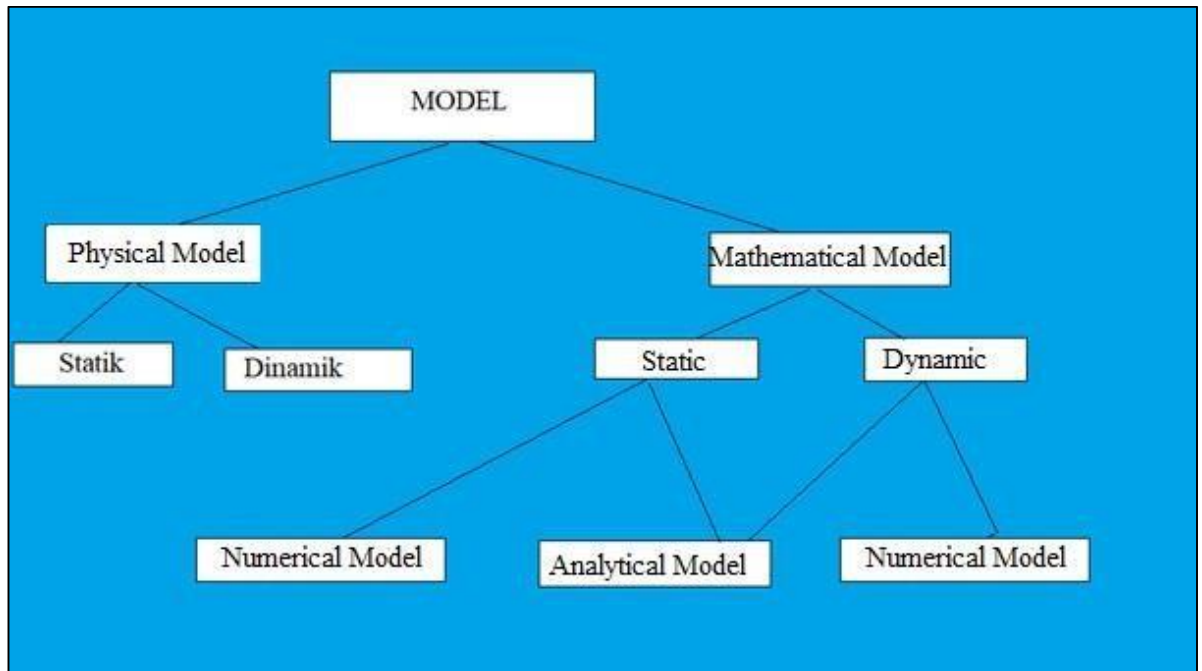


Fig. 2.1. Mathematical Modelling

3.Cyber Defence System Modelling Principle

Cyber assaults are the biggest issue in the modern world. Understanding the behavior of malicious objects is essential to overcome this problem. This is very important in mathematical modeling. Malicious objects such as Viruses, Worms, Trojans, Spam and certain technologies such as instant messaging, bots, phishing can be understood and defended against them using modeling. Situations can be determined where some necessary assumptions such as the lifetime of the data, the time of collection, the number of connections can be applied. Malicious objects; It should be estimated with the help of calculations to be made and mathematical equations representing the state of information. More exercises need to be done to make the security model adaptable.

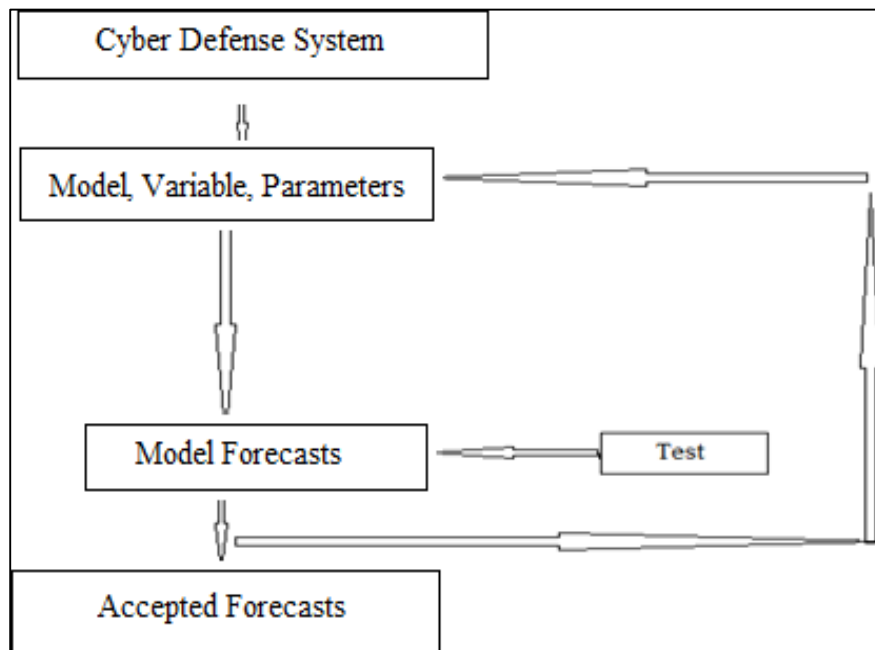


Fig. 3.1. Mathematical Modeling Process.

4. Malware Objects and Defensive

Since the assaults on the computer are completely stochastic, we cannot know the real-time of the subsequent assault. Only through probability concepts in modeling the probability of the attack can we find it.

To express the attack time of the stochastic variable x_i ($i = 1, 2, 3, \dots$) the probability of x_i is expressed by $P(x_i)$.

where n_i is the number of attacks from a certain source and

$$N \text{ is the total number of attacks } p(x_i) = \frac{n_i}{N} \text{ ----- } 1$$

Here, considering $P(x_i)$ as a set of numbers, $\int_R P(x_i) dx_i = 1$, that is, the area under the curve is 1.

We can express $\sum_{i=1}^{\infty} P(x_i) = 1$, which is the probability

density function. There can also be a probability distribution function that gives the probability of small or equal stochastic attacks to a given value.

$$F(x_i) = \sum_{x_i \leq x} p(x_i) \text{ ----- } 2$$

Different measurements of the probability function such as mean, mode, median, and standard deviation can be used to examine the stochastic system. Characteristic equation models can be Linear and Non-Linear. The non-linear system can be expressed by partial differential equations.

Let's assume that the malicious object has P spread feature due to diverse other factors such as A, B, C, \dots . In this case, it can be body forth by $P = f(A, B, C, \dots)$. From here, taking the 1st and 2nd derivatives, respectively;

$$\text{Velocity } \frac{\partial p}{\partial t} = \frac{\partial f(A, B, C, \dots)}{\partial t} \text{ acceleration } \frac{\partial^2 p}{\partial t^2} = \frac{\partial^2 f(A, B, C, \dots)}{\partial t^2} \text{ is calculated.}$$

The imitated conclusions acquired by using particular approximation techniques mentioned down can be used to complement the simulation-created data as well as verify.

1.1. Taylor Series Expansion

Any function with a derivative can be widened by the Taylor formula. In an area close $XX = a$, the function $f(x)$ can be approached using the polynomial for the value of the independent variable x .

$$F(X) = f(a) + f'(a)(x - a) + \frac{f''(a)}{2!}(x - a)^2 + \dots + \frac{f^{(n)}(a)}{n!}(x - a)^n \text{ ----- } 3$$

4.1. Finite Difference Approach Methods

This method divides partial differential equations into small intervals. It does this in two ways;

- I. Advanced Difference Approach: Calculates the gradient of the function at diverse points with the formula

$$f'(x_i) = \frac{(f(x_i + 1) - f(x_i))}{\Delta x} \text{----- 4}$$

- II. Backward Difference Approach: Calculates the gradient of the function at various points with the formula

$$f'(x_i) = \frac{(f(x_i) - f(x_i - 1))}{\Delta x} \text{----- 5}$$

4.2. Higher-Order Derivatives

These derivatives can be used to express diverse significant points in the dispersion according to the formula below

$$f^{(n)} = (f^{(n-1)})' \text{----- 6}$$

Tests can be used to verify the model like polynomial regression tests. Thus, it can be determined whether the values can be placed in a polynomial. The characteristic equation is obtained, the conclusions can be verified experimental or analytical, according to existing standard math hypotheses. To validate the mathematical model, it is the first examination of dimensional homogeneity that requires each term to have the same mesh size. The second is to verify the quality and limit behavior of the models by checking. Apart from these, depending on how large the errors are, some issues such as accuracy and precision, the ability to prepare the data with mean, mode, median or standard deviation can be examined. These data are with ease comparable and can aid us to understand the attitude of malicious objects. For example,

- I. some definitions of the virus can be modeled as follows; Let v be a simple virus that affects existent files and make them behave in the same way, a set of programs P , $v \in P$ and $p_i \in P$, $f(v)$ and $f(p_i)$ is the attitude of virus v and p_i , respectively;

$$f(v) = f(p_i) \text{----- 7}$$

- II. Definition of the virus at a constant t

$$T(v, p_i, e, t, S) = \log \frac{f(v, e, t, S)}{f(p_i, e, t, S)} \text{----- 8}$$

Here $f(v, e, t, S)$ & $f(p_i, e, t, S)$ gives the attitude of programs v & p_i , in order of, at time t in S the system where e the event occurs. Now if $T(v, p_i, e, t, S) = 0$ then the program v is a virus otherwise it is not.

- III. Definition of the virus based on a continuous-time interval Δt

$$T(v, p_i, e, t, S) = \log \int_{\tau_0}^{\tau_1} \frac{f(v, e, t, S)}{f(p_i, e, t, S)} \text{----- 9}$$

Here, the functions $\int_{\tau_0}^{\tau_1} f(v, e, t, S) dt$ and $\int_{\tau_0}^{\tau_1} f(p_i, e, t, S) dt$ respectively It gives the attitude of programs v and p_i in the time range $\Delta t = \tau_1 - \tau_0$ in S the system at the occurrence of e event. If $T(v, p_i, e, t, S) = 0$ then program v is a virus otherwise it is not. Now, to model a cyber defensive system, it is necessary to combine different components such as sensors and abuse, situational awareness, defense contraption, command and

control, strategies and tactics, and science and engineering. A cyber defense system design model using these components is given in figure 3.

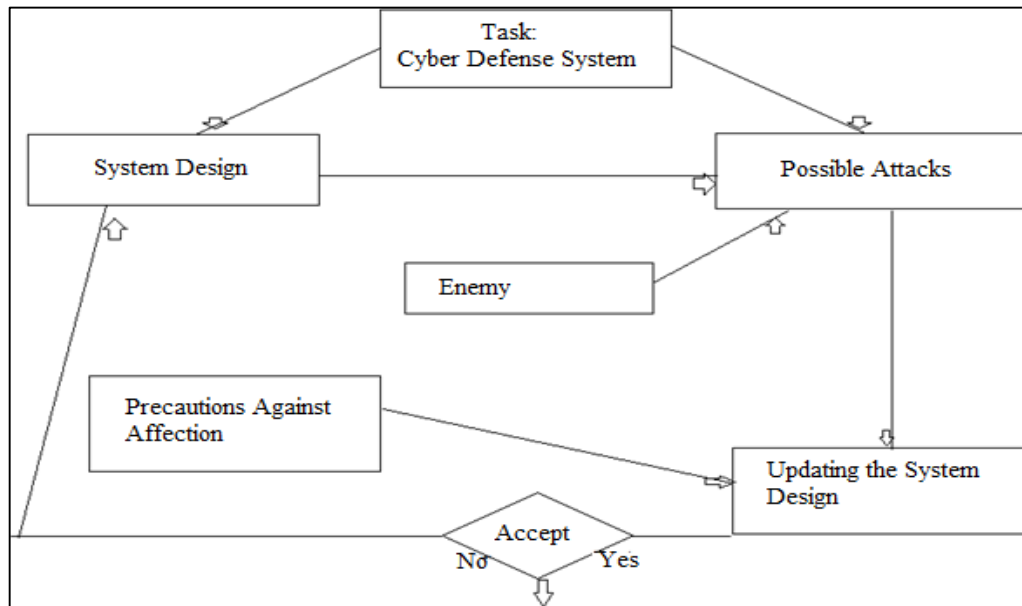


Fig. 4.2. Cyber Defensive System Design Model

5. Conclusion

Although various models and solutions are presented, some problems still await solutions. These problems are mainly:

- All properties of malicious objects must be body forth in the shape of mathematical equations to predict their future behaviour. Also, a realistic model should be created to apply these characteristic equations in the current environment.
- The accuracy of a model can be ensured after it has been analysed and developed based on imitated conclusions. This verification assists to preserve the system against assault by malignant objects. Worms similar code red are modelled with high correctness and are now easily controllable. Although most models have certain verification limits, it is still possible for them to be developed.
- Most malicious objects have an increase in their behavioural complexity, with a lot of features to be identified. Therefore, each feature should be generalized and the feature area should be narrowed.
- Most cyber defence systems incur fixed expenses, such as packet length, increasing data length, or more expensive for comparison, which slows down the current system when implemented. For this reason, it is necessary to provide such a cyber defence system that does not create any more fixed costs. Defence systems that provide recovery for both pre-attack and post-attack must be highly verified and sufficiently predictable based on mathematical modelling.
- It is hard to track down the attacker because of low cognizance in cyber defence Therefore, we need to develop an appropriate policy and awareness to limit such malicious activity.

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The Role of Mathematical Modelling and Formal Methods in Cyber Security Analysis

Mr. Prajwal T. Salunkhe¹, Mr. Yash V. Malakmir², Mr. Prem K. Jadhav³, Mr. Naman H. Shinde⁴,
Prof. Apeksha A. Pawar⁵

^{1,2,3,4}Students, Basic Science and Humanities, YTC, Satara

⁵Assistant Professor, Basic Science and Humanities, YTC, Satara

Abstract In cybersecurity, mathematical modelling has become more important than ever as the frequency of cyberthreats has increased. We can analyse complex assault patterns, foresee potential dangers, and create effective defences thanks to mathematical models. These models, which include statistics, probability, graph theory, and machine learning, are used for risk assessment, communication security, and the identification of anomalous behaviour. The mathematical ideas being used to develop faster, more intelligent, and more robust cyber defence are explained simply in this study. Additionally, it explains how they function in real life, which ones are frequently used, and where they are used. The focus is on providing a clear and realistic explanation, emphasising how the models protect data, systems, and networks in the actual world.

Keywords: Cybersecurity, Mathematical Modeling, Risk Assessment, Cryptography, Anomaly Detection, Game Theory, Network Security, Machine Learning

1. Introduction

In the modern world, cybersecurity is a mathematical problem in addition to a technical one. Conventional security measures are insufficient in the face of increasingly complex cyberattacks. Mathematical modelling can help us identify, anticipate, and defend against risks in a way that is both intelligent and well-organised. Mathematical modelling is the process of simulating real-world cybersecurity problems using mathematical techniques including probability, statistics, graph theory, logic, and machine learning. These models make it easier for systems to detect abnormalities (such as shady login attempts), identify network vulnerabilities, assess the risk of digital assets, and develop encryption techniques to protect data. For example, graph theory helps identify potential weaknesses and how information flows through a network, while probability models help predict the likelihood of attacks. The entire field of cryptography, which safeguards our data online, depends on algebra and number theory. This paper explores the practical applications of mathematical modelling in cybersecurity systems to safeguard our virtual environment. It explores the specifics of these models' operation, the mathematical methods utilised in real cybersecurity systems, and provides instances of their use, from spotting network risks to developing secure encryption algorithms. In order for readers without a background in mathematics to understand how maths underpins modern digital defence, the book attempts to simplify and make these complex ideas approachable.

2. Related Work

In recent years, mathematical modelling in cybersecurity has been extensively studied. Numerous researchers have used a range of mathematical techniques to address issues in cyber defence, cryptography, and threat detection. Anomaly detection methods based on statistical models and machine learning have been developed in the field of threat detection to detect anomalous network behaviour. For example, Chandola et al. (2009) provided an overview of anomaly detection methods that identify anomalous data in networks utilising statistical and clustering models. Mathematics has long been the foundation of cryptographic models. RSA and other public key encryption techniques are grounded on number theory, namely prime factorisation. Galois fields and other algebraic structures are used by the Advanced Encryption Standard (AES) to encrypt data securely. The relationship between attackers and defenders has also been modelled in cybersecurity using game theory. In order to analyse and create the best cyber defence strategies, Manshaei et al. (2013) employed game-theoretic frameworks. In network security, graph theory has been useful because it enables researchers to find hubs, identify vulnerabilities, and stop assaults like denial-of-service (DoS). A study in this

field by Wang et al. (2015) demonstrates how large-scale networks can be mapped and secured using graph-based models.

3. Methodology

Using examples from the actual world, this section describes how mathematical models function in cybersecurity. Depending on the objective—detecting breaches, encrypting communications, estimating risk, or creating defence plans—the models vary. We will examine the models that are most frequently utilised.

3.1 Finding Anomalies Making Use of Machine Learning and Statistics

Finding behaviour that deviates from the norm, like a person getting on at an odd hour or viewing prohibited files, is the main goal of anomaly detection.

Models of Statistics: The determination of 'normal' activity is based on probability distributions, standard deviations, and averages. Anything over these thresholds is picked up.

For instance, the system may flag a user as potentially compromised if they frequently log in from India and then abruptly log in from Russia.

Machine learning models use techniques like neural networks, decision trees, and support vector machines (SVM) to "learn" from previous attacks and spot future ones.

For instance, Gmail uses machine learning to recognise phishing and spam emails based on keywords and trends.

3.2 Cryptography and Number Theory

Data is encrypted and only viewable by the intended recipient thanks to cryptography. Math is the foundation of this entire operation.

Prime factorisation is used by the RSA algorithm. Data is secured because it is easy to multiply two large primes but very hard to factor them.

For instance, RSA is used to safeguard communication in WhatsApp chats and online banking.

The Advanced Encryption Standard, or AES, uses modular arithmetic and algebraic functions. Data is encrypted in chunks. For instance, government agencies like the NSA use it to safeguard sensitive data.

3.3 Using Bayesian networks and probability to assess risk

This model aids in estimating the probability of a cyberattack and the possible damage it could do.

Bayesian Networks: To model uncertain occurrences and their relationships, use probability trees.

For instance, a company can use this model to assess the probability of a phishing assault and decide whether to invest in better email security.

3.4 Strategic Defence Using Game Theory

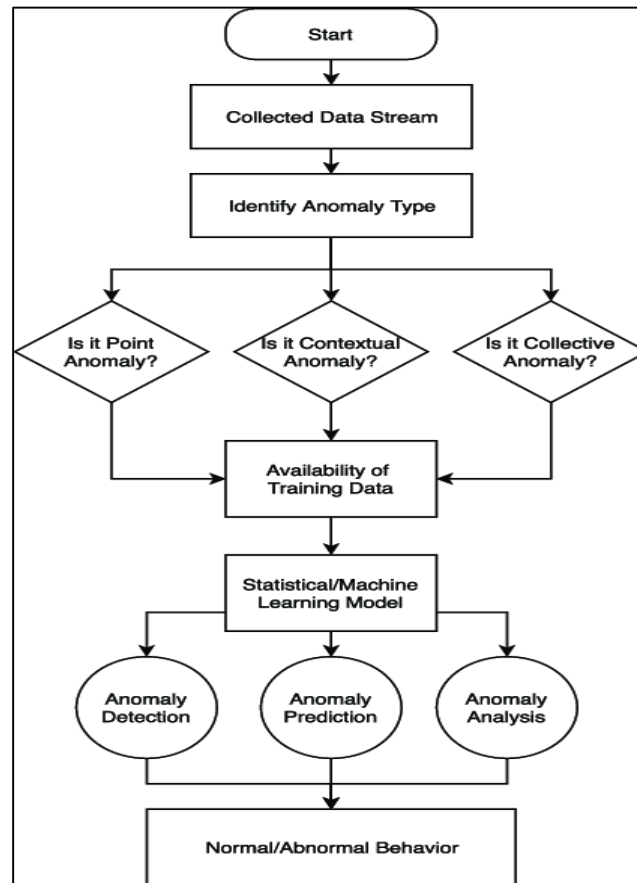
According to game theory, attackers and defenders behave as players trying to outplay one another in a game.

Defender versus. Attacker Models: By predicting the attacker's next action, these models help defenders make the best decision. For instance, military networks use game theory to build resilient systems that change in response to cyberattacks.

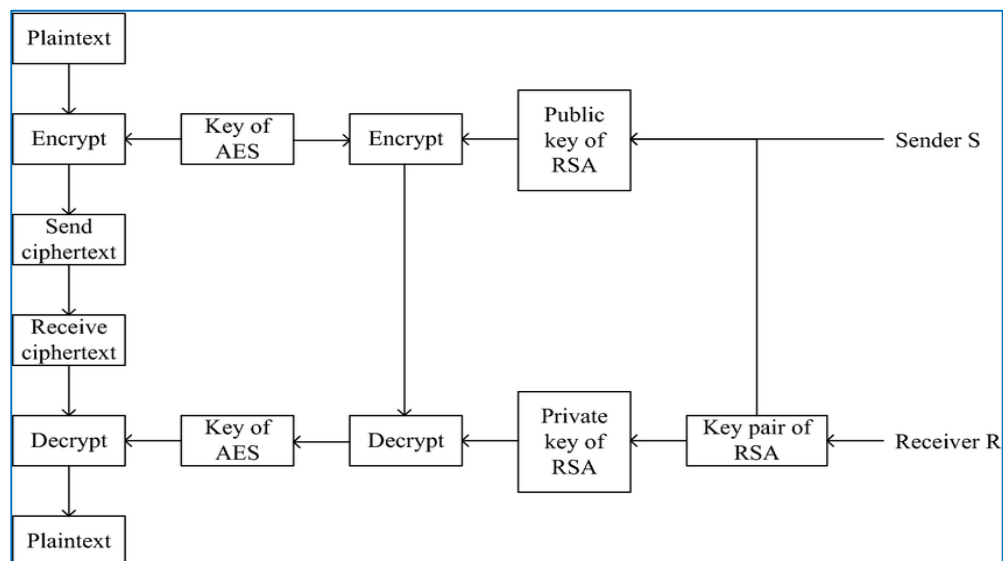
3.5 Graph Theory in Network Security Graphs can be used to depict networks, where nodes are machines and edges are links. To protect important nodes and find weak spots, graph theory is employed. Measures of

Centrality: Locate important nodes. The network may come to an end if a central node is compromised.

Example: Used to strengthen the most important servers against DDoS attacks.



3.1 Anomaly Detection Using Statistics and Machine Learning



3.2 Cryptography and Number

4.Results and Discussion

Several real cybersecurity systems are now using mathematical models, and their effectiveness has been demonstrated in a variety of domains:

- **Threat Detection:** To spot irregularities, software like intrusion detection systems and antivirus programs use statistical and machine learning models. These techniques are used by companies like Microsoft, Google, and IBM in their security software to stop malware and phishing attacks instantly.
- **Cryptographic Security:** End-to-end encryption powered by mathematical models like RSA and AES is

employed by popular apps like WhatsApp, Telegram, and Signal. These approaches ensure that communications can only be viewed by the sender and the recipient, preventing hackers from reading them.

- **Enterprise Risk Analysis:** Businesses use Bayesian models to decide how much money to spend on cybersecurity.
- **Government Cyber Defence:** To anticipate threats to national security, defence and military networks apply game theory. They can create stronger defences and realise attacker techniques thanks to these models.
- **Large Organisation Network Security:** Tech behemoths Facebook and Amazon use graph theory to analyse their networks, spot unusual activity, and stop significant data breaches. These examples demonstrate that mathematical modelling is not a theoretical idea; rather, it forms the foundation of contemporary cybersecurity systems.

5. Conclusion

The number of cyberattacks is growing rapidly, thus preventing them requires clever, foresighted solutions. That is what mathematical modelling offers. Math is at the core of modern cybersecurity, from spotting odd network activity to encrypting private data and predicting dangers.

The use of several concepts, such as statistical analysis, machine learning, cryptography, game theory, and graph theory, to real-world cyber defence mechanisms has been discussed in this work. This study also demonstrated how these models allow for real-time decision-making in addition to assault detection. We can create stronger, more intelligent cybersecurity systems that protect individuals, businesses, and nations by applying and comprehending mathematical modelling. Cyberattacks will become more frequent as technology advances, and one important method for preventing them is mathematical modelling.

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Application of Complex Numbers in Computer Science

Ms. Snehal S. Thorat¹, Ms. Vaishnavi A. Pawar², Ms. Chandana S. Savvashe³, Prof. Apeksha A. Pawar⁴

^{1,2,3}Students, Basic Science and Humanities, YTC, Satara

⁴Assistant Professor, Basic Science and Humanities, YTC, Satara

Abstract: Despite being frequently thought of as abstract mathematical concepts, complex numbers have important and useful uses in computer technology. This essay examines the diverse applications of complex numbers in a number of fields, such as computer graphics, electrical engineering, signal processing, and quantum computing. Intricate fractal patterns are produced, circuit analysis is made simpler, the fundamental ideas of quantum mechanics are supported, and effective signal encoding and manipulation are made possible by complex numbers. Through an analysis of various uses, the study shows that complex numbers are not only pertinent but also necessary for resolving complicated computational issues and promoting technological advancement.

Keywords: Signal processing, Quantum computing, Circuit analysis, AC circuit, complex numbers

1. Introduction

The equation $x^2 = -1$ has no solution in the real number system.

The number i , $i^2 = -1$, is the foundation of this new number system.

Geometrically, complex numbers extend the concept of the one-dimensional number line to the two-dimensional complex plane by using the horizontal axis for the real component and the vertical axis for the imaginary part. The point (a, b) on the complex plane corresponds to the complex number $a + bi$. A complex number is considered purely imaginary if its real part is zero; these numbers' points are located on the complex plane's vertical axis. The argument of a complex number can be based on a complex number with a zero imaginary portion.

2 .History of Complex number:

Complex numbers are credited to Geronimo (or Gerolamo) Cardano (1501–1576) in the history of mathematics.

Complex numbers are said to have been introduced by the Italian mathematician Gerolamo Cardano in the 16th century while he was trying to solve cubic problems. The algebraic extension of the ordinary real numbers by an imaginary number T is the formal definition of the complex number system.

3 .Application of complex number in computer science

- AC Circuit Analysis

In AC circuits, complex numbers are also used to calculate resistance, voltage, or current (AC stands for Alternating Current, which is a current that changes direction and magnitude over time). Calculating the potential difference between two AC power supply in relation to time is a typical use of complex numbers, more especially Euler's formula. An illustration of such a calculation can be found on the right.

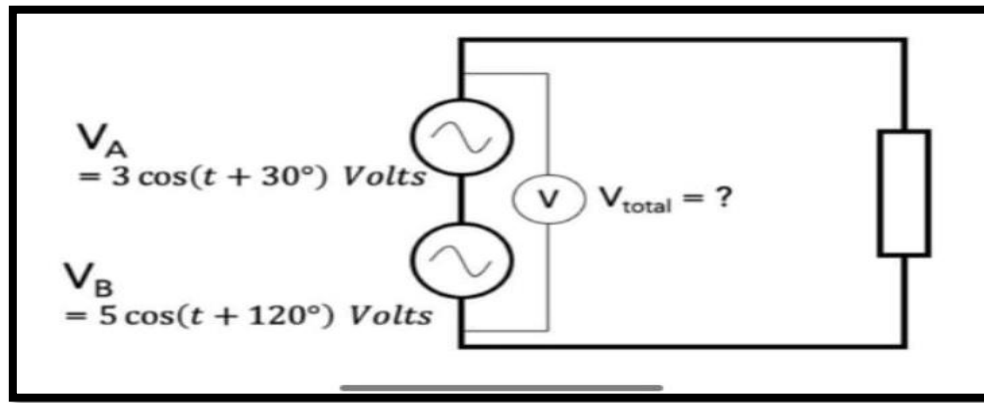


Fig.3.1

Adding V_A and V_B together will not yield the combined potential difference. Nonetheless, both voltages can be represented as a complex number's Real Part (x-coordinate on the Argand Diagram).

Let $Z_A = 3(\cos(t + 30^\circ) + i \sin(t + 30^\circ))$;

hence $V_A = \text{Re}[Z_A]$

And let $Z_B = 5(\cos(t + 120^\circ) + i \sin(t + 120^\circ))$

so that $V_B = \text{Re}[Z_B]$

Note that $Z_A = 3e^{jt30^\circ}$ and $Z_B = 5e^{jt120^\circ}$.

In circuit analysis, it is customary to write imaginary values with j rather than i to prevent confusion with current, which has the symbol i or I .

After that, we may factorize and add the complex numbers:

$Z_A + Z_B$

$$= 3e^{j(t+30^\circ)} + 5e^{j(t+120^\circ)}.$$

$$= e^{jt}(3e^{j30^\circ} + 5e^{j120^\circ})$$

$$= e^{jt}(3(\cos(30^\circ) + j \sin(30^\circ)) + 5(\cos(120^\circ) + j \sin(120^\circ)))$$

$$= e^{jt}(0.098... + 5.830...j)$$

$$= e^{jt} \sqrt{34}(\cos(89.0...^\circ) + j \sin(89.0...^\circ))$$

$$= e^{jt} \sqrt{34} e^{j89.0...^\circ}$$

$$= \sqrt{34} e^{j(t+89.0...^\circ)}$$

Hence $v_{total} = \text{Re}[Z_{total}] = \sqrt{34} \cos(t + 89.0...^\circ)$ Volts

Moreover, the phase and magnitude of impedance in an AC circuit are likewise expressed using complex numbers. Impedance slows down the electrons in the circuit, just like resistance does. The difference is that whilst resistance does not produce a phase shift in the electrical current, impedance does. Having a complex number representation is essential because impedance occurs in typical electrical components like capacitors and inductors. Phase, which is crucial to the analysis of AC circuits, is generally represented using complex numbers.

4. The role of complex numbers in computer science

1. Signal processing and Fourier transforms

Signal processing is one of the main areas in computer science where complex numbers are used. Complex numbers can be used to represent signals, like audio or video, with the real part denoting amplitude and the imaginary part denoting phase. We can use mathematical procedures to modify and analyse signals thanks to complex numbers.

Complex numbers are a major component of the Fourier transform, a potent tool for signal analysis. The Fourier transform breaks down a signal into its constituent frequency components, allowing us to do tasks like compression, noise reduction, and filtering as well as extract valuable information. We can carry out these modifications effectively because the sinusoidal functions that comprise the signal are represented by complex numbers.

2. Quantum computing and quantum mechanics

Quantum computing, a fast developing subject that uses the concepts of quantum mechanics to execute computations, makes considerable use of complex numbers. Complex numbers known as quantum states are used to represent quantum bits, or qubits, which are the fundamental information units of a quantum computer. The idea of superposition in quantum mechanics enables qubits, which are represented as a combination of complex numbers, to exist in several states at once. The probability of witnessing a specific condition during a measurement is determined by these complex numbers, which are called probability amplitudes. Complex numbers are a key component of quantum algorithms, including Shor's algorithm for factoring huge numbers, which take advantage of their characteristics to solve problems tenfold more quickly than traditional computers.

3. Electrical engineering and circuit analysis

Circuit analysis and electrical engineering likewise make extensive use of complex numbers. Voltages and currents in alternating current (AC) circuits are represented as complex numbers that account for both phase and magnitude. Complex numbers can be used to represent the impedance of electrical components, including resistors, capacitors, and inductors.

Engineers can create filters and amplifiers, determine power usage, and examine circuit behaviour by using complex numbers. Engineers can effectively predict and manage the behaviour of complicated electrical systems by using complex numbers, which also make calculations easier.

4. Computer graphics and fractals

Complex numbers play a major role in the representation and manipulation of images in computer graphics. In computer graphics, fractals—complex mathematical patterns that repeat endlessly at various scales—are especially intriguing uses of complex numbers.

For example, complex numbers are used to create the well-known fractal known as the Mandelbrot set. We can ascertain whether a complex number is a member of the set by repeatedly solving a particular mathematical equation for it. Only the characteristics of complex numbers define the elaborate and exquisite patterns that are shown in the ensuing representation. Fractals are used in a number of domains, such as encryption, data compression, and computer graphics.

Conclusion:

Once thought to be completely theoretical, complex numbers have shown themselves to be effective instruments with a wide range of real-world uses in computer science and engineering. Their utility is both extensive and vital, ranging from facilitating signal processing and simplifying circuit analysis to enabling quantum computing concepts and producing complex fractals in computer graphics. Complex numbers will continue to play a fundamental role in advancing innovation and resolving practical computational issues as technology develops.

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Application of Graph Theory in Transportation Problem

Prof. Apeksha A. Pawar¹, Prof. Siddhi R. Sankpal², Prof. Pragati R. Pawar³, Prof. Manisha V. Nikam⁴

^{1,2,3,4}Assistant Professor, Basic Science and Humanities, YTC, Satara

Abstract: Mathematics is used in different fields. One of the important branches is graph theory, which comes under discrete mathematics. Applications of graph theory are in various fields such as computer science, transportation, biology, social networks, and communication systems. A graph is a set of vertices and edges this are used to understand relationship and connection. Graph theory includes the study of optimising network structure shortest path problem, resource allocation, transportation problem and data clustering, This paper describe the applications of graph theory in real word.

Keywords: graph theory , weighted graph , path, cycle

1. Introduction

Graph theory is a branch of discrete mathematics. To understand the concept of graph theory we must have to understand some terminology such as graph , types of graph , path, cycle, etc. there is wide use of graph theory in real word problem. What is the fastest way to travel all over india ? how can set up any timetable for avoiding overlapping ? What is possible wind flow from A to B, All the answers of this questions will get from graph theory.

2. Related Work

What is Graph?

A graph G is an ordered pair (V,E) where V is the set of vertices & E is the set of edges. We can denote graph G as $G(V,E)$ or $G(p,q)$ where p is the no of vertices & q is the no. of edges .

History of Graph Theory : Graph theory invented in 18th century with the work of swiss mathematician Leonhard Euler. Euler's work on konigsberg bridge problem is considered as origin of graph theory. This problem lead to the concept of Eulerian Graph. Euler studied the problem of Koinsberg bridge and constructed a structure to ISSN 2322-0015 solve the problem called Eulerian graph. In 1840, A.F Mobius gave the idea of complete graph and bipartite graph and Kuratowski proved that they are planar by means of recreational problems. The concept of tree, (a connected graph without cycles) was implemented by Gustav Kirchhoff in 1845, and he employed graph theoretical ideas in the calculation of currents in electrical networks or circuits. In 1852, Thomas Guthrie found the famous four colour problem. Then in 1856, Thomas. P. Kirkman and William R.Hamilton studied cycles on polyhydra and invented the concept called Hamiltonian graph by studying trips that visited certain sites exactly once. In 1913, H.Dudeneymentioned a puzzle problem. Even though the four colour problem was invented it was solved only after a century by Kenneth Appel and Wolfgang Haken. This time is considered as the birth of Graph Theory.

Application of graph theory in transportation problem:

Transportation of goods or anything else is a crucial problem in today's life. To overcome this issue, we study graph theory. It gives a solution with the help of different algorithms, such as,

1. Dijkstra's Algorithm
2. Minimum spanning tree (MST) algorithm

Kruskal's Algorithm

Prim's Algorithm

3. Assignment Algorithm

- **Dijkstra's Algorithm:** Let $S \subset V$ & $^S \subseteq V \setminus S$ Let $u_0 \in S$ be the vertex from which we will calculate the shortest path to any vertex v .

Step I: Set $l(u_0) = 0, l(v) = \infty$ for $v \neq u_0, i=0$

Step II: For each $v \in ^S \neq u_0$ for $v \in ^S, i=0$ Replace $l(v)$ by $\min\{l(v), l(u_i) + w(u_i v)\}$. Compute $\min_{v \in ^S} \{l(v)\}$ & let u_{i+1} denote a vertex for which this minimum is attained. Set $S = S \cup \{u_i\}$. if $u_i \in E(G)$ then $w(u_i v) = \infty$

Step III: If $i = |V|-1$ then stop. If $i < |V|-1$, replace i by $i+1$ & go to step II.

1. **Minimum spanning tree (MST) algorithm:** Algorithms to find minimum spanning trees are as follows:

- **Kruskal's Algorithm :**

Step I: Choose e_1 in G such that $w(e_1)$ is as small as possible, where e_1 is not a loop.

Step II: If edges e_1, e_2, \dots, e_i have been chosen: then choose edge e_{i+1} such that a) G is acyclic and b) $w(e_{i+1})$ is the smallest where e_{i+1} is not a loop.

Step III: If G has p vertices, stop after $p-1$ edges have been chosen: otherwise, go to Step II.

- **Prim's Algorithm:**

Step I: Choose any vertex, say v_1 of G .

Step II: Choose an edge $e_1 = v_1 v_2$ of G such that v_1 and v_2 & e_1 has the smallest weight among the edges of G incident on v_1 .

Step III: If edges e_1, e_2, \dots, e_i have been chosen involving end points v_1, v_2, \dots, v_{i+1} , choose an edge $e_{i+1} = v_j v_k$ with $v_j \notin \{v_1, v_2, \dots, v_{i+1}\}$ and $v_k \in \{v_1, v_2, \dots, v_{i+1}\}$ such that e_{i+1} has the smallest weight among the edges of G with precisely one end in $\{v_1, v_2, \dots, v_{i+1}\}$

Step IV: Stop after $p-1$ edges have been chosen: otherwise repeat the step III.

1. **Assignment Algorithm :** The assignment algorithm, or more specifically the **Hungarian algorithm**, is a method used to solve the assignment problem, finding the optimal assignment of workers to tasks to minimise total cost or time.

Check to see if the number of rows and columns are equal; if they are, the assignment problem is considered to be balanced. Then go to step 1. If it is not balanced, it should be balanced before the algorithm is applied.

Step 1 – In the given cost matrix, subtract the least cost element of each row from all the entries in that row. Make sure that each row has at least one zero.

Step 2 – In the resultant cost matrix produced in step 1, subtract the least cost element in each column from all the components in that column, ensuring that each column contains at least one zero.

Step 3 – Assign zeros

- Analyse the rows one by one until you find a row with precisely one unmarked zero. Encircle this lonely unmarked zero and assign it a task. All other zeros in the column of this circled zero should be crossed out because they will not be used in any future assignments. Continue in this manner until you've gone through all of the rows.
- Examine the columns one by one until you find one with precisely one unmarked zero. Encircle this single unmarked zero and cross any other zero in its row to make an assignment to it. Continue until you've gone through all of the columns.

Step 4 – Perform the Optimal Test

- The present assignment is optimal if each row and column has exactly one encircled zero.
- The present assignment is not optimal if at least one row or column is missing an assignment (i.e., if at least one row or column is missing one encircled zero). Continue to step 5. Subtract the least cost element from all the entries in each column of the final cost matrix created in step 1 and ensure that each column has at least one zero.

Step 5 – Draw the least number of straight lines to cover all of the zeros as follows:

- (a) Highlight the rows that aren't assigned.
- (b) Label the columns with zeros in marked rows (if they haven't already been marked).
- (c) Highlight the rows that have assignments in indicated columns (if they haven't previously been marked).
- (d) Continue with (b) and (c) until no further marking is needed.

(f) Simply draw the lines through all rows and columns that are not marked. If the number of these lines equals the order of the matrix, then the solution is optimal; otherwise, it is not.

Step 6 – Find the lowest cost factor that is not covered by the straight lines. Subtract this least-cost component from all the uncovered elements and add it to all the elements that are at the intersection of these straight lines, but leave the rest of the elements alone.

Step 7 – Continue with steps 1 – 6 until you've found the highest suitable assignment.

Conclusion:

In conclusion, graph theory, a fundamental branch of discrete mathematics, plays a crucial role in solving real-world problems across various fields such as computer science, transportation, biology, social networks, and communication systems. By studying graphs, which consist of vertices and edges, we can model relationships and optimise solutions for complex problems like shortest paths, resource allocation, and network structures. The algorithms discussed, such as Dijkstra's, Kruskal's, Prim's, and the Assignment algorithm, provide efficient methods for tackling transportation issues, finding minimum spanning trees, and assigning tasks optimally. The historical development of graph theory, from Euler's work on the Königsberg bridge problem to modern applications, underscores its importance in both theoretical and practical contexts. Overall, graph theory's versatility makes it an essential tool for solving optimisation and connectivity challenges in diverse domains.

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Cryptography- How Maths Secures Internet

Mr. Ketan P. Salunkhe¹, Mr. Aditya D. More², Mr. Vishal R. Chatur³, Prof. Apeksha A. Pawar⁴

^{1,2,3}Students, Basic Science and Humanities, YTC, Satara

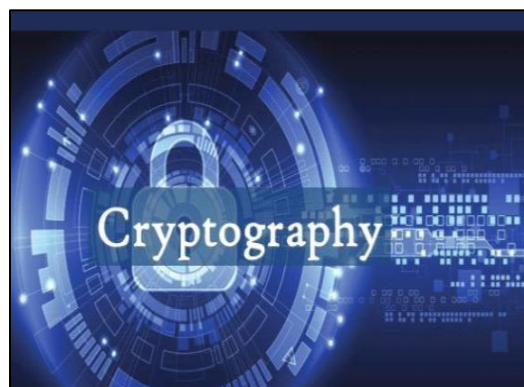
⁴Assistant Professor, Basic Science and Humanities, YTC, Satara

Abstract- Cryptography is the mathematical foundation of secure communication in the digital world. As information systems grow more interconnected, the need for protecting data against unauthorized access, tampering, and theft has become more critical than ever. This paper explores the core principles of cryptography, focusing on both classical techniques and modern public-key systems such as RSA and Elliptic Curve Cryptography (ECC). Emphasis is placed on the mathematical concepts that power encryption algorithms, including number theory, modular arithmetic, and finite fields. We also examine the role of cryptographic protocols in everyday technologies—from secure web browsing and online banking to messaging apps and blockchain networks. By bridging theoretical mathematics with practical applications, this study highlights how cryptography enables trust and privacy in the digital age.

Keywords: Text detection, In painting, Morphological operations, Connected component labelling

1. Introduction

In the modern digital landscape, the secure exchange of information is more important than ever. Whether it's sending a message, making an online purchase, or accessing a secure website, cryptography plays a vital role in ensuring that data remains private and unaltered. At its core, cryptography is the science of encoding and decoding information, using mathematical techniques to protect it from unauthorized access. The modern digital landscape, the secure exchange of information is more important than ever. Whether it's sending a message, making an online purchase, or accessing a secure website, cryptography plays a vital role in ensuring that data remains private and unaltered. At its core, cryptography is the science of encoding and decoding information, using mathematical techniques to protect it from unauthorized access. From ancient ciphers used by military strategists to advanced encryption methods used in today's internet infrastructure, cryptography has evolved alongside human communication. Modern cryptographic systems rely heavily on concepts from number theory, algebra, and computer science. Techniques such as modular arithmetic, prime factorization, and finite fields form the backbone of secure algorithms.



2. Types of cryptography

Symmetric key Cryptography :- Symmetric key cryptography is one of the most fundamental and widely used methods of securing digital information. In this technique, the same key is used for both encryption and decryption. This means that both the sender and the receiver must share a secret key in advance and keep it confidential. Symmetric key cryptography is known for its speed and efficiency, especially in environments where large amounts of data need to be encrypted quickly. However, one major challenge is the secure distribution of the secret key. If the key is intercepted or leaked, the entire communication can be compromised.

Asymmetrical key Cryptography :- Asymmetric key cryptography, also known as public key cryptography, is a method of encrypting and decrypting data using two separate but mathematically related keys: a public key and a private key. The public key is openly shared and can be used by anyone to encrypt a message, but only the corresponding private key—kept secret by the owner—can decrypt that message. Asymmetric encryption is widely used in digital signatures, secure email, SSL/TLS for web security, and blockchain technologies. Its ability to provide confidentiality, authentication, and data integrity makes it a cornerstone of modern digital security.

Mathematical Foundation of Cryptography

The strength and reliability of modern cryptographic systems are built upon rigorous mathematical principles. These foundations not only ensure the security of digital communication but also provide the framework for developing and analyzing encryption methods. Several core areas of mathematics are central to the design and implementation of cryptographic algorithms.

1. **Number Theory** -Number theory is one of the most fundamental mathematical domains used in cryptography. It deals with the properties and relationships of integers, especially prime numbers. Many encryption schemes, such as RSA, depend on the difficulty of factoring large composite numbers, a problem rooted in number theory. Other key concepts like divisibility, greatest common divisors, and modular inverses are used in the process of key generation and message encryption or decryption.
2. **Algebra and Group Theory** Algebraic structures such as groups, rings, and fields provide a formal framework for understanding how cryptographic algorithms behave. Group theory, in particular, plays a significant role in analysing the structure of cryptographic protocols and ensuring their resistance to attacks.
3. **Modular Arithmetic** Modular arithmetic, sometimes referred to as “clock arithmetic,” is used extensively in cryptographic algorithms. It allows operations to be performed within a limited range of values (modulo a number), making computations efficient and well-suited for digital systems. Cryptographic algorithms such as RSA, Diffie Hellman, and Elliptic Curve Cryptography (ECC) rely on modular exponentiation, a process that is easy to perform but difficult to reverse without the proper key.
4. **Euler’s Theorem and Totient Function** Euler’s theorem and the totient function ($\phi(n)$) are used to determine the mathematical relationships in key generation, especially in RSA. These concepts help in generating public and private keys that are mathematically linked but difficult to reverse-engineer without solving complex number theory problems.

❖ Attacks and Security Challenges in Cryptography

While cryptographic systems are designed to protect information, they are not immune to attacks. Understanding the types of attacks and the security challenges involved is essential to building stronger, more resilient encryption systems. Attackers often exploit weaknesses in algorithms, implementation flaws, or user practices to gain unauthorized access to sensitive



Fig4.1 :Examples of Euler's Theorem and Totient Function



Fig. 4.2 : Examples of Euler's Theorem and Totient Function

❖ Brute Force Attack

A brute force attack involves systematically trying every possible key combination until the correct one is found. Although this method is time-consuming and computationally expensive, it can succeed if the key length is too short. To prevent brute force attacks, modern cryptographic algorithms use large key sizes (e.g., 128 bits or more for AES).



Fig. Brute force attack

❖ Man-in-the-Middle (MITM) Attack

In a MITM attack, an attacker secretly intercepts and possibly alters communication between two parties. This type of attack is especially dangerous in public networks.

Cryptographic protocols like SSL/TLS help prevent MITM attacks by using encryption and digital certificates to verify the identity of the communicating parties



Fig. Man-in-the-Middle (MITM) Attack

❖ Human and Implementation Errors

Even a strong algorithm can be weakened by poor implementation. Common mistakes include improper key storage, weak password choices, or insecure random number generation. Educating users and developers is critical to minimizing these human-related vulnerabilities.

❖ Cryptanalysis

Cryptanalysis is the process of analyzing and breaking cryptographic algorithms. This can involve mathematical techniques to find weaknesses in the algorithm's design. For instance, if an encryption algorithm produces patterns in ciphertext, it might be vulnerable to frequency analysis or chosen-plaintext attacks.



Fig. Cryptanalysis

3.Future of Cryptography:-

Cryptography is constantly evolving to meet the growing demands of digital security in a rapidly changing technological environment. As threats become more sophisticated and new platforms emerge, the future of cryptography focuses on strengthening existing systems and developing new approaches to stay ahead of potential vulnerabilities.

- 1) **Post-Quantum Cryptography** One of the most urgent developments in cryptography is the shift toward algorithms that can resist quantum attacks. Quantum computers have the potential to break widely used cryptographic algorithms like RSA and ECC by solving mathematical problems faster than traditional computers. Post-quantum cryptography aims to create new algorithms that remain secure even in the presence of powerful quantum machines. Research is ongoing to standardize these methods, and organizations are preparing to transition to quantum-resistant systems.
- 2) **Lightweight Cryptography** As the Internet of Things (IoT) continues to grow, there is a need for encryption methods that work efficiently on small, low-power devices. Lightweight cryptography focuses on creating secure algorithms that require minimal processing power and memory, making them ideal for embedded systems, smart sensors, and wearable technology.
- 3) **Privacy-Enhancing Technologies** With growing concerns about data privacy, cryptography is increasingly used to develop privacy-preserving tools, such as zero-knowledge proofs, secure multi-party computation, and decentralized identity systems. These technologies help users maintain control over their personal information while still enabling authentication and data sharing.
- 4) **Integration with Artificial Intelligence** As artificial intelligence (AI) becomes more prevalent, it presents both challenges and opportunities in cryptography. On one hand, AI can be used to identify weaknesses in cryptographic systems; on the other hand, it can also assist in strengthening security by detecting anomalies and optimizing encryption techniques. The exploration and analysis of cryptographic techniques reveal the crucial role that mathematical structures and algorithm design play in securing digital communication. Key findings from the study include.

4.Result

- **Algorithm Performance Comparison:** Symmetric algorithms (e.g., AES) outperform asymmetric ones (e.g., RSA) in terms of speed and efficiency for large data encryption, while asymmetric algorithms offer advantages in secure key exchange and digital signatures.
- **Security Challenges Remain:** While current systems are robust against many types of attacks, challenges such as side-channel attacks, implementation flaws, and human error continue to pose risks to cryptographic security.
- **Importance of Key Management:** The strength of cryptographic systems heavily depends on the secure generation, distribution, and storage of keys. Poor key management is often a larger vulnerability than the encryption algorithms themselves.

Effectiveness of Modern Algorithms: Algorithms such as AES, RSA, and ECC demonstrate strong resistance against common attack vectors like brute force and basic cryptanalysis, especially when appropriate key lengths and secure implementation practices are followed.

5. Conclusion

We have implemented an automatic text detection technique from an image for Inpainting. Our algorithm successfully detects the text region from the image which consists of mixed text-picture- graphic regions. We have applied our algorithm on many images and found that it successfully detect the text region.

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Advance Techniques for Graphical Representation

Prof. Supriya S. Shinde¹, Mr. Shlok S. Chavan², Ms. Priyanka S. Jadhav³, Ms. Vaishnavi D. Chavan⁴, Ms. Snehal S. Bhosale⁵

¹Assistant Professor, Basic Science and Humanities, YTC, Satara

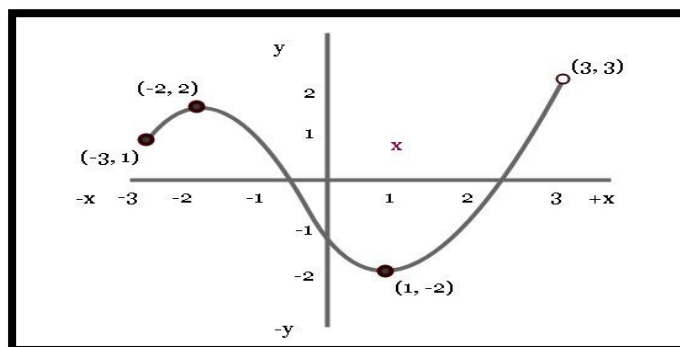
^{2,3,4,5}Students, Basic Science and Humanities, YTC, Satara

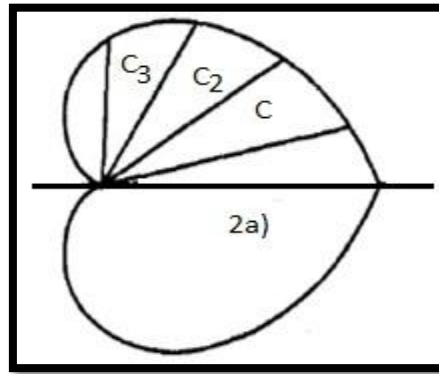
Abstract: -Crucial component of graph theory is graph drawing, especially when it comes to communicating and analysing intricate structures visually. The goal of aesthetic standards for graph drawing is to improve these representations' readability, clarity, and aesthetic appeal. This study examines the main aesthetic considerations that affect graph layout design, such as minimizing edge crossings, placing nodes optimally, attaining symmetry, and making sure that labels are clear. It investigates the trade-offs between various aesthetic principles and how they affect the effectiveness of human comprehension as well as the efficiency of graph algorithms. The study also looks at how aesthetic standards are used in real-world applications like social network analysis, data analytics, and network visualization. The study emphasizes how crucial it is to create algorithms that strike a balance between computational effectiveness and aesthetic considerations. The article ends with suggestions for further developments in graph drawing.

Keywords: Graph drawing, Aesthetic criteria, Visualization, Edge crossings, Node placement, Symmetry, Layout optimization, Graph algorithms, Data visualization, Network analysis.

1. Introduction

The study of mathematics involves organizing and discovering theories, methods, and theorems that have been developed and proven to meet the needs of both mathematics and the empirical sciences. The natural sciences, engineering, medicine, finance, computer science, and the social sciences all depend on mathematics. The basic principles of mathematics are unaffected by scientific experiments, despite the fact that mathematics is widely used to model phenomena. Certain branches of mathematics, like game theory and statistics, are frequently categorized under applied mathematics since they were developed in close relation to their applications. Other fields are referred to as pure mathematics since they are developed separately from any applications, but they frequently find use in real-world situations later on. depiction of statistical data or a functional relationship between variables is called a graph. Graphs are useful for making predictions because they can display broad patterns an illustration of statistical data or a functional relationship between variables is called a graph. Graphs are useful for making predictions because they can display broad patterns in the quantitative behaviour of data. However, they can be imprecise and occasionally deceptive as only estimates.





B] Leaf curve graph

Application:

1. Improved Readability and Clarity:

The overall clarity of the graph is improved by following aesthetic guidelines, such as reducing edge crossings and maximizing node distribution. This facilitates improved decision-making and interpretation by making it simpler for users to comprehend intricate relationships and patterns within the data.

2. Enhanced User Experience:

The user experience is enhanced by a visually appealing and well-structured graph, particularly in applications such as social media analytics and network visualization. By ensuring that graphs are both aesthetically pleasing and functional, aesthetic criteria help users interpret graphs with less cognitive overload.

3. Efficient Cognitive Processing:

In addition to reducing visual clutter, aesthetic designs aid in graph organization that respects human cognitive capacities. Symmetrical layouts and evenly spaced nodes, for instance, facilitate the identification of data structures like clusters or patterns, which enhances user comprehension.

4. Scalability in Visualizations:

Scaling graph visualizations for larger datasets without sacrificing clarity is made possible by aesthetic principles like edge bundling and layout optimization. In big data and network analysis, where intricate graphs can become daunting if proper aesthetic consideration isn't given, this is especially helpful.

5. Increased Computational Efficiency:

It is feasible to create graph drawing algorithms that preserve or even increase computational efficiency while concentrating on aesthetics. Algorithmic performance can be enhanced by optimizing the graph layout using aesthetic criteria to produce layouts that are both aesthetically pleasing and computationally feasible.

6. Applications in Various Domains:

A variety of domains, including computer networks, biology, social network analysis, and geographic information systems (GIS), aesthetic standards enhance graph visualization. Aesthetic criteria help to improve the interpretability of graph structures, making choices in these areas. Improved decision-making in these domains is facilitated by aesthetic criteria that make graph structures easier to understand.

7. Facilitates Effective Communication:

In addition to being more aesthetically pleasing, graphs that follow aesthetic standards are also better at communicating complex information to a wider range of users, including non-experts. This

encourages improved insight sharing and communication amongst stakeholders. not only more user-friendly, scalable, and intuitive, but also more effective at representing data.

METHODOLOGY:

We use a multifaceted approach that integrates theoretical analysis, algorithmic design, and empirical testing to investigate and assess aesthetic criteria for graph drawing. Our approach is broken down into the following crucial steps:

1. Literature Review:

We perform a thorough analysis of the literature on graph drawing algorithms, emphasizing studies that tackle aesthetic standards like readability, symmetry, edge crossings, and node distribution. This aids in locating accepted procedures and knowledge gaps regarding aesthetic optimization in graph visualization.

2. Identification of Aesthetic Criteria:

We define and classify the main aesthetic factors that influence graph drawing based on the literature review. These consist of: Minimization of Edge Crossings: To increase clarity, fewer edge intersections should be used.

Symmetry: Creating layouts that are both aesthetically pleasing and balanced.

Uniform Node Distribution: To prevent clutter, make sure nodes are distributed uniformly.

Readability and Labelling: Nodes and edges should be clearly labelled for improved interpretability.

3. Algorithmic Design and Optimization:

We develop and modify graph drawing algorithms that take these aesthetic standards into account. This entails creating new algorithms or altering current ones in order to optimize layout according to a set of aesthetic standards. We test a range of optimization strategies, such as tree-based layouts, spectral methods, and force-directed algorithms.

4. Empirical Evaluation:

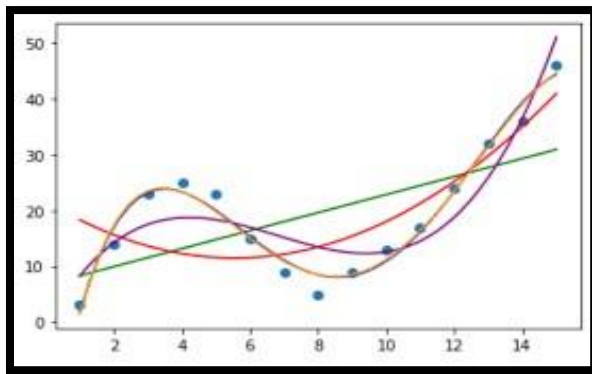
Using benchmark graph datasets, we perform a number of empirical tests to evaluate the performance of the suggested algorithms. We assess the graph layouts' quality using both computational efficiency and aesthetic metrics (such as the number of edge crossings and node distribution). To evaluate the visualized graphs' interpretability and human comprehension, user studies are also carried out.

5. Analysis and Comparison:

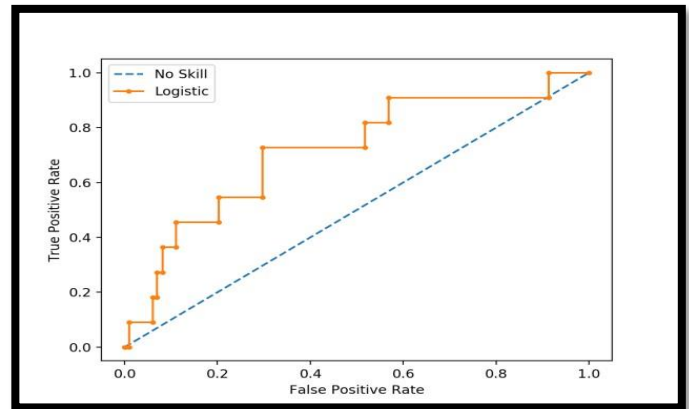
To determine which aesthetic criteria have the biggest effects on graph readability and computational performance, the empirical evaluation's findings are examined and contrasted. Additionally, we look at the trade-offs between algorithmic efficiency and aesthetics and offer enhancements for upcoming algorithmic advancements.

By using this approach, we hope to offer a thorough examination of aesthetic standards in graph drawing and create useful recommendations for improving graph visualizations in practical settings.

DIAGRAMS OF GRAPHICAL REPRESENTATION:-



1] Curve fitting in Python



2] ROC Curve plotting

OBJECTIVES:-

1. Investigate Aesthetic Criteria:-

Investigate the main aesthetic elements that affect graph layout design, such as minimizing edge crossings, placing nodes optimally, attaining symmetry, and making sure that labels are clear.

2. Explore Trade-Offs:

To investigate the trade-offs between various aesthetic principles and how they affect the effectiveness of human comprehension as well as the efficiency of graph algorithms.

3. Examine Practical Applications:

To investigate the role of aesthetic criteria in practical applications such as network visualization, data analytics, and social network analysis.

4. Develop Balanced Algorithms:

To emphasize how crucial it is to create algorithms that strike a balance between computational efficiency and aesthetic considerations.

5. Provide Recommendations:

To make suggestions for upcoming developments in graph drawing methods, highlighting the role that aesthetics play in enhancing the usefulness and interpretability of graph-based data

6. Improving Graph Visualization:

Improving graph representations' readability, clarity, and aesthetic appeal.

7. Advancing Graph Algorithms:

Creating algorithms that strike a balance between computational effectiveness and aesthetics.

8. Informing Practical Applications:

Giving an explanation of how aesthetic standards function in real-world applications

RESULTS:-**1. Definition of Graph Drawing**

The term "graph drawing" describes the visual depiction of graphs in which the edges and vertices are arranged in either two or three dimensions.

The goal is to produce a representation that is both visually appealing to the viewer and accurate in terms of graph theory.

2. Aesthetic Criteria

Guidelines or rules used to assess a graph drawing's visual appeal and clarity are referred to as aesthetic criteria. There are several criteria that are frequently discussed:

Planarity: Unless there is no other option or it is required for clarity, the graph should ideally be drawn without edge crossings, or a planar graph.

Minimal Edge Crossings: It's critical to minimize the quantity of edge crossings. In general, a graph with fewer crossings is easier to read.

Clarity: The layout should emphasize the graph's key features while avoiding superfluous complexity. It should be easy to distinguish between labels and edges.

Compactness: Excessive whitespace and superfluous long edges are avoided in a compact layout. A neatly arranged graph layout saves room without sacrificing readability.

Aspect Ratio: To prevent needless stretching or squishing of the graph, the layout should take into account the aspect ratio of the graph's bounding box.

3. Common Graph Layout Algorithms

Various graph-drawing algorithms seek to maximize these visual standards:

Layouts Directed by Force: With nodes representing charged particles and edges representing springs, these algorithms simulate the graph as a physical system. In order to reduce energy, the algorithm iteratively modifies node positions, which results in a design with tastefully balanced distributions and few edge crossings.

Circular Layouts: Every node is positioned around the perimeter of a circle. This arrangement highlights symmetry and is helpful for cyclic graphs.

Orthogonal Layouts: These layouts make grid-based designs more readable by drawing edges with only horizontal or vertical segments.

Radial Layouts: Often used to depict hierarchical relationships, these method groups nodes in concentric circle.

4. Evaluation Metrics for Aesthetic Quality

Several quantitative and qualitative measures can evaluate how well a graph drawing meets aesthetic criteria

Crossing Number: The minimum number edge crossings in a layout. A lower crossing number indicates a cleaner, more readable graph.

Edge Length Variation: The deviation from the average edge length. A good aesthetic graph layout minimizes this variation to maintain uniformity.

Aspect Ratio Metric: The ratio between the width and height of the bounding box containing the graph. A lower aspect ratio is preferred for a more balanced and compact graph.

Node Distribution: Measures how evenly the nodes are distributed in space, with more uniform distribution being generally preferred.

5. Applications of Aesthetic Graph Drawing Social Network Analysis:

In social networks, it is simpler to identify communities and comprehend relationships when graph layouts are clear.

Biological Networks: When illustrating protein-protein interaction networks, aesthetic graph drawing is crucial because symmetry and clarity can highlight significant patterns.

Geographical Networks: Clear and attractive graph layouts in maps and routing systems can improve navigational clarity and decision-making.

6. Future Directions

Automated Aesthetic Improvement: More work is being done to develop algorithms that automatically enhance the graph's aesthetic quality while maintaining its structural integrity.

User-Driven Customization: More individualized graph visualizations may result from letting users specify aesthetic preferences according to their requirements or visual preferences.

Conclusion:

In order to improve graphs' readability, interpretability, and visual appeal, aesthetic standards for graph drawing are essential. Creating visually appealing graphs becomes increasingly crucial as data and networks become more complex in order to promote improved comprehension and analysis. Minimal edge crossings, uniform edge length distribution, clearly defined node placement, and less visual clutter are important aesthetic requirements. These guidelines guarantee that the graph stays useful and instructive while also enhancing its visual appeal. Additionally, as graph drawing algorithms advance, they continue to improve these aesthetic standards while adjusting to a variety of application domains, including information visualization, social networks, and bioinformatics. In order to achieve a balance between aesthetics and functionality in graph visualization, future research should concentrate on the integration of aesthetic criteria with automated layout algorithms, user-centric design, and domain-specific optimizations.

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Loknete Ma. Hanmantrao Patil Charitable Trust's

ADARSH INSTITUTE OF TECHNOLOGY & RESEARCH CENTRE, VITA

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Babasaheb Ambedkar Technological University, Lonere &
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Address: MIDC, Tasgaon Road, Vita. Dist: Sangli, Pin: 415311
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