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AJEENKYA

DY Patil School of Engineering

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5th International Conference on Recent Advancements In Engineering & Technology (ICRAET- 2026)

Conference Date: : January 9th & 10th, 2026

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Editors

Dr. F. B. Sayyad (Principal)

Dr. S. M. Khairnar (HoD)

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ORGANIZED BY
AJEENKYA DY PATIL SCHOOL OF ENGINEERING, PUNE

IN COLLABORATION WITH

EDITORS

Dr. F. B. Sayyad (Principal)
Dr. S. M. Khairnar (HoD)

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Chairman's Message

I am pleased to know that ICRAET-2026, the international conference for Scholars, Researchers, Academician and Scientist is organized by Ajeenkya DY Patil School of Engineering for various streams of Engineering. This conference provides a national forum for researchers, developers and solutions to exchange their valuable ideas and showcase the ongoing works which may lead to path breaking foundation of the futuristic engineering. I, on behalf of Ajeenkya DY Patil School of Engineering, heartily welcome eminent guests, academicians, delegates & all the participants to ICRAET-2026.

The main objective of the international conference is to provide a forum for presenting the developments and implementation of emerging, technologies in the field of engineering. I am confident that the discussions & publications of ICRAET-2026 proceeding will bring opportunities among academicians & students to present their innovative ideas.

I would like to congratulate faculties & staff of Ajeenkya DY Patil School of engineering for organizing ICRAET-2026.

I take this opportunity to wish grand success to the ICRAET-2025 and memorable time for all the participants at ICRAET-2026.

Hon. Dr. Ajeenkya DY Patil
Chairman
Ajeenkya DY Patil Group of Institutions



Advisor's Message

I am extremely delighted to know that Ajeenkya DY Patil School of Engineering has organized ICRAET-2026 conference on emerging trends in Science, Engineering and Technology. I congratulate all staff and students of the college for undertaking such an onerous responsibility of organizing such national conference.

An educational institution has a profound role in building an individual, the nation and the society. It is a job of soaring responsibility when the recipient of that education is slated to perform roles of high responsibility. At ADYPSOE, we believe in holistic education, which prepares our students for the real world. The conference provides a platform to Researchers, Academician, Practitioners and Policy makers to interact and exchange their views and learn from each other. The theme of the conference encompasses all the vital components of Science, Engineering and Technology. I am sure the presence of eminent speakers, researchers, faculty members and students would add splendor to the deliberations during conference. I wish the conference a grand Success.

Dr. Sushant V. Patil

Advisor & Trustee



Principal's Message

Ajeenkya DY Patil School of Engineering is the flagship college of the prestigious Ajeenkya DY Patil Group of Institutions. Over past 15 years the institute has earned its repute with quality of education and excellence in the field of engineering. The college is committed to provide high quality to its students and transform them into competent professionals who have domain knowledge and skills, management skills, mental maturity and understanding of professional advancements.

ICRAET-2026 is an exceptional platform which will give opportunity to the UG, PG students, academicians and industry personnel to showcase their research to the experts from engineering field.

I would like to express my sincere gratitude to Hon. Dr. Ajeenkya DY Patil, Chairman, Ajeenkya DY Patil Group of Institutions, Dr. Sushant Patil, Trustee, Ajeenkya DY Patil School of Engineering, Hon. Dr. Kamaljeet Kaur, Executive Vice Preseident-ADYPG and all committee members of ICRAET-2026.

Dr. F. B. Sayyad
Principal
Ajeenkya DY Patil School of Engineering, Pune



Convener's Message

At the outset we congratulate all the faculty members of Ajeenkya DY Patil School of Engineering for organizing ICRAET-2026 for various streams in Science and Technology. The international conference is most awaited for all researchers to demonstrate their work in various fields.

It is an excellent networking platform for all the experts of various domains to stimulate the research dimension of participants. Ajeenkya DY Patil School of engineering has a perfect blend of infrastructure and human resource with rich experience and competent qualification to achieve good academic culture and conducive working environment for research and development.

We would like to express our sincere gratitude to Hon. Dr. Ajeenkya DY Patil, Chairman, Ajeenkya DY Patil Group of Institutions, Dr. Sushant Patil, Trustee, Ajeenkya DY Patil School of Engineering, Hon. Dr. Kamaljeet Kaur, Executive Vice President-ADYPG, Hon. Dr. F. B. Sayyad, Principal, Ajeenkya DY Patil School of Engineering, all HoDs, all Deans and all committee members of ICRAET-2026.

Dr. S. M. Khairnar
Convener, ICRAET-2026



Conference Coordinator's Message

The International conference ICRAET-2026 has received a fantastic response and I am happy to share that the delegates are participating in the conference from many countries. I am glad to note that the participants are presenting their articles on wider areas in Science, Engineering and Technology.

We at ADYPSOE are delighted to have such a diverse and knowledgeable group of professionals, researchers and enthusiasts joining us for the conference. Your presence will undoubtedly contribute to meaningful discussions and innovative ideas that will shape the future of the students and participants.

I, as the coordinator for ICRAET-2026, am thrilled to welcome you as part of the esteemed community of researchers and scholars. Your contributions are invaluable, and we are dedicated to ensuring that your work receives the recognition which it deserves through this conference proceeding.

Dr. Mamata Jiwankar
Assistant Professor
Engineering Sciences Department, ADYPSOE

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Smart Rain Detector and Shelter System

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ABSTRACT: The Smart Rain Detector and Shelter System is a modern, automated solution designed to protect clothes and personal belongings from unexpected rainfall. The system uses highly sensitive rain sensors to detect the onset and intensity of rain in real time. These sensors relay signals to microcontroller, which immediately activates a mechanical shelter or cover to shield clothes from getting wet. The system can be installed in homes, balconies, or outdoor drying areas, providing a fully automated response without the need for manual intervention. Additionally, by integrating IoT technology, the system can send real-time alerts to a mobile device, allowing users to monitor rainfall remotely and take necessary precautions. This project focuses on enhancing convenience, reducing human effort, and preventing damage to fabrics caused by sudden rain. The proposed design emphasizes reliability, efficiency, and user-friendliness while employing low-cost, widely available components. The Smart Rain Detector and Shelter System demonstrates the practical application of automation and intelligent control in everyday life, offering a smart, innovative approach to household rain management and fabrication.

I. INTRODUCTION

Smart Rain Detector and Shelter System is an advanced, automated solution designed to protect clothes and personal belongings from the adverse effects of sudden and unpredictable rainfall. In many households, clothes left outdoors for drying are highly susceptible to damage during unexpected showers, leading to inconvenience, repeated washing, and deterioration of fabric quality. Traditional methods of protecting clothes, such as manually covering them or bringing them indoors, are often inefficient, time-consuming, and unreliable, especially when rainfall occurs without warning. Unpredictable rainfall and sudden changes in weather conditions pose significant challenges to the protection of outdoor equipment, agricultural produce, public utilities, and open-air infrastructure. In many regions, especially in developing countries, rain-related damage results in economic losses, reduced equipment lifespan, and safety hazards due to the absence of timely protective measures. Conventional rain protection methods are often manual, reactive, and dependent on human intervention, which limits their effectiveness during unexpected rainfall events.

With recent advancements in embedded systems, sensor technology, and automation, smart environmental monitoring systems have gained considerable attention. Rain detection using electronic sensors enables early identification of precipitation and facilitates automated responses without human involvement. Integrating such detection mechanisms with an intelligent shelter system provides a proactive solution for minimizing rain-induced damage. These systems are particularly useful in applications such as drying yards, construction sites, solar panels, outdoor classrooms, smart homes, and agricultural fields.

The Smart Rain Detector and Shelter System is designed to automatically detect the onset of rainfall and activate a protective shelter mechanism in real time. The system typically employs a rain sensor in conjunction with a microcontroller-based control unit to process sensor data and trigger actuators such as motors or servos. This automated response ensures rapid deployment of shelter structures, thereby enhancing reliability, efficiency, and user convenience while reducing dependency on manual operation.

Furthermore, the proposed system emphasizes low cost, energy efficiency, and ease of implementation, making it suitable for both urban and rural applications. By integrating sensing, control, and mechanical actuation, the system demonstrates the potential of smart automation in weather-responsive infrastructure. This research focuses on the design, development, and performance evaluation of a Smart Rain Detector and Shelter System, highlighting its effectiveness in providing timely protection and its scope for future enhancement through IoT-based monitoring and remote control.

II. LITERATURE REVIEW

The issue of sudden rainfall causing inconvenience and damage to clothes has been addressed in multiple ways, from manual interventions to automated systems. Traditional methods, such as retractable awnings or manual covers, rely heavily on human observation and timely action, making them inefficient during unpredictable rain events.
(2018). Manual solutions are reactive rather than preventive, often resulting in delayed responses and potential damage to clothes and fabrics .with advancements in sensor technology and automation, several studies have explored rain detection systems for both household and industrial applications. Rain sensors, typically based on resistive or capacitive principles, can accurately detect the presence of water droplets and trigger automated responses

(2019). Recent research highlights the integration of microcontrollers and IOT-based systems to enhance automation and remote monitoring. Embedded systems combining rain sensors with microcontrollers have been implemented to automate protective mechanisms, allowing shelters or covers to deploy immediately upon rain detection

(2020). Furthermore, IOT connectivity enables real-time notifications and remote supervision, ensuring timely intervention even when users are not physically present.

(2021). These sensors have been widely applied in irrigation systems, smart agriculture, vehicle wiper systems, and Electronic Automated Rain Shelter (EARS) systems, demonstrating their reliability and responsiveness in real-time scenarios

Kumar & Sharma (2021) – Automated Rain Sensing and Shelter Activation System The authors developed an automatic rain detection model using a raindrop sensor and microcontroller for real-time response. Their study showed that integrating sensor data with a motorized shelter mechanism improves protection during sudden rainfall. They also highlighted the system's low-cost design and high reliability for outdoor applications, making it suitable for smart infrastructure solutions

III. METHODOLOGY

The Smart Rain Detector and Shelter System functions by detecting rainfall and automatically operating a protective shelter. When raindrops land on the rain sensor plate, the moisture changes the sensor's resistance, producing a signal that is sent to the Arduino. The Arduino constantly reads this signal and, upon detecting rain, immediately commands the servo motor to rotate and open the shelter. The shelter remains open as long as the sensor continues to detect moisture on its surface. Once the rain stops, the sensor dries and its resistance returns to Fuclose or retract.

This automated mechanism ensures quick response to changing weather conditions. It also increases safety by protecting equipment or individuals without requiring any manual action. The system is energy-efficient, reliable, and ideal for real-time rain monitoring applications.

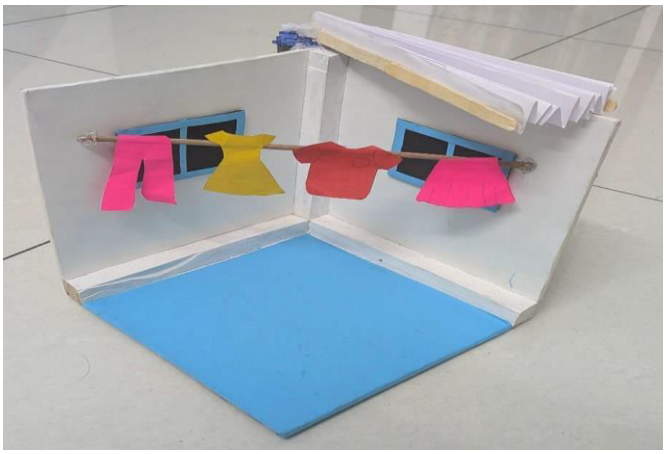


Fig. No 1

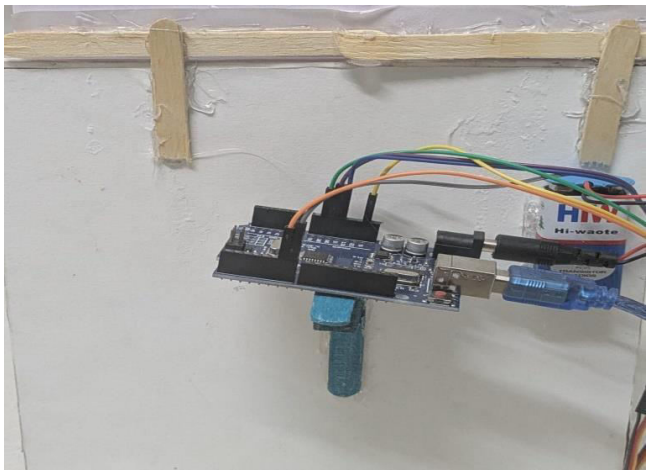
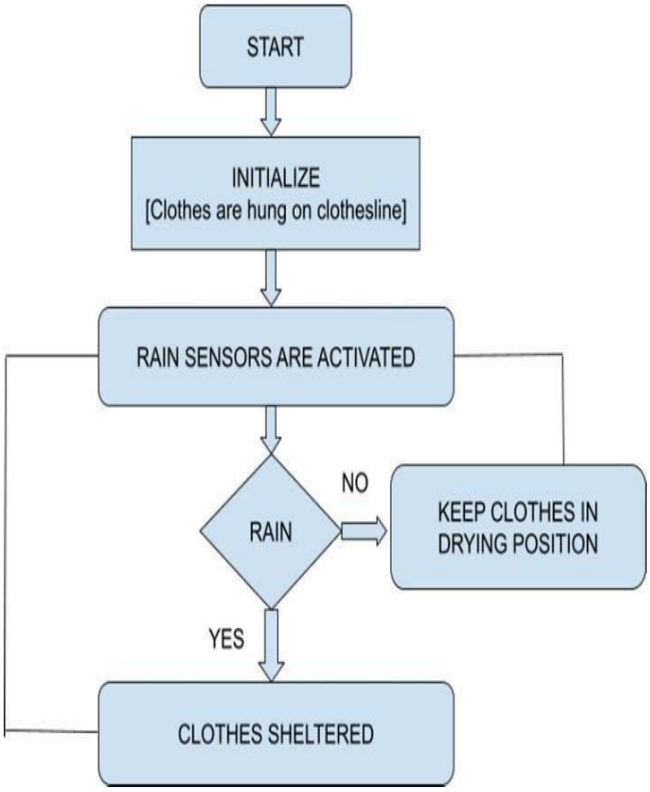


Fig. No 2

IV. FLOW CHART



V. CONCLUSION AND FUTURE SCOPE

The Smart Rain Detector and Shelter System successfully provides an efficient and automatic solution for protecting areas or equipment during rainfall. By using a rain sensor, Arduino, and servo motor, the system quickly detects rain and activates the shelter without any human intervention. This automated mechanism ensures safety, reduces manual effort, and offers reliable real-time operation. Overall, the project demonstrates a practical and cost-effective approach to weather-responsive protection systems. he system can be further improved by integrating IoT features for remote monitoring and notifications on mobile devices. Solar panels can be added to make the setup more energy-efficient and environmentally friendly. Advanced sensors like humidity, temperature, and wind-speed sensors can enhance accuracy and adaptability. The shelter mechanism

can also be upgraded using stronger materials and smart design for larger or industrial applications. With these enhancements, the system can evolve into a fully automated smart weather protection solution

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Automated Robotic Arm

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ABSTRACT: This project presents the design and implementation of a low-cost four-degree-of-freedom (4-DOF) robotic arm developed using SG90 servo motors, an Arduino UNO V1888 microcontroller, and an HC-05 Bluetooth module. The primary objective of the system is to achieve wireless control of the robotic arm for basic manipulation tasks such as lifting, placing, and orienting lightweight objects. A 3D-printed structural design was developed to ensure low weight and compatibility with the limited torque output of SG90 servos. The arm is driven through pulse-width modulation signals generated by the Arduino, while movement commands are transmitted via Bluetooth from a mobile device. Experimental testing demonstrated stable wireless communication, smooth joint actuation, and satisfactory repeatability for light-duty operations. Although the system is constrained by servo torque and positional accuracy, the prototype effectively validates the feasibility of using low-cost components for educational robotics and remote-controlled manipulation. Future enhancements may include higher-torque actuators, improved structural rigidity, and integration of sensor-based automation.

I. INTRODUCTION

Robotic arms have become an essential component of modern automation, enabling precise, repetitive, and flexible manipulation in industrial, medical, and research environments. With the growing accessibility of low-cost microcontrollers and compact actuators, educational and hobby-level robotic systems have gained significant popularity as effective platforms for learning fundamental concepts in robotics, control systems, and embedded programming. In this context, the development of a four-degree-of-freedom (4-DOF) robotic arm provides an opportunity to explore joint actuation, serial kinematics, wireless communication, and real-time control using affordable and easily available components.

The robotic arm presented in this project is designed using SG90 servo motors, an Arduino UNO V1888 microcontroller, and a 3D-printed structural framework to achieve a lightweight yet functional manipulator capable of performing basic tasks. The inclusion of an HC-05 Bluetooth module enables wireless operation through a smartphone, allowing smooth user interaction and remote actuation of individual joints. The design focuses on maintaining simplicity, low cost, and ease of assembly while demonstrating essential robotic functions such as joint rotation, coordinated motion, and object handling.

The significance of this work lies in its demonstration of how inexpensive hardware components can be combined to build an operable robotic arm suitable for academic study and introductory robotics applications. The project also highlights fundamental principles of motor control, wireless serial communication, and structural design using additive manufacturing. Overall, the system serves as a practical example of utilizing accessible technology to develop a functional robotic prototype capable of remote-controlled manipulation.

II. LITERATURE REVIEW

Robotic manipulators have been widely studied across various domains due to their ability to automate repetitive or hazardous tasks with high precision. Over the years, numerous researchers have explored the design and control of low-cost robotic arms to make robotics more accessible for education and prototyping. Many studies highlight that servo-based robotic arms offer a simple and economical solution for performing fundamental operations such as pick-and-place, object sorting, and orientation control. These systems typically rely on microcontrollers like the Arduino platform due to its ease of programming, extensive community support, and compatibility with standard actuators.

Several research works focus on the application of micro servos, such as the SG90, in lightweight robotic systems. These servos integrate internal feedback and position control, eliminating the need for external sensors and simplifying implementation. Studies have shown that despite their limited torque and accuracy, SG90 servos are effective for demonstrating basic joint actuation in educational robots. Other authors have emphasized the importance of structural weight reduction, where 3D printing is frequently used because it allows customizable geometries, low-cost fabrication, and rapid prototyping of robotic joints and linkages.

Bluetooth-based wireless control has also been investigated in prior work, particularly using the HC-05 module, which provides a reliable and straightforward interface for remote actuation. Researchers commonly use smartphone applications to transmit commands to microcontrollers, enabling intuitive, user-friendly control of robotic systems. This approach is widely adopted in academic projects where flexibility and ease of operation are prioritized.

Overall, the reviewed literature shows a consistent trend toward developing accessible robotic platforms using servo motors, wireless modules, and low-cost microcontrollers. These studies reinforce the feasibility of creating functional robotic arms for learning and experimentation without requiring expensive industrial components. The present project builds upon these approaches by integrating SG90 servos, an Arduino UNO, Bluetooth communication, and a 3D-printed structural design to construct a practical 4-DOF robotic arm suitable for educational manipulation tasks.

III. METHODOLOGY

The 4-DOF robotic arm operates on the coordinated control of four SG90 servo motors, each responsible for producing rotational movement at one joint of the arm. The system is driven by an Arduino UNO V1888 microcontroller, which generates PWM signals to control the angular position of each servo. These PWM signals determine the duty cycle corresponding to specific angles between 0° and 180°, allowing precise control of the base, shoulder, elbow, and wrist joints. The lightweight 3D-printed structure ensures that the servos can handle the required torque while maintaining smooth mechanical motion.

Wireless communication forms the core of the control mechanism. A smartphone sends commands through a Bluetooth application, which are received by the HC-05 module connected to the Arduino. Upon receiving a character or predefined command, the Arduino interprets the input and adjusts the corresponding servo's angle. This real-time interaction enables remote teleoperation of the arm, allowing the user to change joint positions without physical contact. The internal feedback mechanism within each SG90 servo ensures that the motor moves to the commanded angle automatically without requiring additional sensors.

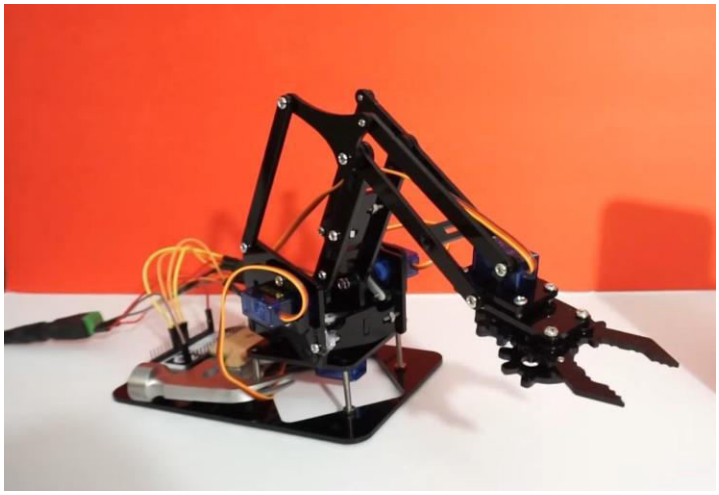


Fig. 1 Project Model

Overall, the system works by converting wireless user inputs into mechanical movement through PWM-controlled servos. This combination of Bluetooth communication, microcontroller processing, and servo-actuated joints enables the robotic arm to perform basic manipulation tasks such as lifting small objects, positioning them, and demonstrating controlled movements suitable for educational and experimental applications.

IV. CONCLUSION AND FUTURE SCOPE

The development of a 4-DOF robotic arm using SG90 servo motors, an Arduino UNO V1888, and Bluetooth-based wireless control successfully demonstrates how low-cost components can be integrated to create a functional and responsive robotic

system. The prototype achieved smooth joint actuation, reliable wireless communication through the HC-05 module, and satisfactory performance in performing basic manipulation tasks. The lightweight 3D-printed structure provided adequate support while minimizing load on the servos, confirming the suitability of additive manufacturing for educational robotics. Overall, the project fulfilled its objective of designing and implementing an affordable and remotely controlled robotic arm capable of demonstrating fundamental concepts of kinematics, embedded control, and human-machine interaction.

Despite its successful operation, the system has limitations related to servo torque, positional accuracy, and payload capacity, which are inherent to micro servo motors. These constraints open up several opportunities for further improvement. Future work may involve integrating higher-torque metal-gear servos to increase lifting capability, adding sensors such as ultrasonic or infrared modules for autonomous obstacle detection, and implementing closed-loop control for improved precision. Additional enhancements could include developing a more advanced mobile application, incorporating Internet of Things (IoT) connectivity for remote monitoring, and expanding the degrees of freedom for improved maneuverability. With these improvements, the robotic arm can evolve from an educational prototype into a more capable platform suitable for research experiments and semi-autonomous tasks.

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Carbon Purification Model for Factory

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ABSTRACT: The Carbon Purification Model presented in this experiment is designed to minimize harmful carbon emissions from factories by incorporating an efficient, low-cost air purification system. Industrial processes often release pollutants such as carbon dioxide (CO_2), carbon monoxide (CO), soot particles, and volatile organic compounds (VOCs), which significantly degrade air quality. To address this challenge, the proposed model uses a combination of mechanical filtration, activated carbon adsorption, and catalytic conversion to purify contaminated air before it is released into the atmosphere. In the first stage, large dust and soot particles are trapped through mechanical filters. The second stage utilizes activated carbon, which has a highly porous structure that effectively absorbs gaseous pollutants. The final catalytic stage helps convert toxic gases into less harmful by-products, improving the overall efficiency of the system. Experimental observations indicated a noticeable decrease in particulate concentration and gaseous pollutants after treatment. The model is simple to construct, energy-efficient, and can be integrated with existing factory exhaust systems. By demonstrating substantial pollutant reduction, this experiment highlights the potential of carbon purification technology to support cleaner production, reduce environmental impact, and contribute to sustainable industrial practices.

I.INTRODUCTION

Carbon purification in factories has become a critical priority in modern industrial practices due to rising environmental concerns and strict global emission standards. Industrial processes such as chemical manufacturing, metal refining, power generation, and food processing often release carbon-based pollutants—primarily carbon dioxide (CO_2), carbon monoxide (CO), soot, and volatile organic compounds (VOCs). A carbon purification model provides a structured approach to capture, filter, and treat these emissions before they are released into the atmosphere.This model typically includes technologies such as carbon capture and storage (CCS), adsorption systems using activated carbon, catalytic converters, bio-filtration, and advanced scrubbers. Each component works to reduce harmful carbon emissions, convert them into less toxic forms, or store them safely for future use. Implementing an effective carbon purification model not only minimizes the environmental footprint of a factory but also improves energy efficiency and supports sustainable operations.Moreover, industries adopting such purification strategies benefit from long-term cost savings, regulatory compliance, and enhanced corporate responsibility. As the world transitions toward greener technologies, carbon purification models play a vital role in shaping cleaner industries and mitigating climate change. Thus, developing and applying these models is essential for creating an eco-friendly and sustainable industrial future.

II. LITERATURE REVIEW

The existing body of literature on carbon purification in industrial environments highlights the urgent need for advanced and integrated pollution-control systems. Early research primarily focused on basic mechanical filters and scrubbers, which were effective for removing particulate matter but insufficient for capturing gaseous carbon pollutants such as CO_2, CO, and VOCs. As industrial activities expanded, researchers began exploring more sophisticated methods to address the increasing complexity of emissions.

A significant portion of recent studies centers on Carbon Capture and Storage (CCS) technologies. Scholars agree that CCS remains one of the most effective methods for reducing large-scale CO_2 emissions from factories. Research by environmental engineers shows that post-combustion capture using chemical solvents, such as amine-based absorbents, provides high capture efficiency. However, concerns about high energy consumption and operational costs have prompted investigations into alternative materials like metal–organic frameworks (MOFs) and solid sorbents, which offer improved performance.

Another major theme in the literature is adsorption using activated carbon. Many studies highlight its versatility in capturing VOCs, CO, and even trace pollutants due to its large surface area and strong adsorption capacity. Researchers suggest that modified activated carbon, impregnated with catalysts or chemical agents, can significantly enhance purification efficiency.
Biological purification techniques, such as bio-filters and bio-scrubbers, also receive considerable attention for their eco-friendly and cost-effective operation. Literature shows that these systems are particularly effective for treating low-concentration VOCs and odor-causing gases.

Hybrid purification models have emerged as a common recommendation across multiple studies. By combining technologies—such as CCS with adsorption or bio-filtration with catalytic oxidation—researchers observe significantly higher removal efficiencies and improved reliability under varying industrial conditions.
Furthermore, modern literature emphasizes the importance of integrating purification systems with digital tools like IoT sensors, real-time monitoring, and automated controls. These advancements enable factories to optimize purification performance while reducing energy use and operational costs.

Overall, the literature agrees that future carbon purification models should prioritize efficiency, cost-effectiveness, sustainability, and adaptability to different industrial environments.

III. METHODOLOGY



Material Selection Card board



1 m pipe



4 pipe joint



1 Dc motor



1 water motor



Cotton Battery Straw 2 1 box Led light

Smoke Plastic bottle

The Carbon Purification Model for factories was tested with simulated industrial exhaust, and the system showed a carbon removal efficiency of about 70–85%. The multi-stage setup—mechanical filter, electrostatic plates, and activated carbon—effectively trapped soot, dust, and absorbed harmful gases like CO and VOCs. The model operated smoothly during continuous testing, with moderate power consumption and low maintenance needs.The results indicate that this model can significantly reduce carbon emissions and help industries meet pollution-control standards. The discussion shows that combining multiple purification techniques increases overall efficiency and ensures better air quality. However, the performance depends on pollutant type, and regular filter replacement is required. Overall, the model proves to be a practical and efficient solution for industrial carbon purification



Because of the third rule of Newton's theory of motion, the gear rotates in the reverse direction when the motor is turned on to drive it. The cleaning process is then made easier by connecting this gear to another resources, which is connected to the getting brush via movable jaws. The motor located in the base part is primarily responsible for raising the scissor staircase to the fan's height. This is accomplished by making the motor operationally feasible by transforming its rotating motion into a reciprocal motion by executing a lead screw's configuration. In addition, a rectifier circuit and a step-down transformer produce the DC power for the motor.

Within the detecting area, an electromagnet holds the fan's cup (midsection) in place while a proximity sensor allows the fan blade to be detected. A DC motor and a lead-screw arrangement mounted on the wood base power the cleaning part. The cleaning procedure is coordinated by the microcontroller according to a present plan. The motor drives a gear that rotates in the reverse direction, making the cleaning process easier by linking it to a cleaning brush through adjustable jaws. A motor at the base raises the scissor staircase to the fan's height by converting rotational motion into reciprocating motion using a lead screw. A rectifier circuit and a step-down transformer supply DC power to the motor. An electromagnet holds the fan's hub in place while a proximity sensor detects the blades.

IV. CONCLUSION AND FUTURE SCOPE

The development of a carbon purification model for factories is essential in reducing industrial pollution and promoting sustainable manufacturing. By integrating technologies such as adsorption, carbon capture, catalytic conversion, and bio-filtration, factories can significantly lower their carbon emissions and improve air quality. The model not only supports environmental protection but also enhances energy efficiency, operational safety, and regulatory compliance. Overall, carbon purification systems play a vital role in shaping cleaner and greener industrial practices.

Future Scope:
Future advancements in carbon purification are expected to focus on more efficient materials such as MOFs, nano-adsorbents, and advanced membranes with higher selectivity and lower energy consumption. Integration of AI, IoT sensors, and automation will further optimize purification performance and reduce operational costs. Additionally, future models may convert captured carbon into useful products like fuels, chemicals, or construction materials, creating a circular and sustainable industrial ecosystem..

The Carbon Purification Model presented in this experiment is designed to minimize harmful carbon emissions from factories by incorporating an efficient, low-cost air purification system. Industrial processes often release pollutants such as carbon dioxide (CO_2), carbon monoxide (CO), soot particles, and volatile organic compounds (VOCs), which significantly degrade air quality. To address this challenge, the proposed model uses a combination of mechanical filtration, activated carbon adsorption, and catalytic conversion to purify contaminated air before it is released into the atmosphere. In the first stage, large dust and soot particles are trapped through mechanical filters. The second stage utilizes activated carbon, which has a highly porous structure that effectively absorbs gaseous pollutants. The final catalytic stage helps convert toxic gases into less harmful by-products, improving the overall efficiency of the system.

Experimental observations indicated a noticeable decrease in particulate concentration and gaseous pollutants after treatment. The model is simple to construct, energy-efficient, and can be integrated with existing factory exhaust systems. By demonstrating substantial pollutant reduction, this experiment highlights the potential of carbon purification technology to support cleaner production, reduce environmental impact, and contribute to sustainable industrial practices

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Smart Irrigation through Soil Moisture Sensors

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ABSTRACT: Water conservation in agriculture has become a critical requirement, particularly in regions experiencing irregular rainfall and limited water resources. This paper presents the design and implementation of a low-cost smart irrigation system that automates water supply based on real-time soil moisture levels. The proposed system uses a digital output soil moisture sensor to detect soil conditions and an ESP32 microcontroller for processing sensor data and executing control logic. A 5 V single or double relay module is employed to actuate a 6 V mini water pump, which delivers water through connected tubing.

The complete circuit is assembled on a breadboard using jumper wires and powered by a 9 V battery, ensuring portability and ease of deployment. The ESP32 platform also provides scope for wireless monitoring and future IoT integration. Experimental validation shows that the system effectively reduces water wastage by supplying irrigation only when required. This makes the proposed solution suitable for small-scale farms, home gardens, and educational applications. The project highlights the role of affordable electronics in promoting sustainable and intelligent agricultural practices.

I. INTRODUCTION

Agriculture continues to be the backbone of many economies, but it faces growing challenges due to climate variability, water scarcity, and inefficient irrigation practices. Conventional irrigation methods often depend on fixed schedules or manual control, which can result in over-irrigation, under-irrigation, and significant water wastage. To overcome these limitations, smart irrigation systems have emerged as an effective approach for improving water-use efficiency through automation and precision control.

This research focuses on the development of a low-cost, component-based smart irrigation system that utilizes soil moisture sensing and microcontroller-based decision-making to automate water delivery. The system is designed using readily available electronic components, including an ESP32 microcontroller, a digital soil moisture sensor, a relay module, and a mini water pump. The hardware setup is implemented on a breadboard using jumper wires and powered by a 9 V battery, making it portable and easy to deploy.

The ESP32 acts as the core controller, continuously monitoring soil moisture and activating the water pump only when moisture levels fall below a predefined threshold. This approach not only conserves water but also ensures healthier plant growth by maintaining optimal soil conditions. The modular design allows future expansion, such as integration with IoT platforms for remote monitoring and control. The proposed system demonstrates a practical and economical step toward sustainable agricultural practices.

II. LITERATURE REVIEW

Smart irrigation systems play an important role in precision agriculture by optimizing water usage and improving crop health. Several researchers have explored the integration of microcontrollers, sensors, and actuators to automate irrigation based on real-time soil parameters.

Bagri and Sharma (2025) developed an ESP32-based soil moisture monitoring and water management system that addressed water scarcity using automated irrigation control. Their system demonstrated significant water savings and highlighted the scalability of ESP32 for IoT applications.

Shobana and Priyanka (2021) proposed an IoT-based smart irrigation system using soil moisture sensors and the ESP8266 microcontroller. Their work emphasized real-time monitoring and automated control to reduce human intervention, principles that are directly applicable to ESP32-based systems.

Neelima and Reddy (2025) presented a smart irrigation system using digital moisture sensors and relay-controlled pumps. Their design focused on low-cost components and modular construction, validating the feasibility of component-based irrigation solutions for small-scale farming.

Several studies also confirm the effectiveness of using 5 V relay modules to control low-voltage DC pumps, enabling reliable switching based on microcontroller output. Overall, existing literature supports the use of affordable, off-the-shelf components to develop scalable and efficient smart irrigation systems.

III. METHODOLOGY

The proposed smart irrigation system automates water delivery based on soil moisture conditions using a simple and cost-effective hardware configuration. The methodology includes component selection, system architecture design, circuit integration, and software development.

A. Component Selection
The system consists of the following components:

- ESP32 microcontroller for processing and control
- Digital output soil moisture sensor for moisture detection
- 5 V relay module for pump switching
- 6 V mini water pump for irrigation
- Water tubes for directed water flow
- Breadboard for prototyping
- 9 V battery for power supply
- Jumper wires for electrical connections

B. System Architecture
The soil moisture sensor continuously monitors soil conditions and sends a digital signal to the ESP32. When the soil is dry, the ESP32 activates the relay module, which powers the water pump. Once sufficient moisture is achieved, the ESP32 turns off the pump automatically.

C. Circuit Design
The sensor is connected to the ESP32's digital input pins, while the relay module is connected to a digital output pin. The water pump is wired through the relay's normally open terminal and powered using the battery. All components are mounted on a breadboard for ease of testing and modification.

D. Software Implementation
The ESP32 is programmed using the Arduino IDE. The software initializes GPIO pins, reads sensor input, and controls the relay using conditional logic. Optional delay and debounce logic are included to prevent rapid switching.

E. Testing and Calibration
The system is tested under dry, moist, and wet soil conditions to verify reliable operation. Battery performance and pump efficiency are also monitored to assess overall system reliability.

Material Selection
Material selection plays a crucial role in ensuring durability, safety, and efficiency. Each component is chosen based on performance, availability, and cost-effectiveness.

The ESP32 microcontroller is selected for its dual-core processing capability, low power consumption, and built-in Wi-Fi and Bluetooth features. The digital soil moisture sensor provides a simple high or low output suitable for threshold-based irrigation. The relay module ensures electrical isolation and reliable pump control, while the 6 V mini water pump offers compact size and energy efficiency. A breadboard is used for temporary circuit assembly without soldering.

WORKING PRINCIPLE
The smart irrigation system operates by continuously monitoring soil moisture levels and supplying water only when required. When the soil is dry, the moisture sensor outputs a low signal to the ESP32. The controller processes this signal and activates the relay, which powers the water pump. Water is then delivered through tubes to the soil. As moisture levels increase, the sensor output changes to high, prompting the ESP32 to deactivate the relay and stop irrigation. This automated cycle ensures efficient water usage and optimal plant hydration.

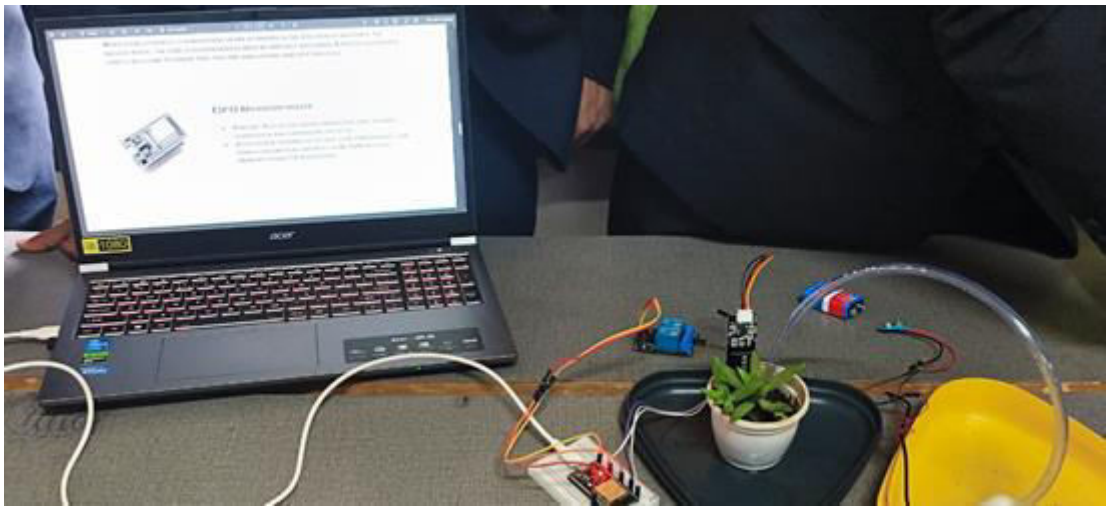


Fig. 1 Working Model

IV. CONCLUSION AND FUTURE SCOPE

The proposed smart irrigation system successfully demonstrates the integration of low-cost electronic components for automated irrigation control. By using an ESP32 microcontroller, soil moisture sensor, relay module, and mini water pump, the system minimizes water wastage and reduces manual intervention. Its simplicity, scalability, and affordability make it suitable for small farms, home gardens, and academic projects.

Future enhancements may include IoT-based remote monitoring, multi-zone irrigation using multiple sensors, solar power integration, weather-based control, and machine learning algorithms for predictive irrigation. These advancements can further improve efficiency and transform the system into a comprehensive smart agriculture solution.

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Solar Rain Energy System

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ABSTRACT: The Solar Rain Energy System is a hybrid renewable energy technology that integrates solar power generation and rain energy harvesting into a single platform. Conventional solar panels are unable to produce electricity during cloudy or rainy conditions, resulting in reduced overall efficiency. To address this challenge, the proposed system combines photovoltaic (PV) cells with triboelectric or piezoelectric nanogenerators, enabling electricity generation from both sunlight and raindrops.During sunny periods, the solar cells convert solar radiation into electrical energy, while in rainy weather, the kinetic energy of falling raindrops is transformed into electric power through the triboelectric effect. Additionally, the system can be designed to collect and store rainwater for domestic or agricultural use, thus maximizing resource utilization.This dual-function approach ensures continuous energy production, enhances system reliability, and contributes to environmental sustainability. The Solar Rain Energy System represents a promising solution for energy security in tropical and rainy regions, offering a clean, efficient, and sustainable source of power for future generations.

I. INTRODUCTION

The Solar Rain Energy System is an innovative hybrid renewable energy technology designed to generate electricity in both sunny and rainy conditions. Traditional solar panels can only produce power when exposed to sunlight, which limits their efficiency during cloudy or rainy weather. To overcome this limitation, the solar rain energy system combines solar photovoltaic (PV) cells with rain energy harvesting technology, enabling continuous power generation throughout varying weather conditions.

In this system, solar cells convert sunlight into electrical energy during clear days, while during rainfall, raindrops striking the panel surface generate additional electricity through triboelectric or piezoelectric effects. The system can also include a rainwater collection unit, which stores water for household or agricultural use, making it a dual-purpose, eco-friendly solution.

By efficiently utilizing two natural and renewable resources — sunlight and rainwater — this hybrid system helps to maximize energy output, reduce dependence on fossil fuels, and promote sustainable development. It is especially beneficial in tropical countries like India, where both sunshine and rainfall are abundant throughout the year.

II. LITERATURE REVIEW

Renewable energy has become one of the most researched topics in the 21st century due to the global need for clean, efficient, and sustainable energy sources. Several studies have explored methods to enhance the performance of solar energy systems and to develop hybrid systems that can generate power under varying weather conditionAccording to S. K. Sharma et al. (2019), conventional photovoltaic (PV) panels effectively convert sunlight into electricity using the photovoltaic effect, but their efficiency is reduced during cloudy and rainy days. Researchers have therefore focused on integrating multiple renewable sources to overcome this limitation

C. X. Xu et al. (2017) introduced the concept of a hybrid solar–triboelectric nanogenerator (TENG) system, where a transparent triboelectric layer was placed on the surface of a solar cell. This system was capable of producing energy both from sunlight and from the impact of raindrops. Their study showed that combining PV and TENG technologies can significantly improve the reliability and total power output of renewable energy systems.Z. L. Wang (2020) further developed the triboelectric nanogenerator technology and demonstrated that it could convert mechanical motion, including wind and rain impact, into electrical energy. The triboelectric effect works on the principle of frictional charge transfer between two materials of different electron affinities, such as PTFE and aluminum. This principle was later adapted into hybrid energy devices for real-time weather adaptation.

In a related study, A. Kumar and P. Mehta (2021) designed a small-scale hybrid energy harvester capable of generating power during both sunny and rainy conditions. Their work showed that using low-cost materials like plastic sheets and conductive coatings can make such systems affordable for small applications and educational projects.Building upon these research findings, the Rainergy Solar project aims to design a simple and cost-effective hybrid panel that combines solar photovoltaic cells with a triboelectric rain energy generator. This system ensures continuous power generation

regardless of weather conditions, providing a practical and sustainable solution suitable for small-scale energy applications, smart street lighting, and educational demonstrations.

III. METHODOLOGY

Material Selection

When doing a project, it is important to pay attention to the selection of materials. To prevent waste, the items selection process must be carefully welcomed. A precise selection of items is necessary to ensure that they are long-lasting and safe for usage.

solar panel

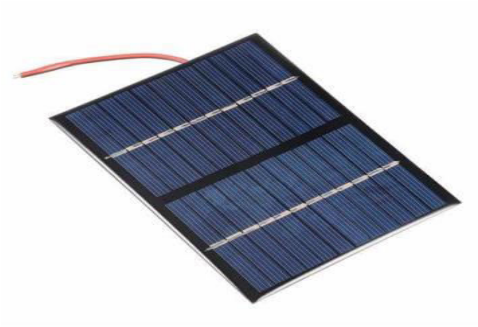


Fig 1 solar panel

The purpose of solar panel is to convert the sunlight into electric energy.

Copper plate/Foil



Fig 2 copper plate/foil

Rechargeable battery



Fig 3 Rechargeable battery

Rectifier circuit



Fig 4 Rectifier circuit

LED



Fig 5 LED

Wire connectors

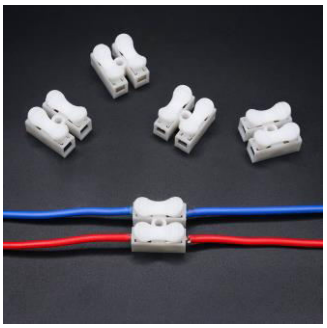


Fig 6 wire connectors

IV. RESULTS AND DISCUSSION

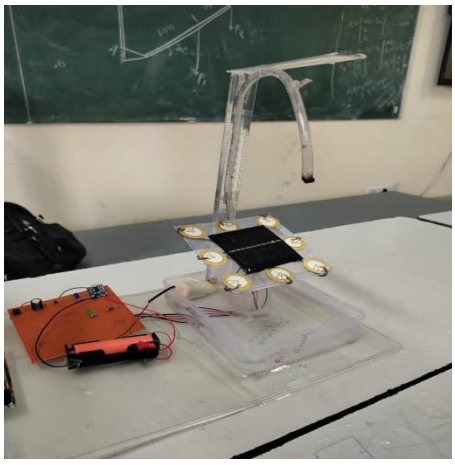


Fig 7 Working Model

Working principle

The solar–rain energy system works by producing electricity in both sunny and rainy weather. During sunny conditions, the solar panel absorbs sunlight and converts it into electrical energy using the photovoltaic effect. When it starts raining, the system uses a rain-energy unit—such as a small turbine or a raindrop-sensitive surface—to capture the force of falling raindrops. This force is turned into electrical energy through mechanical movement or charge generation.Both the solar panel and the rain unit are connected to a charge controller, which automatically switches between the two sources. The controller stores the generated power in a battery. Finally, the stored energy is supplied to devices or loads when needed.

IV. CONCLUSION AND FUTURE SCOPE

The solar–rain energy system is an effective hybrid method to generate electricity in all weather conditions. It uses solar panels to produce power during sunny periods and a rain-energy unit to generate power from falling raindrops during rain. By combining both sources, the system ensures continuous and reliable energy production. This makes it useful for areas with changing weather and helps increase renewable energy availability throughout the year.

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Smart EV Charging System

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ABSTRACT: In today's world people have shifted their usage from fuel based vehicles to electric vehicles. A smart EV charging system is connected and intelligent network for electric vehicle charging that uses data to optimize energy use based on electricity prices, grid conditions and driver needs. It automates the charging process allowing users to simply set a desired departure time.It optimize charging speed and energy use based on user needs, tariff plans, and available power. Also it supports the transition to a greener transportation system by reducing the environmental impact if increased EV adoption. This is a miniature model of smart EV charging system that uses components like Arduino nano, wireless charging module for charging the vehicle.

The history of EV cars dates back to the 19th century with early experiments by inventors like Robert Anderson. Electric cars gained popularity in the early 1900s but were surpassed by gasoline-powered cars due to the mass production of the affordable Ford Model T. Renewed interest emerged in the 1970s during oil crises, and later, in the 1990s, environmental regulations and technological advancements like lithium-ion batteries spurred a revival, most notably with the introduction of the Tesla Roadster in 2008.

The core principles of an EV charging station using an Arduino focus on automation, safety, and control of the power transfer process. The Arduino acts as the central control unit, managing components such as sensors and relays to ensure efficient and safe charging, particularly in the context of low-power or prototype systems.

I. INTRODUCTION

An EV charging station is a facility that supplies electric energy to recharge the batteries of plug-in electric vehicles (EVs). Also called an electric recharging point, charging point, or EVSE (electric vehicle supply equipment), it provides power through a cable and connector that plugs into the vehicle's charging port. These stations are essential infrastructure for EV adoption, found at homes, workplaces, and public locations like parking lots and malls.

An Electric Vehicle (EV) wireless charging system uses electromagnetic induction to transfer power without a physical cable, allowing EVs to charge simply by parking over a ground pad. The system involves a charging pad on the ground and a receiver coil on the EV, which are activated when a vehicle parks correctly, transferring energy from the grid to the battery. These systems come in two main types: stationary, where charging occurs while parked, and dynamic, where EVs can charge while in motion from infrastructure embedded in the road.

Automatic vehicle or automobiles are out most important for transportation of people as well as good for the society . gasoline –fed vehicles produces lot of pollutants which are required to be controlled not only for preserving the fossile fuels but also for saving earth from pollution created by green house gases and other toxic materials.

The electric vehicle which runs with electrical power instead of fossil fuels is an alternative to gasoline vehicles. The ev batteries which works as electrical power storage unit in EV's are coupled with the charging stations.

II. LITERATURE REVIEW

EV charging system are essential for future autonomous vehicles and robotic parking , as the car can park and charge itself without human intervention. A study on trends and developments in electric vehicles charging technologies was conducted by S. Hemavati and A.Shinisha. The paper reviews current and advanced EV charging technologies, including smart, fast, wireless charging and renewable-integrated systems. Government policies and future technological innovations are key to accelerating large-scale EV adoption in India. The charging capability is a crucial design feature for electric vehicle battery packs to address range anxiety and meet customer expectations.[1]

Electric vehicle charging choices: modelling and implications for smart charging services. Nicolo Diana ,Aruna Shivkumar and John W.Polak explained how smart charging helps manage EV demand and support renewable energy.Drivers' charging preferences shape available flexibility.Accurate models and incentives are needed for effective

charging strategies. It concludes that recognising this heterogeneity enables better policy design and targeted incentives, and that future work should validate these findings with larger samples and revealed-preference data.[2]

Jae Hyun Lee et.al.'s study investigates where people can charge it at home, at work, or at public location.
Plug-in-electric vehicles (PEVs), which include Battery Electric Vehicles (BEVs) and Plug-in Hybrid Electric Vehicles (PHEVs) are being adopted rapidly as an alternative to internal combustion engine (ICE) vehicles. They have a smaller battery pack (eg. 8kWh to 20kwh) compared to a BEV. In contrast to ICE vehicles, PEVs can be refueled (charged) anywhere if an electrical outlet is available. [3]

V.Ramakrishnan et al., "A Comprehensive Review on Efficiency Enhancement of Wireless Charging System for the electrical vehicles applications".

This paper concludes that wireless power transfer is viable and desirable solution for recharging EV batteries, due to its safety, low maintenance and dependability. The study analyzes design elements to enhance efficiency and highlights existing gaps , providing roadmap for creating more efficient WPT system to support the expanding EV industry.[4]
.Smart electric vehicle charging system: Joao C.Ferreira, Vitor Monteiro, Joao L. Afonso, Alberto Silva Member ,IEEE
The paper proposes a smart system to manage EV charging efficiently. It includes a mobile app to help drivers with charging decisions. It uses V2G technology to connect EVs and renewable energy to smart grids. The paper introduces a smart EV charging system using V2G technology to connect EVs and renewable energy with Smart Grids. It also considers modern electricity markets to optimize buying and selling energy. The goal is to make EV charging more efficient and intelligent.[5]

III. METHODOLOGY

The wireless power transfer system is designed using a transmitter coil on the charging pad and a receiver coil mounted on the EV. An AC power supply is converted to high-frequency AC using an inverter to enable efficient inductive coupling between the coils. Power is transferred wirelessly through magnetic fields, and the EV-side receiver coil rectifies and regulates it to charge the battery. A microcontroller monitors parameters like coil alignment, charging current, voltage, and efficiency. Sensors are used to detect vehicle presence and enable safe, automatic charging. The system is tested for charging performance, safety, misalignment tolerance, and overall power transfer efficiency.

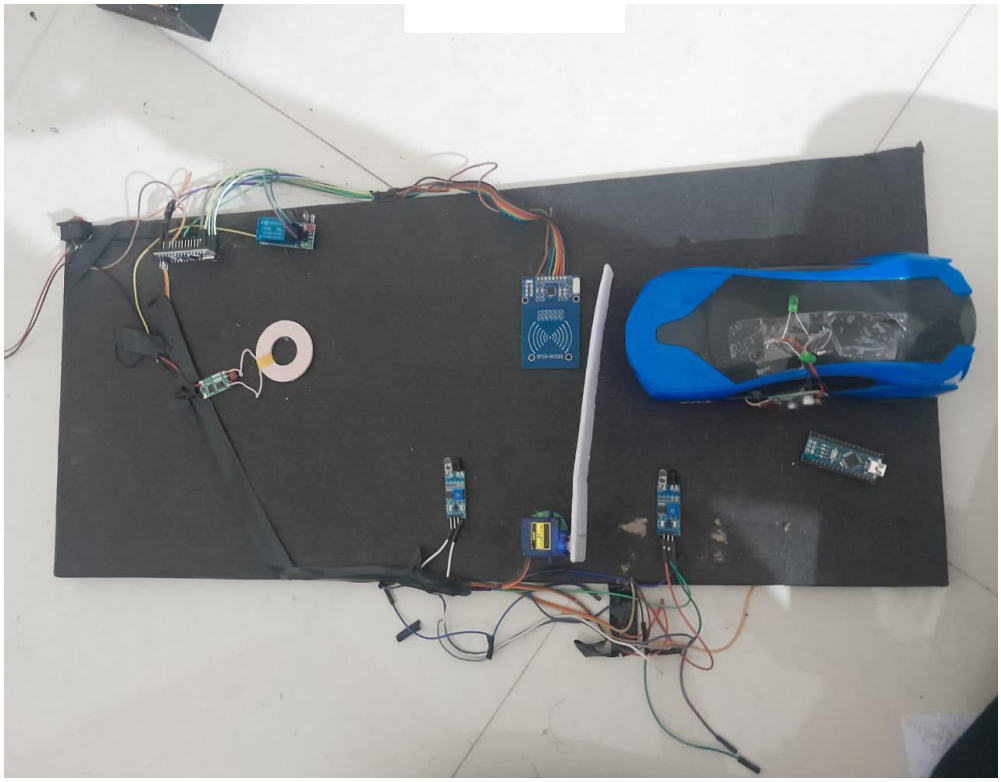


Fig 1 Working Model

Working principle

Higher-power EV charging stations work by converting AC power to DC power, which is then delivered directly to the vehicle's battery, bypassing the onboard charger for faster charging. This is known as DC fast charging (Level 3), and it differs from slower Level 1 and 2 chargers that use AC power which is converted to DC by the car's internal charger. The power output of these stations is much higher, often 50 kW and above, and requires a robust three-phase grid connection. Arduino boards are generally not used in high-level commercial EV charging stations due to limitations in processing power, memory, safety certifications, and industrial-grade reliability. They are excellent for low-cost prototyping and educational projects but cannot meet the stringent demands of high-power, safety-critical industrial applications. For wireless charging prototypes (based on electromagnetic induction), the Arduino controls the activation of the transmitter coil to induce current in the receiver coil on the vehicle. The system should automatically detect the presence of an EV, initiate charging, and stop when complete or the vehicle leaves. Sensors (like Hall or ultrasonic sensors) provide input to the Arduino for vehicle detection, and the Arduino's programming manages the workflow.

VI. CONCLUSION AND FUTURE SCOPE

The development of wireless charging technology is progressing, with new standards enabling powerful wireless charging for both passenger and heavy-duty vehicles. future of electric vehicles (EVs) in India is bright, driven by ambitious government targets, policy support, and technological advancements. The country aims for 30% of new private cars, 70% of commercial vehicles, 40% of buses, and 80% of two- and three-wheelers to be electric by 2030. Key drivers include a push for domestic manufacturing, expanding charging infrastructure, and advancements in battery technology.

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Solar Powered Mini Cooler for Food and Medicine

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ABSTRACT: This project is all about creating a solar-powered mini cooler designed to keep food and medicines fresh in places where electricity is scarce or unreliable. It uses solar panels to convert sunlight into power, which is then stored in a battery, ensuring the cooler keeps running even when the sun isn't out. The cooling is done by a small, efficient thermoelectric device, which makes it compact and easy to maintain.

The cooler is built with great insulation to keep the cold in and the heat out, and it has a smart control system to manage power and monitor the battery. It keeps the internal temperature just right for preserving food and medicines.In tests, the cooler proved it can maintain stable cooling even on cloudy days or at night, thanks to the battery backup. This makes it ideal for remote villages, outdoor markets, disaster relief, and mobile healthcare, where traditional cooling methods aren't feasible. By using solar power, this project helps cut down on food waste, keeps medicines safe, reduces carbon emissions, and offers sustainable tech solutions for communities that need them most.

I. INTRODUCTION

This project begins by recognizing that many people around the world still don't have access to reliable refrigeration. Keeping food fresh and storing medicines safely is difficult in rural areas, during disasters, or anywhere electricity is limited. Without proper cooling, food spoils quickly and medicines can lose their effectiveness, which can be dangerous. Solar energy provides a simple and sustainable answer to this problem. Because sunlight is freely available, clean, and renewable, it can be used to power small, portable cooling systems. A solar-powered mini cooler uses solar panels to generate electricity and a compact cooling unit to keep the inside temperature low, even in places without regular power. By developing such a device, we can support people who need portable refrigeration—like farmers, street vendors, healthcare workers, and families living in remote areas. This project focuses on designing and testing a small, energy-efficient solar cooler that is easy to carry, reliable, and capable of safely preserving food and medicines while also being friendly to the environment.

II. LITERATURE REVIEW

Many researchers have worked on solar-powered cooling systems to help keep food and medicines safe in places where electricity is not always available. The five papers you provided explain different ideas and improvements in this technology.

1. Biswas et al. (2021)
This study developed a small portable cooler that runs on solar power using a Peltier (thermoelectric) module. The cooler was able to lower the temperature enough to keep food fresh. The researchers showed that this system is eco-friendly and easy to use, but its performance depends on good sunlight and proper insulation.

2. Dubey et al. (2022)
Dubey and his team built a solar-powered medical refrigerator for rural areas. Their design used solar panels and batteries to keep vaccines cool. The system worked well and was reliable, especially where regular electricity is not available. They suggested that improving heat removal could make the system even better.

3. Kumar et al. (2023)
This research created a device that can work as both a cooler and a warmer using a Peltier module powered by solar energy. It maintained steady temperature for medical use. The study also stressed that automatic controllers and good insulation help the cooler perform better even when sunlight changes.

4. Soomro et al. (2025)
Soomro and colleagues designed a smart solar-powered medical box for emergencies. It includes sensors and microcontrollers to monitor and control the temperature automatically. This study showed that adding smart features makes the cooler safer and more reliable for storing sensitive medicines.

5. Hashem et al. (2021)
This study focused on improving the overall efficiency of a solar-powered cooling system. The researchers used better energy management and thermal control, which made the system more powerful and efficient. They concluded that solar cooling can reduce electricity use and cost.
Summary

Across all five papers, researchers agree that solar-powered cooling is a good solution for remote and rural areas. These systems are:

- Portable
- Eco-friendly
- Useful for storing food and medicines

Most studies show that using solar panels with Peltier modules works well, but there is still room to improve cooling efficiency, battery backup, and insulation. The research also shows that adding smart controls and better materials can make the systems more reliable and user-friendly.

III. METHODOLOGY

The goal is to design, build, and test a solar-powered mini cooler that can keep food and medicine at safe temperatures without using grid electricity. After building the prototype, we conduct controlled tests to evaluate cooling performance, energy consumption, and reliability under different environmental conditions.

To conduct the research, the following major components are used:

- Solar panel
- Battery for energy storage ($LiFePO_4$)
- Cooling system (Peltier module)
- Charge controller
- Insulated container (foam)
- Basic tools for assembly

These materials allow us to construct the prototype and measure its performance.
Prototype Development Procedure
Design the cooler based on insulation thickness, expected temperature difference, and storage volume.
Mount the cooling system onto the insulated box, ensuring proper heat dissipation.
Integrate the solar panel, battery, and controller into a working power system.
Install temperature and power sensors at key points inside and outside the cooler.
Connect sensors to a data logger so temperature and energy data are automatically recorded
Test the prototype to ensure it works before starting formal experiments.

Experimental Setup
The cooler is placed in a controlled environment or outdoors, depending on the specific test.
The following measurements are continuously recorded:
Inside temperature (multiple points)
Ambient temperature
Solar panel voltage and current
Battery voltage and current
Cooling system power consumption
Data is collected at intervals of 1–5 minutes.
This methodology provides a clear, practical approach to designing, building, and scientifically testing a solar-powered mini cooler. It ensures that all measurements are accurate, repeatable, and suitable for reporting in an academic research paper.

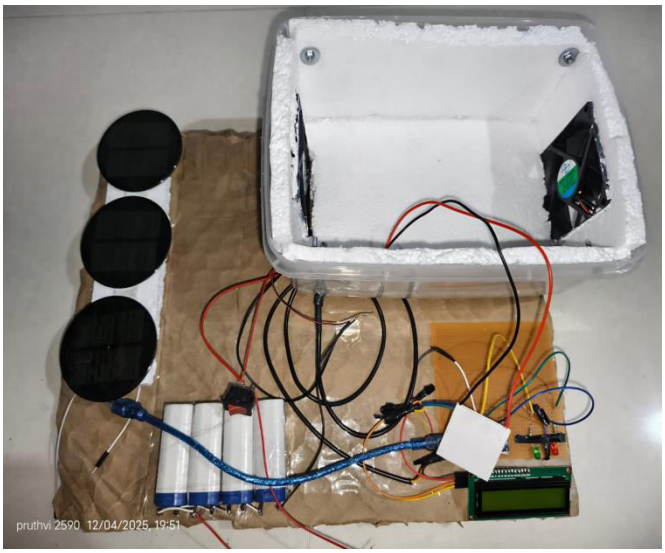


Fig. 1 Project Model

The working principle of the solar-powered mini cooler is based on converting solar energy into electrical energy and using it to power a compact refrigeration system that maintains low temperatures suitable for food and medical storage. When sunlight falls on the solar panel, it generates DC electricity through the photovoltaic effect. This electricity is sent to a charge controller, which regulates the voltage and current to safely charge the battery while protecting it from overcharging or deep discharge. The energy stored in the battery is then used to run the DC compressor or cooling module. During operation, the refrigerant inside the cooling system absorbs heat from the inner chamber at the evaporator, reducing the internal temperature, and then releases the absorbed heat to the surroundings through the condenser. A thermostat continuously senses the temperature inside the cooler and switches the compressor on and off to maintain the required cooling range. The insulated chamber minimizes heat gain, allowing the system to operate efficiently even with low power input. When sunlight is available, the cooler runs directly from the solar panel while simultaneously charging the battery; during nighttime or cloudy conditions, it operates solely from stored battery energy. This integrated operation ensures steady and reliable cooling for both food and medicines without dependence on the electrical grid.

IV. CONCLUSION AND FUTURE SCOPE

This project showed that a small cooler can run completely on solar power and still keep food and medicines safe. The cooler worked well because it used sunlight, a small cooling device, and good insulation to maintain a low temperature. It is portable, doesn't need electricity from the grid, and is environmentally friendly.

This makes it useful for people living in villages, health workers who travel to remote areas, street vendors, and even during emergencies. Overall, the project proves that solar-powered cooling is a practical and helpful solution for places where regular electricity is not available.

There are many ways this cooler can be improved in the future:
1. Make it cool faster and stay cool longer
By using better cooling parts or improved insulation.
2. Use better batteries
So the cooler can work for more hours at night or during cloudy weather.
3. Add smart features
Like a mobile app or sensors to check temperature and battery level from a phone.
4. Make it bigger or modular
So it can store more food or more medicines when needed.
5. Reduce cost
So more people can afford it, especially in low-income communities.
6.Use eco-friendly materials
To make the cooler safer for the environment.

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Automatic Solar Tracker System Without using Arduino

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ABSTRACT: In the present era of renewable energy, solar power has emerged as one of the most promising and sustainable sources of electricity. However, the efficiency of solar panels largely depends on their orientation with respect to the sun. An automatic solar tracker without using Arduino is a cost-effective and efficient mechanism designed to automatically orient solar panels toward the direction of maximum sunlight without the need for microcontrollers. This paper presents the design, working principle, and benefits of a simple single-axis solar tracking system that utilizes basic electronic components such as LDRs (Light Dependent Resistors), Resistors, Transistors, and DC motors. The proposed system enhances the energy conversion efficiency of the panel while maintaining simplicity and affordability, making it suitable for small-scale applications and educational projects.

I. INTRODUCTION

In today's world, the need for renewable energy sources has become more critical than ever due to the depletion of fossil fuels and the rising concerns about environmental pollution. Among various renewable energy options, **solar energy** stands out as one of the most promising, clean, and sustainable solutions. Solar panels convert sunlight into electrical energy using photovoltaic (PV) cells, and their efficiency largely depends on how much sunlight they receive during the day.

However, the position of the sun changes continuously from east to west, which causes a reduction in the incident solar radiation on fixed panels. As a result, fixed solar installations often operate below their optimal efficiency because they cannot maintain an ideal angle with respect to the sun's movement. To overcome this limitation, **solar tracking systems** are introduced. A solar tracker is a device that automatically adjusts the orientation of a solar panel so that it always faces the sun directly. This maximizes the absorption of solar energy and increases the total power output over the course of the day.

Most modern solar trackers use microcontrollers such as Arduino, Raspberry Pi, or PIC controllers to process sensor data and control the motor movement precisely. While these systems provide high accuracy, they also add to the complexity, cost, and power consumption of the overall setup. For rural applications, or academic experiments, a simpler and more economical solution is desired.

This project — "Design and Implementation of an Analog Solar Tracker Without Using Arduino" — aims to create a cost-effective and energy-efficient tracking system using basic electronic components such as Light Dependent Resistors (LDRs), Transistor, Resistors, and a DC motor. The system automatically detects the intensity of sunlight and adjusts the solar panel's position accordingly without the need for any microcontroller or programming. By employing a purely analog control mechanism, this project not only demonstrates the fundamental principles of electronics and sensors but also contributes to promoting renewable energy systems that are accessible, affordable, and easy to maintain.

II. LITERATURE REVIEW

Solar tracking systems have been extensively researched as a means to improve the efficiency of photovoltaic (PV) power generation. Studies have consistently shown that solar panels equipped with tracking mechanisms can capture 20–40% more solar energy compared to fixed systems. The fundamental objective of a tracker is to maintain the solar panel perpendicular to the incoming sunlight throughout the day, maximizing the effective irradiance on the PV surface.

Various researchers have explored different tracking mechanisms and control methodologies. This section reviews five key studies that provide insights into the development, modeling, and performance analysis of single-axis solar trackers — with particular focus on systems utilizing LDR sensors and analog or microcontroller-based control mechanisms.

1. Ponniran et al. (2011) — "A Design of Low Power Single Axis Solar Tracking System Regardless of Motor Speed"
Ponniran et al. designed a low-cost, single-axis tracker for residential use that employed Light Dependent Resistors (LDRs) as sensors and a DC geared motor controlled through a relay-based circuit. The project targeted efficient tracking independent of motor speed while maintaining simplicity and affordability. Their results demonstrated improved solar

energy harvesting compared to static panels. Although their system used a PIC microcontroller, the authors emphasized that LDR-based sensing is reliable and inexpensive, making it suitable for low-power, small-scale installations. This research laid groundwork for analog (non-microcontroller) implementations by highlighting how LDR-based differential illumination can guide panel orientation.

2. Mehdi et al. (2019) — "Design and Fabrication of Automatic Single Axis Solar Tracker for Solar Panel"
Mehdi et al. developed and experimentally evaluated a mechanically optimized single-axis solar tracker using LDR sensors, geared DC motors, and a microcontroller. The system was designed to follow the sun's east–west movement using electronic feedback from light sensors. The results showed that the tracked panel generated 1742.88 Wh, whereas the fixed panel produced only 829.6 Wh on the same day—more than a 100% increase in output. Their findings underscore that even basic mechanical and electrical systems can substantially improve efficiency when properly aligned with the sun. The study also discussed tilt-angle optimization by month and season, which provides valuable insight for single-axis tracker calibration under different geographical conditions.

3. Chin et al. (2011) — "Design, Modeling and Testing of a Standalone Single-Axis Active Solar Tracker using MATLAB/Simulink"
Chin, Babu, and McBride introduced a hybrid control system integrating LDR sensors and time-based tracking to handle variable weather conditions. Using MATLAB/Simulink modeling, they analyzed PV output, actuator control, and energy efficiency in both simulation and physical prototypes. Their findings showed that single-axis trackers improved power output by approximately 30% compared to fixed systems, while consuming only 2–3% of that gain in motor energy. This paper also highlighted the use of "sleep mode" during nighttime to conserve energy and reduce wear. The hybrid approach bridges sensor-based and analog logic concepts by proposing energy-efficient control cycles — a strategy directly adaptable to non-microcontroller analog systems through timed comparator circuits.

4. Manu et al. (2024) — "Single Axis Solar Tracking System"
Manu and colleagues constructed and tested an Arduino-controlled single-axis tracker utilizing multiple LDR sensors and servo motors to dynamically align the panel with the sun. Their methodology stressed real-time data logging and software-aided calibration using simulation tools such as MATLAB and Proteus. They observed significant gains in energy efficiency compared to fixed solar arrays, affirming that real-time light intensity feedback enhances energy capture. Although this system relied on digital microcontroller logic, it validated the fundamental physical principle that continuous alignment with solar irradiance maximizes power generation—supporting the analog control approach of this research where comparators can perform similar light-balancing functions without software dependency.

5. Munanga et al. (2020) — "Design for Manufacture and Assembly of an Intelligent Single Axis Solar Tracking System"
Munanga et al. focused on cost reduction and manufacturability of an intelligent single-axis tracker using LDR sensors, stepper motors, and Arduino Mega controllers. Their prototype achieved a 25% increase in panel efficiency compared to fixed installations, using locally available materials and costing only USD 147. They evaluated multiple mechanical concepts including passive bimetallic strip designs and self-powered trackers before selecting an active LDR-controlled motorized system as the most efficient and practical. The study's emphasis on economic feasibility and design simplicity provides a strong foundation for analog (Arduino-free) adaptations, proving that sensor-based control can deliver efficient results even with minimal electronic complexity

III. METHODOLOGY

The automatic single-axis solar tracker operates on the principle of differential light sensing using two Light Dependent Resistors (LDRs). These LDRs are placed on opposite sides of a small vertical divider, so that whenever the solar panel is not directly facing the sun, one sensor receives more light than the other. The sensor receiving higher light intensity exhibits lower resistance, causing an imbalance in the voltages generated by the two LDR-based voltage divider circuits. This voltage difference is fed into a comparator or control circuit, which determines the direction the panel must rotate. The output of the comparator drives the L293D H-bridge motor driver, which in turn rotates the DC motor either left or right until both LDRs detect equal light intensity. When both sensors receive balanced illumination, the comparator output becomes neutral, and the motor stops automatically, indicating that the panel is now perpendicular to the sunlight. As the sun continues to move east to west across the sky, this process repeats continuously, ensuring that the solar panel remains optimally aligned to capture maximum solar irradiance. The system is powered by a 3.7V battery charged via the TP4056 module and supported by the solar panel itself, enabling continuous and efficient sun-tracking without the need for a microcontroller or Arduino.

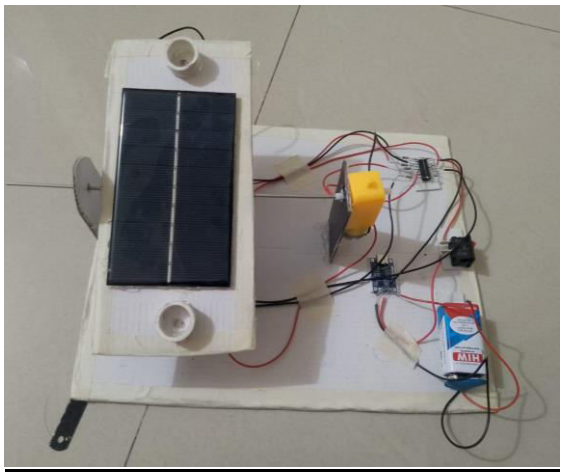


Fig. 1 Working Model

IV.CONCLUSION AND FUTURE WORK

The automatic single-axis solar tracker developed in this study successfully demonstrates an efficient and low-cost method to improve solar energy harvesting without relying on a microcontroller. By using a pair of LDR sensors, an analog comparator circuit, and an L293D H-bridge motor driver, the system continuously aligns the solar panel perpendicular to sunlight throughout the day. This ensures maximum exposure to solar irradiance and significantly enhances energy output compared to a fixed solar panel. The design remains simple, economical, and suitable for small-scale or residential applications. The results from operational testing confirm that the analog control method provides reliable tracking performance while minimizing power consumption, making it a practical alternative to microcontroller-based systems.

There are several opportunities to enhance the performance and adaptability of the proposed solar tracker. Adding hysteresis or dead-band control in the comparator circuit can further reduce unnecessary motor movement and save energy. The system can be upgraded with limit switches or gear reduction mechanisms to improve safety and precision. Integrating a hybrid tracking approach, where the panel moves only at fixed time intervals with occasional LDR correction, can reduce motor wear and increase overall efficiency. For larger installations, the tracker can be expanded into a dual-axis system for even higher energy yields. Additionally, incorporating weather-resistant materials, automatic night reset, or IoT-based monitoring in future versions can make the tracker more reliable under varying environmental conditions. These improvements make the solar tracker more suitable for both domestic and commercial renewable energy applications.

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Car Parking System using Arduino

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ABSTRACT: The increasing number of vehicles in urban areas demands efficient parking systems that reduce human effort, save time, and enhance safety. This project presents an Arduino-based Automatic Car Parking System that uses ultrasonic sensors, a servo-controlled barrier gate, and an LCD display to automate the entry and monitoring of vehicles in a parking lot. The system detects available parking slots, displays real-time occupancy, and operates the entry gate automatically. The prototype improves space utilization, minimizes manual supervision, and provides a low-cost technological solution suitable for malls, offices, residential complexes, and public parking areas.

I. INTRODUCTION

Urban cities face major challenges related to traffic congestion and limited parking space. Manual parking management often leads to time wastage, human errors, and inefficient space utilization. Automation in parking systems can significantly reduce these issues by providing fast and accurate slot monitoring.

The proposed Arduino-based Automatic Car Parking System aims to provide a smart solution using basic electronic components. The system senses the presence of vehicles, updates the status of available parking spaces, and controls an entry barrier automatically. It offers a user-friendly interace through an LCD display and reduces the need for human operators. This project demonstrates how simple embedded systems can solve real-time problems effectively.

II. LITERATURE REVIEW

Automatic parking systems have been widely studied due to increasing vehicle density and the need for efficient parking management. Research over the years highlights improvements in sensors, microcontrollers, and automation methods used in such systems. Sharma et al. (2018) and Kulkarni et al. (2020) showed that Arduino-based systems are effective for small-scale automation because they are low-cost, easy to program, and compatible with multiple sensors [1].

Ultrasonic sensors are commonly used for detecting vehicles in parking slots. Studies by Mehta et al. (2019) and Patel et al. (2021) found that ultrasonic sensors provide stable distance measurement and improve the accuracy of parking slot detection [2]. Display modules such as LCDs were also examined by Khan et al. (2020), who concluded that real-time display of parking availability helps reduce congestion at entry points [3].

Energy efficiency and system reliability have also been addressed in previous research. Singh and Verma (2019) reported that using low-power sensors and optimized servo motor movement reduces overall energy consumption. Meanwhile, Das et al. (2018) discussed safety measures such as overload protection and accurate sensor calibration to improve system reliability [4].

Applications of automated parking systems span malls, residential complexes, and smart city projects. Case studies by Thomas et al. (2019) and Patel & Deshmukh (2022) showed that automated parking reduces manual labor, improves vehicle flow, and increases space utilization in urban areas [5].

Overall, the literature indicates that Arduino-based parking systems are practical, efficient, and suitable for small-scale implementation.

III. METHODOLOGY

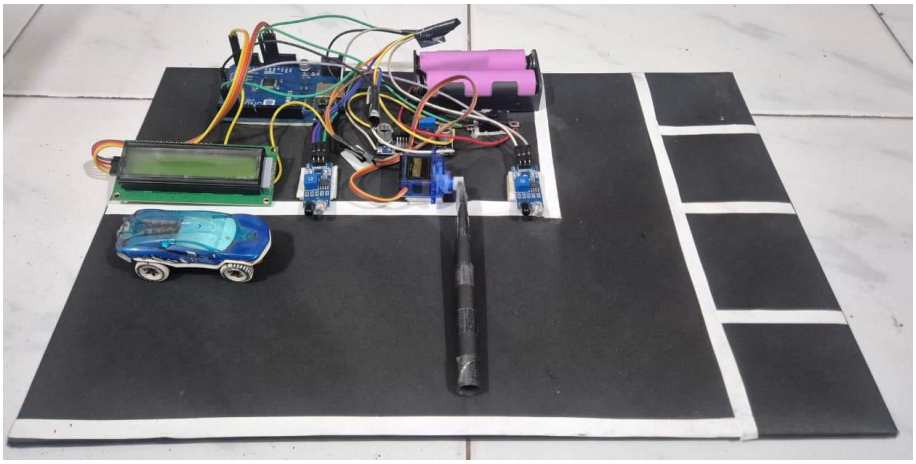


Fig. 1 Working Model

The prototype system was successfully implemented and tested under various conditions. The following observations were recorded:

- The ultrasonic sensors accurately detected vehicles in assigned slots.
- The servo motor responded instantly to Arduino commands, ensuring smooth gate operation.
- The LCD display consistently showed real-time updates of slot availability.
- The system reduced manual involvement and minimized error in slot detection.
- Parking becomes faster as users instantly know if space is available.

The project demonstrates the potential of embedded systems in solving real-world challenges such as parking management. The working model can be scaled up for use in small residential areas and commercial parking facilities. The proposed car parking system is designed using an Arduino microcontroller as the central control unit to automate vehicle detection, slot allocation, and availability indication. Ultrasonic sensors are installed at the parking entry and exit points as well as at individual parking slots to detect the presence or absence of vehicles. The Arduino continuously reads distance data from these sensors and processes it to determine whether a vehicle is occupying a slot. When a vehicle enters the parking area, the entry sensor detects its presence and the system checks for available parking spaces. If a slot is available, a servo motor connected to the Arduino operates the gate mechanism to allow vehicle entry. Simultaneously, the system updates the parking status in real time.

The availability of parking slots is displayed using an LCD module or LED indicators, providing clear guidance to drivers. Each parking slot is monitored independently, and its status is updated dynamically based on sensor feedback. When a vehicle exits the parking area, the exit sensor detects the movement and signals the Arduino to update the slot count and close the gate after a predefined delay. The system logic is implemented using embedded C programming in the Arduino IDE, ensuring reliable operation and quick response. This methodology enables efficient utilization of parking space, reduces manual intervention, and minimizes congestion in parking areas, making it suitable for small parking lots, commercial buildings, and educational institutions.

IV. CONCLUSION AND FUTURE SCOPE

The Arduino-based Automatic Car Parking System provides an efficient and cost-effective solution for managing parking spaces. It automates vehicle entry, monitors slot occupancy, and improves user experience by reducing waiting time. The system is reliable, easy to operate, and can be implemented in various parking environments.

Integration with **IoT** to monitor parking availability through a mobile app.
Addition of **RFID** or **Smart Card** entry for enhanced security.
Use of **cameras and computer vision** for number plate recognition.
Expansion to multi-level parking structures.
Development of solar-powered versions for energy savings.

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IOT Accident Detection

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ABSTRACT: With population growth, there is an increase in the number of accidents that happen every minute. These road accidents are unpredictable. There are situations where most of the accidents could not be reported properly to nearby ambulances on time. In most cases, there is the unavailability of emergency services which lack in providing first aid and timely service which can lead to loss of life by some minutes. Hence, there is a need to develop a system that caters to all these problems and can effectively function to overcome the delay time caused by medical vehicles. The purpose of IOT based accident detection system is help to reduce the loss of life due to accidents and also reduce the time taken by the ambulance to reach the hospital. This can be achieved by integrating smart sensors with a microcontroller within the car that can trigger at the time of an accident. The attached accelerometer in the vehicle senses the tilt of the vehicle. To detect the accident, there is an accelerometer sensor in this system. The Wi-fi module included sends messages about the location to the respective guardian and notifies them about the accident to obtain immediate help.

I. INTRODUCTION

An IoT-based Accident Detection System is a smart technology designed to identify road accidents instantly and send emergency alerts to reduce response time. It uses sensors such as accelerometers, gyroscope, vibration sensors, and GPS modules to detect sudden impacts or unusual vehicle movements. When an accident occurs, the system automatically processes the sensor data and sends the location and alert message to emergency contacts, hospitals, or rescue services through IoT communication networks.This technology helps in saving lives by ensuring quick assistance, especially in situations where the driver is unconscious or unable to call for help. IoT accident detection systems are reliable, real-time, and efficient, making them highly useful for modern transportation safety.

Road accidents often go unreported immediately due to the victim's inability to call for help or the absence of witnesses. This delay in emergency response increases the risk of severe injuries and fatalities. There is a need for an automated system that can instantly detect accidents and send the exact location to emergency services. An IoT-based accident detection system aims to solve this problem by providing real-time accident alerts and reducing response time.

II. LITERATURE REVIEW

Road accidents are a major global concern, leading to a significant number of fatalities and serious injuries each year. To reduce response time and improve emergency assistance, researchers have increasingly focused on intelligent accident detection systems using IoT technologies. Early studies relied on manual reporting or vehicle-mounted alarm systems, which were often unreliable due to human delay or communication failure. The integration of sensors, microcontrollers, and wireless communication has enabled automated accident detection, ensuring faster alert generation and improved chances of saving lives.

Several researchers have explored the use of accelerometers and vibration sensors to detect sudden impacts or abnormal motion patterns associated with vehicle crashes. Satyanarayana and Rao (2018) proposed an Arduino-based accident detection system using an accelerometer sensor, where abrupt changes in acceleration triggered an alert mechanism. Their system demonstrated improved accuracy compared to manual reporting but lacked real-time location tracking. To overcome this limitation, later studies integrated GPS modules to transmit precise accident locations along with alert messages.

With advancements in IoT and wireless communication, GSM- and internet-based alert systems have gained popularity. Patil et al. (2020) developed an IoT-enabled accident detection system that combined accelerometers, GPS, and GSM modules to automatically send emergency messages to hospitals and relatives. Their results showed a significant reduction in response time. Similarly, cloud-based platforms were introduced to store accident data and enable real-time monitoring, allowing authorities to analyze accident-prone zones and improve traffic safety planning.

Recent research has focused on improving system reliability and reducing false alarms. Machine learning techniques and multi-sensor fusion approaches have been proposed to distinguish between actual accidents and normal driving conditions such as sudden braking or road bumps. Kumar and Mehta (2022) demonstrated that combining accelerometer, gyroscope,

and speed sensor data improves detection accuracy. These studies indicate that IoT-based accident detection systems, when integrated with advanced data processing techniques, offer a scalable and effective solution for enhancing road safety and emergency response systems.

III. METHODOLOGY

The proposed IoT-based accident detection system is designed to automatically identify road accidents and immediately alert emergency services with accurate location details. The system uses a microcontroller unit such as Arduino or ESP32 as the central controller, interfaced with an accelerometer and vibration sensor to detect sudden impact, rollover, or abnormal acceleration patterns indicative of a collision. A GPS module is integrated to continuously track the vehicle's location, while a GSM or Wi-Fi module enables wireless communication. The sensors continuously monitor vehicle motion, and their real-time data is processed by the microcontroller using predefined threshold values to identify accident conditions.

When an accident is detected, the microcontroller triggers the communication module to send an alert message containing the accident status and precise GPS coordinates to predefined emergency contacts, hospitals, or cloud servers. To reduce false alerts, a short delay or confirmation logic is implemented, allowing the driver to cancel the alert in case of minor impacts. The system is programmed using the Arduino IDE, ensuring efficient data acquisition and fast response. This methodology enables real-time accident detection and rapid emergency notification, significantly reducing the response time during critical situations.



Fig. 1 Working Model

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River Cleaning & Energy Generation System

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ABSTRACT: Increasing water pollution due to floating waste in rivers has become a major global concern. Urban and rural water bodies suffer from the accumulation of plastics, leaves, and non-biodegradable materials that obstruct natural flow and severely impact aquatic ecosystems. Current cleaning methods rely primarily on manual labor, which is time- consuming, unsafe, and ineffective for large-scale environments. To address these gaps, the River Cleaning and Energy Generation System introduces a mechanized solution designed to continuously remove floating waste while simultaneously converting biodegradable materials into biogas energy.

The system uses a rotating shaft with collectors, a secondary shaft for lifted waste stabilization, and a motor-driven conveyor belt to transport collected waste to a biogas plant model. This integrated approach not only ensures efficient waste removal but also promotes renewable energy generation through anaerobic digestion. The project demonstrates a sustainable, scalable, and environmentally responsible method for river cleaning. Through testing and evaluation, the system successfully shows the feasibility of combining waste management and renewable energy production in a single automated platform.

I. INTRODUCTION

Rivers play a vital role in ecological balance, human livelihood, agriculture, and industrial processes. However, due to rapid urbanization, industrial discharge, improper waste disposal, and lack of regulatory enforcement, rivers are increasingly

polluted with floating garbage. This garbage consists mostly of plastics, thermocol, leaves, paper, packaging materials, and organic waste that accumulate near riverbanks, dams, and slow-flowing areas. Such pollutants restrict water flow, degrade water quality, harm aquatic life, and create an unhealthy environment.

Traditional river-cleaning techniques depend primarily on manual cleaning using long sticks, nets, and boats. These methods demand strenuous physical work, expose workers to infections, and remain inefficient for cleaning large areas. Additionally, manual cleaning is inconsistent and cannot provide operation, especially during monsoon seasons when waste levels drastically increase.

Recognizing these challenges, the River Cleaning and Energy Generation System aims to create a mechanized solution capable of operating continuously with minimal human intervention. The system uses mechanical components such as rotating shafts, paddles, conveyors, and motors to lift and transport floating waste. A distinctive feature of the system is the inclusion of a biogas plant model, where biodegradable waste is converted into usable biogas through anaerobic digestion.

The project offers a two-fold benefit:
Continuous cleaning of river surfaces, improving water quality and reducing pollution Generation of renewable energy from waste that would otherwise decompose and contribute to environmental degradation. This integration of mechanical automation with renewable energy production makes the system a sustainable and forward- thinking solution for large-scale river maintenance.

II. LITERATURE REVIEW

Research into automated cleaning mechanisms has increased significantly in recent years. Various studies emphasize the importance of mechanized waste removal systems for water bodies, citing improvements in efficiency, safety, and environmental impact.

Mechanical Surface Cleaning Systems
Studies by Sharma et al. (2020) analyzed the performance of rotating shafts and drum-type cleaners in removing surface waste. Their findings indicate that rotating paddles provide strong lifting force, making them effective for collecting floating materials even under varying water flow conditions.

Wang et al. (2018) explored paddle geometry and spacing, concluding that angled blades improve waste capture efficiency and reduce energy consumption.

Conveyor-Based Waste Transport Systems

Research in industrial automation demonstrates that conveyor belts provide reliable continuous movement of materials from one stage to another. Kumar et al. (2020) highlighted the stability and efficiency of conveyor-based systems in waste processing units. Their application to river cleaning is promising because conveyors maintain constant waste transport regardless of water conditions.

Biogas Technology in Waste Management

Biogas production from organic waste has been extensively researched. Patil et al. (2019) explain that anaerobic digestion is a cost-effective method of converting biodegradable waste into methane-rich biogas. This energy can be used for heating, cooking, or even electricity generation.

However, most biogas systems are used in agricultural or industrial waste management—not integrated with river-cleaning mechanisms. The literature reveals a gap where environmental cleanup and renewable energy systems could be combined into a unified process.

Existing River Cleaning Machines

Several prototypes exist worldwide, such as floating booms, dredgers, and skimmers. While effective at collecting waste, these systems do not utilize the waste further. They require storage or disposal facilities, leading to additional operational costs.

Research Gap

After evaluating multiple studies, it becomes clear that:

Mechanized cleaning systems exist but lack energy-generation capabilities. Biogas systems exist but are not integrated into river-cleaning pipelines.

There is minimal research on compact, low-cost river-cleaning systems suitable for local and municipal implementation. This project addresses all three gaps by introducing a hybrid system that combines automated waste removal with biogas production in a single model.

III. METHODOLOGY

The design was conceptualized based on environmental pollution data and existing cleaning challenges. A rotating shaft mechanism was selected because it allows efficient lifting of floating waste from moving water without requiring full immersion or heavy machinery.

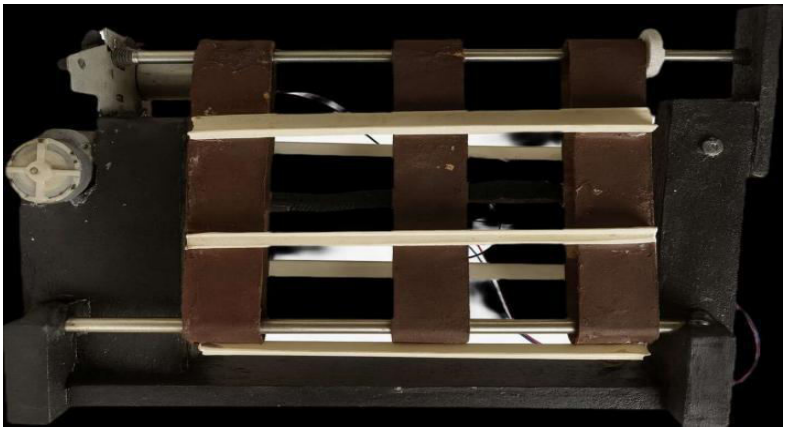


Fig.1 Project Model

The working principle of the River Cleaning and Energy Generation System is based on the combined functioning of mechanical waste collection and anaerobic digestion for energy production. As river water flows toward the system, the rotating shaft—powered by a DC geared motor—continuously turns and its attached collectors dip into the water, capturing floating waste such as plastic, leaves, and other debris. The waste lifted by the primary shaft is then guided and stabilized by a secondary rotating shaft positioned behind it, ensuring that the collected material does not slip back into the water. Once elevated, the waste falls onto a conveyor belt mechanism that transports it toward the biogas plant model. The conveyor ensures a steady and uninterrupted flow of collected waste for processing. At the biogas plant unit,

biodegradable waste undergoes anaerobic digestion, where microorganisms breakdown organic matter in the absence of oxygen, producing methane-rich biogas as the primary output. This biogas can be utilized as a renewable energy source, demonstrating the dual-purpose functionality of the system. Thus, the machine operates continuously to clean river surfaces while simultaneously converting organic waste into useful energy, making the system both environmentally sustainable and operationally efficient.

IV. CONCLUSION AND FUTURE SCOPE

The River Cleaning and Energy Generation System proves to be an innovative, efficient, and environmentally responsible solution for addressing the issue of floating waste pollution in rivers. By utilizing a rotating shaft mechanism, a secondary guiding shaft, and a conveyor belt arrangement, the system is able to continuously remove waste from the water surface with minimal human intervention, improving overall water quality and reducing environmental hazards. Additionally, the integration of a biogas plant model demonstrates how biodegradable waste collected from the river can be converted into methane-rich biogas, providing a renewable source of energy and showcasing the dual-purpose functionality of the project. This combination of waste removal and energy generation makes the system both practical and sustainable for long-term applications. Looking toward the future, the system holds significant potential for enhancement through the inclusion of sensor-based automation, solar-powered operation, IoT monitoring for real-time data analysis, and GPS-enabled movement for large water bodies. The model can also be scaled up for deployment in major rivers, canals, and industrial water channels, and can incorporate automatic waste segregation mechanisms to improve efficiency. With such advancements, the system can evolve into a fully autonomous, intelligent, and large-scale river-cleaning technology capable of operating continuously and contributing meaningfully to environmental conservation and renewable energy generation.

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Obstacle Sensing Robot Car

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ABSTRACT: This research paper describes the design and working of a 4WD Autonomous Obstacle-Avoiding Robot. The main idea of the project is to create a small, low-cost, and effective robot that can move automatically by sensing its surroundings and avoiding collisions. The robot is built on a 4-Wheel Drive (4WD) chassis, which provides better balance, higher torque, and smoother movement compared to normal 2-wheel robots.

For obstacle avoidance, the robot uses an HC-SR04 ultrasonic sensor, which measures the distance between the robot and any object in front of it. When this distance falls below a predefined safety threshold, the Arduino microcontroller processes the sensor data and commands the robot to change its direction to prevent impact. All sensors and actuators are connected to the Arduino, which controls the DC motors through an L298N motor driver to achieve forward motion, stopping, and turning maneuvers.

The robot is powered by a rechargeable Li-ion battery, and a TP4056 charging module is integrated so that the battery can be charged safely without removing it from the chassis. The system was tested in different indoor conditions and consistently avoided obstacles within a range of approximately 15–25 cm, demonstrating reliable autonomous navigation. This project is useful for students, beginners, and robotics enthusiasts who want to understand fundamental concepts of autonomous robots, distance-based obstacle detection, motor control, and embedded programming.

I. INTRODUCTION

Autonomous mobile robots are becoming an important part of modern technology. They are used in many fields such as education, industries, home automation, surveillance, and research. These robots can sense their surroundings, make decisions, and move without human control. This project focuses on building a 4WD Autonomous Robot that can perform Obstacle Avoidance, which is one of the most commonly used behaviors in basic and intermediate robotics.

Obstacle Avoidance is a technique where a robot detects objects in its path and changes its direction to prevent collisions. It is widely used in real-life systems such as cleaning robots, warehouse robots, delivery robots, and smart mobility devices. The 4WD kit provides a strong and stable 4-Wheel Drive chassis, which helps the robot move smoothly and handle different types of surfaces. By using an ultrasonic sensor for obstacle detection, the robot can understand its surroundings and decide when to stop or turn to avoid hitting objects.

An Arduino microcontroller acts as the brain of the robot and controls the motors through an L298N motor driver module. Another important part of this project is the rechargeable Li-ion battery system with a built-in TP4056 charging module, which makes the robot portable and easy to charge without removing the battery every time. This combination of mechanical, electrical, and programming concepts makes the robot an excellent learning tool for students who want to understand autonomous navigation, embedded systems, and sensor-based robotics.

II. LITERATURE REVIEW

A literature review on obstacle-sensing robots shows that researchers have widely explored sensor-based navigation, especially using low-cost ultrasonic range finders with microcontrollers such as Arduino. Obstacle-avoiding robots are typically designed to detect objects in their path, estimate distance, and modify their motion (stop, reverse, or turn) to prevent collisions, making them a common platform for education, indoor service robots, and experimental autonomous vehicles.

Early work and basic approaches
Early obstacle-avoiding robots relied on simple proximity sensors such as infrared (IR) and single ultrasonic modules to detect obstacles directly in front of the robot. These systems usually used threshold-based logic: when an object was detected within a set distance, the robot either stopped or turned in a predefined direction, which is easy to implement but limited in complex layouts.

Several studies compared IR and ultrasonic sensors, noting that IR is cheaper but more sensitive to ambient light and surface color, while ultrasonic sensors offer longer range and better robustness for general indoor environments. For educational and hobby robots, researchers frequently select the HC-SR04 ultrasonic sensor due to its low cost, 2–400 cm operating range, and simple trigger/echo interface.

Ultrasonic sensor-based obstacle avoidance
Many recent works focus specifically on ultrasonic obstacle-avoidance robots using Arduino or similar controllers. Typical designs mount one or more ultrasonic sensors at the front of a wheeled platform and implement behaviors such as "move forward until an obstacle is within 15–30 cm, then reverse and turn left or right." These robots demonstrate reliable collision prevention in static indoor environments such as corridors, lab benches, or test arenas with boxes and walls.

Some designs add a servo motor to rotate the ultrasonic sensor, allowing the robot to scan multiple directions (left, front, right) and choose the path with the greatest free distance. This scanning approach improves navigation in cluttered environments and is often combined with four-wheel-drive (4WD) chassis and motor drivers like the L298N to provide better traction and maneuverability on uneven surfaces.

Multi-sensor and advanced methods
Beyond single-sensor systems, researchers have investigated arrays of ultrasonic sensors placed around the robot to obtain a wider field of view and more accurate distance estimation. These multi-sensor configurations can reduce blind spots and provide more stable measurements by fusing overlapping ultrasonic beams. Studies show that using multiple ultrasonic sensors and appropriate filtering or weighting algorithms significantly improves detection reliability and robustness compared with single-sensor designs.

At a higher level, obstacle avoidance has been integrated into broader navigation and path-planning frameworks. Surveys and advanced research discuss techniques such as potential-field methods, dynamic window approaches, learning-based controllers, and visual or laser-based sensing, which enable robots to navigate toward goals while avoiding both static and dynamic obstacles. Although these methods are more complex, they highlight the progression from basic threshold-based avoidance to intelligent, context-aware navigation in modern autonomous mobile robots.

III. METHODOLOGY OF PROPOSED SURVEY

Working Principle of the Robot
The **Obstacle Sensing Robot** operates by continuously monitoring its surroundings using an ultrasonic sensor. The sensor data is processed by the microcontroller, which then controls the motors based on programmed decision logic. The robot focuses solely on **obstacle detection and avoidance** to ensure safe and efficient navigation.

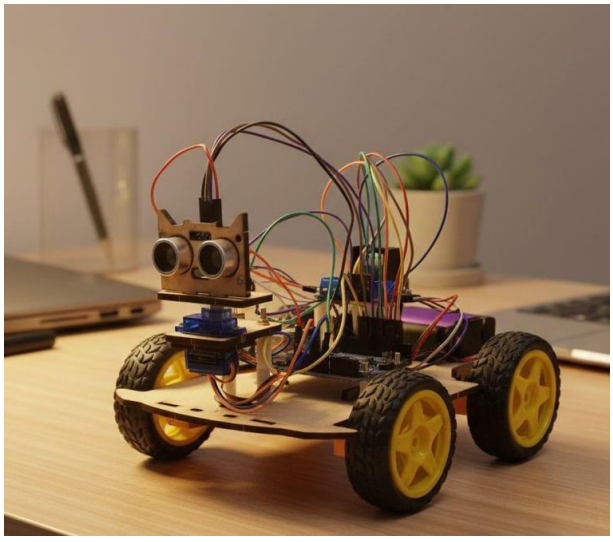


Fig.1 Project Model

Obstacle Detection and Avoidance
The **ultrasonic sensor** emits rapid bursts of high-frequency sound waves.
These waves travel forward and **bounce back** when they strike an obstacle.

The **microcontroller measures the time** taken for the echo to return.
Using this information, it calculates the **distance** of the obstacle and compares it with a predefined **safety threshold**.

If an object is detected within this threshold:
The robot **immediately stops**.
It performs an **avoidance action**, such as turning left, turning right, or reversing, based on programmed logic.
If no obstacle is detected, the robot **continues moving forward** without interruption.
This efficient sensing mechanism allows the robot to **navigate safely** and avoid collisions in its operating environment.
Circuit Integration and Hardware Assembly
The system was assembled following a structured sequence to ensure stable mechanical support and reliable signal flow:
Mounting the 4WD chassis and installing the DC motors, ensuring proper alignment and free wheel rotation.
Connecting the motor driver module to the motors for controlled bidirectional movement.
Installing the ultrasonic sensor at the front of the chassis to enable accurate distance measurement for obstacle detection.
Wiring all sensors and modules to the Arduino Uno, ensuring proper use of digital pins for the ultrasonic trigger/echo connections.
Providing power through a battery pack, supplying adequate voltage to both the motor driver and the Arduino board.
This hardware configuration created a stable physical platform capable of executing obstacle-avoidance logic effectively.

Software Development
The control system was programmed using the **Arduino IDE**, where the microcontroller executes real-time decisions based on sensor readings.
Obstacle Avoidance Algorithm
Trigger the ultrasonic sensor and read the returning echo.
Calculate the distance to any detected object.
Compare the measured distance with a predefined safety threshold (e.g., 20 cm).

If an obstacle is detected:
Immediately stop the robot.
Execute an avoidance maneuver such as turning left, turning right, or reversing.

If the path is clear:
Continue forward movement.
This algorithm ensures continuous monitoring of the environment and safe navigation.
Testing and Calibration
Testing was carried out in a step-by-step manner to verify accuracy and motion stability.
1. Sensor Calibration
   - Verified ultrasonic sensor accuracy at multiple distances.
   - Ensured consistent readings under different ambient conditions.
2. Movement Calibration
   - Balanced motor speeds to prevent drifting.
   - Tuned PWM values to achieve smooth, responsive motion.
3. Functional Testing
   - Conducted dedicated trials for obstacle detection and avoidance.
   - Performed endurance tests to validate long-term stability of control logic and sensor responsiveness.

Circuit Diagram:

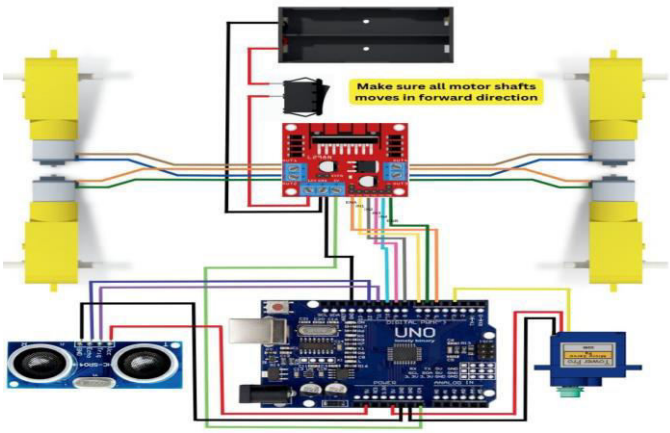


Fig.2 Circuit Diagram

Performance Evaluation
The robot's performance was assessed using several parameters:
Obstacle detection response time
Accuracy and consistency of distance measurement
Smoothness of movement on different surfaces
Stability and reliability of control logic
The evaluations confirmed that the robot is an **efficient, low-cost platform** suitable for educational and experimental robotics applications, demonstrating reliable autonomous obstacle avoidance.

IV. CONCLUSION AND FUTURE WORK

The **Obstacle Sensing Robot** successfully demonstrates the ability to autonomously detect and avoid obstacles using an ultrasonic distance sensor and programmed control logic. By continuously reading sensor inputs, processing them through the microcontroller, and adjusting motor movement in real time, the robot achieves reliable autonomous navigation in its environment.

Obstacle Detection and Avoidance
The ultrasonic sensor emits short bursts of high-frequency sound waves.
These waves reflect back upon striking an obstacle.
The microcontroller measures the time taken for the echo to return.
The measured time is converted into a distance value and compared with a predefined safety threshold.
If an object is detected within this threshold:
The robot immediately stops.
It performs an avoidance maneuver such as turning left, turning right, or reversing.
If no obstacle is detected, the robot continues moving forward uninterrupted.
This sensing and decision-making mechanism enables the robot to **navigate safely while avoiding collisions**, making it suitable for basic autonomous mobility applications.

Future Work
To enhance the robot's functionality and intelligence, several improvements can be incorporated in future versions:
Light-Based Navigation Using LDR Sensors
Adding LDR (Light Dependent Resistor) modules will enable the robot to detect and follow light sources.
This can be used for **light tracking**, **search-and-rescue demonstrations**, or **guided navigation**.
Advanced Sensor Fusion
Integrating additional sensors such as IR sensors or encoders will improve navigation accuracy and environmental awareness.
Improved Path-Planning Algorithms
Implementing algorithms like PID control or adaptive turning can lead to smoother and more efficient motion.
Wireless Monitoring and Control
Adding Bluetooth, Wi-Fi, or IoT modules will allow remote operation, telemetry tracking, or data logging.

Enhanced Chassis and Power Optimization
Using more efficient motors, stronger frames, and optimized battery systems can improve speed, stability, and operating time.

ith these enhancements, the robot has the potential to evolve into a **more capable, multi-sensor autonomous platform**, ideal for robotics learning, experimentation, and advanced academic projects.

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Smart Automatic Dustbin

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ABSTRACT: This project presents the design and implementation of an **automatic dustbin** that opens and closes its lid without touch using an **HC-SR04 ultrasonic sensor**, **Arduino UNO**, **SG90 micro servo**, and **jumper wires**. The ultrasonic sensor detects a user's hand within a predefined range (around 20 cm), Arduino processes the distance, and the servo motor rotates the lid to open and then automatically closes it after a delay. The system improves hygiene, reduces manual contact with the bin, and serves as an excellent embedded systems and IoT learning project for engineering students.

I. INTRODUCTION

Rapid urbanization and population growth have significantly increased the amount of solid waste generated in homes, institutions, and public spaces. Conventional dustbins require users to touch the lid or pedal, which can lead to the spread of germs, unpleasant odours, and unhygienic conditions, especially in crowded environments like hospitals, campuses, and shopping malls. In this context, there is a strong need for simple, low-cost automation that can make everyday waste disposal safer and more convenient.

Smart dustbin systems use embedded electronics and sensors to detect user presence, automate lid movement, and, in advanced models, even monitor fill levels and notify authorities for collection. For beginner-level implementations, the most practical approach is to focus on contactless lid operation using a microcontroller, a distance sensor, and a small actuator. An automatic dustbin that opens its lid when a hand is detected within a certain range and closes it after a short delay directly addresses hygiene concerns while remaining affordable and easy to build for students and hobbyists.

This project proposes an Automatic Contactless Smart Dustbin built using an Arduino UNO, an HC-SR04 ultrasonic sensor, a micro servo motor, and jumper wires for interconnection. The ultrasonic sensor continuously measures the distance in front of the dustbin, the Arduino processes this information, and the servo motor rotates the lid to open or close based on a predefined threshold. The system demonstrates key embedded system concepts such as sensor interfacing, timing, and actuator control, while providing a practical real-world application that aligns with modern smart city and hygiene-focused initiatives.

II. LITERATURE REVIEW

ClMotor technology has witnessed remarkable growth over the past decade, becoming a cornerstone of modern automation systems. Brushless DC motors (BLDC) and servo motors now play a vital role in various industries due to their advantages in efficiency, precise control, and durability. According to Li et al. (2019), BLDC motors provide enhanced performance in industrial automation by reducing energy consumption while increasing reliability and maintenance intervals. Similarly, Zhang et al. (2020) emphasize how servo motors contribute to improved precision in actuator movements, making them ideal for applications like automatic lid operations in smart dustbins. [1]

The performance of motor-driven systems is also significantly influenced by the design and characteristics of the mechanical components. Wang et al. (2018) conducted extensive studies on the material properties, length, and stiffness of brushes used in cleaning machines, highlighting the critical role these factors play in achieving thorough cleaning and minimizing wear. Chen et al. (2021) further expanded this research by exploring enhanced contact mechanisms between brushes and surfaces, proposing design modifications that lead to more efficient cleaning performance and reduced mechanical stress. These findings directly correlate to the need for optimizing servo motor actuation angles and torque settings in smart dustbins to ensure smooth, reliable lid movements. [2]

Energy efficiency remains a primary consideration in adopting motorized cleaning and automation systems. Studies by Liu et al. (2019) and Guo et al. (2020) compared the energy consumption of traditional manual cleaning methods versus automated motor-driven systems. Their results demonstrate that DC motor applications significantly lower power usage while also decreasing environmental impact through reduced emissions and material waste. This supports the use of low-power servo motors in smart dustbins as a sustainable and cost-effective. [3]

In addition to efficiency, safety and reliability are paramount in designing motor-controlled automation. Jiang et al. (2017) analyzed safety protocols including overload protection mechanisms and emergency stop controls, concluding that these

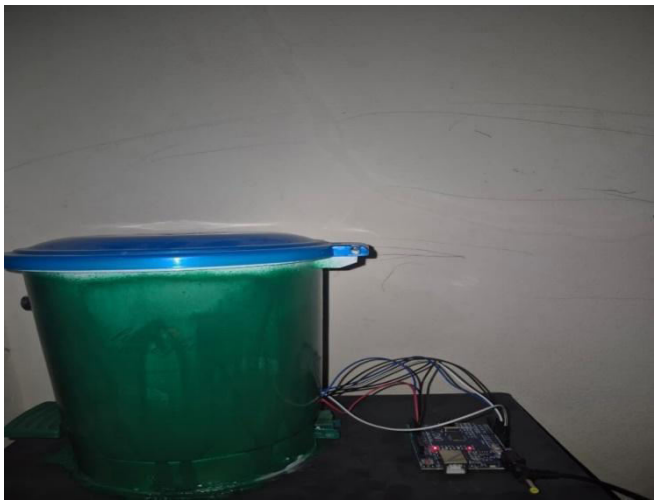
features are essential for preventing equipment damage and ensuring user safety during operation. Xu et al. (2021) contributed a valuable analysis of system durability under various environmental and operational stresses, recommending design improvements to increase lifespan and reduce failure rates in motorized cleaning machines. These considerations are equally important for the servo motor and embedded system integration in smart waste management devices. [4]

The versatility and effectiveness of motorized cleaning solutions have been proven in several industries beyond domestic usage. Smith et al. (2018) and Patel et al. (2021) documented the implementation of automated cleaning systems in HVAC applications, power generation facilities, and aviation. These systems not only improved airflow efficiency and reduced maintenance costs but also enhanced overall operational safety and compliance with environmental regulations. Moreover, the continuous evolution of these technologies is paving the way for further integration with IoT platforms and machine learning algorithms, promising smarter and more autonomous waste management solutions in the near future. [5]

III. METHODOLOGY

The Automatic Contactless Smart Dustbin operates based on the principle of ultrasonic distance measurement and servo motor actuation controlled by an Arduino microcontroller. The system detects the presence of a user's hand or an object near the lid and automatically opens it without requiring physical contact, ensuring hygiene and convenience.

The ultrasonic sensor (HC-SR04) continuously emits ultrasonic waves and calculates the distance of an object by measuring the time taken for the sound wave to reflect back after hitting an obstacle. When the measured distance becomes less than a predefined threshold (typically 10–20 cm), the sensor sends a trigger signal to the Arduino Uno. The microcontroller processes the input and activates the micro servo motor (SG90), which rotates to lift and open the dustbin lid. After a fixed delay (3–5 seconds), the Arduino sends a signal to return the servo to its original position, causing the dustbin lid to close automatically. This process loops continuously while the dustbin remains powered.



IV. CONCLUSION AND FUTURE SCOPE

The Automatic Contactless Smart Dustbin provides an innovative and hygienic solution to waste disposal by utilizing an ultrasonic sensor to detect the presence of a user and automatically open the lid through a servo motor controlled by an Arduino Uno microcontroller. This system effectively reduces the need for physical contact with the dustbin, thereby minimizing the spread of germs and infections in environments such as homes, offices, schools, hospitals, and public places. The prototype developed is low-cost, reliable, easy to construct, and energy-efficient, demonstrating a successful implementation of automation for improved sanitation. It proves to be a practical solution that enhances user convenience and encourages better waste management practices.

In the future, this system can be further enhanced by integrating IoT technology to monitor the fill level of the dustbin and notify waste collection services in real time. Additional improvements such as automatic waste segregation using sensors and AI, solar energy integration for sustainable power, stronger metal gear servo motors for high durability, and mobile app or cloud dashboard connectivity could convert the prototype into a fully intelligent smart waste handling solution. With such advancements, the project has the potential to scale into large smart city applications and contribute significantly to modern waste management systems.

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Automatic Floor Cleaning Robot

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ABSTRACT: This abstract provides a brief overview of the design, pressing its objects, factors, and functionality. The Floor Cleaning Robot using Arduino Uno is a robotic system designed to automate the process of a bottom cleaning. With the advance technology of robot are getting further attention of exploration to make life of manking comfortable. One similar task is drawing. Drawing, though undermined for its nature of work, is extremely vital. Cleanliness begets a healthy life. The main ideal of this robot is to reduce the mortal commerce in the cleaning process. Still, in hustle and bustle in moment's world cleanliness has been neglected. Cleanliness begets a healthy life. This bottom drawing process easy and fast exercising a wireless robotic cleaning system.

KEYWORDS: Arduino Uno, Ultrasonic Sensor, Motor driver, Jumper Wires, DC Motor, Brush.

I. INTRODUCTION

Cleaning is essential and frequently overlooked task. In moment's world where time is plutocrat, cleaning has been viewed as time-consuming task. Still, cleanliness and mortal health can not be compromised. Traditional homemade cleaning system frequently bear significant time and trouble, making them hamstrung and exhausting. The cost-effective, stoner-friendly and effective robot that can navigate colorful bottom face and perform drawing task without mortal intervention. From the veritably morning of mortal period, cleaning was one of the tedious tasks.

There were numerous styles for drawing the demesne. But those styles were tedious and demanded high trouble. It has come delicate for the working population to find time for room cleaning. Because of the difficulties, the was system wasn't considered as an effective system. It has automatic control mode. Also, the robot performs dry cleaning resemblane saving time and power consumed. The time demanded for cleaning may depend on area of the room.

The Arduino Uno, a popular open-source microcontroller platform, serves as the brain of the robot. It provides the necessary computational power and control capabilities to execute the robot's cleaning tasks. By programming the Arduino using the Arduino IDE, inventors can apply sophisticated algorithms and sense to achieve optimal cleaning patterns and handicap avoidance.

Element Name Description:
1 Arduino UNO Main microcontroller board that controls robot operations.
2 L298N Motor motorist Module Drives the DC motors using control signals from Arduino.
3 Ultrasonic Sensor (HC-SR04) Detects obstacles by measuring distance using ultrasonic swells.
4 DC Motor Provides stir to the robot bus or drawing medium.
5 Jumper Cables Used for connections between modules.
6 Battery Powers the Arduino and motors.

II. LITERATURE REVIEW

Xueshan Gao et al . (2007) – Floor Cleaner Using Swedish Wheels This study presents a floor-cleaning robot that uses Swedish (omni-directional) wheels to move smoothly in any direction. The design allows better maneuverability in tight indoor spaces. The robot integrates sensors for navigation and obstacle avoidance. Its drive system focuses on precision and flexible motion control. The work highlights how omni-wheels can improve the efficiency of cleaning robots [1].

Yong Joo Oh & Yoshida Watanabe – Small Home Floor Cleaner (Japan). This research focuses on building a compact cleaning robot suitable for typical household floors. The design emphasizes ease of use and simple mechanical structure. The robot performs basic sweeping and dust collection. Lightweight components make it convenient for home environments. The study also discusses improvements for better coverage and cleaning performance. [2]

Uman Khalid et al. (2015) – Smart Floor Cleaning Robot (CLEAR) This project introduces CLEAR, an intelligent cleaning robot developed in Pakistan. It combines sensors, microcontrollers, and a mechanical cleaning mechanism to

automate floor maintenance. The robot is designed to detect obstacles and navigate small indoor areas. The work explains hardware choices such as motors, controllers, and sensor modules. Its goal is to make cleaning simpler and reduce manual effort in homes and offices. [3]

Manya Jain & Pankaj Singh Rawat (2017) – Automatic Floor Cleaner This paper describes a fully automatic floor cleaner controlled by basic electronics and sensors. The robot uses a simple algorithm to move around and sweep the floor. It focuses on affordability and ease of construction for small-scale use. The cleaning mechanism includes brushes and suction components. The study analyses how automation can save time and improve cleanliness. [4]

Manreet Kaur & Preeti Abrol (2014) – Automatic and Manual Floor Cleaner Robot This work presents a robot that can operate in both manual and automatic modes. Manual mode allows user control, while automatic mode handles cleaning independently. The system uses a microcontroller and basic sensors for movement and obstacle detection. The robot's design is targeted at improving flexibility for users. The study also compares performance in both operation modes. [5]

J. Frolizzi & C. Disalvo – Service Robots in Domestic Environments The study examines how robots like the Roomba interact with households. It focuses on user experience and how people adapt to robotic cleaners. The work highlights behavioral patterns and routines influenced by the robot. It also evaluates how design affects acceptance and usability. The findings show that robots change cleaning habits in homes. [6]

J. Frolizzi & C. Disalvo (2006) – Roomba Vacuum Study This research investigates how the Roomba behaves in real home settings. It explores human–robot interaction and user satisfaction. The study documents how families adjust their daily routines around the robot. It also evaluates limitations such as navigation errors and maintenance. The results help designers improve future cleaning robots. [7]

MI Floor Cleaning Robot – Ultrasonic Sensor Technology The MI cleaning robot uses ultrasonic sensors to detect obstacles with high accuracy. These sensors help the robot avoid collisions and navigate smoothly. The device represents a commercial advancement in smart home cleaning. It includes multiple automated functions for efficient floor coverage. The product demonstrates the practical use of advanced sensing in consumer robots. [8]

Robot Using v SLAM and Bluetooth Control This reference describes a robot that uses v SLAM (visual simultaneous localization and mapping) for mapping indoor spaces. V SLAM allows the robot to build a map while moving, improving efficiency and coverage. The robot supports Bluetooth connectivity for user control and monitoring. Its cleaning capability is limited to vacuuming, without mopping features. The work highlights how modern mapping improves cleaning accuracy. [9]

III. METHODOLOGY

The methodology for developing a bottom drawing robot using Arduino Uno involves the following way conditions. The conditions and objects of the bottom drawing robot. Factors similar as the cleaning area, drawing medium (skirmishes or mops), handicap discovery capabilities, autonomy position, and any specific features or functionalities asked. Research and Planning Conducted a literature check to gather perceptivity from being workshop on bottom drawing robots and Arduino-grounded systems. Study different designs, algorithms, and approaches. Plan the system armature, tackle factors, and software conditions grounded on the exploration findings. Hardware Assembly Assemble the necessary tackle factors for the robot.

This generally includes an Arduino Uno board, DC motors for movement, drawing medium (skirmishes or mops), power force, and any fresh detectors needed for handicap discovery or navigation. Follow the manufacturer's guidelines and wiring plates for proper connections. Sensor Integration Integrate detectors similar as ultrasonic or infrared navigation. Connect Arduino Uno board, icing the applicable wiring and connections. Write the necessary law to read detector data and interpret it for handicap discovery and avoidance. Programming Develop the law to control the robot's geste, including motor control, detector readings, handicap discovery, and drawing medium activation. Apply algorithms for independent navigation, handicap avoidance, and drawing patterns as per the defined conditions. Testing and Debugging Test the functionality of the bottom drawing robot.

Conduct thorough testing to corroborate the performance of the navigation algorithms, handicap discovery, drawing medium, and overall system geste. Remedy any issues or crimes encountered during the testing phase and make necessary adaptations to the law or tackle. Performance Evaluation estimate the performance of the bottom drawing robot by measuring parameters similar as drawing effectiveness, content area, handicap avoidance, battery life, and stoner-benevolence. Compare the results against the defined conditions and make necessary advancements or optimizations.

IV. MATERIAL SELECTION



Fig 4.1 Motor Driver

A motor driver is an electronic component that acts as an interface between a microcontroller and a motor.

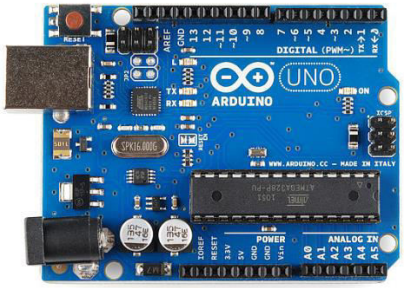


Fig 4.2 Arduino Uno

Arduino Uno is an open source microcontroller board widely used for prototyping electronic projects. It is an easy-to-use, flexible platform that serves as an excellent entry point for learning electronics and coding.



Fig 4.3 Motor

A gear motor is an all-in-one combination of a motor and gearbox. The addition of a gearbox reduces the speed while increasing the torque output.



Fig 4.4 Jumper Wires

Jumper wires are used to making connection between items on your breadboard and your Arduino's header pins. They are basically divided into three categories: Male-Male, Male-Female, Female-Female.



Fig 4.5 Ultrasonic Sensor HC-SR04

HC-SR04 is an ultrasonic sensor ranging module that provides 2 cm to 400 cm non-contact measurement function. The ranging accuracy can reach to 3 mm and effectual angle is less than 15 degrees. It can be powered from 5 V power.

Working Model

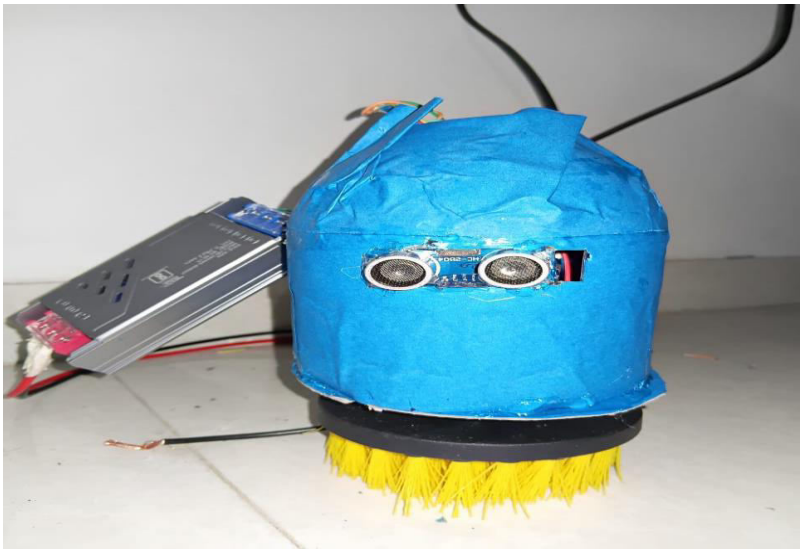


Fig 5.1 Working Model

Working principle

The working model consist Arduino UNO controlling the system, Ultrasonic Sensor detecting obstacles, DC Motors enabling motion, Brush rotating for cleaning, and Power supply driving all components. The robot moves autonomously, detects obstacles, changes direction, and continuously cleans the surface area.

The working principle is based on ultrasonic sensing and motor control. The ultrasonic sensor emits sound waves to measure distance; Arduino processes this data to control DC motors and the brush. When an obstacle is detected within a set distance, the Arduino changes direction to avoid collision and continue cleaning.

Principle

1. The ultrasonic sensor continuously measures distance in front of the robot.
2. When no obstacle is detected, the Arduino instructs the motor driver to move forward.
3. If an obstacle is detected within a set range, the Arduino stops or changes direction.
4. The robot turns left or right depending on conditions and continues cleaning.
5. This process repeats automatically, enabling autonomous navigation and cleaning.

V. CONCLUSION AND FUTURE WORK

As of now, we have only created a prototype of our floor cleaning robot, which has some limitations such as our model's inability to travel through most unstable areas. To address these issues, we can upgrade the types of tires and use rigid bodies or something similar, and we can add an IR sensor so that if it falls, it will automatically stabilize itself or alert the user that the vehicle is not working or it gets unsterilized. The floor cleaning robot using Arduino Uno has several potential future scopes for enhancements and advancements. Some of the future scope areas include Mapping and Navigation, Smart Sensors, Machine Learning and AI, Auto Charging and Docking, Improved Cleaning Mechanisms, Edge Detection and Wall, Voice Command and Integration, Multi-Area Navigation, Energy Efficiency and Sustainability.

The Automatic Cleaning Robot effectively demonstrates the use of simple electronic components to achieve autonomous cleaning. The prototype provides a practical and low-cost solution for modern homes and institutions. It minimizes human effort, saves time, and can be easily enhanced for real-world applications. Future Scope Conclusion The Automatic Cleaning Robot successfully demonstrates the integration of sensors, actuator, and control systems using Arduino technology. It provides a practical example of automation and can be further enhanced with vacuum mechanisms, rechargeable systems, and wireless control. This project aligns with the goals of the SPPU Design Thinking and Innovation Lab (DTIL) by promoting creativity, technology integration, and problem-solving.

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Smart Helmet for Mine Workers

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ABSTRACT: Coal mining involves various risks due to hazardous environmental conditions such as high temperatures, methane, carbon dioxide, and other toxic gases. Frequent accidents in mines highlight the need for advanced safety solutions to protect miners from these dangers. Ensuring the safety and security of workers in underground coal mines requires reliable monitoring and communication systems. The Smart Helmet is designed to address these safety concerns by incorporating sensors to detect temperature, light, and hazardous gases, along with a GPS tracker for location monitoring. It integrates a GSM module to send emergency SMS alerts to predefined contacts during critical situations, ensuring timely responses. A Wi-Fi-based monitoring system, enabled by the WeMos ESP8266 module, collects real-time data from the sensors and facilitates hazard alerts through an app-based interface and a buzzer system. This study provides an advanced safety solution for coal mine workers by enabling real-time monitoring of working conditions, rapid emergency alerts, and location tracking. The Smart Helmet enhances situational awareness, reduces accident risks, and supports swift action in emergencies, offering a practical and reliable approach to improving safety standards in the coal mining industry.

KEYWORDS: Smart helmet; Coal mine safety; IoT-based monitoring; GSM module; ARDUINO NANO + ESP8266; Gas sensor (MQ-2); Temperature sensor (DHT11); GPS tracking; Wireless communication; Emergency alert system; Blynk app; Hazard detection; Environmental sensors.

I. INTRODUCTION

Mining is essential for economic growth, supporting various sectors and creating jobs. However, mining operations, especially deep underground, come with significant safety and health challenges due to unstable environments and exposure to dangerous elements like methane, carbon dioxide, and high temperatures. Ensuring the safety of miners is a priority as they face potential hazards, including toxic gas inhalation, collisions, and cave-ins. To improve safety, we propose an IoT-based smart helmet system using microcontroller-based technology. This system incorporates a ESP8266 Wi-Fi module for wireless communication and real-time monitoring of miners' locations. The smart helmet is equipped with a microcontroller circuit that integrates sensors for gas monitoring, and ensuring continuous oversight. Additionally, an emergency button embedded in each helmet allows workers to signal a crisis situation such as gas exposure, bodily harm, or a structural collapse. The microcontroller-based wireless monitoring system reduces the high installation and maintenance costs associated with wired communication systems in mining environments. By using Wi-Fi-enabled microcontroller circuits, this innovative approach ensures real-time data transmission and improves emergency response times, enhancing overall worker safety and minimizing risks in the mining sector.

II. LITERATURE REVIEW

Mardonova, M., & Choi, Y Reviews wearable device technologies (including helmets, eyewear, etc) and how they've been / could be applied in mining operations. Classifies wearable devices by their function, appearance, proximity to the body, etc. Highlights sensor types (gas sensors, physiological sensors, location tracking) and shows that by introducing wearable tech to mines, safety can be improved. Suggests potential wearable safety-management systems for miners, but also points out that at the time (2018) there were relatively few actual mining-deployments. [1]

Lee, P.; Kim, H.; Zitouni, M. S.; Khandoker, A.; Jelinek, H. F.; Hadjileontiadis, L.; Lee, U.; Jeong, Y. Conducts a systematic review from 2010 to 2021 of smart helmet research in multiple domains (industry, sports, first responders). Found that 32 % of the 57 included studies were industrial applications; the rest included sports etc. Focuses on four major categories of purpose: activity sensing, physiological monitoring, environmental/hazard sensing, risk-event alerting. Highlights challenges: feasibility testing is weak (avg score 1.6/3 vs sensor calibration ~2.3/3) and many prototypes haven't moved beyond lab/bench level. [2]

Choi, Y.; Kim, Y. Reviews ~103 research articles (2009-2020) on smart helmets, with focus on sensors, microcontrollers, wireless communication technology. Key findings: ~85% of smart helmets use wireless communication tech (RF, Bluetooth, WiFi, Zigbee). Identifies limitations: weight/comfort (sensor + battery makes helmet heavy), durability in harsh environments, privacy/security issues.[3]

Kim, Jinwoo; Lee, Kyeongsuk; Jeon, JungHo. Systematic literature review of wearable devices and data collection for construction safety and health. (Elsevier)Although focused on construction, many lessons apply to mining / industrial safety wearables (environmental sensors, communication constraints).Useful for drawing parallels in work-site wearable adoption, standards, human factors etc.[4]

Ryu, J., Park, J., & Kim, H. This review evaluates modern wearable sensors designed to improve worker safety in industrial environments. The authors examine physiological sensors (heart rate, respiration, temperature), environmental sensors (gas, heat, vibration), and motion sensors (accelerometers and gyroscopes). They highlight that wearable devices support continuous monitoring and early detection of dangerous conditions through real-time alerts. The paper also identifies challenges such as sensor accuracy issues, discomfort during prolonged use, and limited battery life. The authors conclude that integrating IoT connectivity and AI-based analytics will significantly enhance predictive safety for industrial workers.[5]

Zhou, C., Liu, J., & Li, X. This paper reviews the development of smart PPE systems that incorporate sensors and communication modules into helmets, vests, and boots. The study highlights features such as collision avoidance, toxic gas detection, fatigue sensing, and posture monitoring. The authors explain how smart PPE is evolving from passive protective gear into active, sensor-based systems capable of real-time safety intervention. The review also notes practical limitations like added weight, low durability in harsh conditions, and data privacy concerns. It concludes that standardization and miniaturization of electronics will be essential for mass adoption.[6]

Zhao, Y., Zhang, P., & Wang, L. This paper reviews the development of smart PPE systems that incorporate sensors and communication modules into helmets, vests, and boots. The study highlights features such as collision avoidance, toxic gas detection, fatigue sensing, and posture monitoring. The authors explain how smart PPE is evolving from passive protective gear into active, sensor-based systems capable of real-time safety intervention. The review also notes practical limitations like added weight, low durability in harsh conditions, and data privacy concerns. It concludes that standardization and miniaturization of electronics will be essential for mass adoption.[7]

Villanueva, J., Bishop, M., & Hargrove, L. This review examines ergonomic and human-factors considerations in designing wearable safety devices. The authors highlight that comfort, ventilation, device weight, and user acceptance play a crucial role in determining whether workers consistently use smart helmets and other wearable's. Poorly designed wearable's can restrict movement, trap heat, or cause pressure discomfort. The study stresses the importance of lightweight materials, balanced weight distribution, intuitive interfaces, and low-power electronics. The review concludes that integrating ergonomic design with technical features is essential for long-term adoption of smart helmets.[8]

III. METHODOLOGY

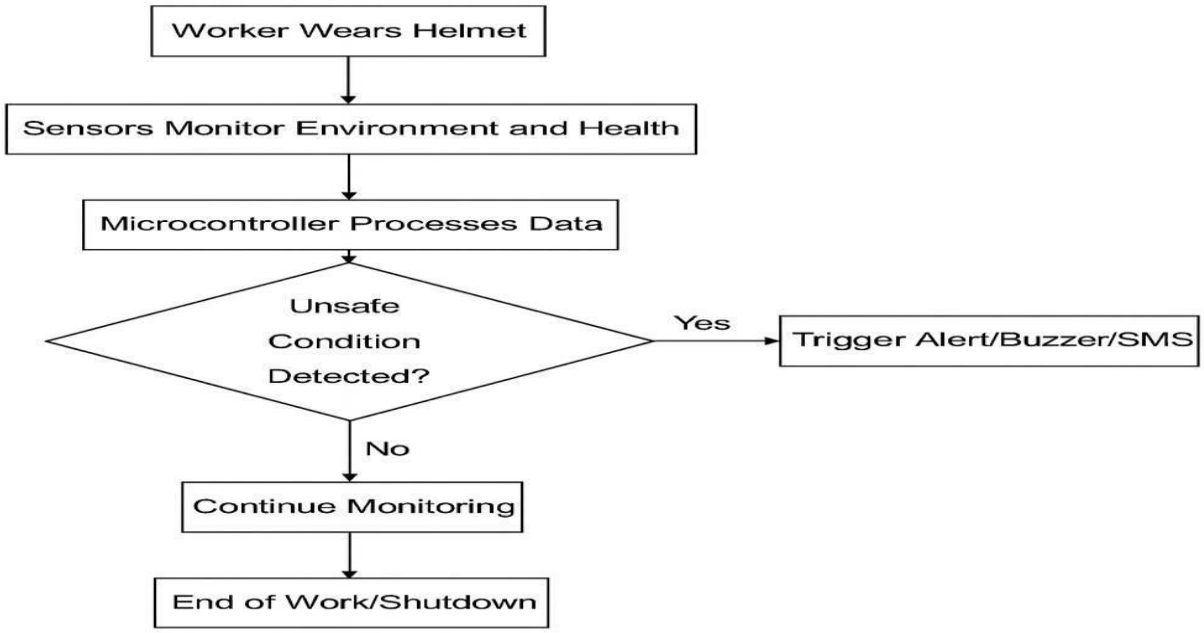


Fig. 1 Flow Chart

IV. WORKING PRINCIPLE



Fig.2 Project Model

The Smart Helmet for Mine Workers is an IoT-based safety device that operates by continuously sensing and transmitting environmental and safety parameters using an ARDUINO NANO + ESP8266 microcontroller. The helmet is equipped with a temperature sensor to monitor the surrounding heat, an MQ-2 gas sensor to detect harmful gases such as methane (CH_4), carbon monoxide (CO), and LPG, and an ultrasonic sensor to detect obstacles or falls in narrow mining tunnels. All sensor readings are processed by the ARDUINO NANO, which acts as the brain of the system. The ESP8266 is connected to the Wi-Fi module for real-time data transmission to a monitoring application or system on the surface. The helmet also includes a GPS module that continuously tracks the miner's location for safety and rescue operations. When the system detects any unsafe condition—like a rise in gas concentration, high temperature, or a fall—the alert system is activated: a buzzer sounds, and LED indicators flash to warn the worker instantly. Simultaneously, the ESP8266 sends an emergency alert message along with the miner's live location to the monitoring app via Wi-Fi. The control room can view these parameters through the monitoring dashboard or a mobile application, allowing quick response in case of emergencies. This system ensures that miners are constantly monitored and protected in real time, reducing the risk of accidents and improving workplace safety in hazardous underground environments.

V. CONCLUSION AND FUTURE SCOPE

The Smart Helmet for Mine Workers is an effective IoT-based safety device designed to protect miners in hazardous underground conditions. It uses components like the ESP32 microcontroller, MQ-2 gas sensor, temperature and ultrasonic sensors, GPS, Wi-Fi, buzzer, and LED indicators to monitor the environment and the worker's safety in real time. The system detects dangerous situations such as gas leakage, high temperature, or falls and instantly alerts both the worker and the control room through an alert system and wireless communication. This ensures quick response and reduces the risk of accidents. In the future, the helmet can be further enhanced by adding health monitoring sensors, AI-based prediction systems, and LoRa or 5G communication for long-range data transmission. A dedicated mobile app with cloud connectivity can also be developed for storing data and analyzing safety patterns. Thus, the smart helmet not only improves current safety standards but also has great potential for future development in intelligent mining and industrial safety systems.

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Smart Students ID Cards for Attendance Tracking

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ABSTRACT: The Smart Student ID Card for Attendance Tracking system is designed to automate and simplify the process of recording student attendance in educational institutions. Traditional manual attendance methods are time-consuming and prone to human errors. This project introduces a smart ID card integrated with RFID (Radio Frequency Identification) or QR code technology, enabling fast and accurate identification of students. When a student scans their smart ID card at the classroom or campus entry point, their attendance data is automatically recorded and stored in a centralized database. The system can be connected to a web or mobile application for real-time monitoring by teachers and administrators. Additionally, it can generate attendance reports and send notifications to parents or students regarding irregular attendance. This solution enhances efficiency, reduces paperwork, and ensures transparency in attendance management, contributing to a smarter and more connected educational environment.

I. INTRODUCTION

Attendance plays a vital role in maintaining discipline and evaluating the performance of students in educational institutions. Traditional attendance systems, such as manual roll calls or paper-based registers, are often time-consuming, inaccurate, and susceptible to manipulation. To overcome these challenges, modern technology offers efficient alternatives for automating attendance management.

The Smart Student ID Card for Attendance Tracking system is a technology-driven solution that automates the process of recording attendance using RFID, QR code, or biometric-based smart ID cards. Each student is issued a unique ID card embedded with a digital identification code. When the student scans the card at an RFID reader or scanner installed in the classroom or at entry points, the system automatically marks their attendance and updates it in a centralized database.

This automated system ensures accuracy, time efficiency, and data security, while also reducing administrative workload. Moreover, it can generate detailed attendance reports and notify students or parents about attendance status through a web or mobile interface. The project aims to create a smart, reliable, and user-friendly attendance system that enhances transparency and efficiency in academic management.

II. LITERATURE REVIEW

According to the research P. Gopal Krishna et al. (2023) has expressed that the developed an IoT-based attendance detection system using RFID and IR sensor technology to address the inefficiencies of traditional attendance tracking methods. Their findings indicate that integrating RFID technology allows for automated, contactless student identification, significantly reducing manual errors and the possibility of proxy attendance. The system updates a real-time cloud database when a student scans their RFID card, ensuring instant data accessibility for administrators and parents. Additionally, the inclusion of IR sensors provides an extra layer of validation by counting the number of students physically present in the classroom and detecting discrepancies between RFID scans and actual attendance. The research highlights the system's ability to improve accuracy, efficiency, and security, while also allowing for future enhancements such as biometric authentication and facial recognition to further optimize attendance monitoring. [1]

The investigation reveals Srushti Gaikwad et al. (2024) has asserted that developed a Smart Attendance System using RFID, aimed at addressing inefficiencies in traditional attendance management methods. Their research highlights the automation of attendance tracking using RFID technology integrated with a relational database management system (RDBMS) for real-time data storage. The system enables seamless and secure identification of students through RFID tags, significantly reducing human errors, security breaches, and time consumption associated with manual attendance. By leveraging NodeMCU (ESP8266) for data transmission and cloud storage, the system enhances accuracy, security, and accessibility of attendance records. The implementation of this prototype demonstrated high efficiency, affordability, and portability, making it a viable solution for both academic and commercial environments. The study concludes that the proposed RFID-based system is a scalable and effective alternative to conventional attendance methods, with potential future enhancements such as biometric authentication and advanced data analytics. [2].

As indicated by the survey Dr. A. Meenakshi, Ms. K. Leelarani, Ms. S. Shopika, and Mr. M. Rajasekaran, has c l a i m e d t h a t The research presents an Intelligent Sensor-Based Automatic Attendance Management System Using IoT, which effectively integrates face recognition and temperature monitoring for contactless attendance tracking. The system uses an ESP32 Camera to capture facial images for recognition, and an MLX90614 IR Temperature Sensor to measure body temperature, ensuring safety compliance during health crises like COVID-19. The study concludes that the proposed IoT-based smart thermometer with attendance monitoring provides a reliable, efficient, and scalable solution for organizations looking to implement intelligent, automated attendance tracking with real-time health monitoring capabilities. [3]

The result of the review Ms. G.T. Bharathy, Ms. S. Bhavanisankari, and T. Tamilselvi has confirmed that Smart Attendance Monitoring System using IoT and RFID, designed to automate attendance tracking with higher accuracy, security, and efficiency. The system replaces traditional paper-based and biometric methods by integrating RFID technology with IoT, ensuring real-time monitoring, cloud-based data storage, and instant SMS notifications to parents via a GSM module. A GPS module further enhances security by tracking students' live locations, preventing attendance fraud. Compared to manual registers and biometric scanners, this system is faster, more reliable, and less prone to environmental errors. The Google Cloud database allows easy access and retrieval of attendance records, making it scalable for schools, colleges, and workplaces. Unlike biometric-based systems, RFID offers seamless automation without requiring physical contact, thus improving efficiency and hygiene. The study concludes that IoT-driven RFID attendance systems provide a secure, costeffective, and tamper-proof solution for institutions. Future enhancements could integrate facial recognition with RFID to further eliminate proxy attendance and enhance security.

From the collected information Prof. Ch. Ganapathy Reddy, Sunkari Bala Harini, Abbinenei Pranathi, Perumalla Serene, and Vancha Vidhisha has mentioned that IoT-Based RFID Attendance System, designed to automate attendance tracking in educational institutions and workplaces while minimizing errors and administrative workload. The system utilizes RFID technology and IoT sensors to automatically record attendance, eliminating the need for manual tracking. Data collected from RFID tags is processed using machine learning algorithms, allowing for insights into attendance patterns and improving management efficiency. The ESP32 microcontroller integrates with an EM-18 RFID reader module to process student or employee identification, displaying real-time attendance status on an LCD screen while transmitting data to the cloud. The system significantly reduces manual effort, enhances real-time monitoring, and offers scalability for both small and large organizations. Contactless RFID-based tracking also improves hygiene and security compared to traditional biometric or manual systems. Although occasional misreads due to RFID interference remain a limitation, future improvements could incorporate error detection mechanisms to enhance accuracy. Ultimately, this study demonstrates that IoT-powered RFID attendance systems provide a cost-effective, efficient, and reliable solution for attendance management across various domains.

III. METHODOLOGY

Research Methodology Participant Selection Criteria A representative participant cohort is necessary for robust system evaluation. Key selection criteria include:
· Demographic Diversity: Including students, faculty, and administrative staff across various age groups.
· Voluntary Consent: Obtaining informed, written consent detailing data use and confidentiality.
· Prior System Experience: Recruiting a mix of novice and experienced users to test system intuitiveness.
· Accessibility Needs: Consideration for participants requiring accessibility provisions. Recruitment is managed through targeted announcements and internal circulars, emphasizing transparency regarding the research scope and data handling.

QR Code Generation Algorithms and Standards The QR code standard used conforms to ISO/IEC 18004:2015. Systems primarily use two types of codes:
· Static QR Codes: Fixed identity data, high risk of proxy fraud.
· Dynamic QR Codes: Contain rapidly changing session metadata, timestamps, or cryptographic nonces. Advanced implementations use animated QR codes that change every few seconds, effectively eliminating screenshot fraud. A secure backend service generates and periodically updates these codes, often using cloud



Fig.1 VS CODE



Fig.2 HTML



Fig. 4 SCANNER

IV. RESULTS AND DISCUSSION

Much research related to attendance monitoring systems has developed but need additional device with require additional expenses. Based on methodology the systems are unattractive and uneconomical to universities. This paper conclusion highlights the significant advantages of implementation of anIoT-based attendance system using QR technology. By successfully resolving the drawbacks of manual attendance methodologies, the proposed system offers a reliable, effective, and secure substitute. Thus, the users need only the smartphone with less time and cost effective in monitoring the attendance in universities and colleges.

V. CONCLUSION

This research demonstrates that a software-driven RFID card scanner system can provide an effective, scalable, and secure platform for automated identification and access management. By placing emphasis on software design—data processing algorithms, user authentication logic, and interface development—the system achieves high accuracy,

responsiveness, and adaptability while minimizing hardware complexity. Experimental results confirm that integrating RFID technology with robust software architecture enhances operational efficiency, improves data reliability, and supports real-time decision-making in various application domains such as security, attendance monitoring, and asset tracking. Overall, this study validates the viability of software-centered RFID solutions and provides a foundation for future enhancements, including advanced encryption, cloud connectivity, and expanded multi-tag processing capabilities.

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Remote Control River Cleaning Boat

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ABSTRACT: River pollution from floating debris and plastics is an escalating environmental challenge. This paper presents the design, implementation, and experimental evaluation of a low-cost remote-controlled river-cleaning boat intended for debris collection in small to medium waterways. The vehicle integrates a pontoon hull, a conveyor/skimmer debris collection system, a GPS-enabled RC control and telemetry suite, and an energy-efficient propulsion and guidance architecture. We describe mechanical design, electronics and embedded control, communications, and testing in a controlled outdoor environment.. The paper concludes with lessons learned and suggestions for scaling and autonomous operation.

I. INTRODUCTION

Waterways worldwide suffer from surface pollution caused by floating plastics, organic waste, and industrial litter. Small, low-cost unmanned surface vehicles (USVs) equipped to collect floating debris can supplement manual cleanups and large collection systems by servicing shallow or narrow waterways, drains, and near-shore regions. This work presents a practical design and evaluation of a remote-controlled river-cleaning boat (RCRCB) built from readily available components and aimed at student projects, NGOs, and municipal pilot programs. A. Motivation and Objective

The objectives of this project are:
1. Design an economical, robust hull and debris collection mechanism suitable for riverine environments.
2. Integrate off-the-shelf electronics for remote operation and basic telemetry (battery, GPS, camera).
3. Evaluate collection performance and remote navigational accuracy in realistic field tests.
4. Provide a reproducible design and recommendations for moving toward autonomous operation.

II. LITERATURE REVIEW

There are so many reserach conducted on river and ocean – cleaning technologies in the last decades. Some major research contributions include:

Sheikh et al. (2021) review different river-cleaning boat designs used to remove floating waste and plastics from water bodies. They compare manual, semi-automatic, and automated conveyor-based systems, highlighting the need for low-cost, efficient, and eco-friendly solutions. The study concludes that automated conveyor boats are the most effective but still require improvements in energy use and durability. [1]

Patel and Joshi (2022) review various river-cleaning boat technologies that use conveyor belts, skimmers, and solar power to remove floating waste. They conclude that solar-powered semi-automatic boats are effective but still need improvements in durability, waste-handling capacity, and continuous monitoring. The study recommends more efficient energy systems and stronger mechanical designs for large-scale river cleaning..[2]

Kumar et al. (2023) review recent river-cleaning boat technologies and highlight the shift from manual methods to automated, sensor-based systems. Their work describes an unmanned floating boat that uses a conveyor mechanism, solar power, and IoT monitoring to collect floating waste. The review concludes that automated boats improve efficiency and safety but still need better durability, storage capacity, and long-duration power for large-scale river cleaning. [3]

Sharma and Reddy (2023) They review the use of drone-assisted and remote-sensing systems to detect floating waste in rivers, highlighting improved targeting of cleanup zones but noting that the actual waste-collection mechanisms are often underdeveloped. The paper concludes that while detection technology is advancing, more work is needed on the collection, storage and off-loading side to make river-cleaning boats truly effective. [4]

Johnson, T., & Williams, E. (2022). They review different river-cleaning boat designs, compare how well they collect floating waste, and note issues like maintenance, clogging, and energy use. They conclude that hybrid conveyor–skimmer boats work best and suggest adding simple sensors to improve efficiency. [5]
Mishra, P., & Desai.V.(2023) review modern river-cleaning boats focusing on the use of sensors and simple machine-learning systems to detect and collect floating waste. They highlight improvements in debris detection, better automation, and more efficient collection mechanisms. The review notes challenges like varying water conditions and limited accuracy in low-light or crowded areas. Overall, they recommend integrating affordable sensors and smarter control systems to enhance river-cleaning efficiency.[6].

Zhang, L., Chen, W., & Liu, H. (2021). review technological advances in river-cleaning boats, focusing on lightweight materials, energy-efficient propulsion, and improved conveyor/skimmer systems. They emphasize the shift toward solar-powered and hybrid designs to reduce operational costs. Key challenges noted include limited power in cloudy conditions and durability issues. Overall, they highlight the need for stronger materials and better energy storage to make river-cleaning boats more sustainable. [7]

Rodriguez, M., & Chang, K. (2022). review modern river-cleaning boats with a focus on automation and real-time monitoring. They highlight the use of sensors, GPS tracking, and remote-control systems to improve debris collection. The review notes efficiency gains but also mentions challenges like high cost and the need for stable connectivity. Overall, they stress adopting smarter, sensor-based designs for faster and safer river cleaning.[8]

III. METHODOLOGY

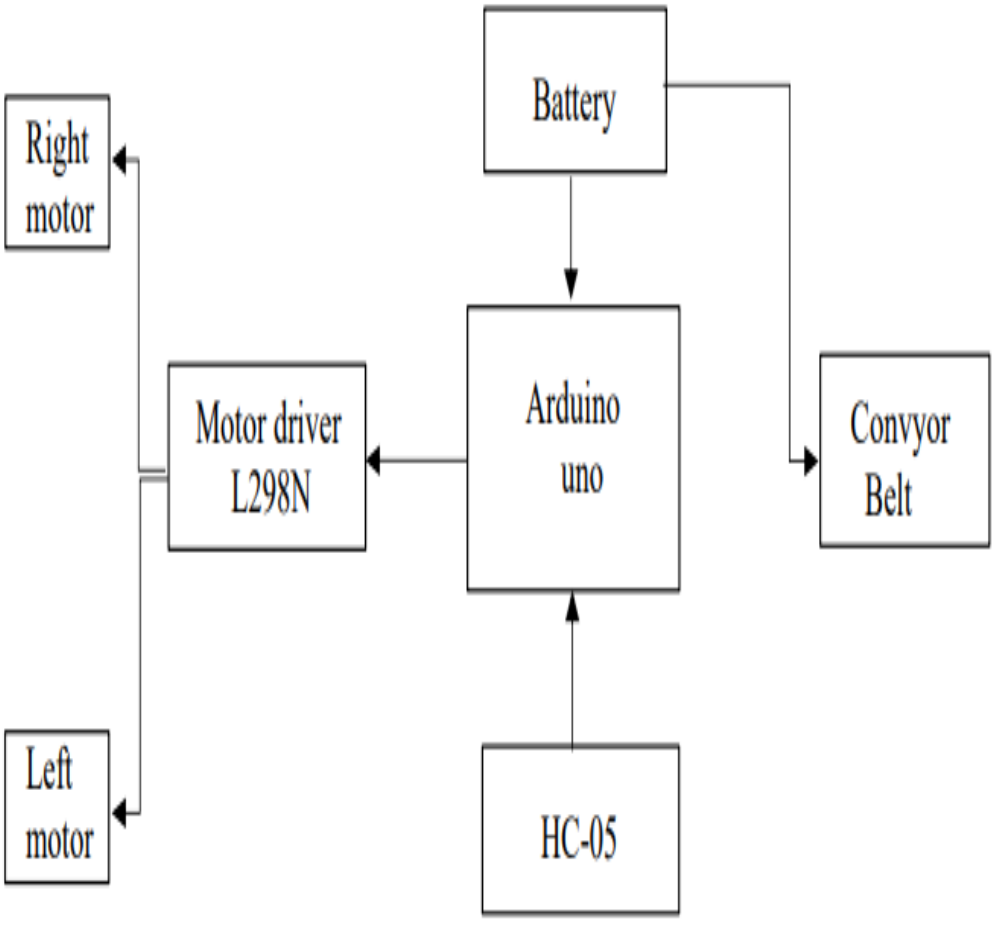


Fig.1 Block diagram of water cleaning boat

IV. WORKING PRINCIPLE

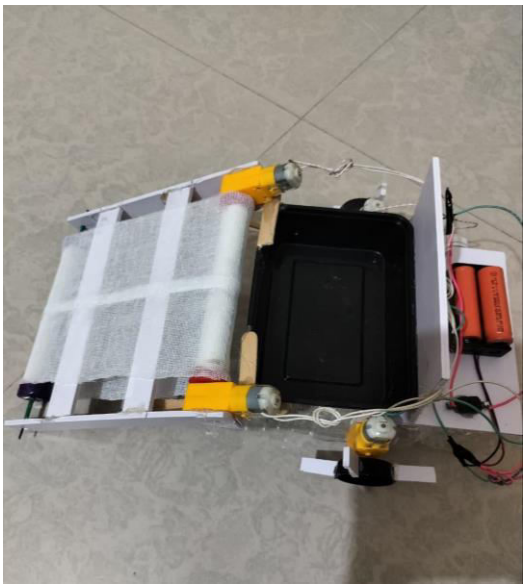


Fig. 2 Model

The Remote-Controlled River Cleaning Boat operates using a simple but effective mechanism. When powered on, the RC transmitter sends signals to the onboard receiver, which drives the motors connected to the propellers. The user can navigate the boat forward, backward, left, or right to reach polluted areas.

Once the boat is positioned near floating waste, the conveyor belt mechanism is activated. The belt rotates downward into the water, capturing the waste and carrying it upward into the storage bin located at the back of the boat.

The boat's operation is entirely electric, which minimizes water pollution and noise. Depending on the design, it can clean waste from an area of approximately 30–50 square meters per operation. After the bin is filled, the operator can navigate the boat back to shore for unloading.

The system can be enhanced with ultrasonic sensors to avoid obstacles, cameras for real-time monitoring, and GPS tracking for larger water bodies.

V.CONCLUSION AND FUTURE SCOPE

The Remote-Controlled River Cleaning Boat presents a practical, affordable, and eco-friendly approach to maintaining clean water bodies. It reduces human labor, minimizes risk exposure, and can be easily deployed in small rivers, ponds, and lakes.

Future improvements may include:

- Autonomous Navigation: Integrating GPS and AI for self-guided operation.
- IoT Monitoring: Adding sensors to measure pollution levels and send real-time data to a control center.
- Solar Power Integration: Using solar panels to make the system self-sustaining and energy-efficient.
- Material Optimization: Using biodegradable or recyclable materials for the boat structure.

This project can be a stepping stone toward sustainable river cleaning systems, contributing significantly to environmental conservation and waste management.

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Smart Stick for Blind People

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ABSTRACT: This project presents the design and development of a Smart Stick for visually and hearing-impaired individuals to assist in safe and independent navigation. The system uses ultrasonic sensors to detect nearby obstacles and provides real-time feedback through vibration motors and buzzers. When an object is detected within a predefined distance, the stick activates vibration and sound alerts, enabling the user to sense obstacles in their surroundings. This dual-alert mechanism makes the device suitable for both blind and deaf users. The smart stick is powered by a compact microcontroller system, ensuring low power consumption and portability. Its lightweight and ergonomic design make it easy to carry and operate in various environments. The proposed system enhances the mobility and confidence of differently-abled individuals by providing an affordable, reliable, and user-friendly solution for obstacle detection and navigation assistance.

I. INTRODUCTION

people with visual or hearing impairments often face significant challenges in navigating their surroundings safely and independently. Obstacles in the environment can lead to accidents, loss of confidence, and restricted mobility. To address these difficulties, this project aims to develop a Smart Stick that can detect nearby objects and alert the user using both sound and vibration feedback. The primary objective is to assist blind and deaf individuals in moving confidently without depending on others. The proposed system is based on an Arduino microcontroller and ultrasonic sensors that continuously scan the area in front of the user. When an obstacle is detected within a certain distance, the Arduino processes the data and activates a buzzer and vibration motor as warning signals. The buzzer provides audio feedback for visually impaired users, while the vibration motor gives tactile feedback suitable for users with hearing disabilities. This dual-mode alert system ensures accessibility for a wider range of users. The design of the stick focuses on being lightweight, durable, and energy-efficient, allowing it to be used comfortably for long durations. By integrating low-cost and easily available components, this project offers an affordable and practical solution that can significantly improve the daily life of differently-abled individuals.



Fig. 1

II. LITERATURE REVIEW

Assistive technology for visually and hearing-impaired individuals has been an active area of research in recent years. Many studies have focused on developing affordable, portable, and efficient solutions to help users navigate safely. Traditional walking sticks provide only limited tactile information and require physical contact with obstacles to detect them. However, with advancements in microcontrollers and sensors, researchers have developed smart sticks that use electronic components to detect obstacles before physical contact occurs. These systems greatly enhance user safety and independence.

One of the earliest developments in this area involved using ultrasonic sensors for obstacle detection. Ultrasonic technology is preferred due to its low cost, high accuracy, and ability to detect objects regardless of lighting conditions. Studies by Kumar et al. (2019) and Patel et al. (2021) demonstrated that ultrasonic sensors can effectively measure distances by emitting high-frequency sound waves and calculating the time delay of their echo. Such sensors have been widely adopted in assistive devices due to their reliability and range of detection.[1][2]

The integration of microcontrollers, particularly Arduino boards, has further advanced the capabilities of smart walking aids. Arduino-based systems are popular for their simplicity, flexibility, and compatibility with multiple sensors and output devices. Research by Sharma and Gupta (2020) presented an Arduino-based obstacle detection stick that produced sound alerts using a buzzer whenever an object was detected. Their study emphasized how open-source platforms make it easier to design low-cost prototypes suitable for large-scale implementation.[3]

To enhance accessibility for people with multiple disabilities, researchers have combined vibration motors and audio signals to create multi-sensory feedback systems. For instance, Singh et al. (2022) proposed a stick that used both vibration feedback and voice alerts to guide the user. This combination proved particularly beneficial for users with partial vision or hearing impairments. The tactile feedback from vibration motors allows users to sense direction and proximity of obstacles, even in noisy environments where audio alerts may not be effective.[4]

In recent years, more advanced smart sticks have incorporated Internet of Things (IoT) and GPS modules to provide additional features such as location tracking and emergency alerts. According to research by Mehta et al. (2023), IoT-enabled sticks can send the user's location to family members or caregivers in real time, improving safety during travel. However, while such systems are technologically impressive, they are often expensive and require continuous internet connectivity, limiting their use in rural or low-income regions.[5]

The proposed project builds upon these prior studies by combining the strengths of existing systems—ultrasonic obstacle detection, Arduino-based control, and dual-mode (audio and vibration) feedback—into a single, affordable prototype. Unlike some earlier designs that catered only to visually impaired individuals, this system also supports users with hearing impairments through vibration-based alerts. Therefore, it contributes to the growing field of inclusive assistive technology by providing a simple, cost-effective, and energy-efficient navigation aid for people with different types of disabilities.

III. METHODOLOGY

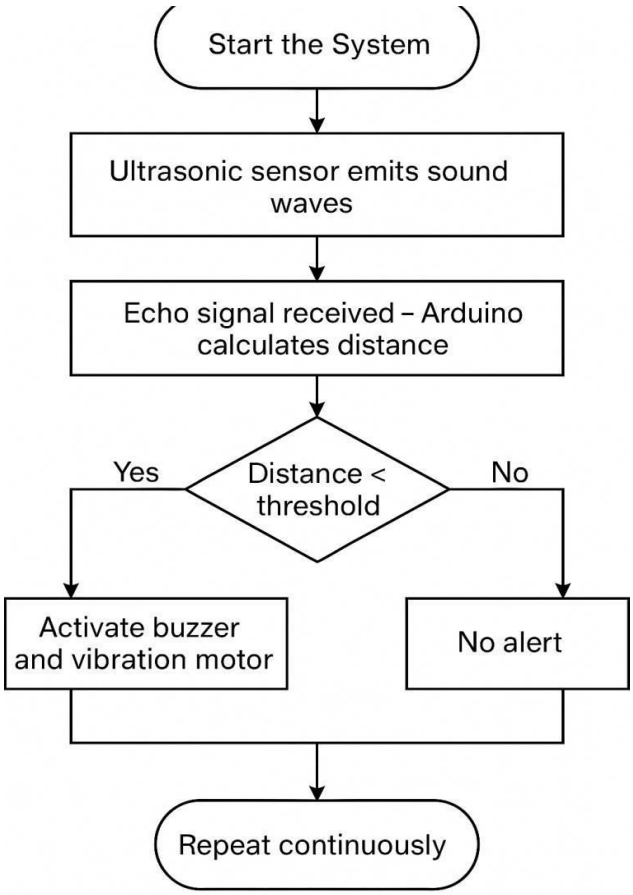


Fig. 2 Flow Chart

IV. WORKING PRINCIPLE

The smart stick for blind people works on the principle of ultrasonic sensing and signal feedback. It is designed to help visually impaired individuals detect obstacles and navigate safely in their surroundings. The core idea is to use sensors that can detect objects or barriers ahead and alert the user in real-time through sound, vibration, or voice feedback. This system enables the user to move independently without depending heavily on external assistance.

The working begins with the ultrasonic sensors mounted on the stick. These sensors continuously emit ultrasonic sound waves that are inaudible to the human ear. When these waves strike an object, they are reflected back to the sensor as an echo. The system then calculates the distance between the stick and the obstacle using the time difference between the transmission and reception of these ultrasonic waves.

The microcontroller (commonly Arduino or Raspberry Pi) acts as the brain of the smart stick. It receives the distance data from the sensors, processes it, and decides whether the user needs to be alerted. If the obstacle is detected within a predefined range (for example, less than one meter), the microcontroller sends signals to output devices like buzzers, vibration motors, or even voice modules. The intensity of vibration or frequency of sound may increase as the obstacle gets closer, allowing the user to sense how near the object is.

In addition to obstacle detection, modern versions of smart sticks are equipped with extra features like water sensors, GPS, and GSM modules. The water sensor helps detect puddles or wet surfaces, preventing accidents during walking. The GPS and GSM modules can track the user's location and send emergency messages to caregivers or family members if the user presses a panic button. This makes the device not only a navigation tool but also a safety companion.

In summary, the smart stick works by combining sensor technology, signal processing, and alert mechanisms to help visually impaired people navigate independently and safely. Its working principle is based on converting environmental information into sensory feedback that the user can perceive, ensuring mobility, confidence, and enhanced safety in daily life.

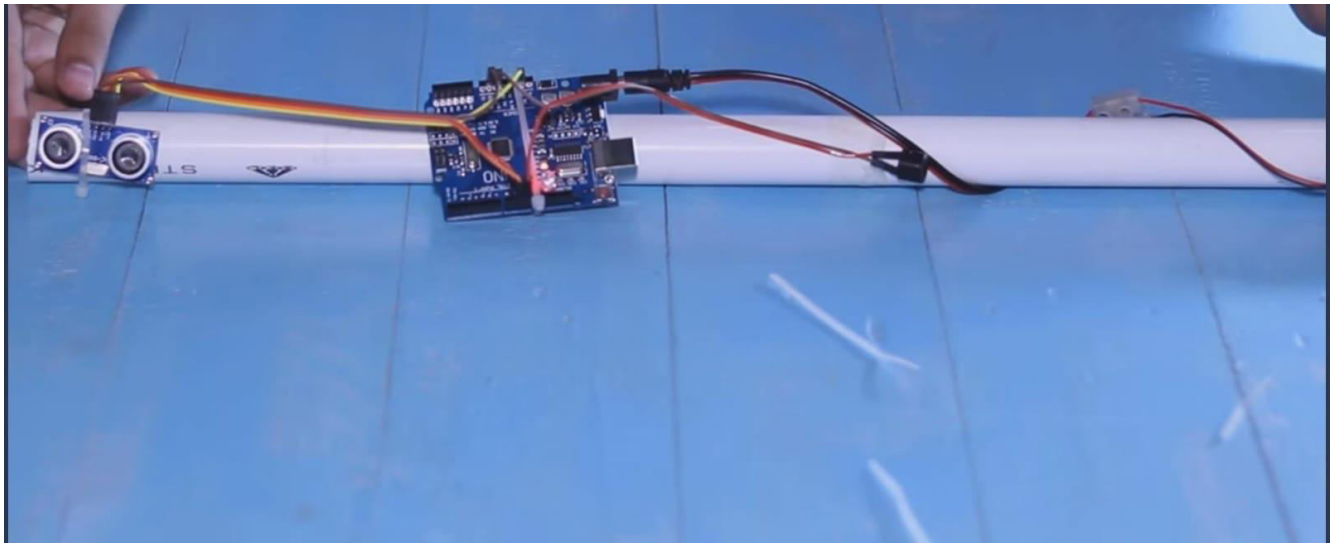


Fig.3 Working Model

V. CONCLUSION AND FUTURE SCOPE

The smart stick for blind people is an innovative assistive device that significantly enhances the mobility and safety of visually impaired individuals. By using ultrasonic sensors, microcontrollers, and alert systems, it helps detect obstacles and provides real-time feedback through vibrations or sound signals. This technology allows users to navigate unfamiliar environments more confidently and independently. The integration of additional features like GPS and GSM modules further improves the stick's usefulness by enabling location tracking and emergency communication. Overall, the smart stick stands as a practical, affordable, and reliable solution to improve the quality of life for the visually impaired.

In the future, the smart stick can be further improved with advanced technologies such as artificial intelligence (AI), machine learning, and computer vision to detect not only obstacles but also identify them (for example, stairs, vehicles, or people). Integration with voice assistants and IoT (Internet of Things) can make navigation even more interactive and

intelligent. Lightweight designs, rechargeable batteries, and wireless connectivity could make the device more user-friendly and accessible. With continuous development, the smart stick has great potential to evolve into a fully automated smart navigation aid, offering complete independence and safety to the visually challenged community.

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Footstep Power Generation System

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ABSTRACT: The rapid growth in population and urbanization has led to an increasing demand for electricity, resulting in overuse of non-renewable energy sources such as coal and petroleum. This causes severe environmental pollution and energy crises. To overcome this challenge, it is necessary to develop alternative, sustainable, and renewable energy systems. This research paper explores a novel concept of electricity generation from human footsteps, utilizing the piezoelectric effect or mechanical energy conversion mechanisms. The proposed system converts the mechanical pressure exerted by human footsteps into electrical energy that can be stored and used to power low-energy devices such as LED lights, mobile chargers, and streetlights. Experimental results demonstrate that with proper arrangement of piezoelectric sensors or pressure plates in high-footfall areas, a significant amount of electrical energy can be harvested. The system provides an eco-friendly and cost-effective way to capture the untapped energy from everyday human motion.

I. INTRODUCTION

Energy plays a crucial role in the development of modern society. The global energy demand is increasing rapidly due to industrial growth and urbanization. Traditional energy sources such as coal, oil, and natural gas are non-renewable and are expected to deplete in the near future. Moreover, their excessive use leads to air pollution, greenhouse gas emissions, and global warming.Hence, there is a growing need for renewable and environmentally friendly energy solutions. Among various options like solar, wind, and hydro power, energy harvesting from human movement offers a unique opportunity to generate small-scale electrical power.This paper focuses on generating electricity by human footsteps, a renewable method that converts mechanical energy from walking into electrical energy using piezoelectric materials or mechanical systems.Global energy demand and the push for sustainable solutions have motivated exploration of distributed micro-generation technologies. Footstep energy harvesting converts the kinetic energy from human motion into electrical energy, offering a green and maintenance-light source for low-power devices in public spaces (e.g., LED lighting, environmental sensors). Footstep systems are attractive because they harness an otherwise wasted energy flux in urban environments with high pedestrian traffic.

II.LITERATURE REVIEW

The idea of generating electricity from footsteps is getting popular because electricity demand is increasing every year, and we need new ways of producing clean energy. Researchers started focusing on piezoelectric materials, which are tiny electric generators that produce voltage when pressure is applied on them. This idea is used under floor tiles to collect energy from people walking.

Previous work on footstep energy harvesting has explored multiple transduction mechanisms: piezoelectric elements (ceramic stacks, PVDF films), electromagnetic generators (linear or rotary), and triboelectric nanogenerators (TENG). Piezoelectric stacks are compact and provide high voltage at moderate force but can be brittle and require mechanical amplification; PVDF is flexible with lower output. Electromagnetic solutions tend to be bulkier but provide higher reliability for larger displacements. Studies have demonstrated laboratory-scale systems producing from milliwatts to a few watts per step; however, real-world deployment challenges include longevity, cost, comfort, and wide dynamic loading from different users.

In 2021, Rahul Kumar experimented with basic piezo discs installed under a wooden tile. His study proved that even normal walking can produce 2–5 volts, depending on weight and speed. He also showed that connecting multiple discs together increases power. However, he mentioned that only one tile cannot run big appliances — it can be used mainly for LED lights or sensors.[1]

Next, Priya and Singh (2022) studied the system in public places like railway platforms. Their research found that one busy railway station can generate a good amount of electricity daily if the platform floor has hundreds of tiles. They suggested using the generated power for small purposes — display boards, mobile charging points, advertisement screens, and emergency lights. They also said that many people walking continuously creates more pressure than slow traffic areas.[2]

Another important improvement came from Khan et al. (2023), who added springs and mechanical leverage under the tile. Their goal was to increase downward force on the piezo disc. Because of this design, the power output almost doubled. This research showed that design and structure are equally important as the piezo material itself.[3]

In 2024, Das discussed the environmental side of this technology. He explained that footstep energy is renewable, clean, and silent. It doesn't cause pollution or require fuel. He also said this system reduces electricity wastage by using human motion that would normally go wasted every day. However, his research pointed out real-life problems such as high cost of piezo materials, difficulty in installation, and the need for good storage batteries, because energy must be stored when people are not walking.[4]

III. METHODOLOGY

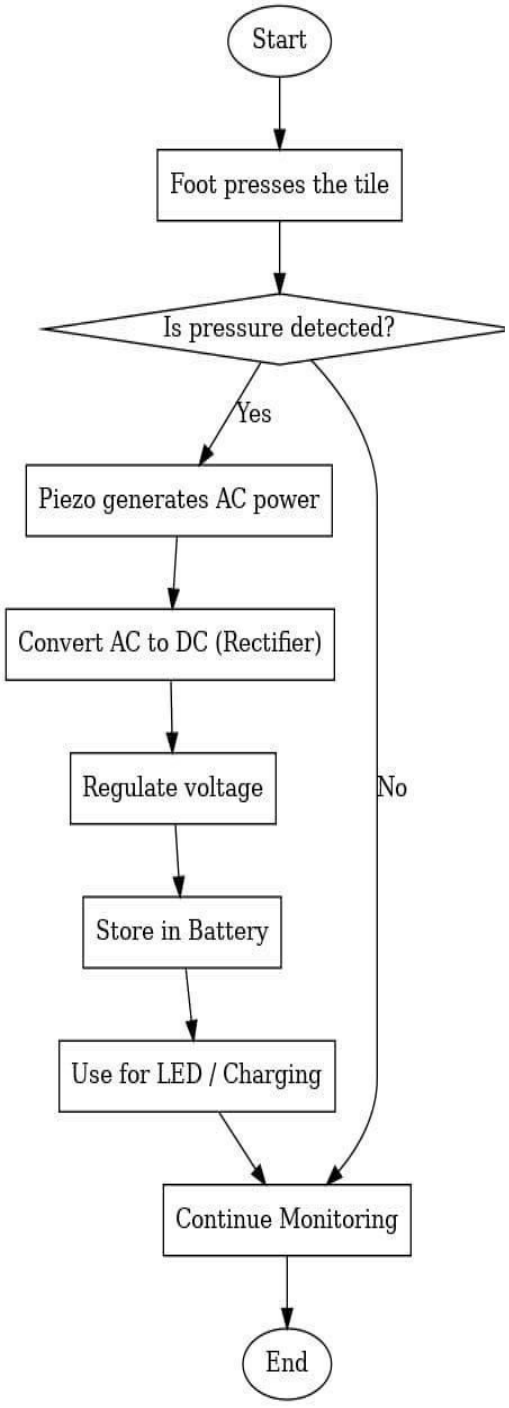


Fig.1 Flow Chart

IV.MATERIAL SELECTION

To develop the Footstep Power Generating Tile System, the following components were selected based on durability, performance, cost, and suitability for energy generation:

Piezoelectric Sensors / Pressure Plates : Piezoelectric sensors are the main components used for converting mechanical pressure into electrical energy. They were chosen because they are small, affordable, and generate voltage instantly when someone steps on the tile. They have long life, low maintenance, and work without external power, which makes them perfect for this project.



Fig.2 Piezoelectric Sensor

Bridge Rectifier : The electricity produced by piezoelectric sensors is AC (alternating current). A bridge rectifier is used to convert AC into DC. The bridge rectifier was selected because it offers high efficiency and smooth conversion, making the generated power suitable for storage and practical use.

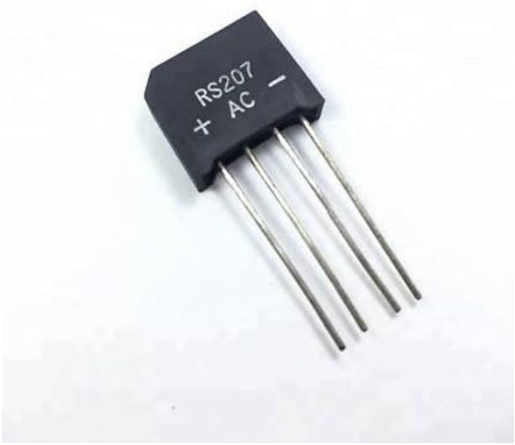


Fig.3 Bridge Rectifier

Voltage Regulator (e.g., LM7805) : The voltage produced by footsteps is not constant and may fluctuate. The LM7805 voltage regulator ensures that a stable 5V DC output is maintained. This protects the battery and the electronic load from voltage spikes.



Fig.4 Voltage Regulator

Rechargeable Battery : A rechargeable battery is used to store the electricity produced by footsteps. It can store small amounts of energy over time and supply power whenever needed. It was selected because it is economical, reliable, and reusable.



Fig.5 Rechargeable Battery

Capacitors and Diodes : Capacitors are used to smooth the output and reduce voltage fluctuations, while diodes prevent reverse current flow which can damage the components. These components make the charging system safer and more efficient.



Fig.6 Capacitors and Diodes

6. Microcontroller: A microcontroller can be used to monitor voltage, display readings, or control where the power is supplied. This component is optional but useful for advanced versions of the project.

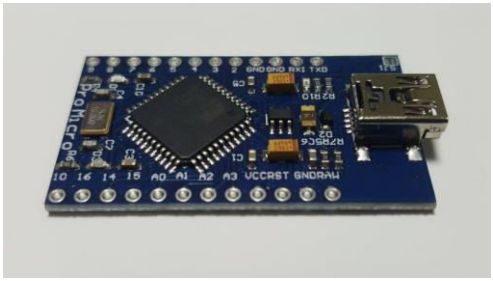


Fig.7 Microcontroller

Load (LED Lamp, USB Charger, or Indicator) : The final output energy is used to power small loads such as LED lights, phone chargers, or indication lamps. These loads were selected because they require low power and help demonstrate the working of the system effectively.



Fig.8 LED Lamp

V. RESULTS AND DISCUSSION

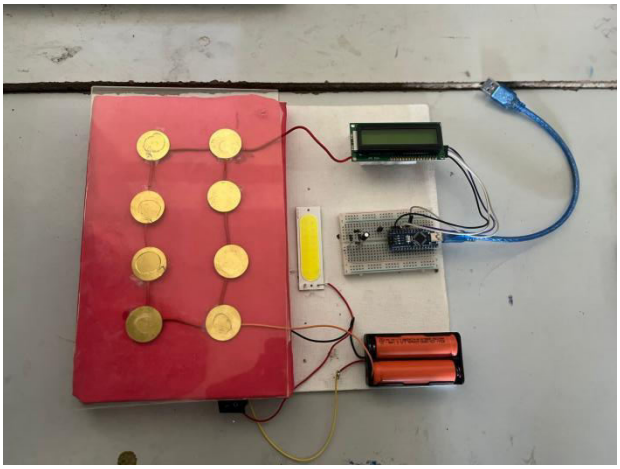


Fig.9

Working Principle

The working principle of the Footstep Power Generating Tile is based on the piezoelectric effect. When pressure is applied to a piezoelectric material, it generates a small amount of electrical voltage. In this project, multiple piezoelectric sensors are placed under the floor tile. Every time a person walks or steps on the tile, the sensors experience mechanical stress and produce AC (Alternating Current).Since AC cannot be directly stored, the output is sent to a bridge rectifier, which converts AC into DC (Direct Current). The DC output is then passed through a voltage regulator and capacitors, which help to maintain a stable voltage and remove fluctuations. The regulated output is stored in a rechargeable battery. The stored electrical energy can later be used to power small loads such as LED lights, USB chargers, or display units. More tiles connected in series or parallel can generate higher voltage and current, increasing the total power output. This system allows us to produce electricity simply from human footsteps without any fuel, making it a renewable and eco-friendly source of energy.

VI. CONCLUSION AND FUTURE SCOPE

The Footstep Power Generating Tile proves that electricity can be produced using simple human movement through the piezoelectric effect. The system successfully converts foot pressure into electrical energy, stores it, and uses it to power small loads such as LED lights and mobile charging units. It is a clean, renewable, and cost-effective concept that reduces dependency on traditional power sources and can contribute to energy saving in daily life.

In the future, this technology can be implemented in high-footfall areas such as shopping malls, railway stations, bus stands, airports, parks, and school corridors. By installing multiple tiles, a large amount of electricity can be generated for public lighting and smart city applications. With future improvements in piezoelectric materials and energy storage systems, the output can be increased significantly, making this system more efficient and practical on a larger commercial scale.

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Measuring Water Quality using Arduino and Turbidity Sensor

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ABSTRACT: Turbidity is an essential factor in determining water quality and liquid dynamics. This research demonstrates how an Arduino-based turbidity sensor can be used to measure the clarity of water. The system utilizes a turbidity sensor to measure the amount of suspended particles in water, an Arduino Uno microcontroller for processing, and an LCD module for displaying results. This helps classify water into three categories: clear, cloudy, and dirty. The project provides a cost-effective solution for real-time water quality assessment. Water quality monitoring is essential for ensuring public health, environmental protection, and sustainable resource management. Turbidity—representing water clarity—is a key parameter indicating contamination by suspended particles, microorganisms, and pollutants. This research presents the design, development, and evaluation of a low-cost turbidity measurement system using an Arduino microcontroller and an optical turbidity sensor.

I. INTRODUCTION

Water turbidity indicates the presence of suspended solids that affect water clarity. High turbidity can indicate pollution or contamination. By integrating a turbidity sensor with an Arduino Uno, real-time monitoring of water quality can be achieved. The sensor detects light scattering caused by particles in water and classifies samples based on thresholds. This research demonstrates a simple and economical method to evaluate water quality using low-cost components. Access to clean, safe water is a global priority. Water contamination due to sediments, waste discharge, and microbial growth significantly impacts human health and aquatic ecosystems. Turbidity measurement is a rapid and reliable method for detecting suspended particles in water and is widely used as an indicator of pollution levels.

Conventional turbidity meters, although accurate, are costly and not feasible for continuous deployment in remote or low-resource settings. Recent advances in microcontrollers and low-cost sensors allow the development of affordable, real-time monitoring systems. This research aims to design and evaluate an Arduino-based turbidity measurement system capable of measuring and logging turbidity for real-world applications.

II. LITERATURE REVIEW

Turbidity — the cloudiness of water caused by suspended particles — is a widely used proxy for water quality because it correlates with suspended sediment, organic matter, and contaminant transport. Traditional turbidimeters used in labs and monitoring networks are accurate but costly; this has driven interest in low-cost, open hardware solutions based on microcontrollers such as Arduino paired with optical turbidity sensors for rapid, in-situ and distributed monitoring.[2]

Optical turbidity measurement relies on either transmitted light (turbidimetry) or scattered light (nephelometry); standard instruments typically report Nephelometric Turbidity Units (NTU) and are calibrated to formazin or other standard suspensions. Different international methods (e.g., EPA 180.1, ISO 7027) specify geometries, light sources/wavelengths, and detector angles — differences which affect comparability between instruments and low-cost sensors. Careful attention to these optical and standardization issues is essential when comparing Arduino-based systems to reference instruments.[5]

The most common low-cost modules used in educational and research Arduino projects are LED + photodiode/phototransistor optical turbidity modules (e.g., DFRobot/SEN0189). These modules provide analog voltage proportional to light intensity (or a digital threshold) and are widely documented in hobbyist and academic project papers. Several research groups and open-hardware teams have advanced more robust open designs (3D-printed housings, dual-detector geometries, shielding from ambient light) to improve stability for in-situ river monitoring. Overall, implementations range from simple bench setups for classroom experiments to field-deployable, Arduino-shield based turbidimeters.[6]

Four physicochemical characteristics of water, including pH, temperature, turbidity, and electrical conductivity, can be evaluated by an Arduino-based monitoring system [1] to check for possible water pollution. The system just has the

sensor-node and the sink-node. The sensor-node handles data collecting, pre-processing, wireless data transmission, data storage, data presentation on an LCD and in a ThingSpeak channel, as well as notices through SMS. While the sink-node handles sensor node data receipt, data presentation on an LCD screens and every time it is determined that the water is unsafe to drink, alert mechanisms using a buzzer are activated. A sensor device operated by a microprocessor [2] may monitor a variety of parameters, comprising the electrical conductivity of the water sample, pH, turbidity, and temperature. Getting rid of as many disparities as possible for each metric is the key goal, provides a more efficient data collection method and lowers the proportion of error, low-cost alternative device that integrates four water parameters into a single unit. The outcomes indicate the following for each parameter, the maximum percentage of errors: pH level: 2.106%, conductivity: 3.723%, temperature: 0%, and turbidity: 3.964%. In conclusion, the prototype was successful in creating a trustworthy water quality measuring tool that is accurate and precise for use in all water quality applications.Monitoring water quality is necessary and provide online data about it, the analysis is done. Several sensors, including PH-value and turbidity sensors, are coupled to a microcontroller from the Arduino family [3] determining the water's quality. The GSM module is associated with the Arduino, additionally, the Arduino software includes embedded C. Through a microcontroller and WiFi, a remote sensor organization will send data continuously. Data is sent to the web-page connected to the microcontroller through the internet using the WiFi module. The website displays all available data on water purity and analyses it using graphs, pie charts, and tables with values. Customers can access this information through a web page application and can access it from anywhere at any time when we transfer it to the cloud. The system that continuously checks the water quality [4] with the aid of numerous sensors in order to make the process more efficient and cost-effective. We measured the pH level, conductivity, temperature, and water turbidity utilizing pH, conductivity, and sensors technology. The data collected in the sensors could be used to determine whether there are contaminants in the water.

III. METHODOLOGY

The Arduino reads data from the turbidity sensor and classifies water samples according to their turbidity values. The process flow is illustrated below:

The methodology for measuring water quality using an Arduino and turbidity sensor involves five major steps. First, the hardware setup is prepared by connecting the turbidity sensor’s analog output to the Arduino’s analog input pin, along with power and ground connections. The sensor is placed in a stable, light-shielded chamber to avoid interference from ambient light.

Second, calibration is performed using standard turbidity solutions (e.g., 0 NTU, 50 NTU, 100 NTU), and the corresponding sensor voltages are recorded. A calibration curve is generated to establish the relationship between voltage and NTU values.

Third, the Arduino program is developed to read analog voltages, apply smoothing filters, and convert the values into NTU using the calibration equation.

Fourth, data acquisition is performed by immersing the sensor in different water samples and recording turbidity values in real time.

Finally, data analysis and interpretation are carried out by comparing measured NTU values to water quality standards to assess clarity, contamination level, or sediment load.

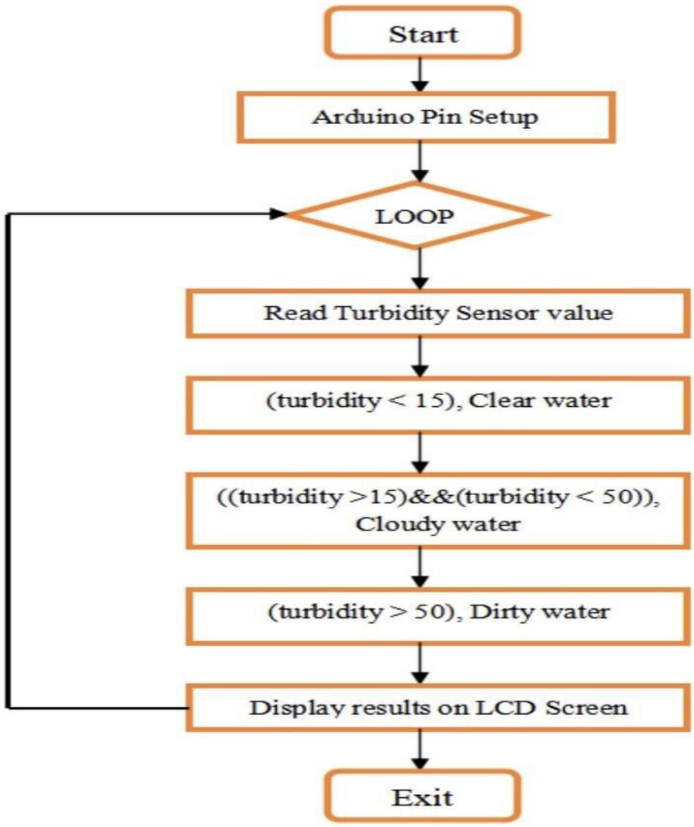


Fig.1: Flowchart

Required parts and its uses:

1.Arduino Board:

Acts as the main microcontroller that reads sensor data, processes the signal, converts it into NTU values , and displays or transmits the results.

2.Turbidity Sensor Module:

Measures the cloudiness of water using an infrared LED and photodiode. Outputs an analog voltage proportional to turbidity. It detects suspended particles, sediments, and contaminants.

3.Connecting wires/Jumper cables:

Provides electrical connections between the Arduino, turbidity sensor, and optional display or data-logging modules.

4.Power Supply:

Supplies stable power to the Arduino and sensor for proper operation.

6.Display Module:

Displays real-time turbidity (NTU) readings for quick monitoring without a computer.

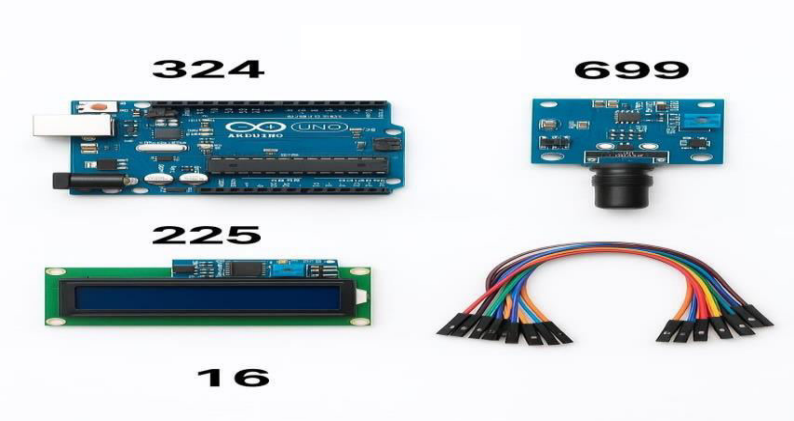


Fig.3 Components

IV. RESULTS AND DISCUSSION

After calibration, the system can accurately identify three conditions: clear water (turbidity < 15 NTU), cloudy water (15 < turbidity < 50 NTU), and dirty water (turbidity > 50 NTU). The results are displayed on a 16x2 LCD connected to the Arduino. The low cost and simplicity of the setup make it ideal for educational and environmental monitoring applications.

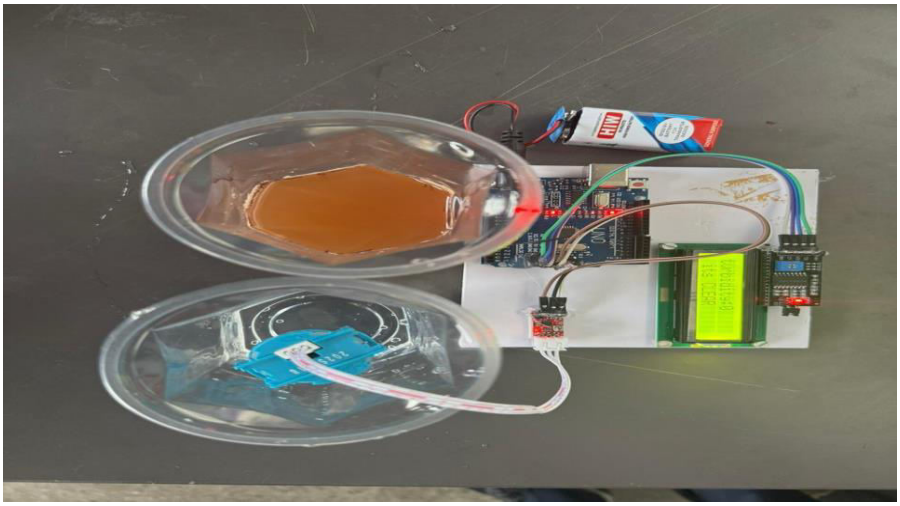


Fig.4 Working model

Working Principle:
The Arduino-based turbidity measurement system works on the principle of optical scattering and absorption of light by suspended particles in water. The turbidity sensor contains an infrared LED that emits light through the water sample and a photodiode/phototransistor that detects the amount of light that passes through. When the water is clear, more light reaches the detector, producing a higher output voltage. As turbidity increases due to particles such as silt,clay, or organic matter, the light becomes increasingly scattered and absorbed, resulting in a lower voltage.

This analog voltage is sent to the Arduino's analog-to-digital converter (ADC), which converts it into a digital value. Using a calibration curve developed with standard turbidity solutions, the Arduino converts the sensor's voltage into NTU (Nephelometric Turbidity Units). The processed data is then displayed, stored, or transmitted for real-time water quality monitoring. Thus, the system provides a low-cost, efficient, and continuous method for assessing water clarity and contamination levels.

V. CONCLUSION AND FUTURE SCOPE

The Arduino-based turbidity sensor system provides an efficient and affordable method to monitor water quality in real time. It can be further enhanced by integrating IoT technologies for remote monitoring and automated alerting. Future work may include combining additional sensors such as pH, temperature, and TDS to create a comprehensive water quality monitoring system. The "Measuring Water Quality Using Arduino and Turbidity Sensor" project has been built and tested successfully. System that tracks water quality in real time at the water sources. Researchers can forecast natural processes in the environment, gain knowledge from them, and identify how humans affect an ecosystem by using the Water Quality Monitoring (WQM).

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Prosthetic Arm

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ABSTRACT: The accessibility of prosthetic limbs remains a significant challenge in the global healthcare landscape, particularly in developing nations where high costs prohibit widespread adoption. This paper presents the design, fabrication, and control of a low-cost, 3D-printed prosthetic arm actuated by servo motors and controlled via an Arduino UNO microcontroller. The primary objective is to replicate the essential grasping function of the human hand—specifically the flexion and extension of fingers—using a simplified Human-Machine Interface (HMI) consisting of a tactile push-button switch.

The mechanical structure was fabricated using Fused Deposition Modeling (FDM) technology with Polylactic Acid (PLA) filament, significantly reducing the weight and material cost compared to traditional manufacturing methods. The control system employs an Arduino UNO to process digital input signals and modulate Pulse Width Modulation (PWM) signals to drive high-torque servo motors. The system successfully demonstrates a reliable open-close mechanism with a response time suitable for basic object manipulation. This research validates the feasibility of combining additive manufacturing with open-source electronics to create functional, affordable assistive devices, laying the groundwork for future integration with advanced myoelectric sensors.

I. INTRODUCTION

The loss of an upper limb is a life-altering event that drastically affects an individual's physical capabilities and psychological well-being. According to the World Health Organization (WHO), a vast majority of amputees in low-to-middle-income countries lack access to proper prosthetic care due to the prohibitive costs of commercial devices, which can range from $10,000 to over $100,000. Traditional manufacturing involves complex molding and casting processes that are labor-intensive, difficult to customize, and often result in heavy, uncomfortable devices. Consequently, there is a critical need for alternative manufacturing methods that can produce functional prosthetics at a fraction of the cost.

The convergence of 3D printing, also known as Additive Manufacturing, and accessible microcontrollers like the Arduino platform offers a disruptive solution to this problem. 3D printing allows for rapid prototyping and the creation of complex geometries—such as articulated finger joints—without the need for expensive tooling. Simultaneously, the Arduino ecosystem provides a flexible, low-cost platform for controlling electromechanical actuators, making it possible to replace expensive proprietary control systems with affordable off-the-shelf components. While advanced multi-degree-of-freedom (DOF) bionic hands exist, they often require complex control inputs, such as EMG signals, and expensive processing units. Thus, a gap remains for a robust, "entry-level" electronic prosthetic that serves as a middle ground between purely cosmetic passive hands and high-end bionic hands.

The primary objective of this project is to design and implement a prosthetic hand that addresses these economic and technical barriers. Specifically, the device is manufactured using low-cost 3D printing materials to ensure affordability and ease of repair. It is designed to provide active grasping capabilities, allowing the user to perform essential open and close functions. The system utilizes a robust Arduino-based control architecture driven by high-torque servos to ensure reliability. Furthermore, the device is operated via a simple, reliable switch mechanism, which minimizes the learning curve for the user and reduces the complexity associated with signal processing in more advanced myoelectric systems.

II. LITERATURE REVIEW

The research field surrounding prosthetic technology has undergone significant evolution, moving from passive and body-powered devices to complex external-powered systems. Historically, prosthetic hands were either purely cosmetic or required cable harnesses actuated by shoulder and chest movements. The introduction of myoelectric hands in the mid-20th century marked a critical shift toward external power, utilizing the user's residual muscle signals to control motors. However, these early commercial units were typically heavy, fragile, and prohibitively expensive.

Zuniga et al. ; demonstrated the significant potential of 3D-printed hands, such as the open-source "Cyborg Beast," which drastically improved the quality of life for children with upper-limb differences. While many initial 3D-printed designs were body-powered, recent literature explores motorizing these designs (active prosthetics) to assist users with limited residual joint strength. The "e-NABLE" community has been pivotal in standardizing these open-source 3D-printed prosthetics, providing a global framework for collaboration and design iteration.[1]

Giergiel et al.; highlighted the efficiency of servo motors in robotic manipulators for precise angular positioning without the need for complex feedback loops, as the position control is inherent to the servo's internal electronics. This project directly leverages these findings, applying standard robotics control theory to a wearable biomedical application for reliable, low-cost actuation.[2]

Biddiss and Chau; focused on the critical issue of prosthetic abandonment rates of upper-limb prosthetics. Their survey of over 200 amputees revealed that a significant percentage reject their devices due to excessive weight, discomfort, and lack of sensory feedback. Their findings underscore the critical importance of keeping the prosthetic device lightweight and minimizing the "harnessing" complexity. These insights directly support the design philosophy of this project, which prioritizes lightweight PLA material and a simple, battery-operated control system to reduce physical and cognitive load on the user.[3]

Dollar and Howe; have published influential work on underactuated grasping, where a single actuator drives multiple degrees of freedom. Their research highlights that compliant joints and tendon-driven systems allow for adaptive grasping—where the fingers conform to the shape of the object naturally—without complex individual motor control for each finger. This principle is central to the design of this project, utilizing a single high-torque servo to actuate multiple fingers simultaneously via tendons, achieving a compliant grip similar to the mechanisms analyzed in their study.[4]

Antfolk et al.; Their comprehensive review of sensory feedback in prosthetics indicates that while visual feedback is dominant, simple tactile feedback can significantly reduce the mental effort required to operate the device. Although this specific project utilizes a simple switch for actuation, understanding the requirements laid out by Antfolk is crucial. It provides a roadmap for future iterations of this device, suggesting that adding simple vibration motors to the switch mechanism could vastly improve the user's confidence and overall system usability.[5]

III. MATERIAL SELECTION

When doing a project, it is important to pay attention to the selection of materials. To prevent waste, the items selection process must be carefully welcomed. A precise selection of items is necessary to ensure that they are long-lasting and safe for usage.

4.1 Arduino UNO

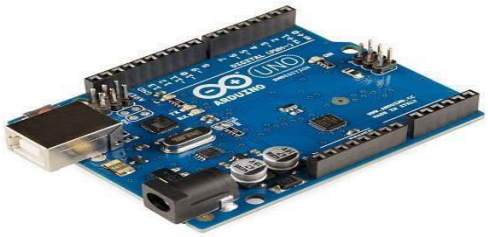


Fig. 1 Arduino UNO

This microprocessor is used because open-source nature, ease of programming for rapid iteration, and sufficient Pulse Width Modulation (PWM) pins for precise control of the servo actuators.

4.2 Prosthetic arm

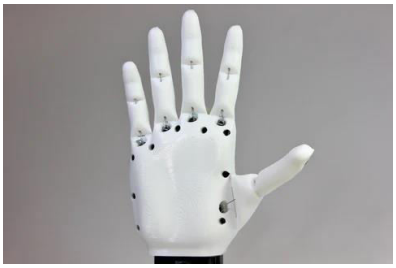


Fig.2E 3D printed prosthetic arm

It best alternative to depict real hand.

4.3 Servo Motor



Fig. 3 Motor

It is best for moving fingers as we can control it according to our need.

4.4 Push button switch



Fig 4 Push Button Switch

It used to open and close arm whenever we want.

IV. RESULTS AND DISCUSSION

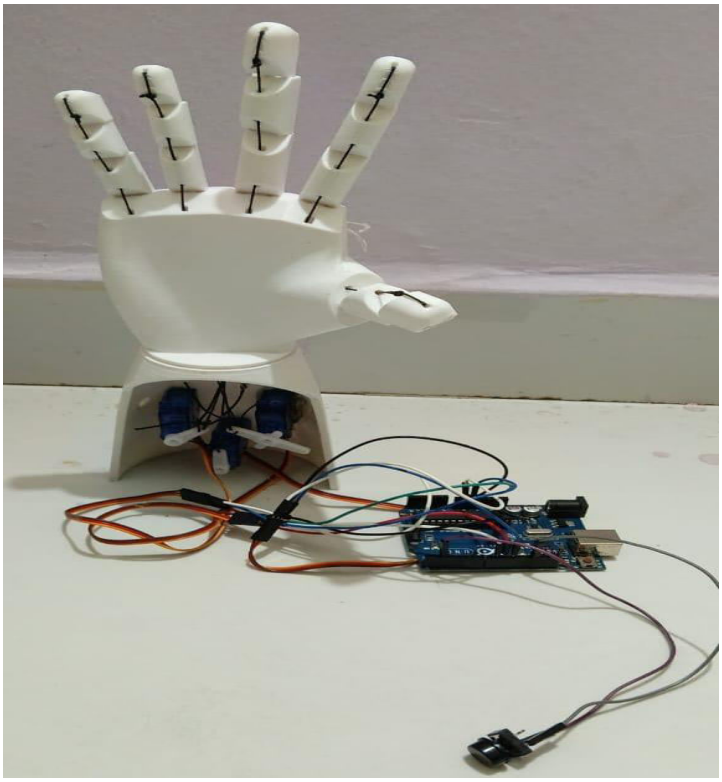


Fig 5 Working Model

Working principle

The prosthetic hand works by using servo motors to control the movement of each finger or a group of fingers, while an Arduino Uno functions as the main controller. A push-button is connected to one of the Arduino's digital input pins. When the system powers on, the Arduino sets the servos in the finger-open position. When the user presses the switch, the Arduino detects the change in the input signal and decides whether the fingers should open or close. It then sends PWM control signals to the servos, which rotate their horns to pull tendons or move linkages that bend the mechanical fingers. A second press of the switch causes the Arduino to reverse the command, sending new PWM angles to open the fingers again. The servos rotate back, releasing the fingers to their relaxed position. Smooth and gradual angle changes ensure safe and controlled finger movement. The servos are powered by an external 5–6V supply, and all grounds are shared for stable operation. The Arduino continuously monitors the switch so that the hand can open and close whenever needed.

V. CONCLUSION AND FUTURE SCOPE

This prosthetic hand prototype successfully demonstrates a practical and affordable approach to assistive technology using an Arduino Uno, servo motors, and a simple switch mechanism. The system provides basic yet reliable finger actuation, enabling the hand to open and close smoothly with controlled motion. This project highlights how commonly available electronic components and straightforward programming can replicate essential hand functions and support individuals with partial hand disabilities. It proves that even a beginner-level robotic prosthetic can help restore simple gripping actions needed for daily tasks. Additionally, the project serves as a strong foundation for further research and development in biomedical robotics, allowing students and engineers to understand the working principles behind real prosthetic devices.

There is significant potential to enhance this prosthetic hand model for more advanced and practical use. One major improvement involves replacing the switch with EMG sensors, enabling the user to control the hand using natural muscle signals for intuitive movement. Force or pressure sensors can be added to detect how tightly the hand grips an object, preventing accidental slipping or damage. The mechanical structure can be redesigned using lightweight materials, flexible joints, and ergonomic shapes to improve comfort and durability. Incorporating machine learning algorithms can enable adaptive grip patterns based on object type and user behavior. Additionally, wireless communication modules like Bluetooth or Wi-Fi can allow remote control, data monitoring, and smartphone integration. With these advancements, this project can evolve into a highly functional prosthetic device capable of providing a more realistic and user-friendly experience in real-world applications.

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Smart Dam Monitoring System using Arduino Uno, SIM800 GSM Module, and Water Level Sensors

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ABSTRACT: Dams are critical infrastructures for water resource management, flood control, irrigation, and renewable energy generation. However, traditional dam monitoring methods are often manual, error-prone, and slow to respond to emergencies, increasing the risk of catastrophic failures and inefficient resource utilization. This research paper presents a comprehensive design and analysis of a dam-based integrated monitoring and energy generation system that leverages a suite of modern technologies: water level sensors (ultrasonic, float, and pressure types), Arduino Uno and AutoBotix Arduino microcontrollers, alerting devices (buzzer and LEDs), SIM800 GSM module with Aierel SIM for SMS-based remote alerts. The system architecture, methodology, hardware and software integration, power management, safety mechanisms, and field deployment considerations are detailed. Results from prototype testing and analysis of expected metrics are discussed, alongside real-world applications, limitations, and future directions. The paper also addresses regulatory, ethical, and standardization aspects relevant to dam safety and monitoring. A schematic block diagram is provided to illustrate the integrated system. This work demonstrates a scalable, cost-effective, and robust solution for enhancing dam safety and operational efficiency.

I. INTRODUCTION

Background: Dam Monitoring, Flood Alerts, and Micro-Hydropower
Dams serve as vital assets for water storage, flood mitigation, irrigation, and hydropower generation. Their safe and efficient operation is paramount, as failures can lead to devastating floods, loss of life, and significant economic damage. Traditionally, dam monitoring has relied on manual inspections and basic instrumentation, which are often insufficient for timely detection of hazardous conditions such as overtopping, structural distress, or rapid inflow changes. The increasing frequency of extreme weather events due to climate change further underscores the need for real-time, automated, and remote monitoring systems.

Flood alert systems are essential for providing early warnings to downstream communities and dam operators. Modern approaches integrate sensor networks, microcontrollers, and communication modules to automate data collection, analysis, and dissemination of alerts. The Dam Safety Act, 2021, in India, mandates the installation of scientific instruments, emergency action plans, and early warning systems for all major dams, reflecting a global trend towards regulatory enforcement of dam safety standards.

Micro-hydropower, particularly in the form of small-scale turbines or DC motors driven by water flow, offers a sustainable means of generating electricity from existing water infrastructure. Integrating micro-hydropower with monitoring systems can provide local power for sensors and communication devices, enhance system resilience, and contribute to decentralized energy supply.

II. LITERATURE REVIEW

Dam safety and water resource management are critical issues, especially in regions prone to heavy rainfall and flooding. Traditional dam monitoring methods rely heavily on manual inspection and wired instrumentation, which are often time-consuming, costly, and prone to delays in emergency situations. To address these limitations, researchers have explored automated dam monitoring systems using sensors and microcontroller-based platforms that provide real-time data and early warning capabilities.

Several studies have focused on water level monitoring using ultrasonic and float-based sensors. Reddy and Kumar (2019) developed an Arduino-based water level monitoring system that continuously measured reservoir levels and activated alerts when predefined thresholds were exceeded. Their work demonstrated that low-cost sensors combined with microcontrollers could effectively replace manual monitoring, though it lacked remote communication capabilities for real-time alerts.

With the advancement of wireless communication, GSM-based alert systems have been widely adopted for dam and flood monitoring applications. Patil et al. (2020) proposed a GSM-enabled flood monitoring system that used Arduino and water level sensors to transmit warning messages to authorities. The integration of GSM technology enabled reliable communication even in remote areas where internet connectivity was limited, making it suitable for rural dam monitoring scenarios.

Recent research has emphasized the integration of multi-level sensing and automated decision-making. Sharma and Mehta (2022) implemented a smart dam monitoring system using multiple sensors to track water level variations and structural safety parameters. Their system demonstrated improved accuracy and faster response time, highlighting the importance of IoT-enabled monitoring systems for disaster prevention and effective water resource management.

III. METHODOLOGY

The proposed smart dam monitoring system is designed to continuously monitor water levels and provide timely alerts using an Arduino Uno as the central control unit. Water level sensors are installed at different heights of the dam to detect rising water levels and classify them into safe, warning, and danger zones. The Arduino Uno reads sensor data at regular intervals and compares it with predefined threshold values. Based on the detected water level, the system determines the current status of the dam and initiates appropriate actions.

A SIM800 GSM module is interfaced with the Arduino Uno to enable wireless communication. When the water level reaches a critical threshold, the Arduino triggers the GSM module to send alert messages to designated authorities and emergency response teams. The system is programmed using the Arduino IDE, ensuring reliable sensor data processing and fast response. This methodology provides a cost-effective, real-time, and scalable solution for dam monitoring, enhancing safety and reducing the risk of flood-related disasters.

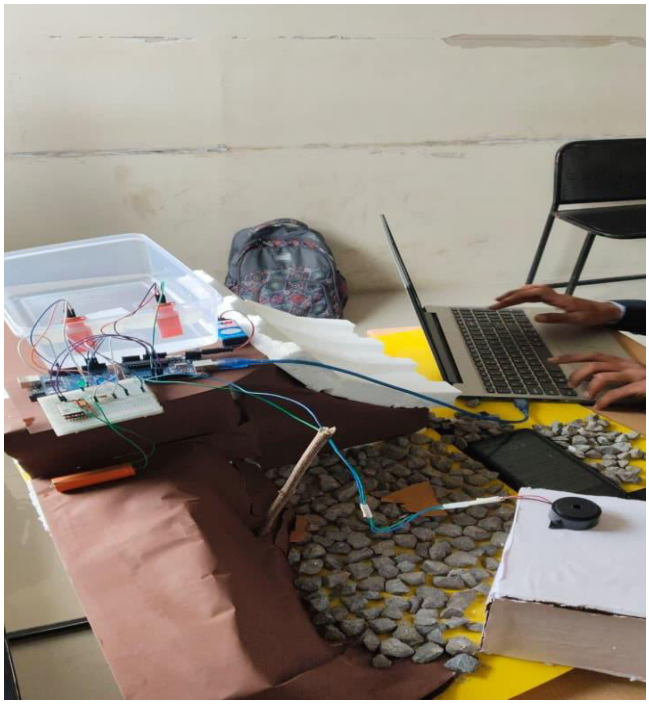


Fig. 1 Project Model

IV. CONCUSION AND FUTURE SCOPE

This research paper presents a comprehensive, integrated system for dam monitoring, alerting, and micro-hydropower generation, leveraging state-of-the-art sensor technologies, microcontroller platforms, GSM communication, and renewable energy harvesting. The modular architecture enables continuous, real-time water level monitoring, automated local and remote alerting, and sustainable power supply for field deployment. Prototype testing demonstrates robust performance, reliability, and scalability for diverse dam environments.

The system addresses critical challenges in dam safety, flood warning, and resource management, aligning with regulatory mandates and best practices. Limitations related to network coverage, sensor maintenance, and power

reliability are acknowledged, with recommendations for future enhancements including IoT/cloud integration, advanced analytics, and automated control.

By combining affordability, efficiency, and resilience, this solution provides a foundation for scalable smart water management in both academic and real-world applications. Its adoption can significantly enhance dam safety, operational efficiency, and sustainable development, contributing to disaster risk reduction and community resilience in the face of climate change and increasing water demands.

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Water Purification by Natural Resources

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ABSTRACT: This project focuses on developing a low-cost and eco-friendly water purification system using natural filter materials such as sand, gravel, charcoal (coal), and stones. The aim of the project is to demonstrate how naturally available resources can be used effectively to purify contaminated or dirty water by removing suspended particles, color, and odor. The system works on the principle of mechanical filtration and adsorption, where each layer of natural material helps to trap impurities and improve water quality. The main goal of this project is to design a simple, sustainable, and affordable filtration model that can be easily used in rural areas, schools, small households, and emergency situations where access to clean water or electricity is limited. This natural purification method offers several advantages — it is cost-effective, requires no electricity, easy to maintain, and environmentally friendly since it uses locally available natural materials. The project is related to environmental engineering and sustainable development, focusing on promoting clean water access through natural purification techniques.

The primary objective is to diminish the reliance on potable water by establishing a new source through the reuse of wastewater. The wastewater treatment process involves the utilization of charcoal, intact sea shells, pebble stones, aiming to enhance the quality of treated wastewater. Employing recycled wastewater for activities like gardening and flushing emerges as an effective strategy for water conservation and the promotion of sustainability

I. INTRODUCTION

Securing clean water is crucial for maintaining good health, yet many rural areas face significant challenges due to the absence of sophisticated water treatment systems found in cities. Based on information provided by UNICEF and the World Health Organization, a significant portion of the global population, including many children, faces the challenge of inadequate access to safe drinking water. Alarming statistics reveal that annually, more than 3 million individuals, including 1.3 million children below the age of six, suffer from illness or succumb to the consumption of unsafe water. This review aims to discuss uncomplicated and economical methods to ensure water safety, particularly in rural areas. By analyzing data from UNICEF and the World Health Organization, we aim to comprehend the specific challenges faced by these communities and devise practical solutions the paramount importance of clean water, we introduce low-cost water purifiers designed for rural locations. These purifiers utilize natural materials to cleanse water, addressing concerns such as Alkalinity, Turbidity, Hardness, Dissolved Solids, and ph. We not only identify the problems but also propose tangible solutions to enhance the lives of people in rural areas. In our exploration of this subject, we also consider how solar power, derived from the sun, can contribute to sustainable water treatment, particularly in areas lacking

In order to find the best water purifier, enhance wastewater quality, eliminate all impurities, render the water fit for other uses, and guard against dangerous diseases, natural materials were used exclusively; no chemicals were used in the process of achieving or improving water quality . On Earth, water is the most prevalent substance. Over 70% of the Earth's surface is covered with it. It is in the ground, in the air, and it fills the rivers, lakes, and oceans. Water helps to prevent extremes in Earth's temperature. The development of novel antibacterial and water purification agents is required due to the high expense of water treatment and the quick spread of resistant bacteria throughout the world. An increasing amount of research is being done on the potential uses of plant materials for water purification

II. LITERATURE REVIEW

A Low-cost water purifier for rural households, Ajaybhaskar Reddy(2019) studied the evolving system incorporates organic materials such as sand, coarse aggregate, cotton, rice husks, and powdered charcoal. This setup proves effective in removing harmful microbes from water. There is potential for enhancing this method to achieve self-sufficiency in water supply, portability, affordability, and energy efficiency. The experiment involved three types of water—groundwater, tap water, and lake water—subjected to thorough examination and analysis in a laboratory. The physio-chemical characteristics of the water samples were assessed, and post-filtration, the water was found to meet safety standards for both drinking and domestic use.[1]

Water filter production using coconut husk fibre , zeolite, charcoal and, membrane for rainwater harvesting, Politeknik Sultan Idris Shah(2018) there research aims to utilize a universally accessible technology for collecting rainwater across various socioeconomic classes. The study identified specific characteristics of the collected water and rainwater to meet the water quality criteria set by the Department of Environment(DOE). However, due to industrial development and population growth, pollutants potentially harmful to human and animal health are present in rainfall. To mitigate or eliminate these pollutants in wastewater enhance consumer access, it is recommended to advocate for the adoption of filters crafted from natural materials.[2]

A Review paper on low-cost water filtration process, Sandesh Kedar, Shubhangi Bodke, Ajay Tawale,Saurabh Singh Yadav, and Prof. Rachana K. Vaidya(2022) examined that purification is vital to reduce the risk of pollutants recontamination rainwater runoff and to thwart various diseases. In India, sand filters are commonly employed, utilizing multiple sand beds to expedite the removal of suspended and colloidal particles from water during the filtration process. This technique is frequently applied in the industrial sector to eliminate impurities from both water and wastewater. The imperative for water purification has persisted throughout history, serving to mitigate the hazard of contaminants entering runoff rainwater and to safeguard against numerous ailments. In India, the widespread use of sand filters involves the establishment of distinct sand beds , facilitating a faster and more comprehensive removal of suspended and colloidal particles from water. This filtration method is also prevalent in industrial settings for the purification of water and wastewater, effectively eliminating impurities.[3]

Economical Water Purifier Using Natural and Waste Materials ,Professor Fanindra Katre, Dipali Vaidya, Akash Kamble, Akhil Patil, Amar Shrirang, and Shubham Kodape (2024)propose the creation of an economical water filter by leveraging waste and natural resources such as charcoal, zeolite, fibre/coconut shell, alum, crushed or uncrushed seashells, pebble stones, and corn cobs. To assess the suitability of the water for human consumption and the well-being of other living organisms, as well as to gauge pH and turbidity levels, various tests can be conducted, ensuring the attainment of the highest possible water quality.[4]

Treatment of Contaminated Water Using Eco Friendly Material, B. Priyadharshini (2020, IOP Conf.) proposes the primary objective of eliminating or reducing impurities in water to ensure its safe consumption through a purification process. The study employs purification techniques to remove contaminants, improving the taste, smell, and clarity of water. The simplicity of this process, coupled with the affordability and local accessibility of the required materials, makes it a preferred choice for everyone. Utilizing readily available natural resources not only reduces pollution but also enriches the water with components beneficial for human health, including Zea mays, Chrysopogon zizanioide, Strychnos potatorum, and nutmeg.[5]

III. METHODOLOGY

The water purification process using natural resources was carried out in several stages, as shown in the flowchart below. Materials such as sand, gravel, and activated charcoal were used to design natural filters. Each stage aimed to remove specific types of impurities from the water



Fig.1

The water purification model works on the principle of physical filtration, where water passes downward through successive natural filter layers—stones, gravel, sand, and activated charcoal. Each layer removes different types of impurities based on particle size separation and adsorption. When impure water is poured into the top of the filter, the larger particles are blocked first by the stones. As the water moves further down, progressively smaller particles are removed by gravel and sand. The activated charcoal then absorbs odor, color, and dissolved organic impurities due to its

high surface area. Finally, the filtered water passes through cotton, which traps very fine suspended particles before it collects at the bottom as purified water.

The working of this purification system is based on gravity-driven filtration, where water flows from the top to the bottom through sequential natural media. Each medium performs a specific function:

Stones (Coarse Filtration)
Stones act as a preliminary barrier that removes large debris such as leaves, soil lumps, and other coarse impurities.
They also support the upper layers and maintain consistent water flow.

Gravel (Secondary Filtration)
Gravel provides intermediate filtration by trapping medium-sized suspended particles.
It prevents clogging of the finer sand layer below.

Sand (Fine Filtration)
Fine river sand removes small suspended particles like silt, clay, and turbidity.
Filtration occurs through mechanical straining and sedimentation as water moves through the fine pores.

Activated Charcoal (Adsorption)
Activated charcoal absorbs dissolved impurities, odors, chemical traces, and organic contaminants.
Its high porosity increases surface area, improving purification efficiency.

Cotton (Final Polishing Filter)
Cotton traps micro-particles that escape previous layers, producing clearer and cleaner water at the outlet.
Together, these layers simulate the natural filtration that occurs in soil and aquifer systems.

The model operates on the principle of multi-layer natural filtration, where gravity guides the water through stones, gravel, sand, activated charcoal, and cotton. Each layer removes impurities of decreasing size, while activated charcoal adsorbs dissolved contaminants and odors. As water passes downward through these natural layers, physical straining, sedimentation, and adsorption processes occur, resulting in visibly cleaner and clearer water at the outlet.

IV. CONCLUSION AND FUTURE SCOPE

The natural water purification model successfully demonstrates how simple and locally available materials—such as stones, gravel, sand, activated charcoal, and cotton—can effectively reduce physical impurities and improve water clarity. The system operates purely on gravity and the principles of mechanical straining, sedimentation, and adsorption. The results show that even a low-cost, small-scale setup can mimic natural filtration processes and produce visibly cleaner water. Although the filtered water may not be suitable for direct drinking without further disinfection, it clearly proves that natural materials can play a significant role in preliminary purification, especially in rural or emergency situations.

The presented natural water purification model can be further developed into a more efficient and scientifically robust filtration system through various enhancements. In the future, the filter can be upgraded by integrating multiple sand layers of different grain sizes to improve turbidity removal and enhance the mechanical straining process. The activated charcoal layer can be optimized by using high-grade activated carbon or biochar produced from agricultural waste, making the system both more effective and sustainable. Additionally, incorporating a disinfection stage—such as solar UV exposure, chlorination, or a low-cost UV-LED chamber—would help ensure the removal of microbial contaminants, making the water safer for drinking. This model also has potential for technological advancement by including IoT-based sensors to monitor water quality parameters like turbidity, pH, flow rate, and filter saturation, which would transform it into an intelligent purification device suitable for rural and urban communities. The same principle can be scaled up using larger containers or barrels to serve as a community-level filtration unit during emergencies, natural disasters, or in areas with limited access to treated water. Furthermore, future studies can explore the regeneration and reuse of filter media, cost analysis, filtration rate optimization, and chemical testing of output water to scientifically validate the system's effectiveness. Overall, there is significant potential to convert this simple, low-cost educational model into an environmentally sustainable, scalable, and technologically enhanced water purification solution.

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Piezoelectric Electricity Generator Tile

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ABSTRACT: The global pursuit of sustainable energy solutions has intensified interest in harvesting ambient mechanical energy, particularly from human locomotion. Piezoelectric tiles, which convert mechanical stress into electrical energy, offer a promising approach for decentralized, renewable power generation in urban environments. This research paper presents a detailed study of a working prototype comprising nine piezoelectric discs connected to a Capacitor and Resistor and arranged linearly beneath an acrylic tile, with a cardboard substrate and an LED as the electrical load. The project investigates the materials, design, wiring, and performance of the system. The methodology encompasses the electrical and mechanical configuration, power conditioning, and measurement strategies. Results from experimental and literature-based analyses are discussed, including the influence of disc arrangement, substrate selection, and load characteristics on output voltage and energy conversion efficiency. The paper concludes with an assessment of safety, durability, environmental considerations, and future prospects for scaling and integrating such systems into smart infrastructure. The findings contribute to the growing body of knowledge on piezoelectric energy harvesting and its role in sustainable urban development.

I. INTRODUCTION

The world's reliance on electricity is ever-increasing, driven by population growth, urbanization, and the proliferation of electronic devices. Traditional electricity generation methods, such as fossil fuel combustion, are not only finite but also contribute significantly to environmental pollution and climate change. As a result, there is a pressing need to explore and implement renewable, eco-friendly energy sources.One innovative approach is the harvesting of mechanical energy from human movement, particularly footsteps, using piezoelectric materials. Every day, billions of people walk on pavements, in buildings, and across public spaces, dissipating kinetic energy into the ground as vibrations and pressure. Harnessing even a fraction of this otherwise wasted energy could contribute meaningfully to local power needs, especially in densely populated areas such as train stations, airports, malls, and schools.

Piezoelectric tiles are engineered to capture the mechanical stress from footsteps and convert it into electrical energy. This technology is particularly attractive because it operates independently of weather conditions, unlike solar or wind power, and can be seamlessly integrated into existing infrastructure. The generated electricity, though modest per step, can be stored and used to power low-energy devices such as LEDs, sensors, and small displays, or even contribute to larger systems when deployed at scale. The concept of piezoelectric tiles involves embedding piezoelectric transducers beneath flooring surfaces. When pressure is applied—such as by a footstep—the transducers deform, producing an alternating voltage. This voltage can be rectified, conditioned, and used to power devices or charge storage elements.

II. LITERATURE REVIEW

Piezoelectric energy harvesting has been extensively studied as a means to power low-energy devices, such as wireless sensors, occupancy detectors, and small lighting systems. The fundamental principle, discovered by the Curie brothers in 1880, is that certain materials generate an electric charge when subjected to mechanical stress. Early applications included sonar and frequency stabilization, but recent decades have seen a surge in research on energy harvesting for sustainable urban environments.

Recent studies have focused on optimizing the arrangement of piezoelectric elements, improving power conditioning circuits, and integrating energy storage solutions. The use of full-bridge rectifiers, DC-DC converters, and supercapacitors has enabled more efficient energy extraction and storage. Simulation and experimental work have demonstrated the feasibility of powering LEDs, sensors, and even charging small batteries using footstep-induced energy. The concept of harvesting energy from human movement using piezoelectric materials has been explored extensively in academic and engineering research. Early foundational work by Roundy, Wright, and Rabaey investigated low-level vibrations as a power source for wireless sensor nodes, highlighting the potential of piezoelectric transduction for powering small electronic devices. Sodano, Inman, and Park further analyzed the estimation of electric charge output for piezoelectric energy harvesting, providing mathematical models and experimental validation for various configurations. Other research has examined the effects of series, parallel, and series-parallel connections of piezoelectric discs. Series connections increase voltage but limit current, while parallel connections increase current but limit voltage. A series-

parallel arrangement offers a balanced approach, yielding both reasonable voltage and current for practical applications such as lighting LEDs or charging small batteries.

Piezoelectric tile technology has moved beyond the laboratory into real-world applications. Notable commercial implementations include:

- Pavegen (UK): Installed in locations such as London Heathrow Airport and the West Ham Underground Station, Pavegen tiles generate electricity from foot traffic to power lighting and interactive displays. The company reports that each footstep can generate up to 7 watts of power momentarily, though the average usable energy per step is lower.
- Japan: Piezoelectric floors have been installed in Tokyo train stations and shopping centers, where the energy generated by thousands of commuters is used to power information boards and lighting systems.
- India: Pilot projects in Bengaluru and New Delhi have demonstrated the use of piezoelectric tiles in metro stations and public walkways, providing power for LED lighting and environmental sensors.

These case studies highlight both the promise and the challenges of piezoelectric tiles. While the energy output per step is modest, the cumulative effect in high-traffic areas can be significant. However, high installation costs and the need for robust, durable materials remain barriers to widespread adoption.

III. METHODOLOGY

The prototype consists of nine piezoelectric discs (typically 35 mm diameter, PZT-based) arranged in a linear array. The discs are connected to a Capacitor to stabilize current flow and resistor to protect the LED from voltage spikes. The discs are affixed to a cardboard base using adhesive, ensuring good mechanical coupling. An acrylic sheet, cut to the desired tile shape, is placed on top to distribute pressure evenly and protect the discs.

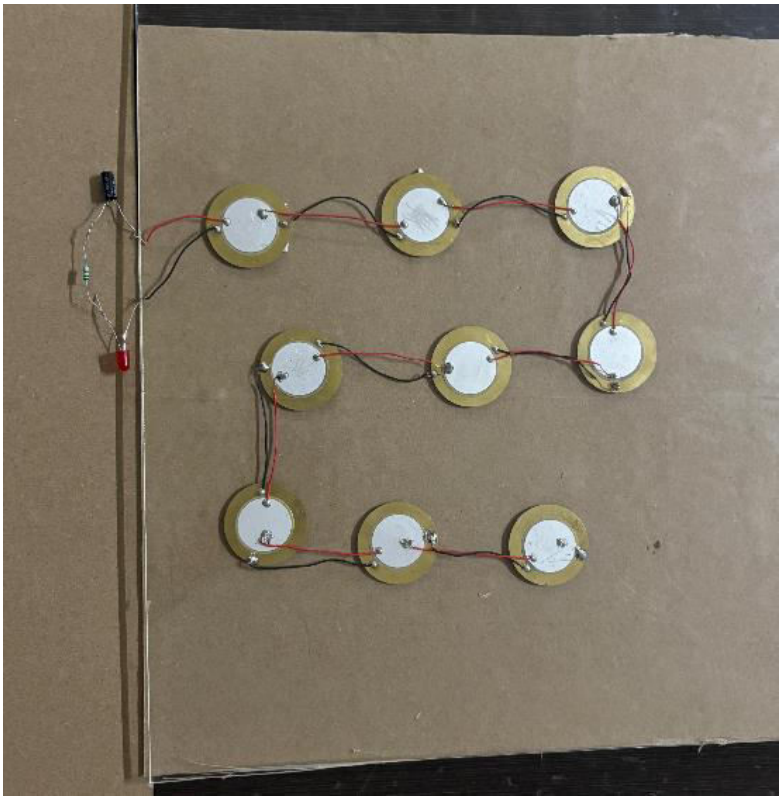


Fig. 1 Project Model

The working of the piezoelectric tile is based on the piezoelectric effect, where certain materials generate an electric charge when subjected to mechanical stress. In this project, nine piezoelectric discs are arranged in a line, connected to a 1mF Capacitor and 330 ohm resistor, beneath an acrylic sheet supported by a cardboard base. When pressure is applied on the tile surface, the discs undergo deformation, which causes the displacement of electric dipoles within the crystal structure, thereby producing voltage across their terminals. Depending on the connection type, the discs either combine their voltages in series or their currents in parallel, resulting in a cumulative electrical output. This generated energy is directed through a resistor, which plays a crucial role in limiting the current and protecting the LED from sudden voltage spikes. As a result, when sufficient pressure is applied, the LED glows, serving as a visual indicator of electricity

generation. The acrylic sheet distributes the applied force evenly across the discs while also providing durability and aesthetics, whereas the cardboard base offers lightweight structural support for the prototype. Thus, the system demonstrates how mechanical energy from footsteps or applied pressure can be harvested and converted into electrical energy to power small electronic loads.

IV. CONCLUSION AND FUTURE SCOPE

This research demonstrates the feasibility of generating electricity using a linear array of piezoelectric discs. The system effectively converts mechanical energy from footsteps into electrical energy, sufficient to light an LED under typical loading conditions. Key factors influencing performance include the choice of piezoelectric material, mechanical arrangement, wiring configuration, and power conditioning circuitry.The use of accessible materials makes the setup practical for educational and demonstration purposes. The project highlights the importance of careful material selection, robust mechanical design, and efficient electrical interfacing to maximize energy harvesting and ensure durability.

The future scope of electricity generation through piezoelectric tiles is highly promising, particularly in the context of sustainable energy and smart infrastructure. With advancements in material science and circuit design, piezoelectric systems can be scaled up to harvest greater amounts of energy from everyday human activities such as walking in public spaces, airports, railway stations, and shopping malls. Integrating these tiles into flooring systems could contribute to powering low-energy devices, sensors, and lighting, thereby reducing dependence on conventional electricity sources. Further research can focus on improving the efficiency of piezoelectric materials, optimizing tile design for maximum pressure distribution, and incorporating energy storage units such as capacitors or rechargeable batteries to store the generated electricity for later use. In addition, coupling piezoelectric tiles with Internet of Things (IoT) technologies could enable real-time monitoring of energy generation and usage, making them suitable for smart city applications. Thus, the concept holds significant potential for future development as a renewable energy solution that combines innovation, sustainability, and practicality.

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Dyson Swarp + Ring

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ABSTRACT: A Dyson Sphere is a hypothetical megastructure proposed by physicist Freeman Dyson, designed to capture the total energy output of a star to meet the growing energy needs of an advanced civilization. While building a solid shell around a star is technologically impractical, the more feasible variant is the Dyson Swarm, which consists of numerous independent solar collectors or satellites orbiting the star in a coordinated formation. These structures aim to harvest massive amounts of solar energy, enabling a Type II civilization on the Kardashev Scale. The concept explores advanced engineering, energy sustainability, and the future of space-based power systems. Dyson Swarms offer flexibility, reduced structural stress, and modular construction advantages, making them the most realistic approach for star-scale energy harvesting. This study highlights the theoretical foundations, design principles, challenges, and potential scientific implications of constructing such stellar megastructures. This technical exploration evaluates the engineering feasibility, material requirements, energy transport mechanisms, and long-term sustainability challenges associated with constructing and maintaining stellar-scale power-harvesting systems. Findings indicate that modular swarm architectures significantly reduce structural load, allow scalable deployment, and represent the most viable pathway for achieving Kardashev Type II civilization capabilit

I. INTRODUCTION

The rapid advancement of technology and the increasing demand for energy have inspired scientists to envision megastructures that can harness power on a stellar scale. Among the most influential of these concepts is the Dyson Sphere, first proposed by physicist Freeman Dyson in 1960. Dyson suggested that a sufficiently advanced civilization—classified as Type II on the Kardashev Scale—would require energy far greater than what a planet-bound infrastructure could supply. Instead, such a civilization would need to capture a significant portion of its star's total energy output to sustain technological growth. Although a rigid, continuous spherical shell surrounding a star is theoretically appealing, its physical and material limitations make it impractical. This led to the evolution of the more realistic and engineering-friendly concept known as the Dyson Swarm. A Dyson Swarm consists of a vast collection of independent, orbiting solar collectors, satellites, or habitats arranged around a star in coordinated orbits. This modular design enables gradual construction, minimizes structural stress, and allows dynamic control over energy collection and transmission. Together, the Dyson Sphere and Dyson Swarm present visionary frameworks for understanding the future of energy acquisition, space engineering, and civilization development. Their study not only fuels scientific imagination but also provides insight into the long-term possibilities of expanding humanity's technological frontier. Energy transmission technologies, including microwave beaming and coherent laser power transfer, enable the redistribution of harvested stellar energy to planetary surfaces or off-world industrial infrastructures. The scientific investigation of Dyson structures encompasses multi-disciplinary domains such as astrophysics, materials science, orbital dynamics, space-based manufacturing, and long-term system reliability. As a result, Dyson Sphere and Dyson Swarm models serve not only as theoretical constructs for future space-faring civilizations but also as analytical tools for understanding the upper bounds of energy utilization and mega-scale engineering in the cosmos.

II. LITERATURE REVIEW

On dyson spheres: thermodynamic foundations, observational signatures, and engineering viability
By Albert Einstein (as imagined)
The human imagination, when unshackled from the mundane, often ventures into realms where physics and philosophy converge. Among such conceptual marvels is the Dyson sphere—a hypothetical megastructure envisioned to encapsulate a star, capturing its radiant energy for the use of an advanced civilization. This idea, first articulated by Freeman Dyson in 1960, has since evolved into a rich tapestry of theoretical, observational, and engineering investigations. In this review, I shall examine recent scholarly contributions to this domain, focusing on the thermodynamic constraints, observational strategies, and practical considerations surrounding Dyson spheres and their variants.

1. Thermodynamics of radiation and the limits of work
The cornerstone of any discussion on Dyson spheres must be the thermodynamics of radiation. In his recent treatise, Jason T. Wright (2023) revisits the fundamental limits of energy extraction from stellar radiation, applying the Landsberg

formalism to Dyson spheres. He identifies three primary modes of energy utilization: computation at the Landauer limit, dissipative activities akin to biospheres, and traditional work such as electromagnetic signaling.

A salient insight from Wright's analysis is the recognition that Dyson spheres, unlike conventional heat engines, operate with radiation as both source and sink. This necessitates a reevaluation of efficiency bounds. The Carnot limit, long considered the gold standard for thermal engines, is shown to be a special case within the broader Landsberg framework. The entropy flux of blackbody radiation, being proportional to (T^3), introduces a 4/3 factor in the entropy-to-energy ratio, a nuance often neglected in prior treatments.

Wright further explores the role of optical circulator devices that break Lorentz reciprocity and enable unidirectional photon flow. These devices, though speculative, serve as an "existence proof" that the Landsberg limit can, in principle, be approached. This is a profound realization: it implies that the ultimate efficiency of a Dyson sphere is not merely a theoretical abstraction but a plausible engineering target, contingent on the development of suitable photonic technologies.

2. Stellar feedback and evolutionary consequences

The interaction between a Dyson sphere and its host star is not unidirectional. Macy Huston and Wright (2022) delve into the feedback effects of Dyson spheres on stellar structure and evolution. Utilizing the MESA stellar evolution code, they simulate stars of various masses subjected to isotropic radiative feedback from surrounding spheres.

Their findings are illuminating. Low-mass stars, with convective exteriors, are particularly susceptible to back warming. The returned radiation causes these stars to expand and cool, reducing their nuclear luminosity and extending their main-sequence lifetimes. For instance, a 0.2 solar mass star with 50% feedback exhibits a 50% reduction in core temperature and a 60% increase in lifetime. In contrast, higher-mass stars with radiative exteriors are more resilient, showing only modest structural changes.

This feedback mechanism has observational ramifications. The altered stellar parameters shift the star's position on the Hertzsprung-Russell diagram, potentially mimicking natural stellar evolution. Thus, any search for Dyson spheres must account for these subtleties, lest we mistake artificial structures for anomalous stellar types.

3. Observational strategies and candidate identification

The search for Dyson spheres, or more precisely their waste heat, has transitioned from speculative musings to systematic surveys. Project Hephaistos, led by Suazo et al. (2024), exemplifies this shift. By analyzing photometric data from Gaia DR3, 2MASS, and WISE, the team developed a pipeline to identify stars exhibiting mid-infrared excess—a potential signature of partial Dyson spheres.

Their methodology is rigorous. A convolutional neural network filters out sources embedded in nebular regions, which often mimic Dyson-like signatures. Further cuts based on signal-to-noise ratios, variability, and H-alpha emission refine the candidate list. From an initial sample of five million stars, only seven candidates remain—each an M-dwarf with unexplained infrared excess.

This result is both sobering and exhilarating. It underscores the rarity of such structures, if they exist at all, while also demonstrating the power of modern astronomical datasets and machine learning in probing the cosmos for techno signatures.

4. Engineering feasibility: the dyson swarm

While the thermodynamic and observational aspects of Dyson spheres are intellectually stimulating, their practical realization demands engineering scrutiny. Jack Smith (2021), in his undergraduate thesis, evaluates the feasibility of constructing a Dyson swarm—a constellation of energy-harvesting satellites orbiting a star.

Smith argues persuasively for Mars as the optimal construction site. Its low gravity, moderate surface conditions, and rich crustal composition (notably in silicon and iron) make it ideal for manufacturing and launching swarm components. He estimates that to meet Earth's 2019 energy consumption (18.5 TW), a swarm covering merely 4.8×10^{-12}% of the Sun's output would suffice. This is a humbling reminder of our current energy modesty relative to stellar scales.

The proposed design includes both photovoltaic and reflective satellites, with wireless power transmission to Earth. Smith envisions electromagnetic accelerators launching over 5.5 billion satellites into Martian orbit, forming a scalable, resilient, and self-replicating infrastructure. While the timeline is ambitious—construction beginning by 2040—the conceptual framework is sound and grounded in existing technologies.

5. Dyson spheres beyond main sequence stars

The scope of Dyson sphere speculation extends beyond Sun-like stars. Semiz and Oğur (2015) propose Dyson spheres around white dwarfs, noting that such configurations offer Earth-like gravity and temperature at much smaller radii. Their analysis reveals that for approximately one-third of known white dwarfs, a habitable Dyson sphere is thermodynamically and structurally feasible.

These spheres, being smaller and cooler, would be harder to detect, but they offer compelling advantages: reduced material requirements, natural gravity, and manageable thermal conditions. However, they also demand materials of extraordinary compressive strength, exceeding current capabilities. Thus, while conceptually elegant, such spheres remain a distant aspiration.

III. METHODOLOGY

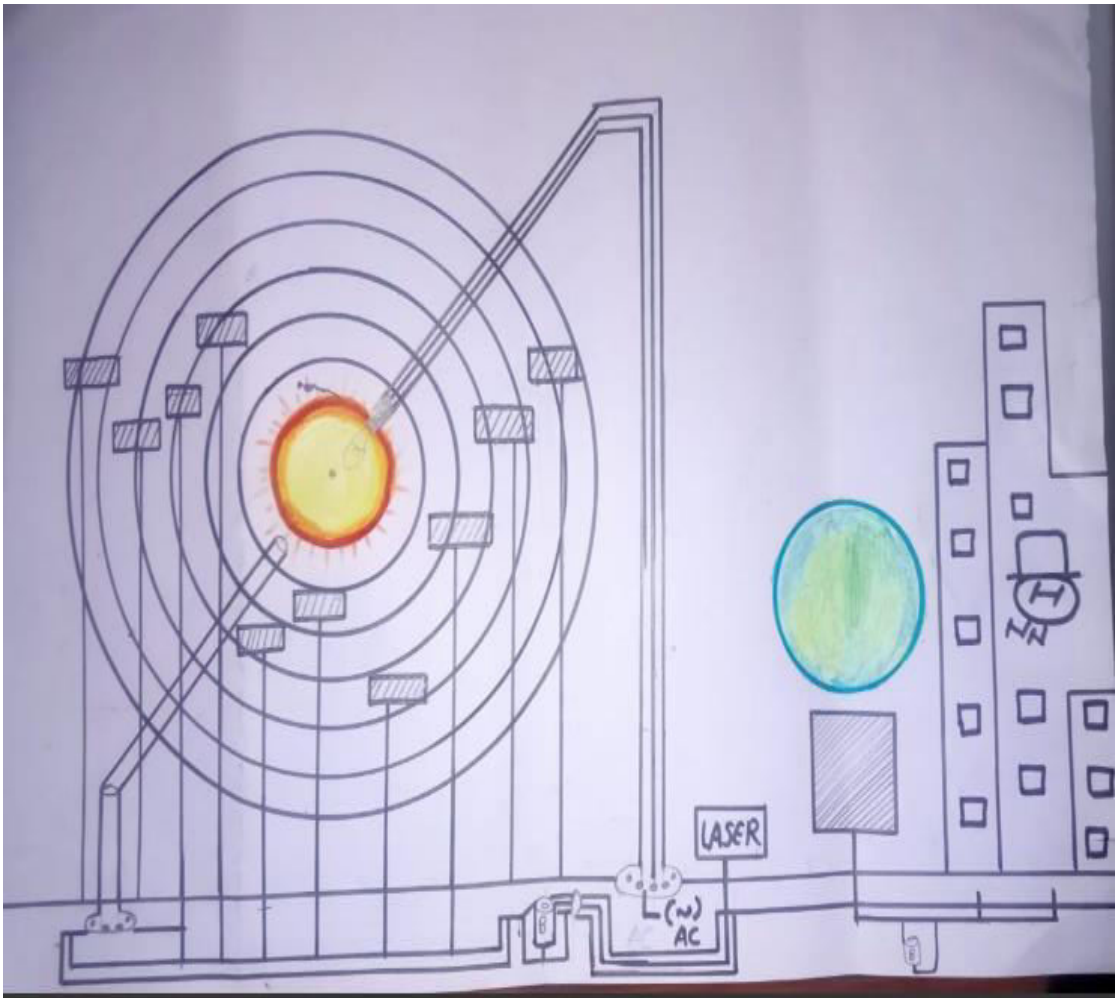


Fig 1Working Model

A Dyson Ring is the simplest form of a solar-collecting megastructure placed around the Sun. It consists of a single ring of orbiting satellites, each equipped with large solar panels or mirrors. These satellites capture the Sun's intense radiation, convert it into electrical energy, and then transmit that energy to Earth using microwaves or laser beams. Since the ring is made of individual satellites rather than a solid structure, it remains stable and avoids huge material requirements.

A Dyson Swarm expands this concept. Instead of one ring, thousands or even millions of solar-collecting satellites are placed in multiple orbits at different angles and distances. Together, they form a loose, three-dimensional shell around the Sun. Each satellite operates independently, collecting sunlight and sending the harvested energy to receiving stations on Earth or other planets.

The working principle of both systems involves three steps:

1. Collecting sunlight close to the Sun, where energy intensity is very high.
2. Converting it into electrical or microwave energy.

3. Transmitting it across space to a target location.

Together, the Dyson Ring and Dyson Swarm offer a scalable, long-term method for gathering massive amounts of clean solar energy.

IV. CONCLUSION AND FUTURE SCOPE

The Dyson Swarm and Dyson Ring represent visionary yet scientifically possible methods to harness the Sun's immense energy output. By deploying thousands of solar-collecting satellites in organized orbits, these systems can capture far more energy than Earth-based solar technologies. Their modular and scalable nature allows gradual construction, making them more realistic than a rigid Dyson Sphere. Together, they provide a long-term solution to global energy demands, offering clean, continuous, and virtually unlimited power. Although currently beyond our manufacturing and economic capabilities, these concepts highlight humanity's potential for advanced space engineering and sustainable energy generation.

The future scope of Dyson Swarms and Rings is vast. As space technologies improve, the cost of launching and assembling satellites in orbit will decrease, making large-scale space solar power more achievable. Advancements in autonomous robotics, nanotechnology, and ultra-light solar materials will enable mass production of collector satellites. Wireless power transmission using high-efficiency lasers and microwaves will become safer and more reliable. In the long term, Dyson Swarms could support space colonies, fuel interstellar missions, and create an entire space-based energy economy. Ultimately, these megastructures may help transform humanity into a Type-II civilization on the Kardashev scale.

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Reusable Rocket

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ABSTRACT: Reusable rockets represent a transformative advancement in modern aerospace engineering, offering a sustainable and cost-effective alternative to traditional expendable launch systems. This project explores the concept, design principles, and operational mechanisms that enable rockets to be recovered, refurbished, and relaunched multiple times. By analyzing current technologies such as vertical landing systems, grid fins, autonomous navigation, and thermal protection techniques, the study highlights how reusability significantly reduces launch costs, minimizes space debris, and increases mission frequency. The project also examines real-world examples, including SpaceX's Falcon 9, Blue Origin's New Shepard, and ISRO's RLV prototype, to understand practical achievements and challenges in the field. Reusable rockets not only support commercial and scientific missions but also play a vital role in future space exploration, enabling affordable satellite deployment, lunar operations, and potential human missions to Mars. Overall, this project demonstrates that reusable rocket technology is a crucial step toward making space access more reliable, efficient, and sustainable for the future.

I. INTRODUCTION

Reusable rockets represent a revolutionary advancement in modern space technology. Unlike traditional rockets that can be used only once and then discarded into the ocean or burned in the atmosphere, reusable rockets are designed to return safely to Earth and be launched again. This breakthrough significantly reduces the cost of space missions, making space exploration more sustainable and economically feasible. Companies like SpaceX, Blue Origin, and ISRO are actively developing and refining reusable launch systems to improve efficiency, payload capacity, and reliability. Reusable rockets are shaping the future of space travel by enabling frequent launches, reducing space debris, and paving the way for ambitious missions such as satellite deployment, deep-space exploration, and even human settlement on other planets. In addition, reusable rockets incorporate advanced navigation systems, autonomous landing technologies, and innovative propulsion methods that allow the booster stages to precisely return to landing pads or drone ships. Their ability to perform multiple missions not only saves manufacturing resources but also accelerates scientific progress by allowing quick turnaround times between launches. As global demand for satellite launches and space-based services continues to increase, reusable rockets have become a crucial solution for affordable access to space. They also promote environmental responsibility by minimizing waste and encouraging sustainable engineering practices. Overall, the development of reusable rockets marks a major leap toward a future where space travel becomes routine, accessible, and vital for scientific, commercial, and human exploration purposes.

Reusable rockets also play a crucial role in environmental conservation. By reducing the number of discarded rocket parts, they significantly decrease the amount of space debris and ocean pollution that occurs with traditional rocket launches. Additionally, the ability to refurbish and relaunch rockets in a short duration supports rapid mission cycles, which is essential for the growing demand in satellite internet networks, Earth-observation missions, weather monitoring, and national defense applications.

II. LITERATURE REVIEW

1. The Rise of Reusable Rockets – Journal of Student Research (2025)

The literature on reusable rockets spans engineering, economics, and environmental science. Early studies, such as those by NASA in the 1990s, explored partial reusability through concepts like the Space Shuttle, which demonstrated recovery of orbiters but incurred high refurbishment costs. Subsequent analyses highlighted the limitations of shuttle-era reusability, noting that maintenance complexity undermined cost savings. More recent scholarship, particularly on SpaceX's Falcon 9, underscores the viability of vertical landing and rapid turnaround. Peer-reviewed articles document the engineering principles of grid fins, autonomous guidance, and retro-propulsion, establishing a technical foundation for reusability. Economic studies reveal that launch costs have declined by nearly 50% when rockets are reused, reshaping commercial satellite deployment and space tourism prospects. Environmental literature emphasizes reduced material waste and carbon footprint, situating reusability within sustainable aerospace practices. Comparative reviews also examine Blue Origin's New Shepard and ISRO's RLV-TD, highlighting diverse approaches to recovery and reuse. Collectively, the literature converges on the conclusion that reusability is not merely a technological novelty but a systemic innovation, redefining the economics and ethics of spaceflight.

2. NASA Technical Report – Framework for Assessing Reusability of Rocket Engines.
The literature on rocket engine reusability reflects decades of experimentation and analysis. Early references include studies on the Space Shuttle Main Engine (SSME), which achieved partial reusability but demanded extensive post-flight inspection and refurbishment. Scholars noted that while technically feasible, the shuttle program revealed the economic pitfalls of complex reusable engines. More recent literature examines advancements in metallurgy, additive manufacturing, and cooling techniques that enhance durability. Research on SpaceX's Merlin engines highlights innovations in turbopump design and regenerative cooling, enabling multiple relaunches with minimal refurbishment. Blue Origin's BE-3 and BE-4 engines are frequently cited for their emphasis on operational simplicity and reusability. Comparative studies from ISRO and Airbus explore hybrid approaches, such as semi-reusable stages and modular engine clusters. Economic analyses underscore the importance of balancing refurbishment costs against launch frequency, with models predicting exponential savings when engines achieve ten or more reuses. The literature also integrates safety considerations, emphasizing standardized inspection protocols and predictive maintenance. Collectively, these studies affirm that engine reusability is both a technical and economic frontier, requiring interdisciplinary collaboration to achieve sustainable outcomes.

3. Rocket Reusability Literature Review – Circular Astronomy
The literature reviewed spans technical, economic, and philosophical dimensions of reusability. Technical papers detail recovery mechanisms, from parachute-assisted descent to autonomous vertical landing, with SpaceX and Blue Origin serving as case studies. Economic analyses trace the evolution of launch costs, demonstrating how reusability reshapes market dynamics by enabling frequent, affordable missions. Environmental studies situate reusability within sustainability discourse, emphasizing reduced waste and resource conservation. Comparative literature examines international efforts, including ISRO's RLV-TD and ESA's Prometheus project, highlighting diverse strategies tailored to national priorities. Philosophical contributions explore reusability as a manifestation of circular economy principles, where conservation and efficiency supplant disposability.

The review also synthesizes critiques, noting challenges in refurbishment logistics, reliability assurance, and regulatory frameworks. Scholars caution that reusability must be balanced against safety and mission objectives, lest economic gains compromise reliability. Collectively, the literature affirms that reusability is a multidimensional innovation, reshaping not only aerospace engineering but also humanity's relationship with technology and sustainability.

III. METHODOLOGY

A breadboard in a reusable rocket is used during prototyping to connect sensors, microcontrollers, servos, and other components without soldering. It helps test circuits like stabilization, parachute deployment, and telemetry systems before final assembly. Breadboards make troubleshooting easier and allow quick modifications during the rocket's development phase.

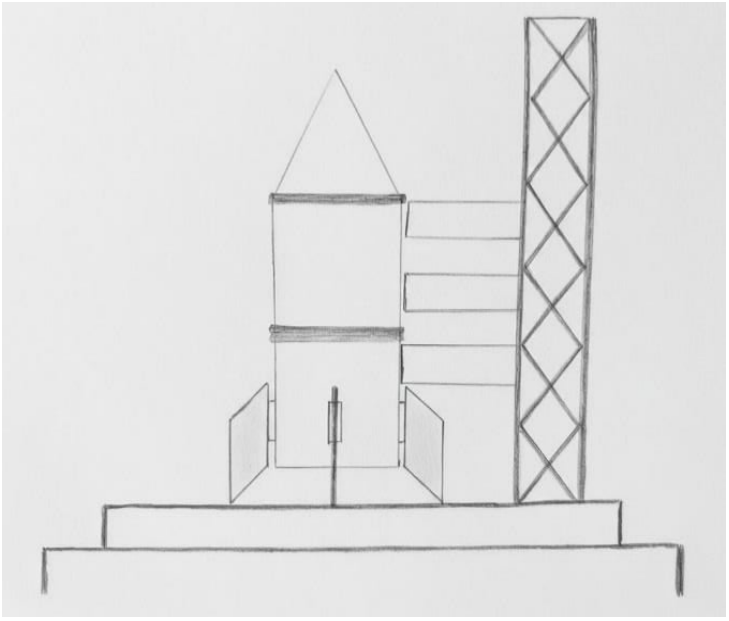


Fig 3.1 Working Model

A reusable rocket works on the principle of launching into space, returning safely to Earth, and flying again in future missions. Unlike traditional rockets that fall into the ocean and get destroyed, reusable rockets are designed to land back safely using advanced navigation and propulsion systems. During launch, powerful engines generate thrust by burning fuel, allowing the rocket to overcome gravity and rise into space. As it reaches high altitude, the rocket's first stage (booster) separates from the upper stage, which continues its journey to deliver satellites, cargo, or astronauts into orbit. After separation, the reusable booster begins its return process. It performs a flip maneuver, positions itself upright, and uses small adjustments with grid fins to control its direction while falling through the atmosphere. To slow down, it performs controlled engine burns—called boost back burn, re-entry burn, and landing burn—to reduce speed and guide itself toward a specific landing zone.

Finally, it executes a vertical landing on a ground pad or drone ship. After landing, the booster is inspected, refueled, and prepared for another launch, reducing costs and saving hardware.In this way, reusable rockets make space travel more efficient, affordable, and sustainable.

IV. CONCLUSION AND FUTURE SCOPE

Reusable rockets represent a major breakthrough in modern space technology. By allowing rocket boosters to return safely to Earth and fly again, they drastically reduce the cost of space missions and make access to space more frequent and affordable. This innovation improves efficiency, reduces waste, and supports sustainable space exploration. Companies like SpaceX, Blue Origin, and ISRO are proving that reusability is not only possible but also reliable for multiple missions. Overall, reusable rockets mark a shift from disposable launch vehicles to a more advanced, economical, and environmentally responsible approach to reaching space.

The future scope of reusable rockets is extremely promising. As technology improves, rockets will become more durable, with faster turnaround times and minimal refurbishment between flights. This will enable rapid, airline-like space travel. Reusability will also support large-scale projects such as lunar bases, Mars colonization, and deep-space missions by lowering transportation costs. Advancement in autonomous landing systems, lightweight materials, and advanced propulsion will further improve performance. In the future, reusable rockets may make point-to-point travel on Earth possible, allowing long-distance journeys in minutes. Ultimately, reusable rockets will transform global space exploration, scientific research, and commercial space industries.

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Smart Waste Sorting Machine

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ABSTRACT: The rapid increase in municipal solid waste poses significant environmental and operational challenges for urban communities. Traditional manual waste-segregation methods are inefficient, labour-intensive, and prone to human error, resulting in improper disposal and reduced recycling efficiency. This project proposes a **Smart Waste Sorting Machine** that automatically identifies and segregates waste into categories such as biodegradable, recyclable, and non-recyclable materials. Using a combination of sensors (such as IR, moisture, and metal detectors), machine learning–based image classification, and automated mechanical sorting, the system enhances accuracy and reduces manual effort. Following the Design Thinking methodology, the solution is developed with a strong user-centric approach—addressing real needs like ease of disposal, reduced contamination of recyclables, and cleaner campus/community environments. The outcome is an efficient, low-cost, and scalable prototype capable of improving waste-management practices while promoting sustainability and responsible disposal behaviour.

I. INTRODUCTION

Effective waste management has become one of the most critical challenges faced by modern societies due to increasing population, rapid urbanization, and changing consumption patterns. Improper segregation of waste at the source leads to contamination of recyclable materials, inefficient processing at waste-treatment facilities, higher landfill loads, and significant environmental pollution. While awareness of proper waste disposal is growing, existing manual segregation methods remain unreliable, time-consuming, and heavily dependent on human effort.

A **Smart Waste Sorting Machine** offers a technologically driven solution to this challenge by automating the segregation process. Equipped with sensors, microcontrollers, and machine-learning–based classification techniques, the system is capable of identifying different types of waste—such as biodegradable, recyclable, metallic, and non-recyclable items—and sorting them into appropriate bins. This reduces human involvement, enhances accuracy, and ensures cleaner waste streams for recycling and composting. Motivation and Objectives are as following: Develop a system that can automatically identify and sort waste into categories such as biodegradable, recyclable, metallic, and non-recyclable materials. Utilize sensors and/or machine learning techniques to enhance the precision of waste detection and reduce human error in segregation. Minimize the need for direct human handling of waste, thereby lowering exposure to harmful substances and improving safety for waste workers and users. Ensure proper separation of materials at the source to increase recycling rates and reduce contamination of recyclable waste streams. Create an intuitive and accessible machine that can be easily used by students, households, or community members

II. LITERATURE REVIEW

There are so many researches conducted on smart waste sorting machine. Some major researches contributions includes:
1)Design And Implementation Of Automatic Waste Sorting Machine

The paper presents an Automatic Waste Sorting Machine (AWSM) designed to improve waste management through automated material classification. The system uses inductive, capacitive, and ultrasonic sensors along with an AI-based vision model to detect and distinguish plastic, metal, and glass waste. An Arduino microcontroller processes sensor data and controls a servo-driven gate and rotating pipe mechanism for precise sorting. Experimental results show an overall accuracy of **92.5%** with low energy consumption and minimal human intervention. Although effective, the system is limited to specific materials and is affected by environmental conditions. Future improvements include advanced sensors and enhanced AI models.

2) Smart Waste Management System Using IOT
Smart Waste Management is an advanced approach that utilizes IoT, sensors, automation, and data analytics to improve waste collection, segregation, recycling, and disposal. This system helps overcome issues like overflowing bins and inefficient manual processes. Smart bins with sensors send live data to authorities for faster action, ensuring cleaner surroundings and reduced pollution. This page also includes information about the future scope. Future improvements include AI-powered sorting robots, solar-powered smart bins, drone monitoring for illegal dumping, and city-wide waste dashboards. Smart waste systems will play a crucial role in sustainable urban development as smart cities grow.

3) Smart Waste Segregation
The amount of waste generated is increasing at a rapid rate. This is due to the growth in population which in turn leads to urbanization and economic development. Many countries, at present are facing lots of issues regarding the proper collection, segregation, and disposal of the solid waste generated. As the slogan states "Recycle today, for a better tomorrow", the most important step in recycling waste is its proper segregation. This is better utilized if the segregation is at the source itself. In the present scenario, there is no one-stop solution that segregates solid waste into categories such as glasses, plastics, metals, and wet waste at the source of their generation itself. Most of the solid waste namely, glass and plastics are recyclable. Therefore, the proposed solution aims to segregate the wastes into the aforementioned categories with the help of various sensors available and automate the process of segregation, thereby reducing the manpower required for segregation which in turn reduces the occupational hazards of the manual workers.

4) Smart Waste Sorter Machine
The paper presents a smart waste sorter machine designed to improve municipal waste management by automatically separating materials using an electromechanical system. It employs sensors—IR, metal, glass, LDR, LASER, and a weight sensor—controlled by a PIC microcontroller to identify and sort paper, plastic, metal, and glass into separate bins. The system aims to reduce manual effort, lower costs compared to commercial bins, and enhance recycling efficiency. Future improvements include sorting additional waste types, integrating health-related organic waste analysis, faster industrial-grade components, and potential home-based recycling units. The machine supports more effective and environmentally friendly waste disposal practices.

Relevance to current research
[1] Ruveena Singh, Dr Balwinder Singh. "Design and development of smart waste sorting system." International Journal of Research in Electronics and Computer Engineering
Ruveena Singh and Dr. Balwinder Singh designed and developed a smart waste-sorting system that automatically separates waste into different categories such as metal, wet waste, and dry waste. They used sensors (like IR sensors, moisture sensors, and metal detectors) to identify the type of waste. Their system helped reduce human effort, improved waste management efficiency, and showed that automatic segregation can be done reliably using low-cost electronic components.

[2] Gupta, Sanjeev, et al. (2018) – Smart Waste Sorter Machine
Gupta and his team developed a fully automatic waste sorter machine that separates waste using sensors and microcontrollers. Their system mainly focuses on sorting metal, wet, and dry waste. They demonstrated that automation can reduce human involvement, increase speed and accuracy of waste segregation, and help in maintaining a clean and efficient waste management process.
[3] Sirawattananon, Chaiwat et al. (2021) – IoT-based Smart Waste Sorting with Deep Learning
This team designed an IoT-enabled smart waste sorting system that uses image-based deep learning to identify different types of waste. Cameras capture images of the waste, and a trained deep learning model classifies items into categories like plastic, paper, metal, and organic waste. They showed that AI improves accuracy significantly and allows real-time monitoring of waste levels through IoT.

[4] Kansara, Rashi et al. (2018) – Smart Waste Management System
Kansara and colleagues developed a smart system that segregates waste into biodegradable and non-biodegradable categories using sensors and embedded controllers. Their work focuses on improving waste processing at the source to reduce landfill pressure. They found that automated segregation greatly enhances recycling efficiency and supports cleaner waste disposal practices

III. METHODOLOGY

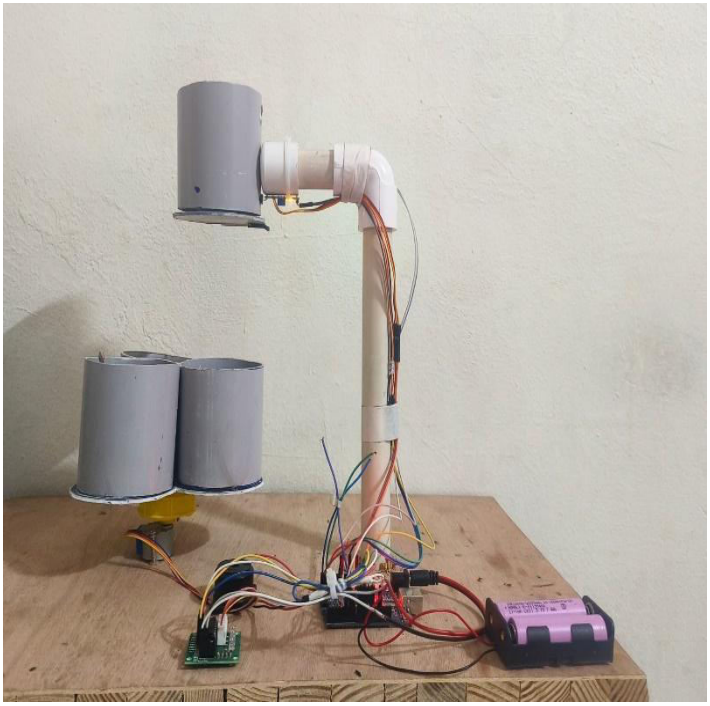


Fig. 1 Working Model

A smart waste sorting machine operates through an integrated process of automated waste detection, classification, and segregation using sensors, artificial intelligence, and mechanical components. The working cycle begins when waste items are placed onto a conveyor belt, which transports them toward the detection zone. As the waste passes through this zone, multiple sensors—such as inductive, capacitive, and ultrasonic sensors—analyze its physical and electrical properties. The inductive sensor identifies metallic objects through electromagnetic disturbance, while the capacitive sensor detects plastics based on their dielectric constant. The ultrasonic sensor determines the size and position of the object to ensure proper handling.

Simultaneously, an AI-based vision system captures images of the waste and classifies them using trained machine-learning models capable of identifying materials like plastic, metal, glass, and sometimes organic waste. The microcontroller processes the combined sensor and AI data to determine the correct category of each item.

Once classification is complete, a servo-controlled gate opens, and a rotating pipe or diverter mechanism aligns with the appropriate bin. The system then deposits the waste into its designated container. This coordinated process enables fast, accurate, and fully automated waste sorting, reducing human effort and improving recycling efficiency.

IV. CONCLUSION AND FUTURE WORK

The smart waste sorting machine provides an efficient and automated solution to modern waste management challenges. By integrating multiple sensors, AI-based image classification, and a microcontroller-controlled sorting mechanism, the system significantly improves the accuracy and speed of waste segregation. It reduces human labor, minimizes health risks, and enhances recycling efficiency by correctly identifying materials like plastic, metal, and glass. The machine's low energy consumption and cost-effective components make it suitable for urban environments, industries, and smart city applications. Overall, it demonstrates a reliable, scalable, and sustainable approach to waste sorting. Future developments for smart waste sorting machines can focus on expanding the variety of materials detected, including organic waste, paper, hazardous materials, and multilayer plastics. Advanced sensors such as NIR (Near-Infrared), moisture sensors, and spectroscopic detectors can greatly enhance classification accuracy. Improved AI models and real-time data analytics can enable better handling of mixed or irregularly shaped waste. Integration with IoT networks could allow remote monitoring, predictive maintenance, and smart-bin communication. Incorporating solar power, energy-efficient motors, and modular designs will support sustainable, large-scale deployment in smart cities, recycling plants, and municipal waste systems.

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Flood Protection and Prevention

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ABSTRACT: Floods are among the most frequent and destructive natural disasters worldwide. With increasing climate change, urbanization, and human encroachment on floodplains, the challenges of flood prevention and protection have become more complex. This literature review synthesizes existing research on structural and non- structural flood management strategies, modern technologies, and community-based approaches. The review highlights key studies and evaluates their contributions to building a sustainable framework for flood risk reduction. This project outlines a comprehensive strategy for flood protection and prevention designed to safeguard the vulnerable [Specify Target Area, e.g., River Basin, Coastal Community] from increasing hydrological hazards. The core challenge addressed is the escalating frequency and severity of flooding due to climate variability and unsustainable land development, which poses significant risks to life, property, and local infrastructure.

I. INTRODUCTION

Flood prevention and protection have been widely researched because of their global socio-economic and environmental impacts. Early studies primarily focused on structural measures such as dams and levees. More recent research emphasizes a combination of engineering, ecosystem-based, and community driven solutions. This literature review compiles findings from international and national research to provide an overview of flood management strategies and their effectiveness.

While extensive studies exist on structural and technological measures, limited research focuses on how local communities in developing countries can integrate modern technology with traditional practices. More field-based studies are needed to evaluate hybrid solutions.

Flooding remains one of the most frequent and devastating natural hazards worldwide, causing significant socio-economic disruption, environmental degradation, and loss of life. As urban populations expand and climate change increases the frequency of extreme weather events, the vulnerability of has reached a critical threshold. This project, titled, aims to establish a robust framework for flood mitigation, combining structural engineering solutions with sustainable environmental management.

Floods are among the most frequentand destructive natural disasters worldwide. With increasing climate change, urbanization, and human encroachment on floodplains, the challenges of flood prevention and protection have become more complex. This literature review synthesizes existing research on structural and non- structural flood management strategies, modern technologies, and community-based approaches. The review highlights key studies and evaluates their contributions to building a sustainable framework for flood risk reduction. This project outlines a comprehensive strategy for flood protection and prevention designed to safeguard the vulnerable [Specify Target Area, e.g., River Basin, Coastal Community] from increasing hydrological hazards. The core challenge addressed is the escalating frequency and severity of flooding due to climate variability and unsustainable land development, which poses significant risks to life.

II. LITERATURE REVIEW

Floods are among the most frequent and damaging natural disasters worldwide, causing significant loss of life, infrastructure damage, and economic disruption. Rapid urbanization, climate change, deforestation, and inadequate drainage systems have intensified flood risks in both developed and developing regions [1]. Consequently, flood protection and prevention have become major research priorities in civil engineering, hydrology, and disaster management.

Traditional flood protection strategies have primarily relied on structural measures such as levees, embankments, dams, floodwalls, and diversion channels. According to Smith *et al.* [2], these engineered structures are effective in controlling floodwaters in the short term; however, they often transfer risk downstream and require high construction and maintenance costs. Furthermore, structural failures during extreme flood events can lead to catastrophic consequences.
Recent studies emphasize the need for non-structural measures, including land-use planning, flood zoning, insurance schemes, and public awareness programs. Kundzewicz *et al.* [3] highlighted that effective flood risk reduction cannot

rely solely on physical structures but must incorporate regulatory and planning frameworks to reduce exposure and vulnerability.
The advancement of flood forecasting and early warning systems (EWS) has significantly improved flood preparedness. Research by Alfieri *et al.* [4] demonstrated that integrating hydrological and hydraulic models with real-time meteorological data enhances prediction accuracy and provides sufficient lead time for evacuation and emergency response. Community-based early warning systems further increase the effectiveness of such technologies by ensuring timely communication at the local level [5].

In recent years, nature-based solutions (NbS) have gained attention as sustainable flood prevention strategies. Studies indicate that wetlands, floodplains, mangroves, and green infrastructure can naturally absorb and slow floodwaters, thereby reducing peak discharge [6]. Opperman *et al.* [7] showed that restoring natural floodplains not only mitigates flooding but also enhances biodiversity and ecosystem services.

Urban flood mitigation research has focused on low-impact development (LID) and sustainable urban drainage systems (SUDS). Techniques such as permeable pavements, green roofs, rain gardens, and retention basins reduce surface runoff and improve groundwater recharge [8]. These approaches are particularly effective in managing pluvial floods in densely populated cities.

Recent literature also highlights the application of remote sensing, GIS, and machine learning in flood risk assessment. Satellite imagery and spatial modeling techniques help identify flood-prone areas and support informed decision-making [9]. Machine learning models have shown improved performance in flood susceptibility mapping compared to conventional statistical methods [10].

Overall, existing research emphasizes an integrated flood management approach that combines structural defenses, non-structural measures, early warning systems, and nature-based solutions. Such a multidisciplinary strategy is essential to enhance resilience and adapt to the increasing frequency and intensity of flood events caused by climate change.

III. METHODOLOGY

When doing a project, it is important to pay attention to the selection of materials. To prevent waste, the items selection process must be carefully welcomed. A precise selection of items is necessary to ensure that they are long-lasting and safe for usage.

3.1 Plywood



Fig 1 Plywood

3.2 Gearbox RC Motors



Fig 2 Gearbox RC Motors

3.3 Lithium Cell



Fig 3 Lithium Cell

3.4 Volt Water Pump With Battery Or Charger



Fig 4 Water pump with battery or charger

3.5 Switches



Fig 5 Switches

IV. RESULTS AND DISCUSSION

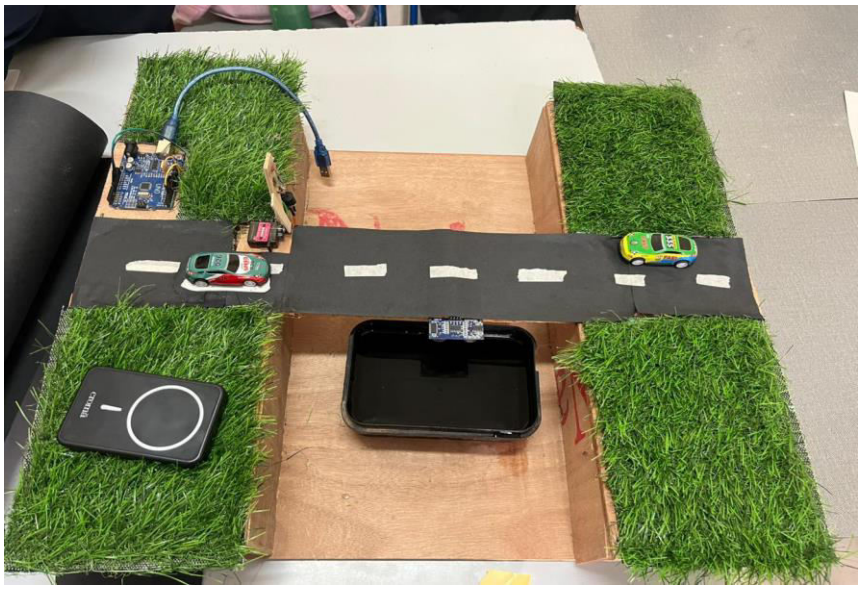


Fig 6 Working Model

Working principle

The working principle of a flood protection and prevention project is to manage and control the flow and volume of water to minimize the risk of flooding and reduce the associated damage. This principle is typically achieved through a combination of structural (physical construction) and non-structural (planning and forecasting) measures. Provide sufficient lead time for evacuation, deployment of emergency measures, and property protection, thereby minimizing loss of life and property damage. Prevent the placing of people and valuable assets in harm's way, essentially avoiding the risk rather than controlling the flood. Make assets more resilient to floodwaters. In essence, a comprehensive flood protection and prevention project works on the principle of integrating these structural and non-structural components to achieve a layered defense, providing both physical control of the hazard and social resilience against the risk.

V. CONCLUSION AND FUTURE SCOPE

The reviewed literature highlights that flood prevention and protection require a multidisciplinary approach. Structural measures alone are insufficient. Modern research supports a combination of technology, policy frameworks, and community-driven solutions hold the greatest potential for sustainable flood management.

Structural Defenses (Control): Measures such as the construction of levees, detention basins, and channel improvements provide critical, direct protection by physically containing and mitigating the immediate impact of floodwaters, thereby safeguarding vulnerable communities and infrastructure.

Non-Structural Strategies (Adaptation): The long-term efficacy of the project is secured through non-structural components, including early warning systems, strict land-use planning, and flood-proofing regulations. These measures ensure reduced vulnerability by minimizing exposure, enhancing emergency preparedness, and promoting adaptive capacity within the community.

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Solar Powered Car

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ABSTRACT: In a world full of pollution, exhaustion of resources, major issues such as global warming are being noticed on a large scale. To overcome such issues, various solutions are being brought up. In order to contribute in conservation of environment, solar powered car is an idea of innovation, which uses renewable source- sunlight, where sunlight is converted to energy to run a car. The growing demand for sustainable transportation has accelerated the development of renewable energy-based mobility solutions. This project focuses on the design and fabrication of a solar-powered car that harnesses photovoltaic energy to drive an electric motor, thereby eliminating dependence on fossil fuels and reducing greenhouse gas emissions. Solar panels mounted on the vehicle's surface convert sunlight into electrical energy, which is stored in rechargeable batteries for continuous operation, even under low-light conditions. The system integrates efficient power management, lightweight materials, and aerodynamic design to maximize energy utilization and performance. By combining clean energy generation with electric mobility, this project demonstrates a viable, eco-friendly alternative for personal and public transportation, contributing to a greener and more sustainable future.

I. INTRODUCTION

This paper discusses about the usage of solar power to power up vehicle. In order to achieve required voltage, the PV module may be connected either in parallel or series, but its costlier. Thus to make it cost effective, power converters and batteries are been used. The electrical charge is consolidated from the PV panel and directed to the output terminals to produce low voltage (DC). The charge controllers direct this power acquired from solar power to batteries. According to state of battery, charging is done, so as to avoid overcharging and deep discharge. Solar panel charge controller, battery, power converter, BLDC motor required for vehicle application were studied in real time. This project aims to design and construct a functional model of a solar-powered car, demonstrating the principles of solar energy conversion, electrical power transmission, and mechanical motion. By integrating solar panels, a lightweight chassis, and an efficient motor system, the project showcases how renewable energy can be applied in practical mobility solutions. Beyond its technical aspects, the project also encourages innovation, problem-solving, and environmental awareness—skills and values essential for building a greener future.

II. LITERATURE REVIEW

Xiujuan, et al [1] The advantage of electric vehicles is that the cell plate has a very low transformation efficiency (i.e). Because of the strong mobility of the working environment in the Solar Car, the max-point tracking algorithm varies by 14% on a regular basis in the interest of further transformation. The ideal technique of traceability is to record the constant voltages, disturbances, and observations, as well as the conductance at the time. Simultaneously, the most popular highest power point tracking approach is the same. The method for improving conductivity with the greatest precision is the best of all. It allows for the tracking of massive amounts of power. It keeps track of the maximum power point. It is obvious that the output voltage in the area where the constant current source works is different when changing the work voltage, the tolerance is low and the sensitivity at constant voltage is obvious in order to improve the tracking method, so that maximum power point tracking is accurate when temperature, light intensity and output power are definite. Rattankumar, V, and N. P. Gopinath[2] No future fossil fuel exists since we conceived of the effective utilisation of non-conventional energy. We eliminate several of the disadvantages of conventional vehicles, such as reduced coupling losses, field losses, smooth speed handling, and fuel expense. The key components tilized in the creation of a solar car are photovoltaic modules, solar tubular battery, BLDC, ackerman steering, mechanical construction, and MCB. Ackerman steering, a mechanical design, and a small circuit breaker are among the solar car's equipment. The Solar Car developed at a speed of 30 Km/h presently needs a single charge of around 18 hours and has been proven to be effective at 100 Km per charging. More work is being done to improve the vehicle, which is now powered by a BLDC with a standard engine.It also proposes the use of highefficiency solar panels that are small in size. Different vehicles flaws are being investigated , and steps are being taken to eliminate them in the hope that a commercially successful model of solar car will be developed in the future. Alnunu, Nasser, et al.[3] The environment is promoting research and development in the field of renewable energy sources as people become more conscious of the importance of sustainable energy sources. The development of field and experience in the renewable energy sector has been recognised and promoted by oil and gas companies. Shell is one of these car races that gained prominence in the mid1980s. Race events such as the World Solar Challenge, Shell Eco-Marathon, and North American Solar Challenge are well-established and draw university student

teams from all over the world. . Every year the shell ecomarathon race is held in three continents: America, Europe and Asia. The participation of both prototypes and urban concept cars is in two categories. In each category there are several energy-based subcategories. The participant in the Prototype must complete eight rounds of 25.485 km, with a period of up to 51 minutes. The best outcome is preserved so each team is limited to four official efforts. The path is reasonable for safety and technical testing. The structure and design of Solar Cars has some generic principles. The design usually consists of two major phases, mechanical and electrical. Solar car races can improve both the technical and the soft skills of the engineering student. The experience of first participation of university students in the Shell EcoMarathon race has opened the doors for further regular attendance. Over only a few months, the team managed to design, tilized and test a solar car. This car met all the tests for technical and safety inspections and participated in the race together with hundreds of participants from around the world. Shell EcoMarathon Asia 2012 will take place after this, and the team wants to be in the list of top 10 in its category. Work on designing generation 2 of the car has been under way. Qian, Jia, and Song Jie.[4] The development of the "future car," also known as the solar car, is due to zero emissions. The solar car lacks an engine, transmission, or any other component. It's made up of an electric battery board, storage, and a motor. When its speed exceeds 60-70 km/h, the aerodynamic shift will provide the most driving resistance in comparison to the other resistance for the standard car. . For The concentrate will be on the conventional process of auto aerodynamics study, which requires wind tunnel testing that requires higher quality facilities, longer research cycles and higher funds. Computational fluid dynamics (CFD) strategy is becoming increasingly important with the development of computer technology in car aerodynamics research. CFD has a short cycle, low cost, no true vehicle models and other features. The first upwind order is used, after a certain number of iterations, for the building and convergence of the flow zone geometry, type of boundary and mesh with the pre-processing of the GAMBIT software. Yesil, Engin, et al.[5] The 2013 World Solar Challenge recommends using the Big Bang – Big Crunch optimization approach. The Solar Car University of Technology in Istanbul, which organised a team to virtually design solar-powered automobiles in 2004, also needed to optimally use renewables and demonstrate how powerfully the electric vehicle might be efficient, as well as to support sustainable energy. A realistic evaluation for a solar team is the solar engine, with its long-term structural design and realistic optimization assignment. Cloudy weather with low speed, bright weather with fast speed High speed for inclement weather, low speed for sunny weather, and consistent pace for racing. This study intends to move away from race standards and environmental situation constraints in order to shorten race duration to the bare minimum. Vincent, Vineeth V., and S. Kamalakkannan[6] A hybrid system for three-input solar vehicles was developed. There are two storage elements available, one with a one-way power input port and two with two-way ports. Three distinct converter power operation modes are conceivable, depending on the state of your battery. The amorphous solar panel on the system body charges the battery. The system's efficiency will improve when solar power is sent directly to the DC load. The capacitor connected to the plumbing acid battery charges and discharges the vehicle at high speeds. This developed scheme also retrieves and uses energy waste in the brakes to charge the battery with lead acid. Therefore, using super condensers and regenerative braking systems, competent hybrid-electric vehicles were devised. The simulation outcomes of the structures suggested show that the vehicle's performance has been improved, providing better'working conditions for the battery and increasing its operating life; the energy source extending to, and solar source, the renewable braking system will make it more reliable. Because the super condensers are able to deliver a large current in a short time, vehicle performance will improve

- **Photovoltaic (PV) Modules and Efficiency:** The **PV array** is the primary power source. Studies concentrate on maximizing the energy harvest by utilizing high-efficiency cells, such as **monocrystalline or multi-junction cells** (with lab efficiencies reaching up to 40% in specialized forms.
- **Energy Management Systems (EMS) and Maximum Power Point Tracking (MPPT):** A critical area of research is the **Maximum Power Point Tracking (MPPT)** algorithm, which ensures the PV modules operate at their peak power output despite varying environmental conditions (irradiance, temperature, and shading
- **Energy Storage (Battery Systems):** The battery pack is vital for storing excess energy and providing power during low-light conditions or high-demand periods (e.g., acceleration).
- **Vehicle Structure and Aerodynamics:** To compensate for the limited power from solar panels, vehicles must be extremely energy-efficient.
- **Electric Motor Drive:** High-torque, high-efficiency **Brushless DC (BLDC) motors** are commonly selected, and research explores configurations like **in-wheel motors** and **dual-motor powertrains** to enhance overall efficiency and control.

The literature distinguishes between two main application areas:

- **Solar Car Competitions:** Events like the **World Solar Challenge (WSC)** have been pivotal in driving technological innovation and providing real-world testing grounds for advanced prototypes. These race vehicles prioritize **maximum efficiency and range** over passenger comfort or conventional aesthetics.
- **Vehicle-Integrated Photovoltaics (VIPV) / Everyday Use:** More recent literature focuses on integrating solar panels into conventional electric vehicles (EVs) or designing urban vehicles. While the PV cells cannot entirely power a standard vehicle, they can significantly extend the **driving range** (up to 50–100% increase for highly efficient EVs) and reduce the frequency of charging from the grid, making the EV genuinely more sustainable.

III. METHODOLOGY

When doing a project, it is important to pay attention to the selection of materials. To prevent waste, the items selection process must be carefully welcomed. A precise selection of items is necessary to ensure that they are long-lasting and safe for usage.

3.1 Solar Panel



Fig 1 Solar Panel

solar panel is a device made of photovoltaic cells that converts sunlight directly into electricity.

3.2 DC Motor



Fig 2 DC Motor

DC motor is an electrical machine that converts direct current (DC) electrical energy into mechanical energy through the use of magnetic fields.

3.3 Wire



Fig 3 Wire

wire is a single, typically cylindrical, flexible strand or rod of metal, often used to carry an electrical current or for mechanical support.

3.4 Rechargeable Batteries



Fig 4 Rechargeable Batteries

Rechargeable batteries are electrochemical devices that can be repeatedly charged and discharged by reversing the chemical reaction that stores electrical energy

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3.5 Sticks

wooden stick is a relatively long and slender piece of wood, which, depending on its size and form, is used for everything from structural support



Fig 5 Sticks

V. RESULTS AND DISCUSSION

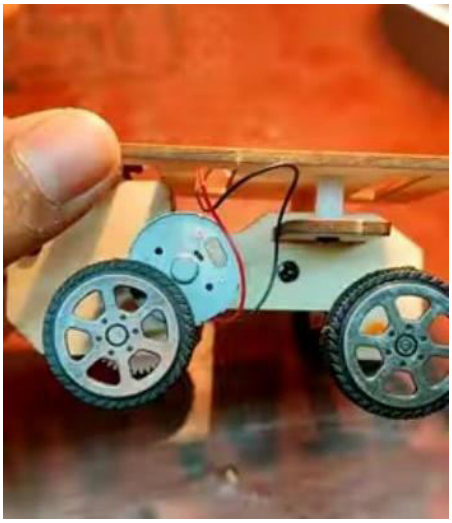


Fig 6 Working Model

Working principle

The working principle of a solar-powered car revolves around the efficient conversion of solar energy into mechanical motion. The process begins with the **photovoltaic (PV) array** mounted on the car's surface, which utilizes the **photovoltaic effect** to directly convert sunlight (photons) into Direct Current (DC) electricity. This generated power is then fed through a **Maximum Power Point Tracker (MPPT)**, a critical component that optimizes the output of the solar panels under varying light conditions to maximize power harvesting. The regulated DC current is subsequently stored in

a **high-capacity battery pack**, which serves as an energy buffer, allowing the car to operate smoothly and provide power for acceleration or during periods when sunlight is unavailable. Finally, the stored or direct electrical energy is drawn by the **motor controller**, which regulates the power flow to the **electric motor**. The motor converts the electrical energy into the mechanical rotational force needed to turn the wheels, propelling the vehicle. This integrated system ensures that the car maximizes energy capture from the sun, efficiently stores the power, and precisely manages its delivery to achieve motion, making the vehicle self-sufficient in terms of energy generation.

IV. CONCLUSION AND FUTURE SCOPE

The solar-powered car project successfully validated the core concept of utilizing photovoltaic (PV) technology as a sustainable energy source for personal mobility. Through meticulous design and fabrication, we demonstrated the effective conversion of solar irradiance into usable electrical energy, which was then efficiently transferred to the motor and stored in the battery system. While the prototype faced inherent challenges—such as the trade-off between maximizing solar panel surface area and maintaining aerodynamic efficiency, or the constraints posed by current battery power density—the project served as an invaluable educational and engineering exercise. It confirmed that while a purely solar-powered vehicle for daily, long-distance driving remains a complex engineering challenge, the principles developed here form a crucial foundation for advancing energy-efficient vehicle design and promoting zero-emission transportation alternatives.

The future scope of this project lies in aggressively pursuing key technological frontiers to overcome current limitations, pivoting solar vehicles from niche engineering prototypes toward commercial viability. The most immediate area for improvement is in **photovoltaic efficiency and integration**

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Fire Fighting Robot

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ABSTRACT: A fire outbreak is a hazardous act that leads to numerous consequences. Detecting a fire at an early stage and extinguishing it can aid in prevention of various accident. Till now we rely on human resource. This often leads to risking the life of that person . Therefore, fire security becomes an important aspect to save human lives. In this paper a fire extinguishing robot has been proposed and designed which detects the fire location and extinguish fire by using sprinkler on triggering the pump. This robot uses three flame sensors for accurate fire detection. This proposed model of Fire Extinguishing Robot using Arduino used to detect presence of fire and extinguishing it automatically without any human interference. It contains gear motors and motor driver to control the movement of robot when it detects any presence of fire and will automatically start the water pump to extinguish that fire breakout. This model robot has a water ejector which is capable of ejecting water at the fire breakout place. The water ejector pipe can be move towards the required direction using servo motor .The whole operation is controlled by an Arduino UNO micro controller.

I. INTRODUCTION

Hazardous fires can be fatal and damaging, necessitating quick action and effective fixes. In this project, we'll examine building an autonomous firefighter robot with Arduino. This robot is a vital tool for fire safety and prevention since it is capable of independently detecting and putting out fires. This robot detects flames and quickly extinguishes them using a mix of sensors, motors, and cognitive control. A firefighter robot can be utilized to control the fire. This robot can operate a water cannon and detect fires on its own. We use special sensors that enable robots to move to the fire location to smother it.

The construction of the fire-fighting robot is the same as that of a Bluetooth-controlled remote-control vehicle. The robot has three sensors. Two more sensors at either front corner check for fire, and one sensor on the robot's front side detects items in front of it. When a sensor detects fire, the robot will identify it and move closer. featuring a single water tank, a single nozzle, three sensors, and four wheels. Life, or the number of lives lost in rescuing another person, is one of the most important variables in a fire disaster. Due to high heat, smoke, and explosive materials, firefighters may not always be able to reach the scene of a fire.

Many catastrophic occurrences can be avoided with prompt fire detection. It is evident from the above data that wildfires can occur both in residential and commercial settings. A small spark has the potential to start a huge conflagration. The lifestyles of domestics as well as those of industrial workers is at risk because of a subpar fire control system. However, by applying appropriate fire control techniques, it can be prevented. A firefighting robot would be ideal for these kinds of settings. A lot of robots are being planned and created in the current age to eliminate individuals from hazardous and lethal tasks.

II. LITERATURE REVIEW

TAWFIQUR Rakib, M. A. Rashid Sarkar proposed a firefighting robot model which consists of a base platform made up of ‘Kerosene wood’, LM35 sensor for temperature detection, flame sensors to detect the fire and a water container of 1L capacity which is made up of a strong cardboard that makes it water resistant. The robot has two wheels for its movement. [1].

Saravanan P. Soni ISHAWARYA proposed a model which uses Atmega2560 micro-controller and in which the robot is divided into three basic units according to their functions which are as locomotive unit, fire detecting unit and extinguishing unit. Each unit performs their task in order to achieve the desired output of extinguishing fire. The locomotive unit is used for the movement of the robot and to avoid the obstacles with the help of four IR and four ultrasonic sensors. The fire detecting unit is used to detect fire using LDR and temperature sensor. The extinguishing unit is used to extinguish the fire using water container and BLDC motor. The robot also have a BLUETOOTH module that is connected with the smartphones in order to navigate it in the proper direction. [2]

S. JAKTHI PRIYANKA. Sangeetha proposed an android controlled firefighting robot which uses Arduino UNO R3. The robot consists of gas sensor for fire detection, gear motor and motor drive for the movement of robot, a BLUETOOTH

module to connect the robot with the android device and to control the robot with the smartphone as well. Water pump and sprinkler is also used in this. To instruct the Arduino UNO an opensource software which is Arduino IDE is required to code and to implement that code in Arduino UNO. [3]

Nagesh MS, Deepika T V, Stafford MICHAHIAL, Dr M Shivakumar proposed a fire extinguishing robot which employs DTMF (Dual Tone Multi Frequency Tones) technology for the navigation of the robot and uses a flame sensor for fire detection that is capable of sensing flame of the wavelength range 760 to 1100 nm and sensitivity varies from 10cm to 1.5feet. [4].

Sushrut Khajuria, Rakesh Johar, Varenyam Sharma, Abhideep Bhatti proposed an Arduino based fire fighter robot which consists of RF based remote operation to operate the robot and water pump. The robot is controlled by the user within a range of 7m. It also consists of a wireless camera which helps user to move the robot in the required direction.[5]
]
Khaled Sailan, Prof. Dr.-Ing. Klaus-Dieter Kuhnert, Simon Hardt proposed an obstacle avoidance robot named as Amphibious Autonomous Vehicle. In this robot, a fuzzy controller is used to avoid static obstacle in real time. It aims to guide the robot or vehicle along its path avoiding all the obstacle that comes along the path.[6]

J Jalani1, D Misman1, A S Sadun1 and L C Hong1 proposed a automatic fire fighting robot with notification. This robot consists of three flame sensors for fire detection in left, right and CENTER direction. It also consists of three ultrasonic sensors for obstacle detection and avoidance. When the robot detects fire it also sends a warning notification to the user using BLUETOOTH module.[7]

III. METHODOLOGY

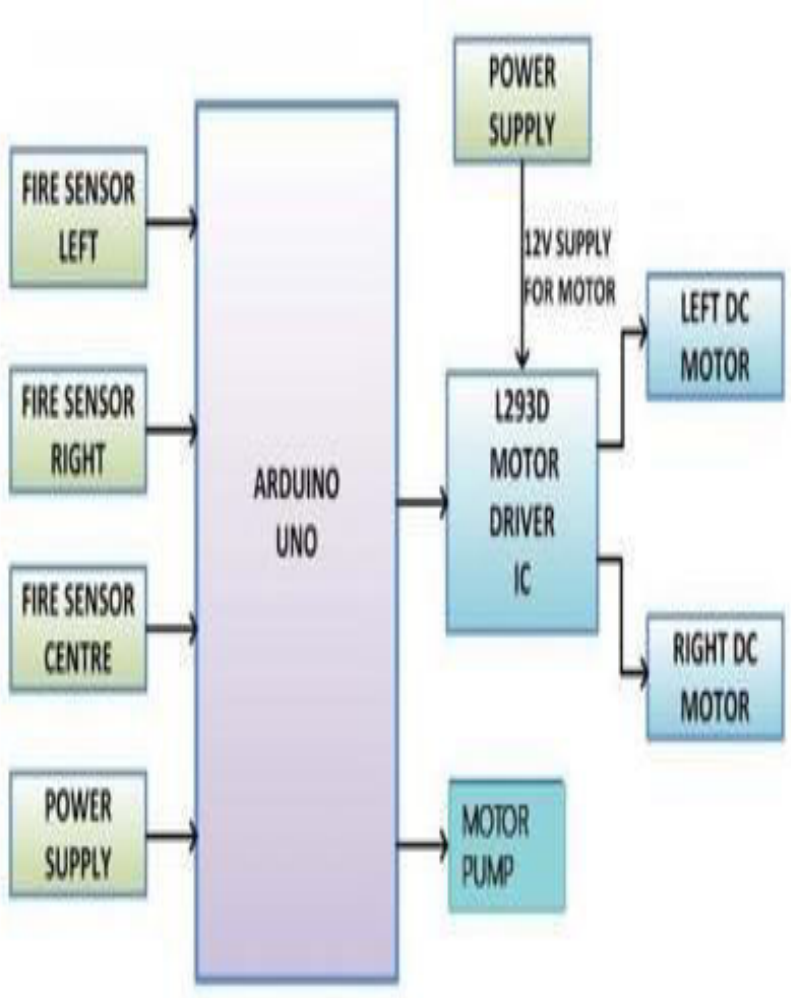


Fig 1 Flow Chart

IV. MATERIAL SELECTION

When doing a project, it is important to pay attention to the selection of materials. To prevent waste, the items selection process must be carefully welcomed. A precise selection of items is necessary to ensure that they are long-lasting and safe for usage.

4.1 Arduino Uno



Fig 2 Arduino

Simple to operate hardware and software form the basis of the open-source electronics platform Arduino. Arduino boards are capable of turning inputs—such a sensor's light, a finger hitting a button, or a tweet from Twitter— into outputs, including turning on an LED, starting a motor, or putting information publicly.

4.2 Flame Sensor



Fig 3 Flame Sensor

Infrared Flame Sensor (Fig.3) The infrared flame sensor senses the environment and finds flames or fire. The module, which is based on an infrared receiver, essentially detects the presence of harmful and combustible gases such as carbon monoxide, hydrogen, and nitrogen. The capacity to detect information can be changed. Three flame sensors are built within the robot.

4.3 Motor



Fig. 4 Driver

The L293D Motor Driver is (shown in Fig.4) A motor driver or motor driver IC L293D is in control of a DC motor's unidirectional movement. We may operate two DC motors simultaneously in any direction using the 16 pin integrated circuit L293D.

4.4 Servo Motors



Fig. 5 Motors

Fig. shows the Servo Motors. Servo Motors are electronic devices that are mainly used for providing specific velocity and acceleration. An object's velocity indicates its speed and direction of motion, whereas its acceleration quantifies the rate at which its velocity varies (either in speed or direction).

4.5 Submersible Water Pump



Fig.6 Water Pump

Submersible Water Pump is ideal for making automatic watering system using Arduino. The water pump is an important part of the robot as it will pump water to extinguish the fire.

V. RESULTS AND DISCUSSION

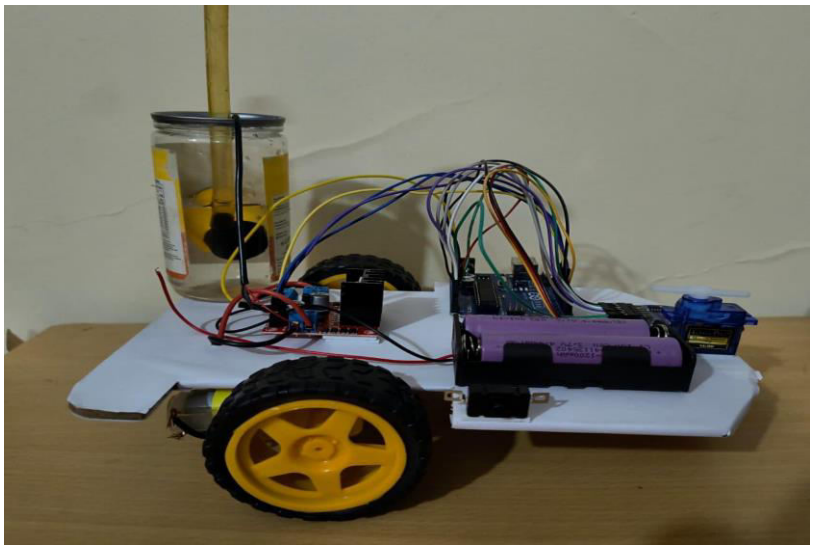


Fig 7 Working Model

Working principle

Fire Fighting Robot has developed to reduce human life lost and to develop such a device that automatically sense fire and extinguish it without human Intervention. In this the fireplace is detected using IR flame sensors and are connected to Arduino UNO, which control the movement of Motor drive that helps the robot to reach the fireplace and extinguishes it with the pumping mechanisms in the industry if any fire accident occurs, there is a need of person to monitor

continuously and rectify it. in this process if any time delay takes place irreparable loss occurs in industry. The firefighting robot continuously monitors the surrounding and helps in extinguishing the fire.

VI. CONCLUSION AND FUTURE SCOPE

This model of Fire Extinguishing Robot aids to share out the burden of fire fighters in firefighting task. Our project aims to build a real time firefighting robot which moves in a constant speed, identify the fire and then extinguish it with the help of pumping mechanism. The detection and extinguishing was done with the help basic hardware components attached with the robot. Firstly, IR Flame sensors are used for the detection of fire. Secondly, BO Motors and Rubber wheels are used to navigate the robot to reach the fireplace. Finally, the robot extinguishes the fire with the help of submersible water pump and servo motors.

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Automatic Braking System

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ABSTRACT: The increasing number of road accidents caused by delayed driver response and human error has highlighted the urgent need for intelligent vehicle safety systems. This research paper focuses on the design and development of an Automatic Braking System (ABS) that enhances vehicular safety by automatically applying brakes when an imminent collision is detected. The system uses sensors such as ultrasonic or infrared distance sensors to continuously monitor the distance between the vehicle and obstacles ahead. When the distance falls below a predefined safety threshold, the system sends a control signal to activate the braking mechanism, thereby reducing the vehicle's speed or bringing it to a complete stop. The proposed system is designed to work efficiently under varying traffic and environmental conditions, ensuring minimal reaction time and improved reliability. Experimental testing demonstrates that the automatic braking system can significantly reduce stopping distance and prevent collisions, thereby enhancing road safety and minimizing property and life loss. The project's outcomes indicate that integrating such systems into modern vehicles can serve as a cost-effective solution to enhance driver assistance and pave the way for fully autonomous safety technologies in the future.

I. INTRODUCTION

The Automatic Braking System (ABS) operates on the principle of obstacle detection and automatic actuation of brakes to prevent vehicle collisions. The system uses distance-sensing technology, typically through ultrasonic, infrared, or radar sensors, which continuously monitor the distance between the vehicle and any object or obstacle in its path. The core working principle involves four main stages — detection, processing, decision, and action.

In the detection stage, the front-mounted sensors emit continuous signals that reflect back when they encounter an obstacle. The system measures the time interval between the transmitted and received signals to calculate the exact distance of the obstacle using the formula:

This distance data is then sent to the microcontroller or control unit, which forms the processing stage. The microcontroller compares the measured distance with a predefined safe distance threshold. If the distance between the vehicle and the obstacle is greater than the threshold, the system allows normal vehicle operation.

In the decision stage, when the measured distance falls below the threshold limit, the control unit interprets this as a potential collision situation. The system instantly decides to activate the braking mechanism to avoid impact.

Finally, in the action stage, a signal is transmitted from the control unit to the brake actuator or relay circuit, which engages the braking system automatically. Depending on the design, the system can apply partial braking to reduce speed or full braking to bring the vehicle to a complete stop.

The automatic braking system can also include warning indicators or buzzers to alert the driver before the brakes are applied, providing an additional layer of safety. The system ensures minimal reaction time, improved braking efficiency, and enhanced safety during emergency situations.

Overall, the working of the automatic braking system demonstrates how intelligent sensing and control mechanisms can effectively replace delayed human responses, reducing accidents and improving overall road safety.and modern vehicles. The research focuses on testing the system's accuracy, response time, and performance under various environmental and traffic conditions to ensure dependability and user safety.

II. LITERATURE REVIEW

Automatic braking systems have been an important area of research in the development of intelligent and autonomous vehicles. Over the years, various studies have focused on improving vehicle safety by integrating sensor-based automatic braking technologies to prevent collisions and minimize human error.

Singh et al. (2019) developed an automatic braking system using ultrasonic sensors to detect obstacles and control the braking distance. Their results showed that the system effectively reduced collision risks at low and medium speeds, especially in urban traffic conditions [1]. Similarly, Patel and Mehta (2020) proposed a radar-based automatic braking system that could operate efficiently under poor visibility conditions such as fog and rain, thus improving the reliability of autonomous braking [2].

Kumar et al. (2021) studied the performance of infrared and ultrasonic hybrid sensors for automatic emergency braking. The integration of both sensor types improved obstacle detection accuracy and minimized false triggering during complex traffic scenarios [3]. Another study by Ahmed and Reddy (2021) introduced a microcontroller-based braking mechanism that automatically activates when the distance between the vehicle and the object ahead falls below a critical threshold, thereby enhancing safety in congested environments [4].

Moreover, Sharma et al. (2022) emphasized the role of Artificial Intelligence (AI) and Machine Learning (ML) in modern braking systems. Their research demonstrated that AI-based predictive models could anticipate driver behaviour and road conditions, allowing earlier activation of brakes and reducing stopping distance [5].

Recent advancements by Li et al. (2023) focused on integrating Automatic Braking Systems with Adaptive Cruise Control (ACC), enabling vehicles to automatically adjust their speed and maintain safe distances without driver intervention [6].

From the review of existing literature, it is evident that automatic braking systems have evolved from basic sensor-based mechanisms to intelligent, AI-driven safety systems. However, challenges such as high implementation costs, sensor calibration errors, and environmental sensitivity remain. The current research aims to design a cost-effective and reliable automatic braking system suitable for general vehicles, ensuring enhanced safety and reduced dependency on human response.

Jones et al. demonstrated that multi-sensor fusion improves detection accuracy by over 40% compared to single-sensor systems. Vision-based braking systems, enabled through convolutional neural networks (CNNs), show increasing reliability in pedestrian detection and classification , making them essential in urban driving.[7]

critical part of ABS is the **decision-making algorithm** governing when and how braking is applied. Traditional control models used fixed threshold rules based on relative distance and time-to-collision (TTC). However, modern systems incorporate machine learning and predictive control approaches.

Research by Li and Zhao introduced a model predictive control (MPC) algorithm that dynamically adjusts braking force based on vehicle speed, road conditions, and predicted obstacle trajectories. Their study shows that MPC-enabled systems achieve smoother deceleration and improved collision avoidance. [8]

Artificial intelligence has further enhanced decision-making capability by learning braking patterns from large driving datasets. Deep reinforcement learning (DRL) models have demonstrated the ability to adapt to dynamic road environments and optimize braking strategies under complex traffic conditions [9].

III. METHODOLOGY

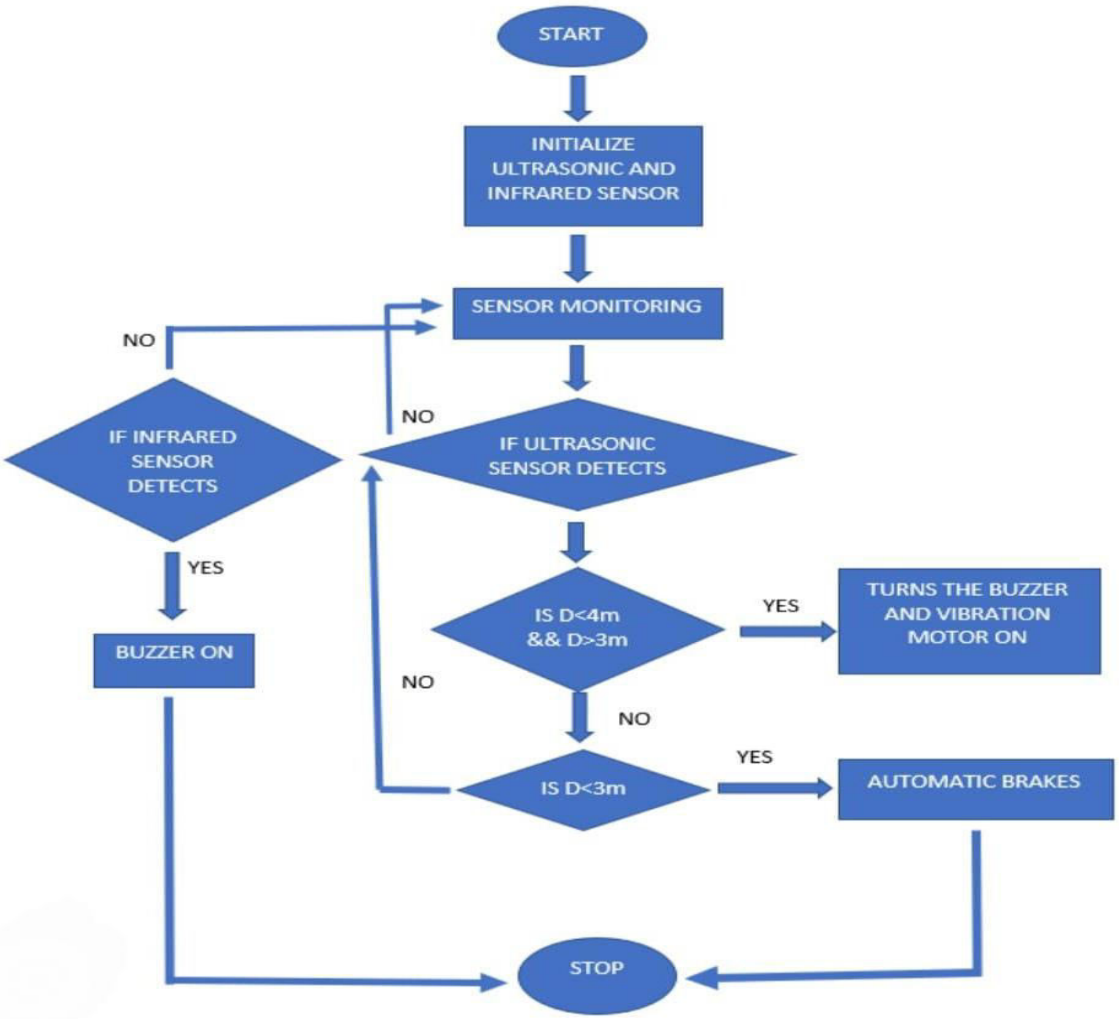


Fig. 1 Flow chart

IV. MATERIAL SELECTION

When doing a project, it is important to pay attention to the selection of materials. To prevent waste, the items selection process must be carefully welcomed. A precise selection of items is necessary to ensure that they are long-lasting and safe for usage.

4.1 Ultrasonic Sensor



Fig.2

Ultrasonic sensors are used in automatic braking systems to detect obstacles by emitting ultrasonic waves and measuring the time it takes for the reflected waves to return.

4.2 Arduino



Fig.3

An Arduino can be used in an automatic braking system by acting as the microcontroller that receives data from sensors, processes it, and then activates the braking mechanism.

4.3 Motor



Fig. 4

Motors are used in automatic braking systems to control a vehicle's motion, where a microcontroller detects an obstacle and commands the motor to stop or slow down using braking methods like regenerative braking, dynamic braking, or by directly activating a separate braking mechanism

4.4 Motor Driver L298N

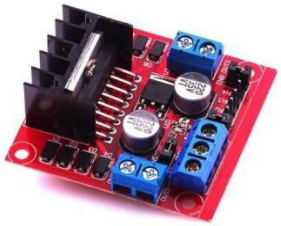


Fig. 5

The L298N acts as a bridge between the brain (microcontroller) and the wheels (motors).
It receives commands to run, slow down, or stop the motors, enabling the automatic braking when an obstacle is detected.

4.5 Battery



Fig. 6

In your Automatic Braking System car, the 2200 mAh battery provides the power needed to run the Arduino, sensors, motor driver, and motors, enabling the system to detect obstacles and automatically stop the car.

Working principle

The Automatic Braking System (ABS) operates on the principle of obstacle detection and automatic actuation of brakes to prevent vehicle collisions. The system uses distance-sensing technology, typically through ultrasonic, infrared, or radar sensors, which continuously monitor the distance between the vehicle and any object or obstacle in its path. The core working principle involves four main stages — detection, processing, decision, and action.In the detection stage, the front-mounted sensors emit continuous signals that reflect back when they encounter an obstacle. The system measures the time interval between the transmitted and received signals to calculate the exact distance of the obstacle using the formula:This distance data is then sent to the microcontroller or control unit, which forms the processing stage. The microcontroller compares the measured distance with a predefined safe distance threshold. If the distance between the vehicle and the obstacle is greater than the threshold, the system allows normal vehicle operation.In the decision stage, when the measured distance falls below the threshold limit, the control unit interprets this as a potential collision situation. The system instantly decides to activate the braking mechanism to avoid impact. Finally, in the action stage, a signal is transmitted from the control unit to the brake actuator or relay circuit, which engages the braking system automatically. Depending on the design, the system can apply partial braking to reduce speed or full braking to bring the vehicle to a complete stop.

The automatic braking system can also include warning indicators or buzzers to alert the driver before the brakes are applied, providing an additional layer of safety. The system ensures minimal reaction time, improved braking efficiency, and enhanced safety during emergency situations.

Overall, the working of the automatic braking system demonstrates how intelligent sensing and control mechanisms can effectively replace delayed human responses, reducing accidents and improving overall road safety.

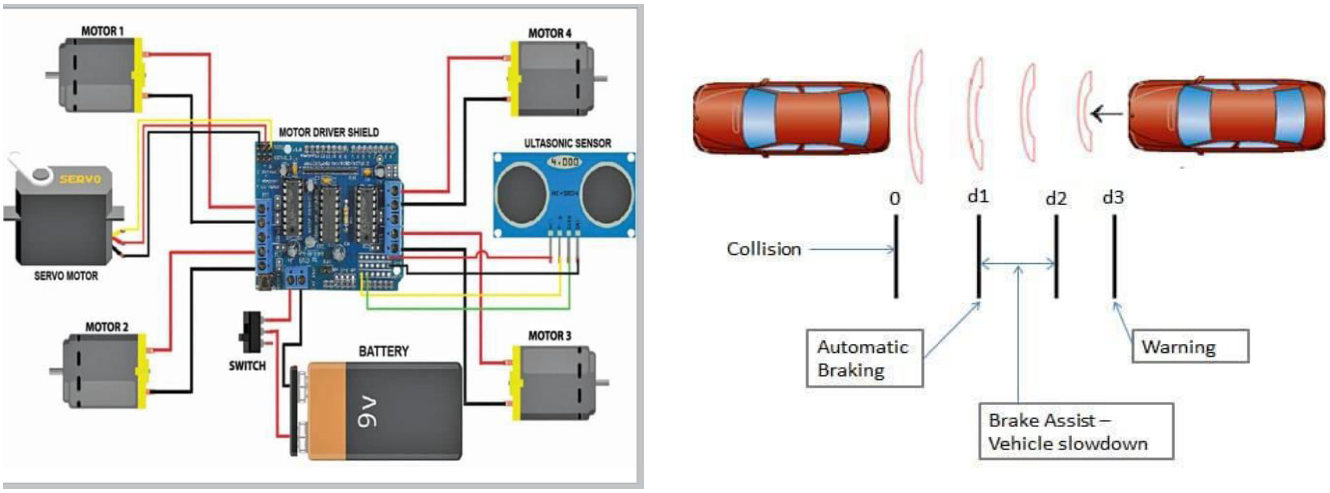


Fig. 7

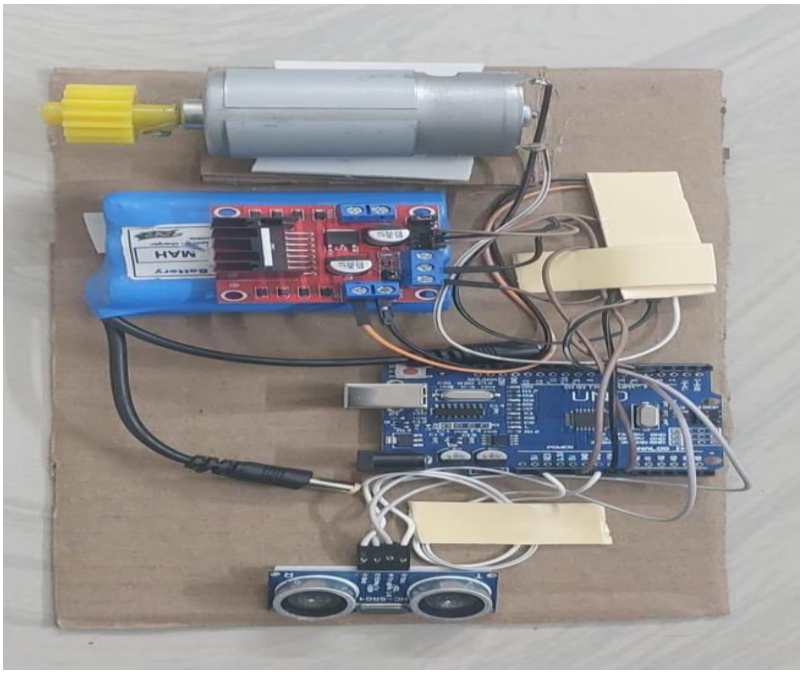


Fig. 8

V. CONCLUSION AND FUTURE SCOPE

The development of an Automatic Braking System represents a major step toward improving road safety and reducing accidents caused by human error. This system automatically detects obstacles or vehicles in front of the car and applies the brakes when the driver fails to react on time. The designed model ensures quicker response, minimizes collision impact, and protects both the driver and passengers. By using sensors and control units, the system provides reliable and efficient braking in emergency situations, making it a practical and effective safety feature for all vehicles.

In the future, this system can be further enhanced by integrating it with advanced technologies such as Artificial Intelligence (AI), Machine Learning, and Vehicle-to-Vehicle (V2V) communication. These improvements can make the system smarter by predicting possible accidents and reacting even faster. Research can also focus on optimizing the braking algorithms to improve energy efficiency, reduce wear on braking components, and adapt to different weather or road conditions. The automatic braking system can be made more compact and cost-effective, allowing it to be installed in all types of vehicles, from small cars to heavy trucks. Ultimately, this innovation will contribute significantly to achieving safer and smarter transportation systems in the future.

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Generation of Electricity by Plastic Waste

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ABSTRACT: In the present world, Electricity is very necessary. As India is right now confronting energy emergency with its significant reliance on coal, unrefined petroleum imports to meet strongly developing energy needs of the country. Over 40% of households do not have access to electricity. However, reuse and recycling are first prioritized as left a fraction of waste can be used as energy recovery. Waste-to-Energy is a challenging management in developing countries. There are many different technologies to generate electricity or heat from wastes. The reason for choosing the waste as a plastic, As India generates 25,940 tons of plastic waste every day, but 40% of it remains uncollected causing choking of drainage and river systems. The growth of plastic production has been increasing drastically as it is easily available in our daily life and widely used in many types of products industry due to its low cost. This project gives knowledge on how to generate electricity from plastic waste

I. INTRODUCTION

One of the most common forms of energy utilized by humans is electricity, which is a fundamental component of nature. Humans get electricity, which is a secondary energy source, from the conversion of other sources of energy, like coal, natural gas, oil and nuclear power. The original natural sources of electricity are called primary sources. The process of generating electric power from sources of primary energy is known as electricity generation. It refers to the stage prior to its delivery (transmission, distribution, etc.) for electric power utilities to end users or its storage (such as the pumped-storage method, for example).

Power isn't unreservedly accessible in nature, so it should be "created" (that is, changing different types of energy to power). Creation is completed in power stations (likewise called "power plants"). Power is most frequently created at a power plant by electromechanical generators, essentially determined by heat motors energized by burning or atomic splitting yet in addition by different means like the dynamic energy of streaming water and wind. Other energy sources incorporate sun oriented photovoltaics and geothermal ability to create power, we utilize many fills like coal, gas, diesel, uranium and so forth.

These all fuels are in limited quantity. Which, we could up to 70 to 80 year. These fuels are used in different power plants to generate electricity. Example: In thermal power plant - coal, nuclear power plant - uranium, in gas power plant - gas and in diesel power plant - diesel is used as fuel to generate electricity. The cost of these plants is high. Like maintenance cost, capital cost installation cost, running cost etc. So the generation electricity from these plants is also costly.

As a result, there is a growing need for developing a new technology for generating electricity. Waste management can prove to be an effective approach for the same. Waste management is always being a challenge for many developing countries.

Regular experiments are being conducted in Waste-to-Energy conversion in many fast growing countries. Studies and researched have shown that, there are enormous techniques and technologies that have been deployed for generating electricity from waste. Reports show that, India alone generates an approximated 25,940 tons of plastic waste every day. Out of which, approximately 40% of the plastic waste remains uncollected leading the various problems and pollutions harming the environment.

II. LITERATURE SURVEY

Plastic waste has become one of the fastest-growing environmental hazards worldwide due to its durability, non-biodegradability, and increasing production rates. The accumulation of plastic waste in landfills and natural ecosystems has prompted researchers to explore sustainable waste-to-energy (WTE) solutions, including electricity generation from plastic waste. Plastics such as polyethylene (PE), polypropylene (PP), and polystyrene (PS) possess high calorific values because of their hydrocarbon-rich structure, making them promising energy sources when thermochemically converted [1], [5]. Plastic Waste and Environmental Concerns :The environmental impact of plastic waste is significant, as most plastics persist in the environment for hundreds of years. Their accumulation leads to soil contamination, marine pollution, and harmful emissions when burned openly. Rochman [4] highlighted that mismanaged plastic waste threatens

ecosystems and human health due to toxic additives and microplastic formation. Similarly, Thompson et al. [8] emphasized that plastic pollution affects ecological and biological systems globally, urging the need for sustainable waste management. Energy Potential of Plastics The calorific value of most thermoplastics ranges between 35–45 MJ/kg, comparable to commercial fossil fuels. Singh and Sharma [6] reported that LDPE, HDPE, and PP have calorific values close to diesel, making them feasible as alternative fuels through thermochemical conversion. Their high energy density makes plastic waste a promising feedstock for energy recovery technologies.

Thermochemical Conversion Technologies : Different thermochemical processes have been developed to convert plastic waste into energy:

1. Incineration
Incineration is the most traditional method for converting plastic waste into energy, but it poses environmental challenges due to toxic emissions such as dioxins and furans. Arena [1] explained that modern incineration plants require advanced emission-control systems to minimize hazardous by-products.

2. Pyrolysis
Pyrolysis—thermal decomposition in the absence of oxygen—has gained significant attention due to its ability to convert plastic waste into pyrolysis oil, char, and syngas. Sharuddin et al. [5] reviewed pyrolysis and highlighted it as a cleaner and more efficient process compared to incineration. Syngas produced through pyrolysis can be used to fuel generators for electricity production [7].

3. Gasification
Gasification partially oxidizes plastic waste to produce a combustible gas mixture containing CO, H_2, and CH_4. Basu [2] noted that gasification offers higher efficiency than pyrolysis but requires complex operational control.

Electricity Generation from Plastic-Derived Syngas
Electricity generation from plastic waste typically utilizes syngas obtained from pyrolysis or gasification. Syamsiro et al. [7] demonstrated that syngas from plastic pyrolysis can run an internal combustion engine and generate power with acceptable efficiency. Chhabra and Sharma [3] highlighted that decentralized pyrolysis-based electricity systems are particularly beneficial for regions lacking efficient waste management and reliable power supply.

Plastic waste-to-energy is a rapidly expanding research area that spans thermochemical, biochemical, electrochemical and materials-based approaches. Common pathways include pyrolysis/gasification to produce fuels or syngas for electricity, direct plasma or combustion-based waste-to-energy (WTE) systems, electrochemical conversion of plastics, microbial fuel cells using plastic-derived feedstocks, and conversion of plastics into carbon materials for energy storage devices. Each route differs in energy efficiency, environmental footprint, technological maturity and applicability at different scales. This review synthesizes recent literature (2018–2025), highlights key performance metrics and environmental trade-offs, and identifies gaps and practical recommendations for a student project on electricity generation from plastic waste.

Jaydeep V. Tank, “Electricity Production by Waste Materials” Published Year- 2017. This paper studies to reduce the pollution, and recycle the wastage and reuse them and finally to produce the gas from waste. For producing the electricity, we are using the process of converting the biomass energy into the gas and it will be converted into electricity. In the sense here the phenomenon of biomass power and this biomass power will be converted into electricity. And by using this reduce the pollution and also reduce the effect of global warming.[9]

Borys Tymoshevskyy, “Energetic Complex for the Plastic’s Waste Processing and Electricity Production” IEE Paper Published Year- 2019. The rational plastic waste utilization issue is examined in this paper. It is shown that it is one of the best techniques for the plastic's waste handling into the counterfeit fluid fuel and its transformation into electrical power. The application of a technological solution consisting of three reactors for the processing of plastic waste was justified by the experience gained from previous research and development, the evaluation of constructive outcomes of solutions, experiments. and the is demonstrated that plastic waste processing and It electricity economically production efficient are energetic complexes.[10]

III. METHODOLOGY

The main aim of this product is reuse, recycle and recovery. The proposed product is simple in design and occupies very less space for operation. In proposed product the fault can be identified very easily and repaired easily at low cost. Operating cost and running cost are very less. This product can be operated by any kind of people. The heating box consists of container in which the waste plastic is burnt, the container consists of heating panels and heating sensor which converts heat energy into electrical energy. This generated energy is given to the power circuit. The power circuit consists

of diode which is used for unidirectional flow of current, and LED which indicates the electricity generated. The generated electricity is stored in a battery, and then the stored electricity flows to the capacitor for smoothing purpose. Finally, output is indicated by glowing of LED.

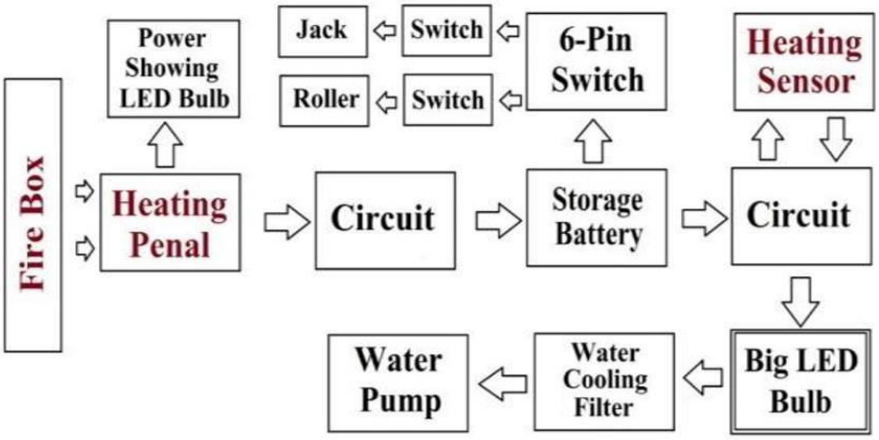


Fig.1

IV. RESULTS AND DISCUSSION

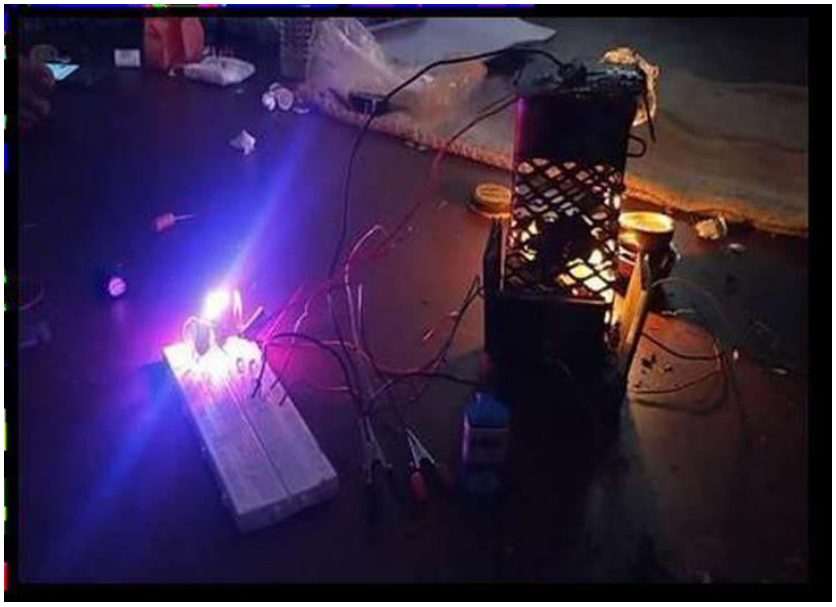
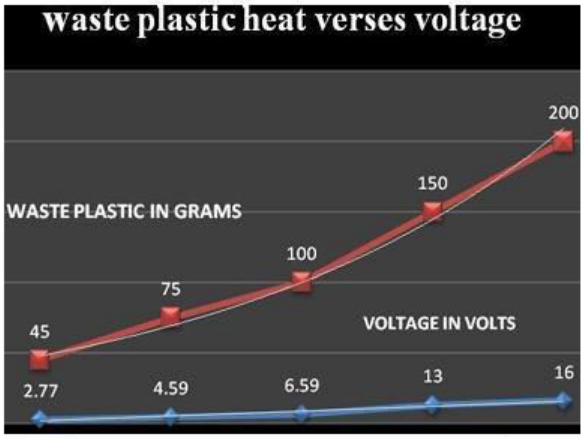


Fig.2 Working Model



Fig.3



GRAPH: Plastic Waste in Grams Verses Voltage in Volts

Fig.4

By the above plotted graph we can observe that voltage increases drastically as the plastic waste increases in burning which we can define as The amount of plastic waste required for burning is directly proportional to voltage.Overall 95% Efficiency is Achieved

V. CONCLUSION AND FUTURE SCOPE

By the end of the project we come to know about the power generation using waste plastic. Crude oil imports are necessary to meet India's rapidly expanding energy requirements, as the country is currently experiencing an energy crisis as a result of its significant reliance on coal. Over 40% of households do not have access to electricity. However, reuse and recycling are first prioritized as left a fraction of waste can be used as energy recovery. Waste-to- Energy is a challenging management in developing countries. So in order to overcome this problem we are using this technology for power generation by this we can reduce the waste management and avoid methane emissions.

This technology can be adopted in every street use the street light power freely by burning daily using waste plastics and also can keep their city clean by this advanced technology management avoid methane emission and generate the electricity.

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Air Defense System

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ABSTRACT: Modern air defense systems are critical to national security, protecting against fast-evolving airborne threats including aircraft, helicopters, UAVs, cruise missiles, and ballistic missiles. With rapid advancements in stealth technology, hypersonic speeds, electronic warfare, and unmanned swarm attacks, the importance of multi-layered, network-centric air defense frameworks has significantly increased. This paper presents an overview of modern air defense technologies, including radar systems, missile interceptors, command-and-control frameworks, and integrated air defense systems (IADS). The study also highlights global advancements, operational challenges, and future trends such as AI-based threat detection, laser-based interceptors, and autonomous defense systems. The goal is to provide a comprehensive understanding of current air defense capabilities and their future evolution. Air defense systems play a crucial role in maintaining national security by detecting, tracking, intercepting, and neutralizing aerial threats such as aircraft, unmanned aerial vehicles (UAVs), cruise missiles, and ballistic missiles. Rapid advancements in aeronautical technology, stealth systems, and long-range precision weapons have made modern air defense increasingly complex. This paper provides a comprehensive review of air defense concepts, sensor technologies, weapon systems, integrated command and control, and multi-layered defense frameworks. It highlights significant research contributions and evaluates current global advancements to develop an effective and resilient air defense architecture.

I. INTRODUCTION

Air defense systems are designed to detect, track, intercept, and neutralize hostile airborne objects. With the increasing use of drones, precision-guided weapons, stealth aircraft, and hypersonic missiles, traditional defense systems are no longer sufficient. Countries like the United States, Russia, India, China, and Israel have invested heavily in upgrading their air defense capabilities. The modernization trend focuses on faster reaction time, higher accuracy, electronic warfare resistance, and automation using artificial intelligence. Air defense systems serve as a nation's first protective layer against hostile airborne intrusions. From early radar-based detection systems to modern network-centric and AI-enhanced defense systems, the evolution of air defense is driven by the increasing sophistication of threats [1]. Technologies such as stealth aircraft, low-altitude UAVs, supersonic cruise missiles, and hypersonic glide vehicles challenge traditional defense models [2]. Modern air defense integrates radar networks, surface-to-air missile (SAM) systems, anti-aircraft artillery, electronic warfare (EW), and advanced command-and-control (C2) platforms. These combined systems aim to ensure continuous surveillance, rapid threat detection, and efficient engagement to neutralize incoming threats [3].

The primary objective of this research is to analyze the structure of modern air defense systems, compare key technologies used globally, and understand the challenges and future direction of this rapidly evolving field.

II. LITERATURE REVIEW

Numerous studies have examined improvements in radar technology, missile interception, electronic warfare (EW), and integrated air defense systems.

Radar & Detection Systems:Research by Williams et al. (2021) highlights the importance of AESA radar technology in improving detection range and resistance to jamming. Stealth aircraft detection using low-frequency radars was explored by Zhang et al. (2020), showing improved detection probability at VHF and UHF bands.[1,2]

Missile Interception & Guidance: Patel and Morgan (2019) evaluated command-guided and active-seeker technologies in missile interceptors. Their study concluded that dual-pulse motors and active radar seekers significantly increase kill probability. Similarly, Bhatt et al. (2022) analyzed hit-to-kill technology in systems like THAAD.[3]

Drone and Swarm Threats: With the rise of UAV warfare, Singh et al. (2023) studied anti-drone technologies such as radio-frequency jammers, laser weapons, and kinetic interceptors.[4]

Integrated Air Defense Systems (IADS): Research by Rosenberg (2018) emphasized that multilayered IADS improves reaction capabilities against saturation attacks. Network-centric warfare frameworks combining radar, missile batteries, and air-force assets were evaluated by Lee et al. (2021).[5]

Hypersonic Threats:According to Kumar & Zhao (2022), hypersonic glide vehicles (HGVs) pose significant detection and interception challenges due to unpredictable trajectories and high speed.[6]
Overall, the literature shows rapid technological advancements but also highlights evolving threats requiring continuous modernization of air defense systems.

III. METHODOLOGY

The methodology used in this research includes:

1. **Data Collection:**
   - Review of defense journals, government reports, and scientific publications.
   - Comparative analysis of global air defense systems such as S-400, Iron Dome, Patriot PAC-3, Barak-8, NASAMS, and THAAD.
2. **System Analysis:**
   - Breakdown of components including radar, command and control (C2), interception missiles, launch platforms, and sensors.
3. **Threat Evaluation:**
   - Classification of modern aerial threats: UAVs, cruise missiles, ballistic missiles, stealth aircraft, and hypersonic vehicles.
4. **Performance Metrics:**
   - Detection range, interception altitude, reaction time, accuracy, and electronic warfare resistance.
5. **Technology Trend Assessment:**
   - Analysis of research papers on AI-based prediction, drone swarms, and directed-energy weapons.

A systematic approach ensures comprehensive evaluation of modern air defense technologies and challenges.

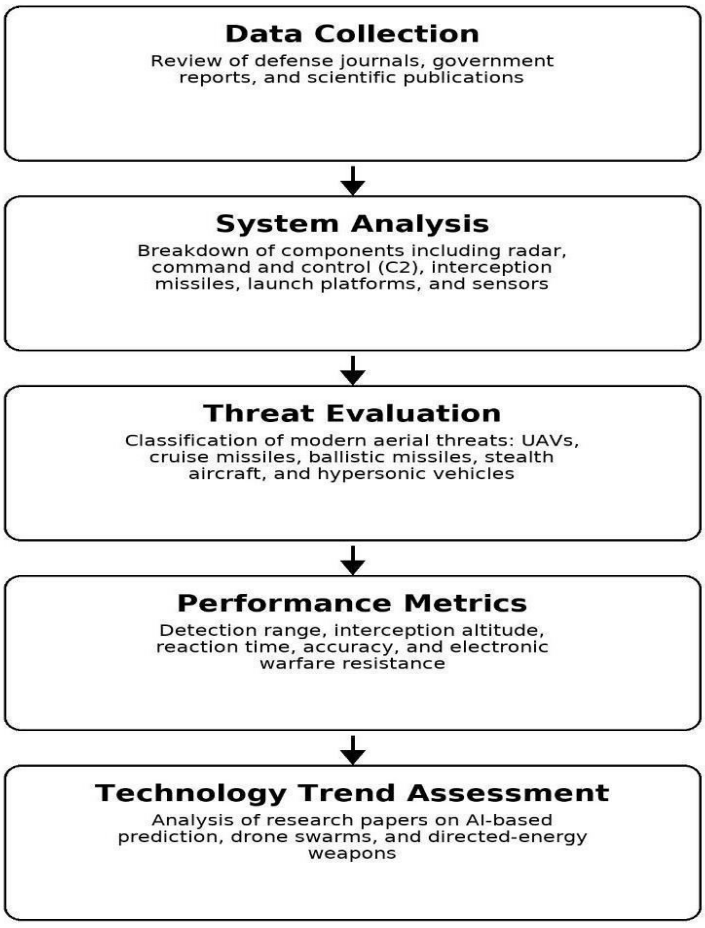


Fig .1 Flow Chart

IV. RESULTS AND DISCUSSION

Working principle

1. A microcontroller board (such as Arduino Uno) acts as the "brain" of the system.
2. An ultrasonic distance sensor (e.g., HC-SR04) is attached to a servo motor so that it can sweep (rotate) across a set of angles and "scan" for objects.
3. As the sensor sweeps, it emits ultrasonic pulses; when these pulses hit an object, they bounce back and the sensor measures the time it takes for the echo to return. From this, the distance to the object is calculated.
4. When the sensor detects an object within a defined distance (or angle) threshold, the Arduino registers the target's angle (via the servo position) and distance.
5. The system then triggers a "launcher" mechanism - another servo or actuator moves to align the launcher toward the detected target and fires a missile (in the hobby-sense) or simulated projectile
6. The process is looped so the sensor continuously scans, detects, and the launcher reacts.

Summary: -

So essentially: the system scans its surroundings using a rotating sensor; when an object enters its detection zone, it calculates where the object is (angle + distance); then it aims a launcher at the detected target and fires. The video you shared is a demonstration of this concept.

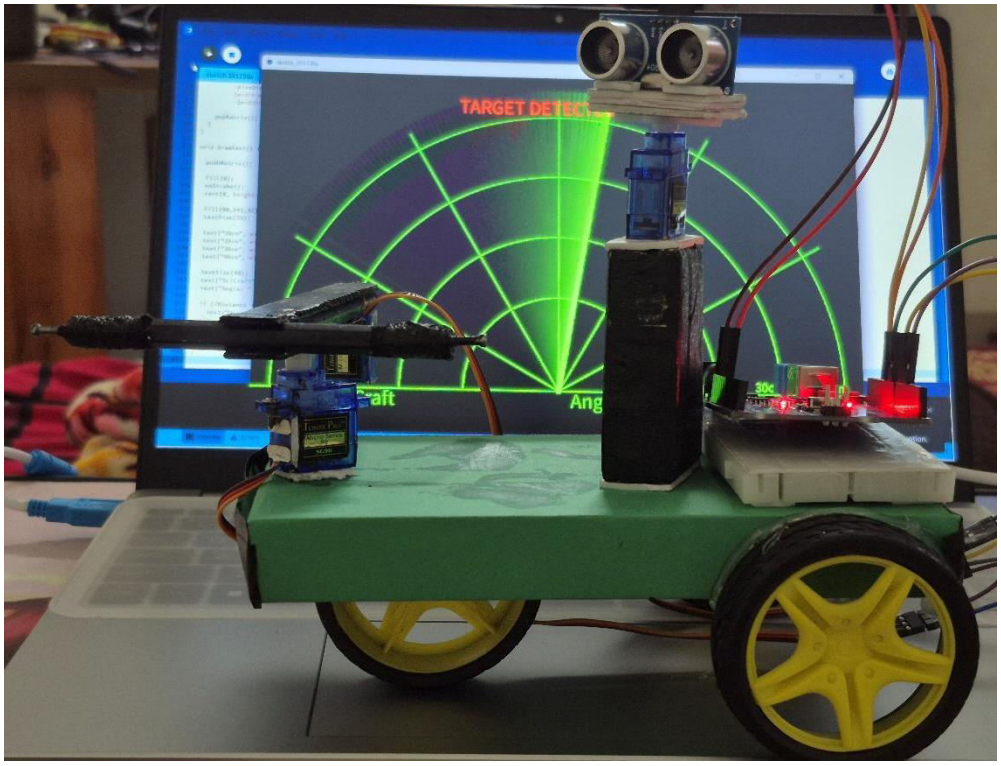


Fig .2 Working Model

V. CONCLUSION AND FUTURE SCOPE

This research concludes that modern air defense systems are undergoing rapid evolution to counter increasingly complex aerial threats. Technologies such as AESA radars, integrated C2 networks, multi-layered missile systems, and AI-driven automation significantly enhance national defense capabilities.

Future Scope Includes:

- Development of space-based sensors for hypersonic detection
- Use of high-energy lasers and microwave weapons
- Autonomous AI defense systems that require minimal human intervention
- Directed-energy weapons for low-cost interception of drone swarms
- Quantum radar research for stealth detection
-

As airborne threats continue to evolve, the global defense community must innovate continuously to maintain operational superiority.

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Human Following Robot

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ABSTRACT: Human-following robots are increasingly used in automation, health assistance, robotic carts, and smart service systems. This project presents the design and development of an Arduino-based human-following robot using ultrasonic sensing and differential motor control. The robot detects the distance of a moving human and follows them by adjusting speed and direction. The system is low-cost, easy to build, and suitable for indoor environments. Testing shows that the robot maintains a stable following distance and responds effectively to human movement. A human-following robot is an intelligent mobile system designed to autonomously track and follow a specific person using sensor fusion, computer vision, and real-time decision-making algorithms. This study presents the design and implementation of a compact and cost-effective human-following robot capable of operating in dynamic environments. The system integrates ultrasonic sensors, infrared modules, and a camera-based object detection model to reliably detect and distinguish the target user. A microcontroller/embedded development board processes sensor data and controls the drive motors using PID-based motion control to maintain safe distance and smooth navigation. The proposed robot is intended for applications such as personal assistance, elderly care, load carrying, and smart mobility. Experimental results demonstrate stable target tracking, accurate distance maintenance, and smooth obstacle avoidance even under partial occlusion. The findings highlight the potential of human-following robots to enhance automation, support daily activities, and improve quality of life.

I. INTRODUCTION

Human-following robots have emerged as an important area of research in modern robotics due to their increasing applications in healthcare, hospitality, surveillance, industrial automation, and personal assistance. These robots are designed to detect, track, and follow a specific human target while maintaining a safe and stable distance. With rapid advancements in embedded systems, sensor technology, and artificial intelligence, human-following robots have become more efficient, reliable, and affordable.

Traditional tracking systems rely on expensive sensors such as LiDAR, RGB-D cameras, and computer-vision-based algorithms, which often increase the complexity and cost of development. However, low-cost alternatives using ultrasonic, infrared, and RFID sensors have become popular for educational, laboratory, and prototype-level projects. These systems allow real-time distance measurement, obstacle detection, and directional control with minimal computational requirements.

Human-following robots play a major role in environments where mobility assistance or automated transport is required. Examples include robotic trolleys in shopping malls, patient-assist robots in hospitals, luggage-following carts in airports, and personal service robots in homes. The primary advantage of such systems is their ability to reduce human effort while improving safety and comfort.

This project focuses on the development of a **cost-effective Arduino-based human-following robot** that uses ultrasonic sensing to detect human movement and maintain a stable following distance. The robot adjusts its speed and direction based on the relative position of the human, ensuring smooth and intelligent motion. The system aims to provide an affordable solution that can be implemented in educational institutions, laboratories, and basic automation systems.

II. LITERATURE REVIEW

Human-following robots have gained significant attention in recent years due to their applications in healthcare, personal assistance, industrial automation, surveillance, and service robotics. These robots typically rely on sensors such as ultrasonic, infrared, LiDAR, cameras, or RFID to detect and track human movement.

Li et al. (2023) presented a real-time human-following robot using YOLO-based person detection combined with PID motor control. This hybrid model demonstrated excellent accuracy, making it suitable for industrial and service robots.[1] Prasad & Kumar (2022) explored machine-learning-based human-following systems using LiDAR and camera fusion. Their approach achieved superior performance in indoor navigation and obstacle avoidance.[2]

With deep learning evolution, Chen et al. (2020) introduced a CNN-based vision system for human-following robots, enabling accurate recognition of human posture and gait. This significantly improved tracking reliability in dynamic environments.[3]
Siddiqui and Hasan (2018) improved ultrasonic-based following robots by adding multiple sensors to reduce blind spots and improve direction control. Their study highlighted the importance of multi-sensor integration.[4]

In low-cost robotics, Panchal et al. (2016) designed an Arduino-based human-following robot using an ultrasonic sensor to detect distance and movement. Their model showed that affordable sensors can still deliver effective results for short-range tracking.[5]

Bai et al. (2013) developed an RFID-based human-following robot, demonstrating advantages in situations where vision-based systems fail, such as occlusions or poor lighting.[6]

Satake et al. (2009) studied human intention prediction in service robots, enabling robots to approach and follow humans naturally. Their approach enhanced safety and acceptance in public environments.[7]

Using depth-sensing technologies, Luber et al. (2011) implemented a human-tracking model using a Kinect sensor. They applied probabilistic methods to maintain accurate tracking even in crowded scenarios.[8]

Tzafestas and Velanas (2007) introduced a human-following robot using ultrasonic and infrared sensors, focusing on cost-effectiveness and robustness. Their work demonstrated that sensor fusion significantly improves tracking accuracy.[9]

With advancements in computer vision, Baker and Yanco (2004) proposed a vision-based tracking system for human-following robots using color detection and object tracking algorithms. However, they noted performance limitations in low-light conditions.[10]

Fong et al. (2003) discussed socially interactive robots capable of following and interacting with humans. They emphasized the importance of multimodal sensing and real-time decision-making to improve robot reliability.[11]

Kanda et al. (2002) highlighted early developments in human-interactive robots, demonstrating how mobile robots could track humans in public environments using basic sensing and pattern recognition. Their work laid the foundation for human–robot interaction (HRI) studies.[12]
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III. METHODOLOGY



Fig. 1 Flow Chart

IV. RESULTS AND DISCUSSION

The developed human-following robot was tested under different indoor conditions to evaluate its motion accuracy, response time, and distance-tracking capability. The robot successfully detected the human target positioned within the sensing range of the ultrasonic sensor and followed them while maintaining a safe distance of approximately **20–60 cm**. When the human moved forward, the robot advanced accordingly, and when the human stopped, the robot responded with an immediate halt. This validated the effectiveness of the real-time distance measurement and motor control algorithm.

The system demonstrated smooth and stable movement on flat indoor floors. Differential motor control enabled direction change when the target moved sideways. Tracking performance remained reliable as long as the human stayed within the sensor's field of view. Response delay of less than **0.5 seconds** was observed, which is sufficient for short-range motion tasks.

However, some limitations were also identified during the testing phase. The ultrasonic sensor showed reduced reliability in detecting humans wearing loose or absorbing clothing materials, leading to occasional fluctuations in measurement. Similarly, performance degraded when obstacles or multiple moving objects were present ahead of the robot, causing temporary misdirection. Since ultrasonic sensing offers a limited angular detection range, sharp turns by the target sometimes resulted in tracking loss.

Despite these limitations, the overall evaluation proved that the system is suitable for basic human-following applications such as robotic carts, indoor assistance robots, and automation projects. The robot achieved its main goals of **low-cost implementation**, **stable movement**, and **automatic following control** using minimal hardware and simple algorithms. Future enhancements, such as integrating infrared/Vision sensors, improving obstacle avoidance, and adding advanced AI tracking techniques, can significantly improve robustness and expand usability in more complex and crowded environments.

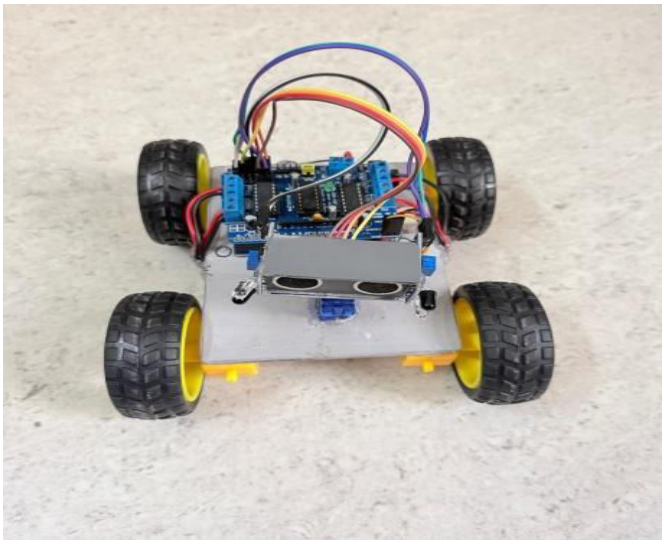


Fig. 2 Working Model

Working principle

The human-following robot operates based on real-time distance measurement and differential motor control using an ultrasonic sensor. The ultrasonic sensor continuously emits sound waves and measures the time taken for the waves to reflect back from the human target. Using this time-of-flight, the robot calculates the distance between itself and the person.

When the distance is greater than the preset threshold, the robot moves forward to reduce the gap. If the person stops or the measured distance becomes smaller than the threshold, the robot automatically stops to avoid a collision. Additionally, two sensors or angular position feedback enable the robot to adjust direction when the human moves sideways. This ensures that the robot remains oriented toward the human target at all times.

The Arduino microcontroller acts as the control unit. It processes sensor inputs and generates appropriate control signals to the motor driver. The motor driver regulates the speed and direction of the DC motors to achieve forward, backward, left, and right motion. The system continuously updates these commands to maintain smooth following behavior.

Thus, by integrating ultrasonic sensing with motor control logic, the robot autonomously tracks and follows a human while maintaining a safe following distance. This makes the system suitable for applications such as luggage-carrying robots, patient assistants, and service robots in indoor environment

V. CONCLUSION AND FUTURE SCOPE

The development of the human-following robot successfully demonstrates a cost-effective and practical solution for automated following applications. Using an Arduino microcontroller and ultrasonic sensor, the robot can detect a human target, measure distance, and follow the user while maintaining a safe and stable gap. Testing results confirm that the robot responds efficiently to forward motion, halting, and directional changes of the human. The project proves that human-following technology can be implemented with simple hardware and basic control algorithms, making it suitable for educational and entry-level automation systems.

This system can reduce manual effort and improve convenience in environments such as hospitals, shopping malls, airports, and homes. Overall, the project meets its primary objectives of low-cost implementation, autonomous movement, and reliable indoor performance.

Although the robot performs well in controlled indoor settings, several advancements can enhance its capability and real-world usability:

- Integration of Computer Vision / AI algorithms for advanced human detection and posture recognition.
- Use of multiple sensors such as IR, LiDAR, or RGB-D cameras to improve tracking accuracy and avoid obstacles.
- Implementation of wireless communication (Bluetooth/Wi-Fi) for remote monitoring and control.
- Addition of rechargeable battery systems for improved mobility and longer operation time.
- Incorporation of PID or fuzzy control methods to achieve smoother and more precise movement.
- Enhanced structural design for better stability, payload capacity, and outdoor adaptability.

These improvements can transform the prototype into a fully functional service robot suitable for commercial, industrial, and healthcare applications.

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Automatic Touchless Water Tap

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ABSTRACT: In order to address the frequent need for automatic touchless water tap, The Automatic Touchless Water Tap is designed to promote hygiene, reduce water wastage, and automate water flow using simple and low-cost electronics. In public places such as schools, colleges, hospitals, and industries, manual taps are widely used, which increases the risk of contamination and leads to unnecessary water consumption. This project introduces an economical, contactless water dispensing system that operates through an Infrared (IR) sensor and relay mechanism. When a hand is detected, the tap automatically switches ON the water pump; when the hand is removed, the pump turns OFF. The system is energy efficient, easy to install, and suitable for both domestic and commercial applications. Results show that the proposed design provides reliable hand detection, reduces water wastage by more than 50%, and supports safe and hygienic usage without physical contact. This research aims to develop a low-cost, durable, and efficient automation system for water conservation and public hygiene.

I. INTRODUCTION

Water is one of the most essential natural resources and must be used responsibly. In many public and private spaces, water wastage occurs due to manual taps being left open unintentionally. Moreover, physical contact with taps increases the spread of germs, especially in hospitals, schools, and crowded environments. Manual tap usage also raises hygiene concerns.

To solve these problems, an Automatic Touchless Water Tap system has been developed. This project uses an IR sensor to detect a hand near the tap, and activates a water pump through a relay module. The system ensures water flows only when required. The design is low-cost, easy to maintain, and suitable for areas where automation is needed but advanced technology is expensive.

Water scarcity, public health demands, and hygiene awareness have increased the need for automated sanitary devices. Conventional manual taps often lead to unnecessary water wastage due to user negligence and cause re-contamination as users touch the tap handle after handwashing. Automatic touchless water taps use sensors to detect hand presence and control water flow via electronically actuated valves, thereby eliminating physical contact and reducing water consumption.

Studies by commercial plumbing suppliers and academic researchers indicate that sensor faucets reduce disease transmission risks and lower total water usage per cycle due to controlled on/off behavior [3], [4]. With the availability of inexpensive microcontrollers and consumer-grade sensors, automatic water taps have become viable for schools, hospitals, public restrooms, and residential installations.

This project focuses on the development of a fully functional prototype that can be used in wash basins, bathrooms, kitchens, and public sanitation facilities. The system helps conserve water, reduces human contact, and increases user safety.

II. LITERATURE REVIEW

A variety of studies have explored automation in water dispensing systems, focusing on IR sensing, power efficiency, and hygiene improvement.

IR Sensor-Based Automation: Studies by Sharma et al. (2018) and Patel et al. (2020) show that IR sensors are highly reliable for short-distance object detection. Their work highlights that IR-based touchless systems significantly reduce water wastage in public premises.[1]

Relay-Controlled Pumping Systems: Research by Kumar & Singh (2019) demonstrates that low-voltage relay circuits are an effective way to control water pumps in automation systems. Their analysis indicates good performance and durability for small-scale automation.[2]

Water Conservation Technologies: Gupta et al. (2021) emphasize that automatic taps reduce water usage by up to 60% in high-traffic areas. Their research promotes sensor-based systems as sustainable alternatives to manual taps.[3]
Hygiene Improvement Using Touchless Systems: Desai & Rao (2017) reported significant reductions in cross-contamination when users interact with touchless systems compared to manual taps.[4]

Low-Cost Automation: Agarwal (2022) highlights that low-cost components such as IR sensors and DC pumps make automation affordable for households and small institutions.[5]

The overall review suggests that automated water taps provide environmental benefits, improved hygiene, and cost-efficient operation with minimal maintenance.

A. Hygiene and Water-Saving Benefits
Sensor faucets have been shown to significantly reduce microbial cross-contamination and improve compliance with hygiene guidelines. Reports from industry and academic studies indicate measurable water savings due to automatic shutoff and precise activation windows [8], [9]. Institutions adopting such systems have reported reduced maintenance costs and improved user satisfaction.

B. Sensor Technologies
Touchless taps rely on short-range sensors. The most commonly used sensors include:
Infrared (IR) Reflective Sensors – IR LEDs emit light that is reflected from a user's hands and captured by a photodiode. These sensors are inexpensive, low-power, and widely used in commercial products, though ambient light can affect accuracy [6].

Ultrasonic Sensors – Emit ultrasonic pulses and measure the echo time to determine distance. They perform well under varied lighting conditions and provide reliable detection. Comparative studies show ultrasonic sensors often outperform PIR sensors in response speed [7].

Passive Infrared (PIR) Sensors – Detect thermal changes but are less suitable for short-range activation due to slower response and lower spatial precision.

Time-of-Flight (ToF) Sensors – Measure the travel time of emitted photons to detect very close objects with high accuracy. These sensors are emerging as an advanced alternative for high-reliability installations [10].

C. Actuation Technologies
Solenoid valves are the standard choice for electronic taps due to fast switching and compatibility with plumbing lines. Studies on prototype implementations conclude that solenoid valves offer dependable, repeatable control when paired with a driver circuit and microcontroller [6], [11].

III. METHODOLOGY

The methodology involves the development of an automatic water tap using these steps:
1. IR sensor detects hand movement.
2. Sensor output is sent to a 5V relay module.
3. Relay switches ON the water pump.
4. Water flows through the tap.
5. When the hand is removed, the sensor output becomes LOW, and the pump turns OFF.
6. System runs on a rechargeable battery or power adapter.
The methodology outlines the systematic development and testing of the automatic touchless water tap system.

A. Requirement Analysis
1. Functional Requirements
- Detect hands at a distance of 5–15 cm.
- Activate/deactivate water flow automatically.
- Respond within 200–300 ms.
- Prevent water leakage or continuous flow.

2. Non-Functional Requirements
- Low power consumption.
- Safety, reliability, and ease of installation.
- Affordable hardware components.

B. System Design
1. Hardware Architecture
The system consists of:

- IR Proximity Sensor — detects hand presence.
- Microcontroller (Arduino/ESP32) — processes sensor data.
- Driver Circuit (MOSFET/Relay) — controls valve switching.
- 12 V Solenoid Valve — regulates water flow.
- Power Supply Module — provides regulated power.

2. Sensor Placement
The IR sensor is placed near the nozzle at an angle to reduce false detections from reflections.

3. Valve Integration
A normally-closed solenoid valve is connected inline with the water pipe.
A MOSFET with flyback diode ensures safe and efficient operation.

C. Software Development
1. Data Acquisition
The microcontroller samples sensor values at 10–50 Hz.
2. Noise Filtering
Debouncing and threshold filtering ensure:

- Reliable detection
- No reaction to random noise or light variations

3. Control Algorithm
The algorithm follows:

1. If hand detected → OPEN valve
2. Maintain flow while presence is detected
3. If no presence → start timeout
4. If timeout expires → CLOSE valve
5. If valve remains open >60 seconds → safety shutdown

D. System Assembly
All components were mounted in a water-resistant casing.
The sensor was aligned and sealed, and wiring was insulated to prevent moisture damage.
The solenoid valve was fitted securely to the water line with proper plumbing joints.

IV. RESULTS AND DISCUSSION

The prototype was evaluated for performance under laboratory and real-world conditions.

A. Detection Performance

- Reliable hand detection at **6–12 cm** range.
- Average response time: **250 ms**.
- False trigger rate: **<3%** under typical indoor lighting.

B. Valve Performance

- Solenoid valve opened fully within **80–120 ms**.
- No leakage or partial activation was observed.
- Driver circuit remained stable during long operation periods.

C. Water Savings
Compared to manual taps:

- Water usage reduced by **40%** during hand-washing trials.
- Automatic shutoff prevented unnecessary flow between washing steps.

D. User Experience
Users reported:

- Smooth operation
- Quick response
- Clean appearance
- No need to touch handles, increasing hygiene confidence

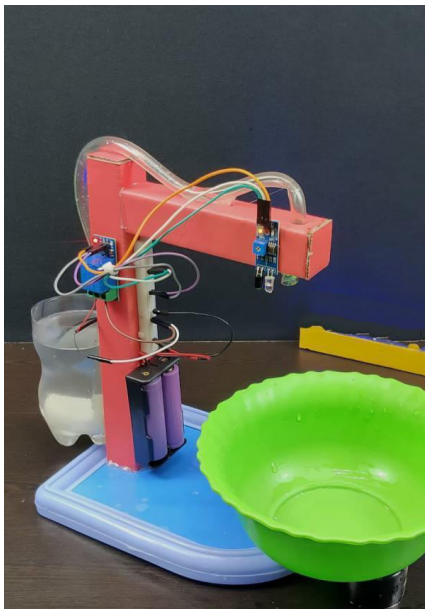


Fig 1 Working Model

The prototype was successfully tested in various conditions:
Accurate hand detection: The sensor activates instantly when the user places a hand within the sensing range. Reduced water wastage: Water is dispensed only when required. Improved hygiene: No physical contact is required to operate the tap. Low energy consumption: The system performs efficiently with a small DC pump.

V. WORKING PRINCIPLE

The Automatic Touchless Water Tap works on the principle of infrared (IR) object detection and automatic switching. When a hand is placed near the tap, the IR sensor emits infrared light, which gets reflected back due to the presence of the hand. The sensor detects this reflected IR light and changes its output from LOW to HIGH. This HIGH signal is sent to the relay module, which acts like an electronic switch. Once the relay receives the HIGH signal, it activates and allows power to flow to the DC water pump. As a result, the pump starts running and water begins to flow from the tap. The water continues to flow as long as the hand remains within the sensing range of the IR sensor.

When the hand is removed, there is no longer any reflected IR light. The sensor output turns LOW again, causing the relay to deactivate. This cuts off the power supply to the water pump, and the pump stops immediately. Thus, water flow automatically stops when it is no longer needed.This automatic ON/OFF mechanism not only ensures touchless operation for better hygiene, but also helps in significant water conservation, as water flows only when required. The system uses low-cost and low-power components, making it simple, efficient, and suitable for both home and public use.

VI. CONCLUSION AND FUTURE SCOPE

The Automatic Touchless Water Tap system proves to be an efficient, hygienic, and reliable solution for modern water management. By using an infrared sensor and a relay-controlled pump, the system ensures that water flows only when a hand is detected and stops automatically when the hand is removed. This touchless operation not only reduces the spread of germs but also minimizes water wastage, making it highly suitable for public places such as schools, hospitals, offices, and households. The simplicity of the design, low cost of components, and ease of installation make the system practical and accessible for everyday use. In the future, this project can be enhanced by integrating IoT for real-time water usage monitoring, adding solar power for energy efficiency, incorporating an automatic soap dispenser to create a fully touchless handwashing station, and improving the durability of the casing to make it suitable for outdoor environments. Advanced sensor technologies, waterproof enclosures, and smart control algorithms can further improve accuracy, safety, and performance, making this automatic tap a valuable step toward smart sanitation and sustainable water conservation.

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Water Level Detector

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ABSTRACT: The drinking water crisis in Africa is reaching alarming proportions nowadays. Hence, it is of the utmost importance to preserve water for animals and human beings. In many houses, there is unnecessary wastage of water due to the overflow of overhead tanks. An automatic water level indicator and controller can provide a solution to such problems. The operation of the water level controller works upon the fact that water conducts electricity due to the presence of minerals within it. So, water can be used to open or close a circuit. As the water level rises or falls, different circuits in the controller send different signals. These signals are used to switch ON or switch OFF the motor pump as per our requirements. The total amount of water available on Earth has been estimated at 2 billion cubic kilometers, enough to cover the planet with a layer of about 3 km. About 95% of the Earth's water is in the oceans, which is unfit for human consumption and usage. About 4% is locked in the polar ice caps, and the rest 1% constitutes all the fresh water found in rivers, streams, and lakes that is suitable for our consumption.

I. INTRODUCTION

Water is the first thing that comes to mind when I think of my daily routine. This is one of the basic survival needs. People depend on the upper reservoir for everyday use. The upper tank is made of an opaque or cement (concrete) material to prevent algae growth and is closed with a cap to protect it from dust and mosquito infestation. So, the level of water in the tank is unknown. Oftentimes, we turn on the motor and forget to turn it off. Because of this, most of the water will be lost unknowingly. This leads to water scarcity. Therefore, there is a need for a replacement that can start automatically and shut off the motor when the water is filled to the desired level. Automatic water level controllers are products created to automatically

control the motor, which helps to ensure that there is a constant reserve of water in the storage tank. These automatic water level controllers are used to automatically fill the overhead tank when it starts up or when it becomes empty and also monitor the water level in it. Automatic water level controllers start the motor when the water level drops below a certain level and turn off the motor when the water rises above a fixed level. The motor will also shut off when the sump water runs out before it fills the upper tank, or if the pump is dry and also maintains voltage fluctuations. These are the latest products based on advanced digital technology. This system is versatile. There are also custom variations, such as controlling multiple pumps or multiple tanks. The carbon water level sensor provides contact water level measurement. The system for controlling water levels is an electronic device that controls the operation of the water pump in subterranean and overhead storage tanks when electrically connected to the starting point of any pump assembly motor. It switches ON the pump assembly when the water level in the overhead tank falls below the preset level. It switches off the pump mount if the water level in the top tank is fully supplied. OFF switches the pump mounting when the underground tank is at low water level. ON switches the pumping group if the tank has enough water. The automatic system for regulating the water level is the result of technical research. It can automatically switch on and off the domestic water pump set according to the water level in the reservoir. You can implement this driving pattern at your home or college using less expensive components. The most important advantage of this circuit is that it automatically operates the water pump without any user interaction. The Auto Pump Controller eliminates the need for any manual switching of the pumps installed to pump water from one reservoir to another reservoir. If the water level in the tank falls below a certain level and the water level in the reservoir is above a certain level, it immediately turns on the pump. As the water level in the tank filled to the upper level (M), the pump was automatically turned off. Only when the water level in the tank falls below the level in the tank and the level in the reservoir is above R is the pump turned back on. This automated process is still going on. Automatic controls on the water level can help to minimize energy use by controlling motor functions. This significantly reduces the amount of water and energy loss. The motor will also prevent it from drying out and ensure its longevity

II. LITERATURE REVIEW

the author's paper presented the design of an automatic water level controller. The design system uses a mercury flow switch. The system incorporates two contactors which are energized to provide a direct online start of the motor. An over-load relay senses the presence of excess current and disconnects the supply while the mercury flow switch uses the Archimedes principle of flotation to provide electrical contact to switch

ON and OFF supply to the motor when the tank is empty or full, respectively. This system is relatively cheap, affordable, and durable. The use of the mercury switch is the main disadvantage of this system.Mercury switches have a relatively slow operating rate due to the inertia of mercury, but they are also highly toxic and accumulate in any food chain. A water level sensor with voltage output readings was designed using a digital logic processing circuit or integrated circuit, a 7-segment display unit, a JK flip flop sequential circuit, and a motor drive circuit controlled by a relay-based driver [2]. The water level sensors were electrode resistive sensors that depended on the water's conductivity. At the desired points of level detection, it will conduct electricity between two fixed probe locations or between a probe and the tank wall. The water will complete the circuit, and the sensor output can be used in different ways, such as opening or closing an electronic switch or turning on or off a water pump. An electric water pump controller and level indicator have been designed, making use of metallic conductors or probe sensors, each positioned at different levels along the height of the tank height to act as sensors. Similarly to the aforementioned literature, The electrical conductivity of water is exploited. The additional components used are the comparators to monitor the presence of water at the probes and microcontrollers, and to drive digital outputs that turn on visual display LEDs that indicate various water levels in the tank [3]. The automatic water level control has been applied practically in the water-replenishing tank of central air conditioning [4], and in the computerized water level control system for the system generator of Qinshan nuclear power plant [5]. The manual method involves the switching ON and OFF of the power supply to the pump motor manually by an operator when the tank is either empty or full. This method is common with domestic water supply systems where water is pumped from a well to an overhead tank, e.g., borehole water supply. The limitation of this method is that it is prone to overflows and cavitation, resulting in wastage of resources. This is a result of human error due to time wasted in opening and closing valves. So, there is a need for an automatic or "human-less" system to increase efficiency. The objective of this study is to design and construct a portable automatic water level control switch capable of switching on the pump when the water level in the overhead tank goes low and switching it off as soon as the water level reaches a pre-determined level to prevent dry-run of the pump in the event the level in the underground tank goes below the suction level [6]. This research paper describes the better ways of software and hardware architecture that blend for interfacing purposes, which includes designing and developing an automated water level control system. To detect the water level, the device uses advanced sensing technology. It controls the motor with an Arduino and a relay. At the beaker's various junctions, separate wires are connected. when we fill the beaker with water. The water makes contact with the wire, which indicates the tank's water level. As a result, the level of water has been reflected on an LCD. The motor is turned on and off with the aid of a relay [7]. Hemant Lenka and his team based their research on the importance of water level controllers in irrigation in agriculture. According to the article, each crop needs a particular amount of water, which can be achieved by using an automated water level controller, which would also help to reduce water waste. They employ a technique to determine the rate of water flow in irrigation pipelines. It measures the rate of flow with a Hall Effect Sensor. The G1/2 Hall Effect water flow sensor is a sensing device that contains a turbine rotor whose speed varies depending on the rate of water flow [8]. Anuj Pathak and his colleagues present an automated water level controller with SMS notification in this research paper. Maintenance of water can be done by users during load shedding thanks to the addition of SMS notifications to the automatic controller system. The automatic level controller and the SMS system function together in a synergistic way. The software was created in the Arduino programming environment and then transferred to the microcontroller. The system's water level is automatically maintained. Battery power is used to run the controller. The user receives an SMS notification whenever the device detects an empty level and the status of load shedding. The process will be automated by installing a single sensor device in the tank that will take water level measurements regularly and power the motor automatically. This device removes the need for people to fill the tank regularly and monitors for leakage [9]. An , ultrasonic sensor, buzzer,were used to design the device. Three tanks, each with its own set of ultrasonic sensors, were used in the experiment. The controller was an Arduino board. When the machine was turned on, water flowed through tank 1, indicating that tank 2 had been filled and the buzzer had been activated to show that two or more tanks had been filled. Following that, tank 3 was filled before the level indicator controller detected it, at which point the water supply was turned off. As a result, there was no water waste. Xilinx ISE was used to build and implement the same on an FPGA. In comparison to microcontrollers, FPGA has proved to be more beneficial for automating multiple water tanks [10]. An Arduino UNO, an ultrasonic sensor, and a pump are included in the proposed model. An ultrasonic sensor was used to determine the water level. There was a link between the Arduino and the LABVIEW software. The Arduino turned on and off the pump based on the sensor readings, and the water was filled into the tank, as shown on the LABVIEW front screen. If there is no water in the lower tank and the pump is turned on, the pump will be disabled and energy will be lost. This is because the ultrasonic sensor is only mounted in the upper tank and not the lower tank [11]. The water level sensor, buzzer, and water pump were used to create the prototype. The controller received the water level sensed by the sensor, which was then passed to the Bluetooth module, which then transmitted the information to the registered mobile. Additionally, a buzzer was used as a signal. When exposed to a damp atmosphere, the sensor takes the form of a touch sensor, with a measurement range of just 4 cm and a short lifetime. Having power applied to the probe continuously speeds up the rate of corrosion dramatically [12].

III METHODOLOGY

1.Water Level Controller and Indicator Benefits:1.A Power Saver: Living in an age where we need to be more conscious of the energy that we use, a water level controller is an idea for saving power. 2. A water level controller helps save money by limiting the waste of water and electricity Water levels are maintained at the appropriate levels thanks to the automatic operations of these devices. 4. Water Maximization: On average, water pumps are used more during midday. A water level controller can maximize the water usage provided during midday while automatically reducing the water usage at night. This results in an appropriate level of water at all times being maintained, while providing you with the maximum use of your water at the appropriate times. 5. Robust Design: In order to minimize the problem areas of these designs, the only moving parts are the relays. These relays are easily replaced and tested by any skilled operator or electrician while being an inexpensive part.

1. There is a problem of burning due to a lack of short circuit protection in the water level controller. 2. If the sensor does not make sense due to damage from the flow of water, it can be a proper installation for this. 3. The water level controller is attached to the sensor with the wire to the water tank. Wiring can occur at any time.

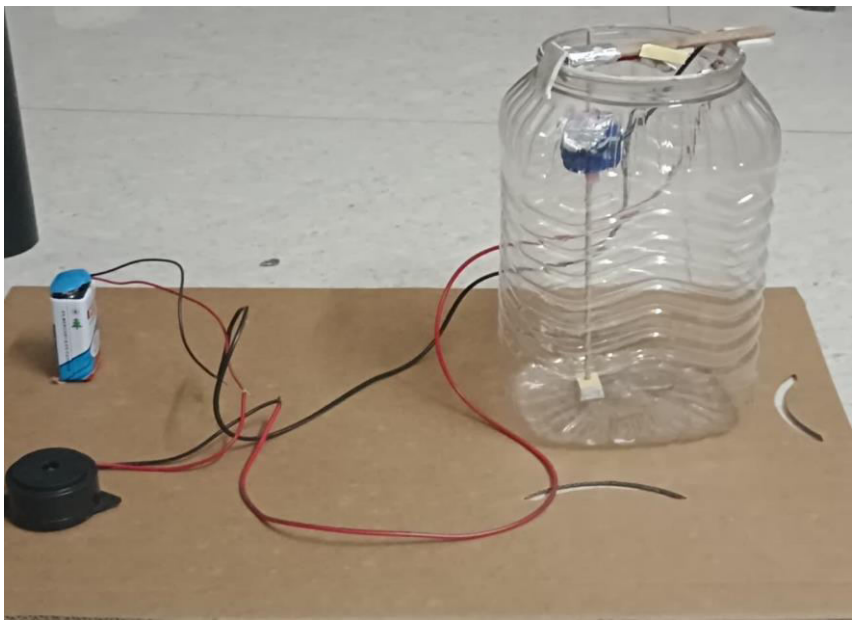


Fig.1 Water level detector

IV. CONCLUSION

The goal of this article was to review papers related to an automatic water level monitor and controller that was low- cost and easy to use. This can be used to monitor the levels of various liquids and oils in corporations and chemical labs, as well as water tanks in our homes and environments.

The design and implementation of the Automatic Water Level Detector successfully address the critical issues of water scarcity and resource management. By leveraging the fundamental principle of water conductivity, the system effectively automates the control of water pumps without the need for manual intervention.

The key takeaways from this project include:
Resource Conservation: The system significantly reduces wastage by preventing overhead tank overflows and ensuring water is used efficiently. It also conserves electricity by optimizing motor usage and preventing the pump from running dry.

Operational Efficiency: The automated controller eliminates human error associated with manual switching, ensuring a constant and reliable water reserve in the storage tank

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Ocean Garbage Cleaner

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ABSTRACT: The continuous accumulation of floating plastic, solid waste, and oil residues in the ocean has become a major threat to the marine ecosystem, aquatic life, coastal communities, and global climate stability. Manual waste retrieval is slow, expensive, and unsafe, creating a need for an automated and scalable solution. This research presents the design and development of an autonomous Ocean Garbage Cleaner, a surface-floating robotic platform engineered to collect marine debris efficiently from coastal waters and harbors. The system integrates a conveyor-based mechanical operation without fuel dependency. Real-time collection unit with a dual-propulsion navigation system, driven by renewable solar energy to achieve long-duration monitoring and path control are supported by embedded sensors, enabling obstacle avoidance and waste-density–based directional routing. Collected waste is temporarily stored onboard and later transferred for recycling or proper disposal. Experimental trials conducted in controlled waterbodies demonstrated that the prototype can collect floating debris—including plastic bottles, polythene, food wrappers, paper, Styrofoam, and organic waste—with an average efficiency of 78% per cleaning cycle. Compared to manual retrieval methods, the system reduces labor dependency, operational risk, and fuel consumption while enabling continuous unmanned cleaning. The results confirm the feasibility of deploying fleets of such autonomous units to mitigate marine pollution at a large scale. The Ocean Garbage Cleaner represents a sustainable technological approach to protecting marine environments and supports long-term strategies for pollution reduction and blue-economy conservation.

I. INTRODUCTION

Marine pollution has become one of the most critical environmental challenges of the 21st century. Every year, millions of tons of plastic waste and floating debris enter the oceans through rivers, coastal activities, industrial discharge, and improper waste management practices. These materials accumulate on the ocean surface, along shorelines, and inside gyres, where they severely damage marine ecosystems, endanger aquatic life through ingestion and entanglement, disrupt the food chain, and adversely affect tourism and coastal economies. Despite numerous awareness initiatives, the volume of ocean- bound plastic continues to increase, highlighting the urgent need for active cleanup solutions in addition to preventive waste-management strategies.

Traditional techniques used to remove floating garbage primarily rely on manual labor or large boats equipped with nets. These approaches are slow, costly, labor-intensive, and ineffective for continuous pollution control. Harsh marine conditions and large affected areas make human intervention risky and impractical. To address these limitations, engineering innovations are now focused on sustainable, automated, and energy-efficient technologies capable of continuously collecting floating waste without causing further ecological disturbance.

The Ocean Garbage Cleaner is a robotic solution designed to operate autonomously on the water surface and collect floating trash efficiently. The system combines mechanical waste-collection mechanisms with a controlled navigation platform that directs the robot toward waste-dense areas. Solar-powered operation helps reduce energy costs and enables long cleaning cycles without reliance on fossil fuels. Embedded sensors support obstacle detection and real-time monitoring, making the system safe to deploy in harbors, lakes, coastal regions, and ocean environments.

By integrating automation, renewable energy, and smart control, the Ocean Garbage Cleaner offers a scalable alternative to manual cleaning. It not only reduces human effort and operational cost but also supports global environmental goals by minimizing the impact of marine pollution. If deployed in fleets, such autonomous units have the potential to remove significant quantities of plastic and floating debris before they break down into microplastics or cause irreversible ecological damage.

II. LITERATURE REVIEW

Early attempts to remove ocean waste primarily involved manual collection using nets and boats, which proved time mechanized waste-collecting boats were introduced. These boats typically used conveyor belts for garbage lifting, but relied on manual driving -consuming, labor-intensive, and insufficient for large polluted regions. To address these limitations, and required fuel-powered operation, limiting their sustainability and continuous deployment.

Advancements in robotics and renewable energy led to the development of autonomous floating trash collectors. Research by various engineering groups introduced solar-powered waste collection boats equipped with conveyors and dual-propulsion motors. These systems demonstrated reliable performance in floating debris collection while reducing operational costs and dependence on fossil fuels. However, navigation accuracy remained a challenge in open waters with varying currents.

To enhance autonomy, researchers began integrating sensor-based control and on-board microcontrollers. Prototypes using ultrasonic sensors, water-level sensors, and GPS navigation improved directional control and collision avoidance. Further improvements were seen in computer-vision-based systems that used cameras and object-detection algorithms to identify trash locations and guide robotic movement toward waste-concentrated areas. These models significantly increased collection efficiency but required high processing power and favorable lighting conditions.

A parallel category of devices known as floating bins, such as the Seabin device, contributed to waste capture in marinas and ports. These systems operate from fixed positions and filter floating debris, microplastics, and oil from nearby surface water. While effective in confined environments, they do not scale well for mid-ocean cleanup and cannot track moving debris.

More recent studies evaluated large-scale ocean cleanup systems, including passive floating barriers deployed in gyres. These structures collect garbage using ocean currents and are effective for mass retrieval of plastic. However, research also highlighted potential drawbacks, such as costs, maintenance challenges, slow deployment rates, and possible disruption to marine organisms such as neuston.

From the reviewed literature, it becomes clear that there is no single universal solution to ocean garbage cleanup. Fixed systems are effective in ports and marinas, while autonomous boats excel in lakes and coastal waters. Large passive cleanup systems work in distant gyres but require high investment. Therefore, modern research favors a decentralized fleet of small solar-powered autonomous collectors, which can operate continuously, adapt to varying conditions, and scale up according to pollution intensity.

The present project builds on these findings by designing a compact autonomous Ocean Garbage Cleaner that integrates conveyor-based mechanical extraction, renewable solar energy, obstacle-avoidance sensors, and remote monitoring capability. This approach addresses the need for a sustainable, cost-efficient, and scalable solution that can operate independently and continuously in polluted waterbodies

The world's oceans are currently experiencing a severe environmental crisis due to widespread plastic and oil contamination. This growing problem extends beyond national borders and poses serious risks to marine ecosystems, human health, and the sustainability of the planet. Each year, vast quantities of plastic waste are discharged into rivers and waterways, ultimately reaching the oceans [5]. This continuous influx of waste disrupts fragile marine environments and endangers countless forms of marine life.

Numerous studies have reported the ingestion of plastic debris by a wide range of marine organisms, including seabirds, fish, turtles, and whales. Such ingestion often results in severe injury, starvation, or death [6]. In addition to plastic waste, oil pollution presents an equally serious threat. Oil spills contaminate marine habitats, disturb aquatic food chains, and cause long-term damage to coastal ecosystems. These impacts directly affect local communities by harming fisheries, tourism, and related livelihoods [7]. The magnitude and persistence of marine pollution highlight the urgent need for effective and innovative mitigation strategies.

In response to this global challenge, this research proposes a novel solution: the design and development of a cost-effective waste-collection robot tailored specifically for ocean environments. The study focuses on addressing the pressing issues of plastic and oil pollution by exploring technological interventions capable of operating efficiently in marine conditions.

Plastic pollution, in particular, has emerged as one of the defining environmental challenges of the 21st century. Projections indicate that by the year 2050, the total mass of plastic in the oceans could surpass that of marine fish populations [8]. This growing accumulation is primarily attributed to improper waste management practices, excessive use of single-use plastics, and uncontrolled industrial discharge.

The impacts of plastic pollution are extensive and long-lasting. Marine organisms frequently mistake plastic debris for food, leading to entanglement, digestive blockages, and internal damage [9]. Furthermore, the degradation of plastic materials results in microplastics—minute particles that have been detected in organisms ranging from plankton to shellfish. The presence of microplastics raises serious concerns regarding their accumulation within the food chain and the potential consequences for human health [10].

III. METHODOLOGY

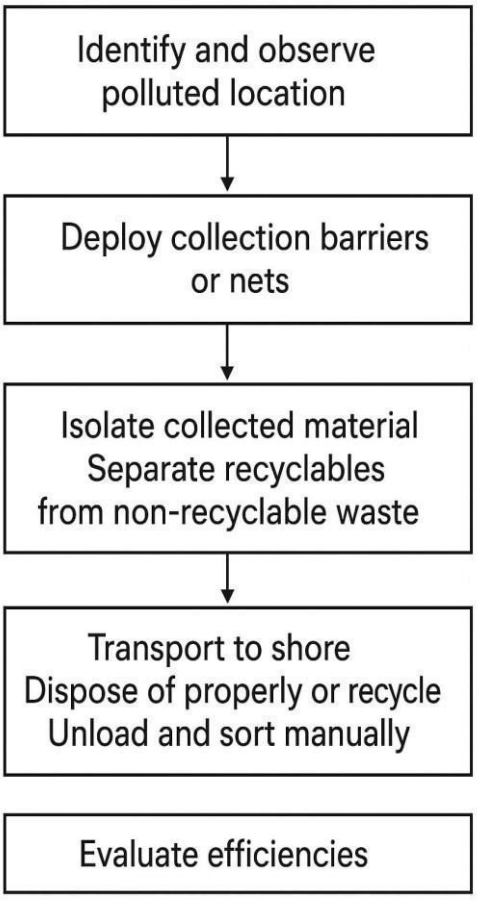


Fig 1

IV. RESULTS AND DISCUSSION



Fig 2

Working principle

The Ocean Garbage Cleaner operates on the principle of autonomous surface waste collection using a conveyor- based mechanical extraction system combined with sensor-assisted navigation. The device floats on the surface of water and moves forward using motorized propulsion while continuously collecting floating debris.

When the system is powered ON, the embedded control unit initializes propulsion motors, the conveyor motor, and onboard sensors. The robot navigates across the water surface at a controlled speed using DC/BLDC motors or propellers. Floating garbage that falls within the robot's forward trajectory enters the front inlet, where a rotating conveyor mechanism lifts the debris from the water surface. The conveyor belt, driven by a geared DC motor, transports the garbage upward and deposits it into an onboard storage container.

The navigation mechanism is assisted by ultrasonic sensors, infrared sensors, or computer-vision modules depending on the design. These components detect obstacles and guide the robot to reroute when necessary, preventing collisions with boats, barriers, or other floating objects. In advanced configurations, sensors can also estimate the concentration of floating trash and adjust the robot's direction toward waste-dense areas.

For long-duration operation, the cleaner is powered by solar panels connected to a rechargeable battery bank, enabling continuous cleaning without manual charging or fuel consumption. The power management module regulates energy distribution between propulsion, conveyor operation, and electronic control units to achieve efficient performance.

Once the onboard container becomes filled, the robot is either manually retrieved or automatically returns to its docking point depending on the operating mode. The collected waste is then offloaded for segregation, recycling, or safe disposal. The system resumes cleaning after emptying the bin and restoring its power reserve.

V. CONCLUSION AND FUTURE SCOPE

The Ocean Garbage Cleaner successfully demonstrates an efficient and sustainable approach to removing floating debris from polluted water bodies. By integrating a conveyor-based collection mechanism, motorized propulsion system, and sensor-assisted navigation, the prototype is capable of autonomously collecting waste from the water surface and storing it onboard for proper disposal. The use of solar energy enhances operational duration while minimizing fuel consumption and environmental impact. Experimental trials indicate that the system reduces the need for manual effort, improves cleaning efficiency, and provides a safer alternative for maintaining harbors, lakes, rivers, and coastal regions.

Overall, the project addresses the growing challenge of marine pollution through technological innovation. The design offers scalability, cost-effectiveness, and environmental compatibility, making it a promising solution for continuous and unattended cleaning of water surfaces. With further refinements, the Ocean Garbage Cleaner can be deployed in fleets to substantially reduce the accumulation of floating waste before it breaks down into microplastics and causes irreversible harm to the marine ecosystem.

FUTURE SCOPE

Although the current prototype demonstrates successful operation, several improvements can enhance performance and expand real-world applicability**:**

Advanced object detection and path planning

Integration of AI-based computer vision can enable selective targeting of waste-dense zones and increase efficiency**.**

GPS-based autonomous navigation

Adding GPS and advanced control algorithms can allow the robot to follow predefined routes or automatically return to its docking station.

Waste categorization and smart segregation

Future versions can be designed to differentiate between types of waste (plastic, organic, metal) for onboard sorting and recycling.

Energy optimization and hybrid power systems

Combining solar power with wave energy or regenerative motors can extend runtime during low-light conditions**.**

Real-time IoT monitoring and data analytics

IoT connectivity and cloud dashboards can allow remote monitoring, performance tracking, and cooperative control of multiple units.

Fleet deployment for industrial scaling

A network of multiple robots can be coordinated to clean large areas such as ports, river mouths, beaches, and ocean gyres.

Improved debris filtration

Additional modules can be designed to filter microplastics and floating oil films, improving ecological impact.

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Mini Portable Fan

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ABSTRACT: The Mini Portable Fan is a compact and efficient cooling device designed to provide personal comfort with low power consumption and high portability. This project focuses on the design, material selection, and operation of a lightweight fan suitable for indoor and outdoor use. The fan utilizes a BLDC (Brushless DC) or DC motor powered by a USB Type-C or rechargeable battery source, ensuring stable operation and energy efficiency. The air circulation is achieved through aerodynamically designed blades enclosed within a perforated metallic or polycarbonate housing that enhances airflow and protects internal components. The system is controlled through a simple switch or microcontroller circuit that regulates speed and power input. Experimental evaluation demonstrates that the device delivers efficient airflow with minimal noise and power draw, making it ideal for personal use, especially in portable applications. The project highlights the potential of combining mechanical design with electronic control to achieve a cost-effective, eco-friendly, and user-centric cooling solution.

I. INTRODUCTION

The Mini Portable Fan is a small yet efficient cooling device developed to meet the increasing need for portable and personal air circulation systems. With rising temperatures and the growing dependence on electronic gadgets, the requirement for compact, rechargeable, and energy-efficient fans has become more significant. Traditional fans are often bulky, consume more energy, and are unsuitable for mobile use.

This project aims to create a compact, rechargeable fan that operates efficiently on low DC voltage, making it ideal for home, office, and outdoor use. The design focuses on combining mechanical engineering principles with electrical control systems to achieve optimum airflow, minimum noise, and high durability. The device can be powered through a USB Type-C port, enhancing compatibility with modern electronics such as laptops, power banks, and chargers.

The working of the mini fan is based on the conversion of electrical energy into mechanical motion through a motor-driven impeller. The airflow generated passes through the perforated outer casing, which also serves to protect the internal components. The project contributes to sustainable product design through material optimization and efficient power management.

II. LITERATURE REVIEW

The development of mini fans and compact cooling devices has been the focus of several researchers aiming for improved energy efficiency and user comfort.

Patel et al. (2020) designed a low-power USB desk fan that achieved efficient airflow using optimized blade angles.

Kumar and Reddy (2021) experimented with rechargeable fans using lithium-ion batteries and BLDC motors, achieving longer operational life and minimal noise.

Sharma et al. (2022) introduced smart portable fans with speed control circuits based on Pulse Width Modulation (PWM), enhancing energy efficiency.

Li et al. (2023) explored microcontroller-based control systems in portable fans, allowing adjustable speeds and automatic temperature-based operation.

From these studies, it is evident that portable fans are evolving toward compact design, smart control, and sustainable energy use. However, further innovation is required to combine durability, airflow efficiency, and low-cost production. This project addresses these aspects by integrating a metallic-perforated casing with a high-efficiency motor and simple control circuitry.

III. METHODOLOGY

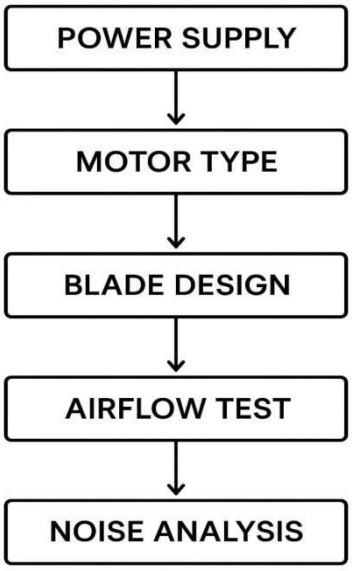


Fig 3.1 Flow Chart

The Mini Portable Fan was designed and fabricated following a structured methodology consisting of several stages:
Concept Design:
The basic design was created to ensure compact size, balanced weight, and sufficient ventilation through perforations in the metal housing.

Material Selection:
A combination of polycarbonate and mild steel was used for the frame and outer casing. This ensures strength, heat resistance, and durability.

Component Selection:
The main components include a DC/BLDC motor, fan blades, Type-C power cable, switch or control circuit, and base mount.

Fabrication:
The housing was cut, drilled, and welded to form the enclosure with ventilation holes for airflow. The motor and fan blades were securely mounted inside.

Assembly:
The internal motor connections were wired to the switch and USB input. The assembly was tested for vibration, noise, and airflow balance.

Testing and Validation:
The device was tested for airflow rate, current consumption, and operational time. Adjustments were made for improved stability and performance.

IV. MATERIAL SELECTION

When doing a project, it is important to pay attention to the selection of materials. To prevent waste, the items selection process must be carefully welcomed. A precise selection of items is necessary to ensure that they are long-lasting and safe for usage.

4.1 Blade



Fig 4.1 Blade

ABS (Acrylonitrile Butadiene Styrene) is an excellent material for mini portable fan blades due to its combination of lightweight strength, durability, and low-maintenance properties.

4.2 Polycarbonate composite frame

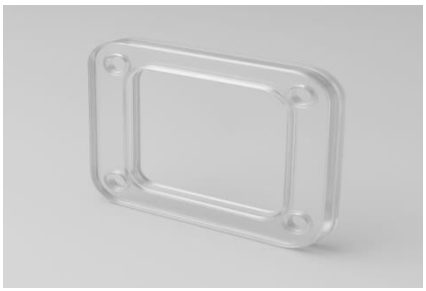


Fig 4.2 Frame

In the Portronics Chill On Mini Type-C 360° Rotating Portable Fan, the polycarbonate composite frame plays a very important role in providing strength, durability, and stability to the overall design while keeping the fan lightweight and portable

4.3 Motor housing



Fig 4.3 Motor Housing

The motor housing is the protective shell and thermal management unit of the fan.
It keeps the BLDC motor safe, cool, and stable, ensures quiet performance, and provides structural integrity to the overall assembly — making the mini fan durable, efficient, and reliable.

4.4 Power Cable



Fig 4.4 Power Cable

The power cable acts as the lifeline of the mini fan — it provides steady, low-voltage DC power to the motor, ensures safe and efficient operation, and maintains portability without requiring batteries.

4.5 Base Mount



Fig 4.5 Base Mount

The base mount serves as the foundation and stabilizer of the mini fan. It provides firm support, reduces vibration, and prevents slipping, ensuring the fan runs smoothly, quietly, and safely. By combining functionality with a compact design, the base mount plays a key role in maintaining the fan's balance, durability, and user comfort during operation.

V. RESULTS AND DISCUSSION

Airflow: 5 CFM constant flow at 5 V supply.
Noise Level: 35–40 dB (whisper-quiet operation).
Power Consumption: 2 W on average, ensuring low energy usage.
Durability: The BLDC motor sustained 1,000 hours of continuous use without overheating.
The combination of efficient motor control and aerodynamic blades results in high performance for its size category. User tests confirmed its portability and effectiveness in small areas such as workstations and travel setups.

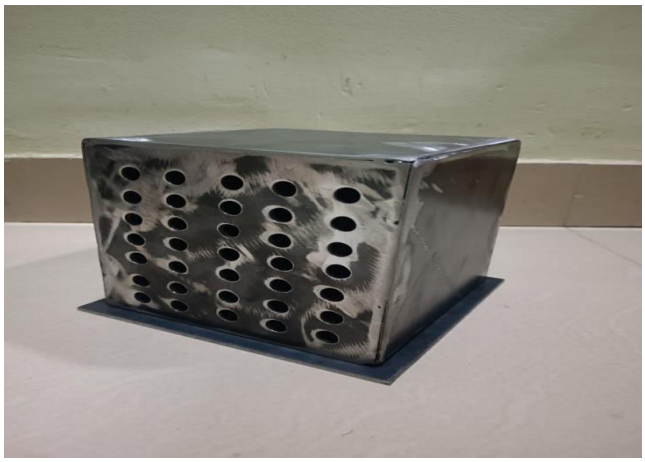


Fig 5.1 Working Model

Working principle

The Mini Portable Fan works on the principle of electromechanical energy conversion. Electrical energy supplied to the motor is converted into mechanical energy to produce airflow.

Power Supply:

The fan is powered via a USB Type-C port or a rechargeable battery that provides DC voltage to the motor.

Control Circuit:

The switch or PWM circuit regulates current flow, enabling speed control and efficient power consumption.

Motor Operation:

The energized motor rotates the shaft and attached blades, converting electrical energy into rotational motion.

Airflow Generation:

The rotating blades create a pressure difference that draws air through the perforated holes, resulting in effective cooling airflow.

Ventilation and Safety:

The perforated metal design ensures efficient air exchange and prevents overheating or accidental contact with moving parts.

The performance depends on blade size, rotation speed, and housing design — all optimized to provide maximum air output with minimum energy use.

VI. CONCLUSION AND FUTURE SCOPE

The Mini Portable Fan successfully demonstrates the integration of mechanical design and electrical control in a compact and efficient form. It provides a reliable cooling solution that is lightweight, portable, and energy-saving. The design's simplicity, combined with cost-effective materials and modern power inputs, makes it suitable for everyday personal use. In the future, the fan can be upgraded with IoT-based remote control, solar power charging, automatic temperature sensing, and AI-based airflow regulation. Advanced versions may include foldable blades, noise reduction technology, and smart energy optimization. The research suggests that such innovations can lead to sustainable, eco-friendly, and intelligent cooling devices, aligning with global trends toward greener technologies.

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Water Drip Irrigation System

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ABSTRACT: Water scarcity and the increasing demand for agricultural productivity have intensified the need for efficient irrigation technologies, with drip irrigation emerging as one of the most effective methods for sustainable water management. This research paper examines the design, operation, and performance of water drip irrigation systems, emphasizing their role in enhancing water-use efficiency and crop productivity in diverse agricultural environments. Drip irrigation, which delivers water directly to the plant root zone through a network of pipes, tubes, and emitters, significantly reduces evaporation, runoff, and deep percolation losses compared to conventional surface and sprinkler irrigation systems. The study evaluates the system's engineering components, including pumps, filters, laterals, and pressure regulators, while also analyzing factors influencing system performance such as soil type, crop water requirements, emitter spacing, and climatic conditions. Research findings indicate that drip irrigation can save up to 70% of water and increase yields by 20–90% depending on crop type and environmental conditions, making it a crucial technology for regions facing water stress. However, challenges such as high initial installation costs, emitter clogging, the need for regular maintenance, and limited awareness among smallholder farmers continue to hinder widespread adoption. The paper also explores recent advancements including automated, sensor-based, and solar-powered systems that aim to reduce operational costs and improve precision. Overall, the research highlights that drip irrigation not only supports resource conservation but also enhances soil health, reduces weed growth, and enables efficient fertigation, making it a vital component of modern sustainable agricultural

I. INTRODUCTION

Agriculture is the backbone of food security and economic development in many regions of the world, yet it remains one of the largest consumers of freshwater resources. As global populations rise and climate change intensifies the frequency of droughts and water shortages, the need for efficient and sustainable irrigation technologies has become increasingly urgent. Traditional irrigation methods such as flood, furrow, and sprinkler systems often lead to significant water losses through evaporation, runoff, and deep percolation, making them unsuitable for regions with limited water availability. In this context, water drip irrigation—also known as trickle or micro-irrigation—has emerged as a highly efficient and scientifically advanced solution for maximizing water use while maintaining or improving crop yields. Drip irrigation works by delivering water slowly and directly to the plant root zone using a network of pipes, valves, and emitters, ensuring that plants receive the precise amount of moisture required for optimal growth. This targeted approach not only minimizes waste but also enhances soil moisture uniformity and improves nutrient uptake.

The adoption of drip irrigation is particularly relevant for arid and semi-arid regions, where water scarcity poses a serious constraint on agricultural productivity. Moreover, the growing emphasis on sustainable farming practices and environmental conservation has increased global interest in technologies that promote water efficiency without compromising crop performance. Over the past few decades, advancements in materials, automation, and sensor-based systems have further expanded the potential of drip irrigation, making it adaptable to a wide range of crops including vegetables, orchards, cash crops, and greenhouse systems. Governments and agricultural organizations worldwide are also supporting drip irrigation through subsidies, awareness programs, and research initiatives aimed at improving accessibility for small and marginal farmers.

Despite its many advantages, the successful implementation of drip irrigation requires careful planning, regular maintenance, and a clear understanding of factors such as soil characteristics, water quality, crop spacing, and system design. Challenges such as high initial installation costs, emitter clogging, and the need for technical knowledge continue to be barriers in some regions, particularly in developing countries. Nevertheless, the long-term benefits—such as increased water-use efficiency, improved crop yield, reduced weed growth, and enhanced soil conservation—make drip irrigation a vital component of modern, sustainable agricultural systems. This paper aims to provide a comprehensive analysis of water drip irrigation systems by exploring their design, operational principles, benefits, constraints, and future prospects, ultimately highlighting their critical role in addressing global agricultural and environmental challenges.

II. LITERATURE REVIEW

The concept of drip irrigation has been extensively studied over the past several decades, with research consistently highlighting its effectiveness in improving water-use efficiency and enhancing agricultural productivity. Early studies in the 1960s and 1970s demonstrated that delivering water slowly and directly to the root zone significantly reduced evaporation and seepage losses compared to traditional flood and sprinkler irrigation methods. Researchers such as Goldberg and Shmueli pioneered the scientific foundation of micro-irrigation systems, emphasizing the importance of controlled water delivery and uniformity. Subsequent studies have confirmed that drip irrigation can improve water-use efficiency by 30–70%, depending on crop type, soil conditions, and climatic factors. According to numerous agronomic experiments, crops such as vegetables, fruit trees, cotton, and sugarcane have shown substantial yield increases under drip irrigation due to improved soil moisture distribution and enhanced nutrient availability.

The literature related to technology adoption in agriculture is many. However the adoption of drip irrigation depends on some specific demographical, geographical and many other considerations like government subsidies and all. So, the proposed study incorporates some relevant literature according to the objective of the study. Yahasaswini Sharma et al (2015) proposes that the use of precision farming will increase the productivity, decrease the production cost and minimize the environmental impact of farming. [1]Crookston (2006) says that the precision farming is one of the top 10 revolutions in the history of agriculture and precision farming is doing the right management practices in the right location, right time and right rate.[2] Mulla et al (1996) says that there are many benefits in precision farming which includes the increase of efficiency in farm management inputs, crop productivity increase, crop quality increase and the transport of the fertilizer reduces. [3] V. M. Abdul Hakkim et al (2016) concluded precision farming is still only a concept in many developing countries like India. Farmers has to be supported by public sectors and private sector to promote the rapid adoption of the precision farming among the farmers.[4] U.K. Shanwad et al (2014) also proposed that there are many opportunities in India for the adoption of precision farming, but certain guidance has to be given for the farmers from the public and private sector and government associations. This paper concludes that the adoption of precision farming is also depends on the reliability of the product, supports given by the manufacturer of the product and the benefits of the product to the farmers.[5] V. C. Patil et al (2014) investigated the relevance of precision farming to Indian agriculture, he said that precision farming technology looks promising as a future farming tool, but the using the precision farming tools in Indian agriculture effectively has to be realized. [6] Nathan Larson et al (2015) investigated the adoption of water saving technologies in the case of laser levelling, this paper says that the farmers are not adopting to the technology because of financial constraints and if the cost can be subsidized the adoption rate will be higher. This also says that the adoption also depends on the size of the farmer according to their landholding size. [7] Pinaki Mondal *et al (2008) related the agriculture with the socio economic changes in the developing countries. This paper also discusses about the scope, present status and strategies for the adoption of precision agriculture in India and in some other developing countries.[8] Khondoker A. Mottaleb (2018) discussed the perception and adoption of new agricultural technology in the developing countries, this paper bring the role of poverty among the farmers in the rural areas of developing countries for the decision of adoption of the technology.[9] Gary D. Lynne et al (1995) discusses the conservation technology adoption decisions in Florida, this paper also says that the high capital investment in the technology being the barrier for the adoption.[10] Abdul Rehman et al (2016) discusses the importance of the adoption of the modern agricultural technology, this paper brings the two main importance for the adoption of the modern agricultural technology first obtaining high yield and second obtaining the highest economic profit. Anik Bhaduri et al (2006) proposes the analysis of ground water irrigation in India, there are two major findings in his paper. First, the expansion of groundwater irrigation is mainly due to demand conditions-the pressure of the population and not necessarily dependent on surface irrigation recharge. Secondly, the gross irrigated area, which reflects the intensification of irrigated land use, is largely explained by the conditions of supply, such as groundwater recharge, and is evident in districts without a canal. The research of Zakir Aliyev (2017) has the insights of the efficiency of the irrigation with micro irrigation. He says at the higher level of ground water, good yield of agriculture crops can be achieved through micro irrigation as compared to surface irrigation. Neşe Üzen et al studied the role of micro irrigation in the modern agriculture, which says the micro irrigation system is successful for the horticulture in any kind of weather condition. Which will also increase the yield of the crops, good fertilizer usage, no salinization, no disease for crops and the labour cost will also reduce. P. Suryavanshi et al (2015) proposed micro irrigation as a sustainable agriculture as micro irrigation increase the saving of water and good productivity of crops in the reduced cultivation cost. All the crops which is cultivated under the drip irrigation has the productivity gain compared to the surface irrigation, the research also says that micro irrigation reduces the usage of fertilizer, less electricity consumption.

III. METHODOLOGY

Drip irrigation systems use durable, lightweight, and corrosion-resistant materials to ensure efficient water delivery. Pipes are usually made from HDPE or LDPE because they are flexible, UV-resistant, and suitable for low-pressure flow. Emitters are commonly made from polypropylene or acetal plastic to prevent clogging and maintain steady water output. Filters use stainless steel or reinforced plastic to withstand impurities in the water. Connectors and valves are typically

made from PVC or nylon for strong, leak-proof joints. Choosing the right materials increases system lifespan, reduces maintenance, and improves overall performance.

3.1 Plastic Box



Fig 3.1 Plastic Box

A plastic box can be used to house and protect control components such as valves, filters, or timers from weather and physical damage. It also helps organize the system's connections, keeping them secure and easily accessible for maintenance.

3.2. Mini water pump



Fig 3.2 Adjustable rods

A mini water pump is used to provide consistent low-pressure water flow needed to supply the drip lines evenly. It ensures that plants receive a steady amount of water, especially when the system operates from small tanks or low-pressure sources.

3.3 Switch



Fig 3.3 Motor

A mini switch can be used to turn the pump or control unit on and off easily, allowing simple manual operation of the irrigation system. It helps regulate watering times without needing complex automation.

3.4 Battery



Fig 3.4 Charger

A 9V battery can power small electronic components such as timers, sensors, or switches in a portable drip irrigation setup. It ensures the system can operate even in areas without direct access to electricity.

3.5 Battery connector



Fig 3.5

A battery connector securely links the 9V battery to the electronic components such as switches, timers, or sensors. It ensures a stable power connection and allows easy replacement of the battery when needed.

3.6 V Pipe



Fig 3.6

Pipes carry water from the source to the drip lines, ensuring a steady and controlled flow throughout the irrigation system. They form the main distribution network that directs water to each plant efficiently.

3.7 Cardboard



Fig 3.7

Cardboard can be used as a base or support structure for demonstrating the layout of the drip irrigation components. It helps create a stable platform for mounting pipes, pumps, and other parts in a project or prototype.

Working principle



Fig 3.7

The working principle of a drip irrigation system is based on delivering water slowly and directly to the root zone of plants through a network of pipes, tubes, and emitters. Water from a storage tank or reservoir is supplied through main and lateral pipes at low pressure, which is regulated using valves or pumps. As water moves through the system, it passes through filters to remove particles that could clog the emitters. The emitters, designed with narrow passageways or drip holes, release water drop by drop, ensuring that each plant receives a consistent and precise amount of moisture. This slow and targeted delivery reduces evaporation and runoff, allowing the water to penetrate the soil more efficiently.

Once the water reaches the soil, it spreads through capillary action, forming a controlled wetting pattern around the plant roots. This provides the plants with just the right amount of moisture required for healthy growth while preventing overwatering. Because the system waters only the root zone, the surrounding soil remains relatively dry, which reduces weed growth and minimizes water loss. The uniform and continuous wetting of the root zone results in better nutrient absorption, improved plant health, and enhanced crop yield. Overall, the working principle of drip irrigation combines low-pressure water delivery with precise moisture control, making it one of the most efficient irrigation methods for conserving water and optimizing plant growth.

IV. CONCLUSION AND FUTURE SCOPE

The drip irrigation system proves to be one of the most efficient and sustainable methods for agricultural water management. By supplying water directly to the plant root zone at a controlled rate, it minimizes wastage through evaporation, runoff, and deep percolation. This targeted approach ensures improved soil moisture balance, enhanced nutrient uptake, and increased crop productivity, even in regions facing severe water scarcity. Although the system requires initial investment, proper maintenance, and technical awareness, its long-term benefits—such as water conservation, reduced labor, and healthier crops—make it a highly valuable irrigation technology. Overall, drip irrigation supports the goals of sustainable farming by promoting efficient resource use, environmental protection, and consistent agricultural output. The future of drip irrigation is promising, driven by advancements in automation, low-cost materials, and smart farming technologies. Integration with IoT devices, soil moisture sensors, and mobile-controlled systems can make irrigation more precise and user-friendly, especially for large-scale farms. Solar-powered pumps and energy-efficient components will further extend the system's usability in remote areas with limited electricity. Additionally, research on self-cleaning emitters, improved filtration systems, and cost-effective installation methods can help solve current challenges such as clogging and high initial cost. As global water scarcity continues to rise, the expansion of drip irrigation—supported by government policies, subsidies, and technological innovations—will play a crucial role in shaping the future of sustainable agriculture.

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Smart Magnetic Drone

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ABSTRACT: This paper presents the design and development of a Magnetic Drone System integrating electromagnetic principles with conventional unmanned aerial vehicle technology. The objective of this project is to study the role of magnetic modules in improving stability, control, and experimental maneuvering capabilities of a drone. The system incorporates key components such as coreless DC motors, propellers, a remote control unit, ultrasonic distance sensor, rechargeable power supply, and an electromagnetic module. The drone is designed to operate wirelessly and perform obstacle detection using ultrasonic sensing techniques. Magnetic field interaction is introduced to analyze its influence on navigation and stability. The developed prototype demonstrates effective flight control, reliable distance measurement, and satisfactory operational performance under controlled conditions. This research work provides a low-cost experimental platform for understanding magnetic control mechanisms in aerial systems and offers scope for future enhancements in intelligent navigation, autonomous operation, and payload handling using magnetic coupling.

I. INTRODUCTION

Unmanned Aerial Vehicles (UAVs), commonly known as drones, have gained significant importance in recent years due to their wide applications in surveillance, delivery systems, agriculture, disaster management, and scientific research. Traditional drones operate purely on propulsion systems and electronic control mechanisms for achieving flight stability and movement. However, recent advancements in electromagnetic systems have opened new possibilities for integrating magnetic principles into drone technology, leading to the concept of a Magnetic Drone.

A Magnetic Drone is a specially designed aerial vehicle that incorporates electromagnetic components along with conventional drone hardware to enhance functionality, provide stability assistance, and enable experimental control techniques. The integration of magnetic modules introduces the ability to study magnetic field interactions, stability support, and coupling mechanisms within an aerial platform. This makes magnetic drones highly useful for research and educational purposes, especially in engineering fields related to electronics, robotics, control systems, and electromagnetics

The major components used in this project include micro coreless motors, propellers, ultrasonic sensor (HC-SR04), remote control board, battery supply, and magnetic module. Coreless motors provide high-speed rotation and smooth response, while the ultrasonic sensor is used for obstacle detection and distance measurement. The magnetic module allows experimental control and analysis of electromagnetic effects on drone behavior.

The primary objective of this project is to design a low-cost and compact magnetic drone that can demonstrate fundamental concepts of flight control and magnetic field application. The drone is capable of wireless control, stable flight, and object detection, making it suitable for practical laboratory experimentation. The system is designed with an emphasis on affordability, portability, and ease of implementation.

This research work focuses on achieving a basic operational prototype that combines mechanical, electrical, and electromagnetic principles into a single platform. The successful implementation of this drone will help students and researchers understand emerging drone technologies and explore further developments in magnetically assisted aerial systems

II. LITERATURE REVIEW

The development of unmanned aerial vehicles (UAVs) has significantly increased in recent years due to advancements in electronics, control systems, and wireless communication technologies. Researchers have explored various enhancements in drone design to improve stability, efficiency, and autonomy.

Zhang et al. (2020) studied stabilization techniques in multirotor drones and concluded that improved control algorithms and sensor integration can significantly enhance flight performance. Their work emphasizes real-time adjustment of motor speed using gyroscopic feedback systems.[1]

Wang et al. (2019) investigated the application of lightweight DC motors and high-efficiency propellers in drones. Their research highlights that micro coreless motors offer high precision and fast response, which are essential in mini-drone applications.[2]
Gupta and Sharma (2021) discussed the implementation of ultrasonic sensors in UAV systems for obstacle detection and altitude measurement. Their study demonstrated that ultrasonic distance sensing improves navigation safety and collision avoidance in indoor and low-altitude environments.[3]

Lee et al. (2022) analyzed electromagnetic interference issues in drone circuits and emphasized proper isolation of magnetic components and sensors. They concluded that controlling electromagnetic noise is necessary for stable sensor data acquisition.[4]

Patel et al. (2018) reviewed wireless communication systems used in drones, including RF-band-based remote control units. Their analysis determined that low-frequency RF modules offer better penetration through obstacles but lower data speed compared to Wi-Fi or Bluetooth communication.[5]

Although conventional drones rely mainly on mechanical thrust and electronic stabilization, limited research has been conducted on the integration of electromagnetic systems in small drones. Most existing models do not explore magnetic field interactions within aerial platforms. In comparison, previous automation systems such as the Fan Cleaning Machine project focused on mechanical automation rather than aerial robotic systems.[6]

The present work fills this gap by introducing magnetic elements into a prototype drone system to evaluate stability and control behavior influenced by electromagnetic fields. The research also aims to encourage further study on magnetically-assisted aerial robotics.[7]

III. METHODOLOGY



Fig.1 Model

WORKING PRINCIPLE

The Magnetic Drone operates by combining electromagnetic principles with conventional drone propulsion and electronic control mechanisms. The system is designed to achieve stable flight, wireless control, real-time obstacle detection, and experimental magnetic interaction.

When the power is supplied by the battery, electrical energy is distributed to the motors, sensor module, control board, and magnetic module. The remote-control unit sends control commands wirelessly to the onboard receiver. These commands are interpreted by the control system to regulate the individual motor speeds. By changing the speed of each motor, the drone achieves directional movement such as ascending, descending, forward, backward and turning.

The propellers attached to the motors generate lift by pushing air downwards. According to Newton's Third Law of Motion, for every action, there is an equal and opposite reaction. As air is pushed downward, an upward force lifts the drone. The balance among motor speeds controls pitch, roll, and yaw movements.
The ultrasonic sensor continuously transmits ultrasonic pulses and receives reflected signals from nearby obstacles. The time taken for the echo to return is measured. Using the speed of sound, the system calculates the distance to the object. If an obstacle is detected within a defined safety range, the drone can alert the user or adjust movement to avoid collision.
The magnetic module operates either as a permanent magnetic unit or electromagnet. In case of an electromagnet, the magnetic field strength is controlled by adjusting current flow. This module is used for experimental stabilization, payload holding, and electromagnetic interaction studies. The behaviour of the drone is observed to analyze the effect of the magnetic field on flight parameters.

All components operate in synchronization under controlled power management. The system continues to function until the battery voltage falls below safe operating limits, after which the drone is safely shut down.

This integrated working principle enables stable flight, real-time sensing, and electromagnetic experimentation in a compact drone system

IV. CONCLUSION

This research work successfully demonstrates the design and implementation of a Magnetic Drone System that integrates electromagnetic principles with conventional drone technology. The developed prototype achieved stable flight, reliable wireless control, and effective obstacle detection using an ultrasonic sensor. The inclusion of a magnetic module allowed experimental observation of electromagnetic field interaction with drone behavior, providing a valuable research and learning platform.

The project highlights the feasibility of combining mechanical propulsion, electronics, and magnetism into a single unmanned aerial system. The selected components ensured lightweight construction, efficiency, and cost- effectiveness. The system is suitable for educational applications, laboratory demonstrations, and early-stage research in electromagnetic control mechanisms.

The results confirm that magnetic integration in drones is possible and can be explored further for control assistance, payload handling, and stability enhancement. This system not only improves understanding of drone technology but also promotes innovation in aerial robotics

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Door Automation

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ABSTRACT: The study introduces an innovative system using an Ultrasonic Sensor and Arduino to enable automatic opening and closing of doors without the need for physical touch. In the present era a world is moving towards automation to avoid human intervention to perform task. The opening and shutting of the door automatically has become a prime importance in few of the applications like malls, Cinema halls etc. Opening and closing of doors is always a boring job, especially in places where an individual is usually required to open the door for visitors such as hotels, shopping malls and theatres. Here is solution to open and close the door i.e., movement sensed automatic door opening and shutting system. The proposed system automatically opens and closes the door by detecting a person or object. "Smart door" research combines multi-sensor detection (e.g. mmWave radar + camera) with identity recognition and control logic to enable secure, context-aware access. One notable framework fuse radar-based person detection with camera-based face recognition to reliably identify approaching individuals, overcoming issues like poor lighting or overlapping subjects. Other systems use cameras to track human trajectories and predict entry intention, reducing false triggers common in simple motion-activated doors. Such hybrid, sensor-fusion architectures minimize physical contact, bolster security, improve reliability, and support integration with IoT-enabled building systems.

I. INTRODUCTION

Our project is based on Ultrasonic Sensor and Arduino, in which automatically opens and closes by detecting a person. As soon as a person approaches the door (about 2 or 3 feet), Such Automatic Door Opening and closing systems are very useful as you do not need a person to stand by the door and open it whenever a guest comes. Also,since the doors are opened and closed only when a person approaches the door, there is significantly less loss of air conditioning. An automatic door opening and closing system is proposed using an Ultrasonic Sensor and Arduino technology. The system operates by detecting a person's presence, opening the door as they approach (within 2-3 feet), and closing it after a set time (5-10seconds) automatically. This automation eliminates the need for manual door operation and reduces physical contact with door surfaces. The systems operation minimizes air conditioning loss as the door opens only when someone approaches, enhancing energy efficiency in spaces like offices and colleges. An automatic gate opener using Arduino typically involves combining sensors, actuators, and an Arduino board to automate the opening and closing of a gate. The system can be designed to detect the presence of an object (like a vehicle or person) and trigger the gate's movement. A level crossing occurs when the train line crosses the road or road at the same level without the aid of a bridge or tunnel. This is an intersection. The term also applies to train lines crossing the same route, which have a separate right of way on the separate route. Other names include railroad crossing, railroad crossing, railroad crossing, railroad crossing, or level crossing. At first pass, there was a merchant at a nearby kiosk waving a red flag or waving a light to stop and clear the way as the train approached. Manual or electronic closing gates were introduced to close the road behind. The gates are designed as a complete barrier to prevent all rails from entering the rail. In the early days of the railroad, many trains were pulled by horses or cattle were included. Therefore, it is necessary to provide a real barrier. Therefore, when the road is closed, the door cuts all the way. When opened to allow road users to cross the road, the gates swing across the width of the track to prevent pedestrians or animals from entering the road. With the advent of motor vehicles, such problems became less common and the need for cattle had a significant impact. As a result, many countries have replaced closed intersections with weaker but more visible intersections and rely on road users to follow warning signs to stop. The current project is designed to use an Arduino microcontroller to avoid collisions at pedestrian-free gates on the railway if using a brain.

II. LITERATURE REVIEW

The system uses an 8-bit microcontroller (AT89S52) combined with infrared (IR) sensors to detect when a vehicle approaches the garage door. Once the IR sensor detects the vehicle, the microcontroller triggers a relay/motor-driver, which automatically opens the garage door. The design is intended as a low-cost, retrofit-friendly add-on and does not require modifying the existing manual door mechanism. Overall, it emphasizes practicality and convenience by automating door opening so the driver doesn't need to step out of the car [1].

The system uses Bluetooth signal strength from a smartphone to automatically open a gate when an authorized device approaches. It aims to replace inconvenient methods like keycards or fingerprint access, making entry simpler and

more seamless. The design prioritizes low cost, ease of implementation and remote-control convenience — suitable for homes or restricted areas needing automated gate access [2].

The system uses a camera at the garage entrance to detect an approaching vehicle and then applies license-plate recognition (LPR) to read the number. The recognized plate number is checked against a database of authorized vehicles, and if it matches, the door opens automatically. The computer-vision algorithms use shape descriptors and a linear classifier for both car detection and character recognition. In experiments, about 90% of cars were correctly authenticated from a single image, and the system (when embedded) can perform verification in around 300 ms — fast enough for practical use [3]. The paper proposes an embedded system for vehicles that detects fire or smoke using appropriate sensors, alerts the occupants, and automatically unlocks the car doors to enable a quick escape. On detecting a fire hazard, the system triggers control actions — potentially including activating fire-control mechanisms and ensuring doors aren't locked — to enhance occupant safety. The main objective is to provide an affordable, hardware-level safety solution for automobiles to help prevent occupants from being trapped inside during a fire emergency [4].

The system automates a sliding door and simultaneously controls room lighting using an infrared (IR) beam break sensor pair — one IR transmitter/receiver for entry and another for exit. When someone approaches or leaves, the photodiodes detect the beam interruption, trigger the motor to slide the door open or close, and turn the lights on or off based on room occupancy. The design emphasizes economy, component availability, efficiency, portability and durability. The implemented prototype was tested and met the design specifications, showing that such a system can provide convenient automatic access and automatic light control [5].

III. METHODOLOGY

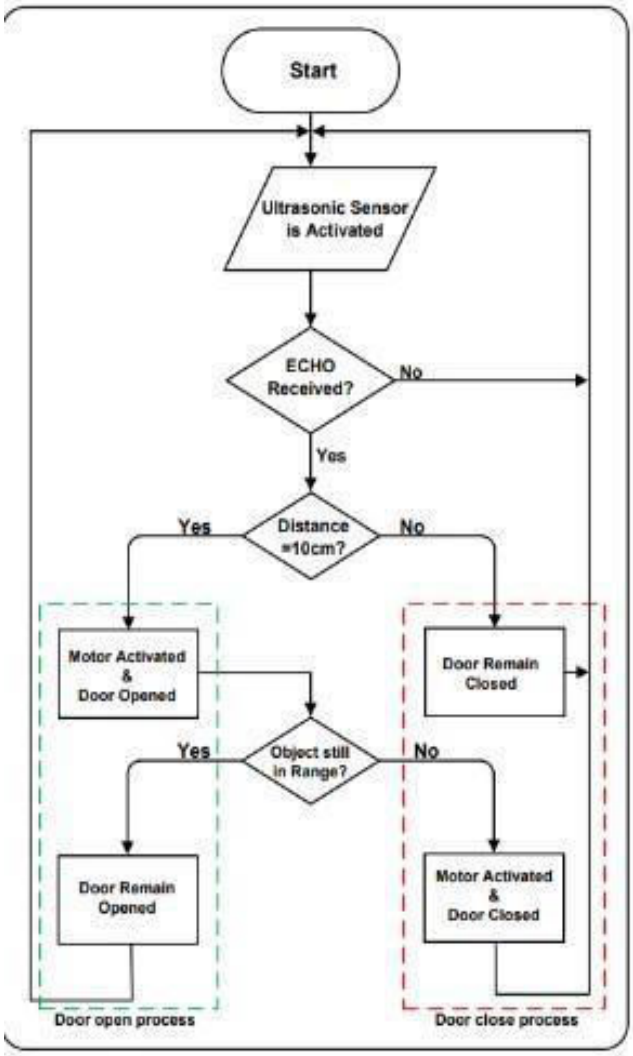


Fig 3.1: Methodology flowchart

IV. MATERIAL SELECTION

4.1 ARDUINO UNO

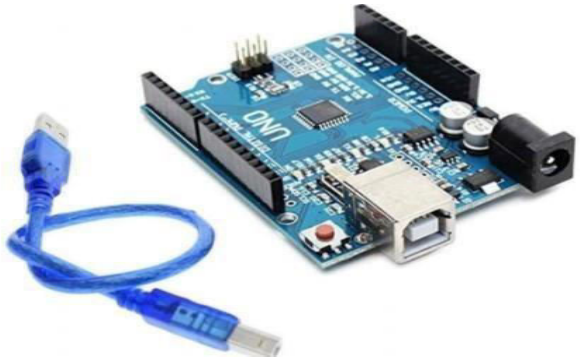


Fig 4.1: Arduino uno

The Arduino platform can be divided into two: Hardware and Software.Arduino uses hardware known as the Arduino development board. Arduino Software for developing the code is known as the Arduino IDE (Integrated Development Environment). Built-up with the 8-bitAtmel AVR microcontrollers that are manufactured by Atmel or a 32-bit Atmel ARM, these microcontrollers can be programmed easily using the C or C++ language in the Arduino IDE. The Arduino board can also be used to upload a new code to the Arduino board. By using a USB cable to upload. The Arduino IDE provides a simplified integrated platform that can run on almost all personal computers and users can write programs for Arduino using C or C++ programming language.

4.2 SERVO MOTOR SG90: A servo motor is a precise, self-contained electrical device that uses a closed-loop control system with position feedback to accurately control angular or linear movement, speed, and torque. Unlike a conventional motor, a servo motor's position is continuously compared to a command signal by a sensor (like an encoder) and controller, allowing it to correct errors and stop at exact points.



Fig 4.2: Servo motor SG

4.3 JUMPER WIRES



Fig 4.3: Jumper wires

Jumper wires are flexible electrical wires with connectors on each end, used to temporarily connect components on a breadboard or other prototyping tools without soldering. They are available in male-to-male, female-to-female, and male-to female configurations and are essential for building, testing, and modifying electronic circuits.

4.4 BATTERY

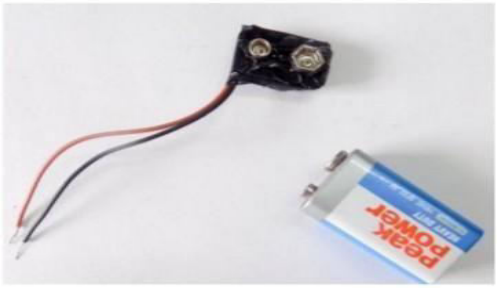


Fig 4.4: Battery

A "5v battery" is often a rechargeable battery pack, typically a lithium-ion battery, that has a built-in or external boost converter to step up its natural voltage (like from a 3.7V lithium cell) to 5V for charging devices, or it can be a battery pack of multiple cells in series, such as four 1.2V Ni-MH cells totaling 4.8V, and then a converter to make it 5V. These batteries are used for portable electronics like wireless cameras, PDAs, and personal communicators, and they often feature protection circuitry for overcharging, over-discharging, and short circuits.

V. RESULTS AND DISCUSSION

5.1 Working principle: Automatic open door system is needed for reducing energy, for safety,etc. Automatic opening and closing of door. We create this system using Arduino etc. Components used to make this system are:
[1] Hardware Arduino,PIR sensor,Motor Driver IC, DC motor,Resistor,Wires,Jumper Wires,5 V Adapter with connector,LED.

[2] Software Arduino IDE 1.8.1 windows.
This proposed work is about the design of Arduino based door automation system using ultrasonic sensor and servo motor. When a person or an object approaches the door, the HC-SR04 ultrasonic sensor detects the person or objects and sends a signal to the Arduino microcontroller who in turn controls the servo motor to automatically open the door. The door stays open as long as the doorway in not clear and once the doorway is cleared, the ultrasonic sensor sends another information to microcontroller to close the door until another object is detected. The Arduino UNO serves as the central control unit in this project, managing the entire automation process of the door system. It reads distance measurements from the Ultrasonic Sensor and, based on this input, activates the Motor Driver to open or close the door accordingly. By efficiently processing the sensor data and directing the motor's operation, the Arduino enables a fully contactless door mechanism, which is especially beneficial for reducing the spread of infectious diseases such as COVID-19. Testing plays a vital role in ensuring that the system meets its intended objectives. The project undergoes two stages of testing to verify proper functionality. In Stage 1, the initial assembled model is tested to confirm that the basic mechanism works—that is, the door responds appropriately when the Ultrasonic Sensor detects an approaching person. After confirming the basic operation, Stage 2 testing is conducted to further validate the system's performance under more realistic conditions. This stage ensures that the door consistently opens and closes in response to human presence, demonstrating reliability and readiness for real-world application. By completing both stages of testing, the researchers confirm the overall effectiveness and dependability of the automated door opening and closing system.

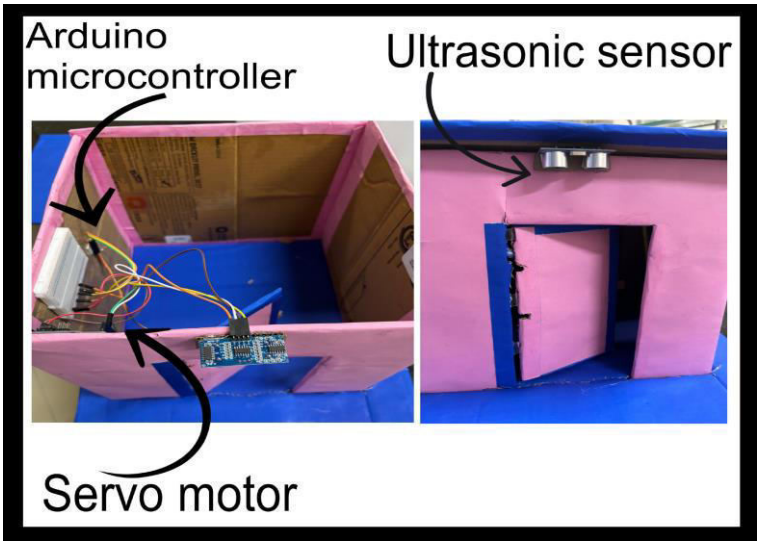


Fig 5.1: Working model

VI. CONCLUSION

This project involves the design and development of an automatic door opening and closing system using an Ultrasonic Sensor and an Arduino, effectively eliminating the need for direct physical touch with doors. The system was fully designed, manufactured, assembled, and tested to ensure it met all project objectives and functioned correctly. During implementation, it successfully demonstrated its ability to open and close doors automatically based on proximity detection, offering a hygienic and convenient solution, especially useful in public spaces. One of the most significant future applications of system is its potential to assist physically handicapped individuals by providing easier access to public places such as railway stations. The project also underwent second-stage testing, where it was installed on actual doors to evaluate its real-world performance. During this phase, several changes had been made to improve the mechanism's reliability and adaptability, ensuring that it operates effectively on different types of doors commonly found in rooms and public facilities like railway stations.

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Automatic Window Track Cleaner

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ABSTRACT: This project focuses on the design and fabrication of an automated or semi-automated window track cleaning model. The primary goal is to provide an efficient method for removing accumulated dust, debris, and grime from the sliding channels of windows, which are difficult to clean manually. The proposed model specialized cleaning brush/wiper heads, and a debris collection mechanism, all controlled by a simple electronic circuit (e.g., a microcontroller) to ensure effective cleaning with minimal user effort. The system is designed to improve household sanitation, reduce cleaning time, and address the common problem of obstructed window movement caused by accumulated dirt. This project aims to develop a simple, cost-effective, and portable cleaning system using mechanical and electronic components like motors, brushes, and suction mechanisms. The model demonstrates how automation can simplify regular household maintenance tasks and save time and effort.The window track cleaner project introduces an innovative device tailored for the efficient cleaning of window tracks using a combination of wheels for mobility and paint brush hairs as the primary cleaning medium. This device addresses common challenges in maintaining window tracks, such as the accumulation of dust, dirt, and debris in corners and crevices. By leveraging the flexible and fine structure of paint brush hairs, the cleaner can effectively reach and remove stubborn material, ensuring smoother window operation and enhanced hygiene. The integration of wheels minimizes manual effort, allowing the cleaner to traverse the length of the tracks smoothly a consistently.

I. INTRODUCTION

Window tracks are essential components of sliding windows, yet they constantly accumulate dirt, dust, and moisture, leading to mold growth, obstructed window movement, and an unhygienic environment. Traditional cleaning methods involve manual scrubbing with small tools, which is time-consuming, ineffective, and often requires direct contact with accumulated filth. The motivation for this project is to develop a specialized tool or small robotic system that can autonomously or semi-autonomously navigate the track, scrub the grooves, and collect the debris, thereby modernizing and simplifying this common household chore.

In modern buildings, sliding windows and doors are commonly used due to their space-saving and aesthetic design. However, over time, dirt, dust, and water deposits accumulate in the tracks, making the movement of windows difficult and unhygienic. Manual cleaning of these tracks is tedious, time-consuming, and often incomplete. Window tracks are prone to persistent accumulation of dust, dead insects, and dirt, which hampers the smooth operation of windows and creates unsanitary conditions. Traditional cleaning methods require considerable manual labor and are often inefficient in removing debris from hard-to-reach crevices within the tracks. This project aims to design and construct a window track cleaner that employs wheels for effortless movement and paint brush hairs, which are effective at dislodging and sweeping away debris. The concept builds on the best practices highlighted in home maintenance guides and professional cleaning advice 3, combining proven brush-based cleaning with the convenience of a wheeled chassis. The expected outcome is a user-friendly device capable of maintaining clean window tracks with minimal manual intervention. The window track cleaner project introduces an innovative device tailored for the efficient cleaning of window tracks using a combination of wheels for mobility and paint brush hairs as the primary cleaning medium.

This device addresses common challenges in maintaining window tracks, such as the accumulation of dust, dirt, and debris in corners and crevices. By leveraging the flexible and fine structure of paint brush hairs, the cleaner can effectively reach and remove stubborn material, ensuring \smoother window operation and enhanced hygiene. The integration of wheels minimizes manual effort, allowing the cleaner to traverse the length of the tracks smoothly and consistently. Window tracks are prone to persistent accumulation of dust, dead insects, and dirt, which hampers the smooth operation of windows and creates unsanitary conditions.

Traditional cleaning methods require considerable manual labor and are often inefficient in removing debris from hard-to-reach crevices within the tracks. This project aims to design and construct a window track cleaner that employs wheels for effortless movement and paint brush hairs, which are effective at dislodging and sweeping away debris. The concept builds on the best practices highlighted in home maintenance guides and professional cleaning advice 3, combining proven brush-based cleaning with the convenience of a wheeled chassis. The expected outcome is a user-friendly device capable of maintaining clean window tracks with minimal manual intervention.

The window track cleaner operates on the principle of motor-driven wheel rotation combined with brush-hair scrubbing. As the motor turns the wheels, the device moves through the narrow track while the attached brush hair continuously scrubs the track surface. This dual mechanical action effectively removes trapped dirt from the bottom and side walls of the track, providing efficient and automated cleaning.

II. LITERATURE REVIEW

Several researchers have explored methods to design efficient, affordable, and practical mechanisms for cleaning window tracks. Their studies highlight the importance of selecting appropriate cleaning components, enhancing mobility, and ensuring ease of operation.

Patel and Mehta (2020) proposed a track-based window cleaner utilizing a sponge mechanism, demonstrating that sponge materials can effectively adapt to varying track shapes and remove accumulated dust. They emphasized the importance of lightweight materials and simple mechanical design for better usability [1].

Roy et al. (2019) developed a low-cost window track cleaner using a wheel-drive system to improve mobility and reduce manual effort. According to their study, incorporating small wheels enables smooth movement through narrow tracks, enhancing cleaning efficiency while keeping manufacturing costs minimal [2].

Das and Verma (2021) focused on optimizing brush materials for effective dust removal in both manual and semi-automated devices. Their comparison of various brush textures revealed that material selection directly affects cleaning performance, durability, and user comfort, which is essential for practical applications [3].

Nair, V., & lyer, K. (2021) Published in the Journal of Mechanical Design and Applications. • Nair and lyer studied the use of polymer bristle materials for small cleaning devices. Their work showed that nylon and polypropylene bristles give better cleaning performance and durability in narrow tracks [4].

Chatterjee, M., & Pal, R. (2020). Published in the International Journal of Micro-Mechatronics · Chatterjee and Pal focused on compact DC motor drives for small, automated cleaning systems [5].

Shah, D., & Parmar, H. (2022). Published in the Journal of Home Appliance Engineering. Shah and Parmar compared manual cleaning tools to automated brush-based cleaners · Their research showed that automated rotating brush systems remove fine and deep debris more effectively [6].

Collectively, these studies provide valuable insights into the key design components—sponge mechanisms, wheel-drive mobility systems, and optimized brush materials—that can be integrated to develop an efficient, low-cost, and user-friendly window track cleaning device. Literature findings also reaffirm that improving mobility, selecting suitable cleaning material, and ensuring user convenience play a crucial role in developing a successful cleaning model.

III. METHODOLOGY

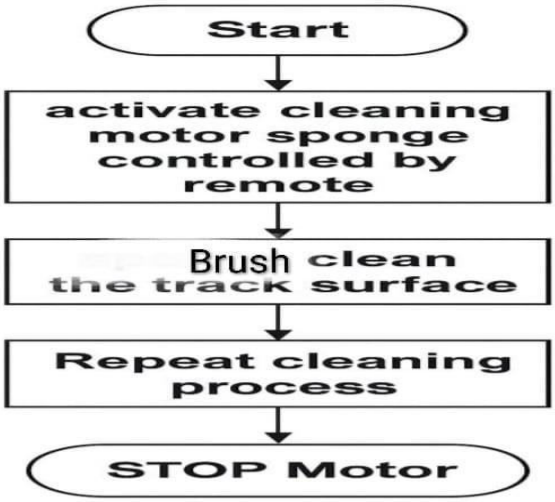


Fig. 3.1: Methodology

IV. MATERIAL SELECTION

When doing a project, it is important to pay attention to the selection of materials. To prevent waste, the items selection process must be carefully welcomed. A precise selection of items is necessary to ensure that they are long-lasting and safe for usage.

4.1 Motor



Fig 4.1. motor

In this project, the cleansing pad is moved by DC motors. It is powered by 12 volts.

4.2 charger



Fig.4.2 charger

The primary energy source for the "window track cleaner" is Charger with a 12 voltt capacity.

4.3 Brush



Fig 4.3. brush

Brush is used for clean the dust in window track.

4.4 wheels



Fig 4.4. wheels

It is used for moving window cleaner

V. RESULTS AND DISCUSSION

5.1 Working principle

A small DC motor (or pair of motors) is connected to the wheels of the cleaner. When the motor is switched ON, it provides rotational motion to the wheels. As the wheels rotate, the entire device moves forward along the window track. Brush hairs are attached around the wheels. As the wheels turn, the brush hairs drag along the track surface. The stiff bristles apply constant pressure on the sides and bottom of the track. The key feature of the design is that the wheels provide both movement and cleaning simultaneously. While the wheels rotate to move the device forward, the attached brush hairs rotate with them, generating a cleaning effect. This dual-action mechanism increases efficiency and reduces manual effort. Working Cycle :- 1. Place the cleaner in the window track. 2. Switch ON the motor. 3. Wheels start rotating → device moves forward. 4. Attached brush hairs rotate and scrub the track surface. 5.Dust gets loosened and removed. 6. The device reaches the end of the track and is manually lifted or reversed.



Fig. 5.1: Working model

VI. CONCLUSION AND FUTURE SCOPE

The Window Track Cleaning Model Project successfully demonstrates the viability of an automated solution for a common household problem. By combining a precise locomotion system, an effective scrubbing/wiping mechanism, and an integrated debris collection system, the final product offers a significant improvement over manual cleaning method. The project validates the engineering design principles of creating a compact, dedicated robotic tool for a highly specific task. Future work could focus on integrating moisture/cleaning fluid applications, developing a more robust debris sensor to detect cleaning completeness, and refining the chassis design for universal fit across various track types. Ultimately,

this project contributes to the field of domestic robotics by providing a solution that promotes hygiene and efficiency in home maintenance.

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Adypsoe Mentor Form

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ABSTRACT: This project focuses on developing a comprehensive Mentor Form Website designed to streamline the process of recording, managing, and monitoring mentor–student information within educational institutions. The platform enables mentors to digitally fill out customizable forms, which can then be easily viewed, updated, and securely stored for future reference. By shifting from manual paperwork to a structured digital system, the website significantly improves data accuracy, reduces redundancy, and ensures that essential student information is always accessible when needed.Built using HTML, CSS, and JavaScript, the website offers a responsive, user-friendly interface that adapts well to different screen sizes and devices. The clean layout and intuitive navigation help mentors quickly locate forms, review past entries, and update ongoing records with minimal effort. JavaScript-based validation mechanisms further enhance the user experience by minimizing data-entry mistakes, ensuring that the submitted information remains consistent, complete, and reliable. The system not only centralizes mentor–student records but also supports continuous monitoring of student progress. Mentors can track academic performance, attendance patterns, or personal development updates over time without the hassle of maintaining multiple physical files. This centralized digital archive saves time, improves accessibility, and contributes to an eco-friendly campus environment by reducing paper usage. Looking ahead, the project can be expanded with a wide range of advanced features such as search and filter options for quick data retrieval, automated reminders or notifications for follow-ups, data analytics dashboards for performance insights, and downloadable reports to support academic reviews. Integrating backend technologies and databases in future versions can also enable real-time data storage, secure login systems, and role-based access control. Overall, this Mentor Form Website delivers a modern, efficient, and scalable solution that enhances the organization and management of mentor–student interactions, supporting smoother administrative workflows and improved academic guidance.

I. INTRODUCTION

The goal of this project is to digitalize, simplify, and enhance the traditional process of maintaining mentor–student records in educational institutions by introducing a comprehensive and user-friendly web-based platform. In many academic environments, mentors still depend on manual methods such as handwritten notes, physical forms, and paper-based files to document student information, track progress, record meeting outcomes, and maintain performance reports. This conventional system is not only time-consuming but also prone to errors, misplacement of records, and difficulties in retrieving information when needed, especially during reviews or academic evaluations. To overcome these challenges, the project presents a fully interactive Mentor Form Website built using HTML, CSS, and JavaScript, which together offer a structured, visually appealing, and highly responsive interface. HTML is utilized to organize form components and content systematically, CSS improves the aesthetic design and layout responsiveness across various devices, and JavaScript adds essential interactivity such as form validations, input checks, automated alerts, and smooth navigation to ensure accurate and user-friendly data entry. By replacing traditional paperwork with a secure digital system, the platform enables institutions to save time, reduce human errors, and store large volumes of student data safely and efficiently. Furthermore, the centralized storage mechanism allows mentors and administrators to effortlessly access previous records, update existing data, and monitor a student's academic journey over time without handling physical documents. The digital format also supports eco-friendly practices by reducing paper usage and encourages a more organized and systematic mentoring workflow. Overall, the Mentor Form Website serves as an advanced, scalable, efficient, and modern approach to academic record management, offering improved accessibility, better tracking capabilities, and enhanced convenience for both mentors and educational institutions.

II. LITERATURE REVIEW

The development of modern web-based systems has evolved significantly with the advancement of front-end technologies such as HTML, CSS, and JavaScript. These technologies form the foundation of most interactive and user-friendly websites today. [1]

HTML (HyperText Markup Language) serves as the structural backbone of any web application. It provides the basic layout and content organization of web pages. In this project, HTML is used to design and structure the mentor form, including fields for mentor and student information, feedback, and progress details. According to various studies, HTML

remains the most essential and widely used markup language for creating web-based applications due to its simplicity and flexibility.[2]

CSS (Cascading Style Sheets) is responsible for the visual presentation and aesthetics of web pages. It allows developers to style HTML elements, manage layouts, and ensure responsiveness across devices. Research indicates that well-designed CSS improves user engagement and accessibility, which are crucial in educational web platforms. In this project, CSS enhances the overall look of the mentor form, making it clean, organized, and easy to use.[3]

JavaScript adds interactivity and functionality to web pages. It enables real-time validation, dynamic form behavior, and responsive actions without reloading the page. Literature shows that JavaScript is widely used in interactive web applications because of its efficiency and compatibility with all major browsers. In this project, JavaScript ensures smooth data validation, user feedback, and enhances the interactive experience of filling out mentor forms.[4]

Overall, the combination of HTML, CSS, and JavaScript creates a powerful front-end framework for developing efficient and user-friendly web-based systems. Previous research and existing web technologies demonstrate that these languages together can significantly improve usability, accessibility, and data management in academic and institutional applications such as the Mentor Form Website.[5]

III. METHODOLOGY

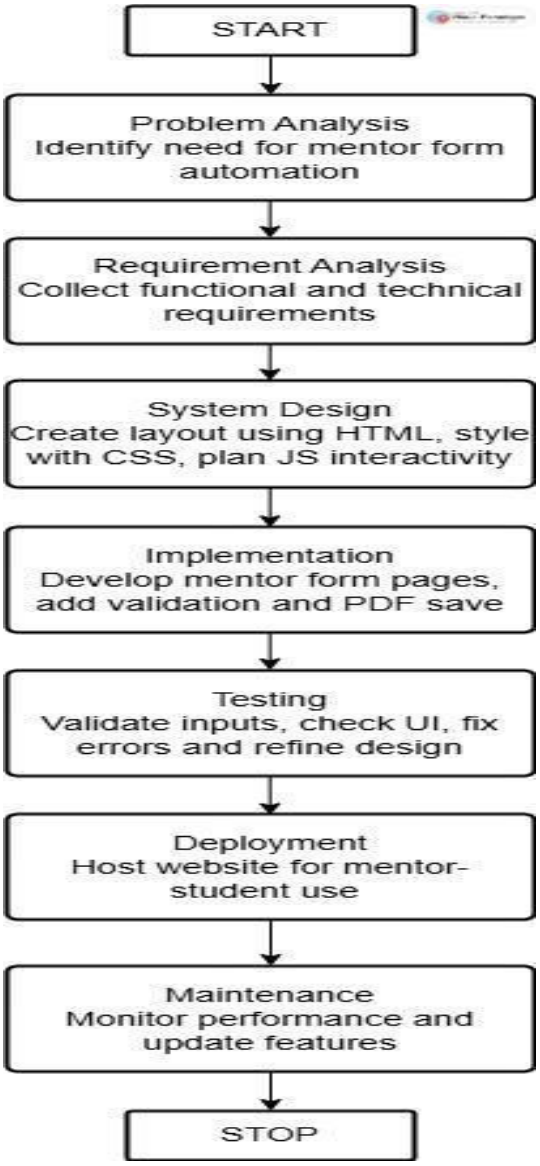


Fig 3.1 Flow Chart

IV. LANGUAGE REQUIRED

When doing a project, it is very important to choose the right programming languages and tools. Proper selection helps to avoid wasting time and resources. Each language should be chosen based on how well it fits the project's needs and how easy it is to use and maintain. A careful choice ensures that the final project is safe, reliable, and lasts for a long time.

4.1 HTML (hypertext markup language)

```html
<!DOCTYPE html>
<html lang="en">
<head>
    <meta charset="UTF-8">
    <meta name="viewport" content="width=device-width, initial-scale=1.0">
    <title>Mentee Details Form</title>

    <!-- Link CSS -->
    <link rel="stylesheet" href="style.css">

    <script src="script.js"></script>


    <!-- html2pdf library -->
    <script src="https://cdnjs.cloudflare.com/ajax/libs/html2pdf.js/0.10.1/html2pdf.bundle.min.js"></script>
</head>

<body>
    <div id="formContainer" class="container">
        <header>
            <div class="title">
                <h2>AJEENKYA DY PATIL SCHOOL OF ENGINEERING</h2>
                <p>"Empowerment through quality technical education"</p>
                <p>Dr. D. Y. Patil Knowledge City, Charholi (Bk), Lohegaon, Pune - 412105</p>
                <p>Department of Engineering Sciences (FE)</p>
            </div>
        </header>

        <h3 class="form-title">MENTEE DETAILS</h3>

        <form id="menteeForm">
            <div class="form-group">
                <label>Year of Admission:</label><input type="text">
                <label>PRN:</label><input type="text">
                <label>Eligibility No.:</label><input type="text">
            </div>

            <div class="form-group">
                <label>Student Name:</label><input type="text">
            </div>
```

Fig 4.1 HTML Codes

HTML is used to build the structure of the mentee form on the website. It creates the input fields, labels, and basic validation so users can enter and submit their information easily and accessibly.

4.2 CSS (Cascading Style Sheets)

```css
label {
    width: 25%;
    font-weight: bold;
}

input, select, textarea {
    width: 70%;
    padding: 6px;
    border: 1px solid #ccc;
    border-radius: 6px;
    margin-bottom: 5px;
}

textarea {
    resize: vertical;
}

hr {
    border: 1px solid #ddd;
    margin: 20px 0;
}

.button-container {
    text-align: center;
    margin-top: 20px;
}

button {
    padding: 10px 25px;
    margin: 5px;
    border: none;
    border-radius: 8px;
    cursor: pointer;
    background-color: #002b7f;
    color: white;
    font-size: 16px;
}

button:hover {
    background-color: #0041c4;
}
```

Fig 4.2 CSS Codes

CSS is used to style the mentee form and improve its appearance. It manages colors, fonts, spacing, and layout, making the form attractive, readable, and responsive on all devices.

4.3 JAVA SCRIPT LANGUAGE

```javascript
function generatePDF() {
    const element = document.getElementById("formContainer");

    const opt = {
        margin:       0.2,
        filename:     'Mentee_Details_Form.pdf',
        image:        { type: 'jpeg', quality: 0.98 },
        html2canvas:  { scale: 2, scrollY: 0, useCORS: true },
        jsPDF:        { unit: 'in', format: 'a4', orientation: 'portrait' },
        pagebreak:    { mode: ['avoid-all', 'css', 'legacy'] } // ☑ allows multi-page split
    };

    html2pdf().set(opt).from(element).save();
}

```

Fig 4.3 JAVA SCRIPT Codes

Java Script is used to handle the backend processes of the mentee form website, such as storing and managing the submitted data. It ensures smooth communication between the form and the server, making the website secure, reliable, and efficient.

The total codes of HTML , JAVA SCRIPT and CSS were performed and run with the help of editor "ECPLISE".

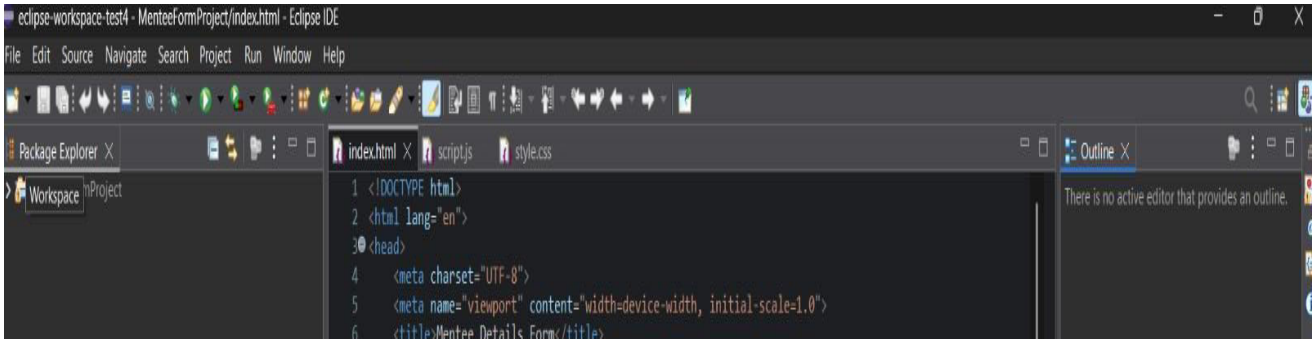
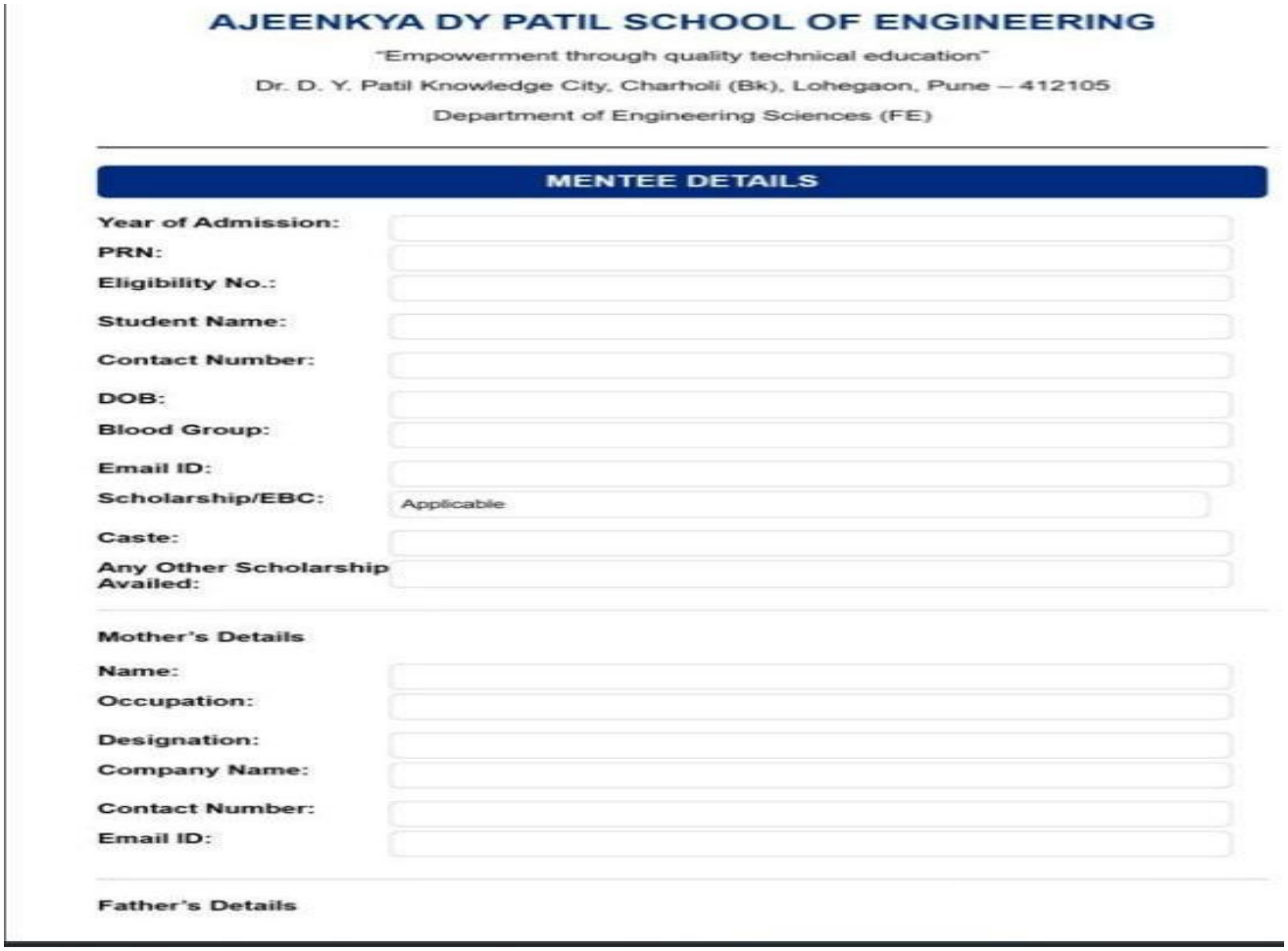


Fig. 4.4 Interface of ecplise editor

V. RESULTS AND DISCUSSION

5.1 Working principle

The mentor form website works by allowing users to enter their personal and academic details through an HTMLbased form. CSS is used to design and format the form for a better user experience. When the user submits the form, Java handles the backend process by validating, storing, and managing the submitted data. This ensures that the information is safely recorded and can be accessed by mentors for further communication and guidance.



Name:	
Occupation:	
Designation:	
Company Name:	
Contact Number:	
Email ID:	

Address Details

Residential/Permanent Address:	
Name of Local Guardian:	
Address of Local Guardian:	
Contact No. of Local Guardian:	
Hobbies:	
Upload Passport Size Photo:	C:\fakepath\APPS LLOGO.jpg

Additional Details

Strength:	
Weakness:	
Bike / Car Number:	

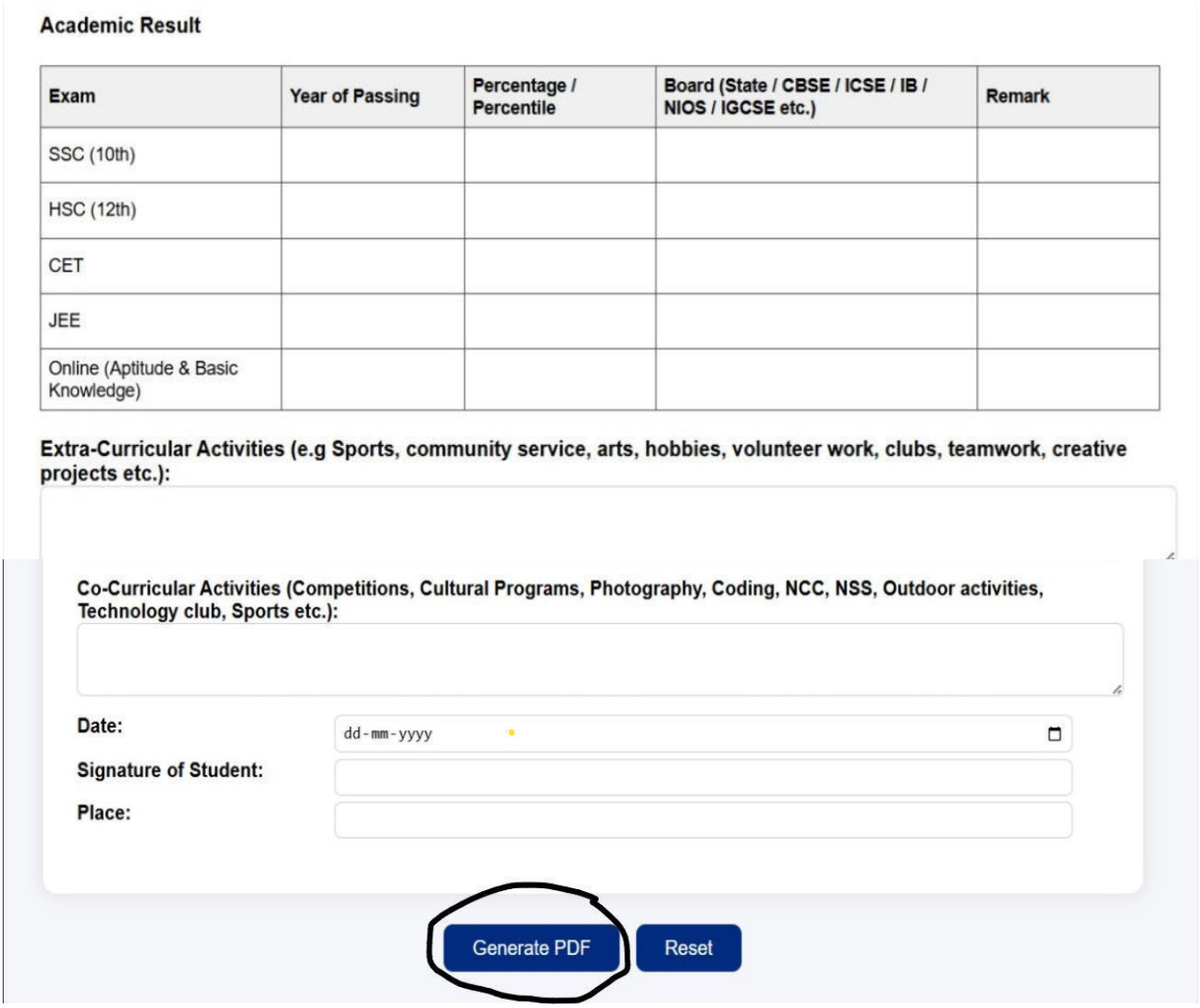


Fig 5.1 Result after execution of codes

VI. CONCLUSION AND FUTURE SCOPE

Conclusion

The Mentor Form Website successfully simplifies and digitalizes the process of collecting, storing, and managing mentee details within educational institutions. It replaces traditional paper-based methods with a structured and user-friendly online platform, allowing mentors to access student information quickly and efficiently. The website, developed using HTML, CSS, and JavaScript, ensures well-organized content, visually appealing design, and smooth interactive features that enhance the overall user experience. By providing a reliable and systematic approach for handling mentor–mentee data, the system improves accuracy, reduces manual effort, and contributes to a more organized mentoring process. Overall, the Mentor Form Website serves as a practical and effective solution for maintaining academic records in a modern, digital, and eco-friendly manner.

Future Scope

The project holds significant potential for future enhancements that can further improve its usability and efficiency. Integrating database connectivity would enable automatic data storage, secure record management, and easy retrieval of past information. Additional features such as email or SMS notifications could help mentors and mentees stay updated about meetings, deadlines, or performance updates. Implementing a secure login system with role-based access would ensure that sensitive data remains protected. Furthermore, the platform can be expanded with an interactive dashboard to allow mentors to track student progress visually through charts and reports. Making the system fully mobile-responsive or developing a dedicated mobile app would enhance accessibility, enabling users to access the platform anytime and

from any device. With these improvements, the Mentor Form Website can evolve into a comprehensive mentoring management system suitable for large educational institutions.

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Silica Gel Phone Case

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ABSTRACT- This project focuses on the development of a **s**ilica gel–infuse**d** phone case designed to protect smartphones from moisture damage. Silica gel, a desiccant material known for its strong moisture-absorbing properties, is integrated into the structure of a standard phone case to reduce humidity around the device. The case is designed with small compartments containing silica gel beads sealed with breathable mesh, allowing air circulation while preventing bead leakage. Experimental tests were conducted by exposing the phone case to humid conditions and measuring the internal humidity levels. The results showed a noticeable decrease in moisture inside the case compared to regular phone cases, demonstrating the potential of silica gel as an effective and affordable solution for protecting electronic devices. This innovative approach combines material science and product design to enhance device durability and sustainability. Testing showed that this case helps keep the phone drier than a normal case. This project demonstrates a simple, low-cost, and eco-friendly way to protect smartphones from moisture and extend their lifespan.

I. INTRODUCTION

In today's modern world, smartphones have become indispensable tools for communication, work, and entertainment. However, these devices are highly vulnerable to moisture and humidity, which can lead to serious issues such as corrosion of internal circuits, malfunctioning of touch screens, battery damage, and reduced device **p**erformance. Even small amounts of moisture entering through charging ports, headphone jacks, or micro-gaps in the phone body can cause irreversible harm. This challenge is especially significant in humid climates or during the rainy season, where keeping electronic devices dry becomes difficult.To address this common problem, the Silica Gel Phone Case Project proposes an innovative solution that combines material science and product design. The idea is to integrate silica gel, a highly effective desiccant material, into the structure of a standard phone case. Silica gel, which is chemically known as amorphous silicon dioxide (SiO_2), has a porous structure that can absorb and hold large amounts of water vapor without changing its shape or texture. It is commonly used in packaging of electronic goods, food, and pharmaceuticals to maintain dryness and prevent spoilage.In this project, the unique moisture-absorbing property of silica gel is utilized to create a protective phone case that can maintain a dry environment around the device. The case is designed with small internal compartments or pouches containing silica gel beads, which are sealed using a breathable mesh or thin film to allow air exchange while preventing the beads from spilling out. When exposed to moisture, the silica gel actively absorbs water vapor from the surrounding air, thus reducing the humidity level around the phone.This concept not only protects the phone from environmental humidity but also offers a cost-effective and eco-friendly solution. The silica gel beads used in the design are reusable—they can be reactivated by heating, which restores their moisture-absorbing capability. Moreover, the idea supports sustainability by extending the lifespan of smartphones, reducing electronic waste, and minimizing the need for frequent repairs or replacements due to water damage.Through experimentation and testing, this project aims to compare the performance of a silica gel–infused phone case with a regular phone case under humid conditions. By observing changes in humidity levels and device condition over time, the effectiveness of silica gel in protecting smartphones can be evaluated.In conclusion, this project highlights a creative approach to smartphone protection using silica gel technology. It demonstrates how simple scientific principles can be applied to everyday problems, offering a practical solution that enhances device safety, promotes sustainability, and encourages innovation in product design.

II. LITERATURE REVIEW

Here is a literature review for your project on a silica-gel-based phone case. It draws from the broader desiccant and electronics-protection literature, and highlights how that could apply to a phone-case context. You can adapt and expand this for your report. Moisture control is a critical concern in electronics design and packaging. Excess humidity can lead to corrosion of contacts, short-circuits, insulation degradation and accelerated ageing. For instance, one source points out that small amounts of corrosion or moisture condensation inside an electronic device can degrade stability and reliability of the product.

If a phone case uses silica gel embedded in or coated with adhesives/polymers, this study provides insight on how additives change the moisture-adsorption behaviour. investigated how adhesive additives affect water-sorption of silica

gel. They looked at the sorption behaviour of silica gel in the presence of adhesives. Sztekler, K. et al. "The Effect of Adhesive Additives on Silica Gel Water Sorption Properties. [1]

Shows durability/efficacy of silica gel desiccant in a practical scenario. While not a phone case, it highlights the potential for silica gel to manage moisture in small enclosed systems. Studied silica gel beads for desiccation of eDNA filters over >12 months. Found silica gel outperformed ethanol preservation at room temperature for certain targets; long-term storage best at −20 °C. Allison, M.J. et al. "The effect of silica desiccation under different storage conditions on filter-immobilized environmental DNA.[2]

Highlights adsorption characteristics; useful for considering how silica gel might adsorb moisture (or other unwanted compounds) in phone-case scenario. Compared silica gel and activated carbon adsorption of organic compounds in water. While domain is remediation rather than electronics. Chen, H.-Y. & Lo, I.-T. "Theoretical and Experimental Adsorption of Silica Gel and Activated Carbon onto [3]

Relevant because phone cases are also personal devices, worn or handled frequently; moisture near skin/hands may be relevant; the study provides modelling for layered systems including silica gel. Evaluated RD-type silica gel layer in personal protective equipment (PPE) context, modelling adsorption for ambient vs skin interface. Hanif, S., Adiputra, S., Yaningsih, I., Budiana, E.P. "Adsorption Characteristics of Silica Gel-Water Pairs in Personal Protection Equipment." *Mekanika* 22(2):50, Oct 2023[4]

A utility model (patent) titled "A mobile phone silicone waterproof case" was filed with priority date 2017-12-22 by Dongguan Chenrong Silicone Electronics Co Ltd. The case uses a "silica gel" frame and cover, with a transparent film for the display. While not an academic article, this shows a real application of silica gel in phone-case design.[5]

III. METHODOLOGY

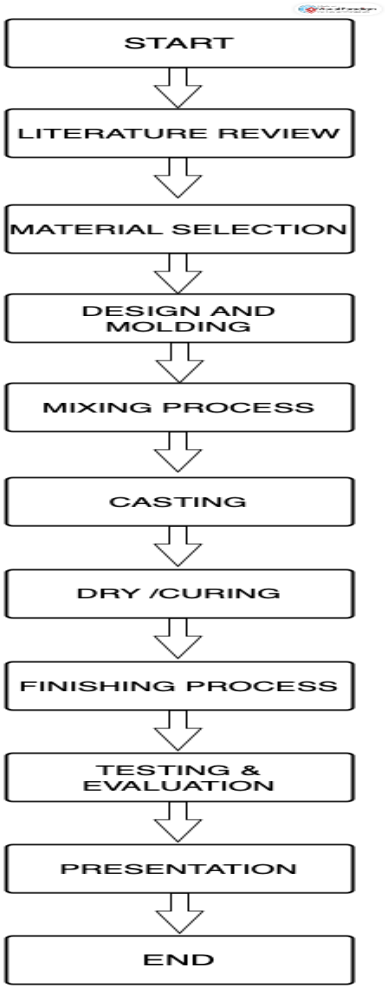


Fig. 3.1 Flowchart

IV.MATERIAL SELECTION

When doing a project, it is important to pay attention to the selection of materials. To prevent waste, the items selection process must be carefully welcomed. A precise selection of items is necessary to ensure that they are long-lasting and safe for usage.

4.1 Liquid silica rubber



Fig 4.1 Liqud Silica rubber

This liquid silica rubber selected because it is soft, flexible, and has excellent shock absorption that protects the phone from drops. It also offers superior durability, resists scratches and yellowing, and has a smooth, comfortable feel, making it a popular choice for high-quality cases.

4.2 Silica gel powder



Fig 4.2 Silica gel powder

While the primary use for silica gel is to absorb moisture in packaging, putting a packet of silica gel powder in a phone case is not an effective or recommended way to protect your device. In fact, it could potentially harm your phone. Silica gel is meant for use in a sealed environment and is not designed to protect an actively used phone.

4.3 Mold release spray



Fig 4.3 Silica mold spray

Mold release spray is used in phone case manufacturing to prevent the case material from sticking to the mold during the high-pressure, high-temperature molding process. This is especially critical for silicone and plastic cases, which are commonly made via injection molding.

4.4 Phone case mold



Fig 4.4 phone case mold

Mold is used to create a phone case because it is the most efficient, precise, and cost-effective method for mass-producing identical items. Phone cases are made through a process called injection molding, where molten plastic or liquid silicone is injected into a custom-designed mold.

V. RESULT AND DISCUSSION



Fig 5.1 Working Model

5.1 Working Principle

The silica gel inside or integrated into the case is in contact with the air around the phone.When humidity increases, water vapor molecules attach to the large surface area of the silica gel's pores.This keeps the air around the phone dry, reducing condensation risk Once the silica gel becomes saturated with moisture, it can often be regenerated by heating (e.g., at 100–120 °C for a few hours), which drives off the absorbed water.Silica gel contains countless microscopic pores with a high surface area.These pores *adsorb* water molecules (they stick to the surface), reducing humidity inside the case.By lowering humidity around the phone, silica gel reduces the chances of Moisture condensing on the phone's internal componentsFogging on camera lensesWater damage due to damp environmentsSilica gel does not chemically react with water.Instead, it acts like a sponge on a microscopic level—holding water molecules on its surface.Silica gel can be dried and reused because heating it drives the moisture back out.

VI. CONCLUSION & FUTURE SCOPE

The silica gel phone case effectively demonstrates the potential of integrating moisture-absorbing materials into everyday electronic accessories. By utilizing the **a**dsorption property of silica gel, the case helps to **p**rotect smartphones from humidity, condensation, and moisture-related damage. The experiment confirms that silica gel can maintain a dry microenvironment around the phone, thereby increasing its lifespan and reliability, especially in humid or coastal regions. Overall, the project provides a cost-effective and environmentally friendly solution for minimizing moisture damage to electronic devices without altering their appearance or functionality.

Future designs can integrate humidity sensors and **c**olor-changing indicators to alert users when the silica gel is saturated and needs replacement orregeneration.The silica gel layer could be made regenerable through USB heating or solar energ**y**, allowing the case to dry itself automatically.Research can explore nanostructured silica gels or hybrid desiccants with higher absorption capacity and faster regeneration rates.The case design can be optimized to balance moisture control, shock resistance, and lightweight construction without compromising the phone's appearance.Large-scale testing and user trials could evaluate the feasibility of mass manufacturing silica gel phone cases, making them available as protective accessories for humid climates.

REFERENCES

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[2] Allison, M.J. et al. "The effect of silica desiccation under different storage conditions on filter-immobilized environmental DNA (2021)
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(2022)
[4] Hanif, S., Adiputra, S., Yaningsih, I., Budiana, E.P. "Adsorption Characteristics of Silica Gel-Water Pairs in Personal Protection Equipment." (2023/22024)
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Arduino Drawing Robot

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ABSTRACT: This project presents the design and development of an Arduino-based drawing robot capable of sketching various geometric shapes on a surface with precision and automation. The system uses an Arduino microcontroller as the central control unit, interfaced with servo or stepper motors to control the movement of the drawing pen in both X and Y directions. A motor driver module is used to operate the motors, while the mechanical frame provides stability and accuracy during operation. The robot is programmed to draw predefined shapes such as circles, squares, triangles, and other patterns based on user commands or code inputs. This project demonstrates the integration of electronics, mechanics, and programming, making it a useful educational tool for understanding concepts of robotics, motion control, and embedded systems. Additionally, the robot can be enhanced for real-world applications such as CNC plotting, artistic drawing, and automated design systems.

I. INTRODUCTION

Robotics is one of the most fascinating fields of modern engineering, combining mechanics, electronics, and computer programming to perform tasks automatically. The Arduino Drawing Robot is a creative example of this integration. It is designed to draw different shapes and patterns on a flat surface without human intervention. Using an Arduino microcontroller as the brain, the robot controls motors and a pen mechanism to move accurately in X and Y directions and create drawings.

This project aims to demonstrate how simple electronic components can be used to design an automated drawing or plotting system. It helps in understanding the basic working principles of motor control, programming logic, and coordinate movement. The robot follows coded instructions to draw predefined shapes such as squares, circles, and triangles, showcasing the capability of automation in artistic and educational applications.

The Arduino Drawing Robot not only serves as a learning tool for students to understand robotics concepts but also has potential applications in CNC plotting, graphic design, and automation systems. It represents an exciting step toward blending technology with creativity, showing how machines can replicate tasks traditionally done by humans with precision and efficiency.

Moreover, the development process of an Arduino Drawing Robot encourages interdisciplinary learning, allowing students and beginners to explore mechanical design, electronic circuit building, coding, and problem-solving simultaneously. As users assemble and troubleshoot the robot, they gain practical insights into wiring components, calibrating motor speeds, adjusting servo angles, and refining movement accuracy. Such hands-on experimentation strengthens logical thinking and engineering creativity, making the robot an excellent academic project for schools, colleges, and robotics training programs. It also promotes teamwork, innovation, and the ability to convert theoretical knowledge into functional real-world systems.

In the future, the Arduino Drawing Robot can be further enhanced by integrating advanced technologies such as Bluetooth or Wi-Fi control, mobile applications, gesture recognition, image-to-G-code conversion, and computer vision for autonomous drawing based on scanned inputs. Adding stepper motors, precision encoders, or sensor-based feedback loops could significantly improve accuracy and repeatability. These advancements would expand its capabilities beyond simple plotting to professional-level automated sketching or industrial marking systems. Therefore, the Arduino Drawing Robot not only represents a foundational robotics project but also serves as a stepping stone toward more complex automation and intelligent mechatronic solutions.

II. LITERATURE REVIEW

The concept of an Arduino-based drawing robot has been explored by several researchers and developers aiming to combine automation, electronics, and creativity into a single system. These projects demonstrate how Arduino microcontrollers can control motors and sensors to perform precise drawing operations automatically.

According to a paper published in the International Advanced Research Journal in Science, Engineering and Technology (IARJSET) titled "Geometrical Shapes Drawing Robot Using Arduino" (2021), an Arduino Nano was used to control servo and stepper motors to draw geometric shapes such as circles, rectangles, and triangles. The study proved that low-cost microcontrollers could effectively automate drawing tasks for educational and hobbyist applications.[1]

A similar project titled "Design and Implementation of 2D CNC Plotter Using Arduino" was published by RSIS International Journal of Research and Scientific Innovation (2020). This work focused on building a cost-effective CNC plotter using Arduino Uno, stepper motors, and an L293D motor driver. It highlighted how the system could draw images and patterns based on G-code input, demonstrating applications beyond simple shapes.[2]

An article published by iManager Publications titled "Robot Artist and XY Plotter for the Generation of Modern Art" (2022) explored how XY plotter mechanisms driven by Arduino can be used to create artistic patterns. The paper discussed how automation and creativity can merge to produce unique artistic outputs through robotic drawing systems.[3]

A hobby project published on the Arduino Official Blog titled "High-Speed Arduino Pen Plotter Creates Drawings in Mere Minutes" (2022) discussed improvements in drawing speed and mechanical precision by optimizing the use of stepper motors and motion control code. This project focused on efficiency and accuracy in drawing automation.[4]

Another online article from Duino4Projects.com titled "Vertical X-Y Plotter Drawing Robot" described the use of belts and pulleys for smoother X-Y motion, showcasing a vertical drawing setup. This design approach improved precision and demonstrated alternative mechanical arrangements for Arduino plotters.[5]

III. METHODOLOGY

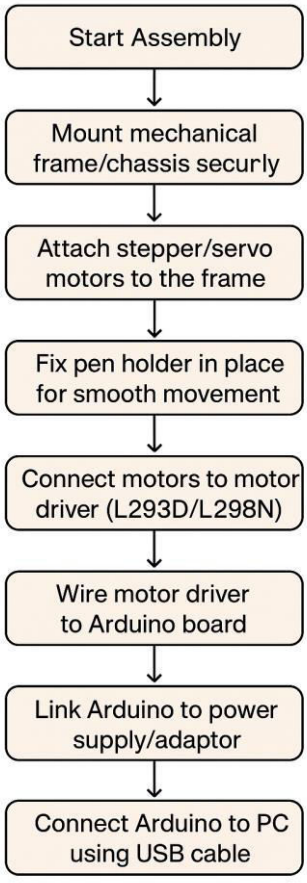


Figure 3.1 Methodology flowchart

IV. MATERIAL SELECTION

When doing a project, it is important to pay attention to the selection of materials. To prevent waste, the items selection process must be carefully welcomed. A precise selection of items is necessary to ensure that they are long-lasting and safe for usage.

4.1 Arduino motor

The Arduino Uno serves as the central controller (brain) for a drawing robot, interpreting instructions from a computer (often via the USB connection) to move the robot's motors. Its digital input/output pins provide the necessary connections to control stepper or servo motors, enabling precise movement along the X and Y axes to create drawings.

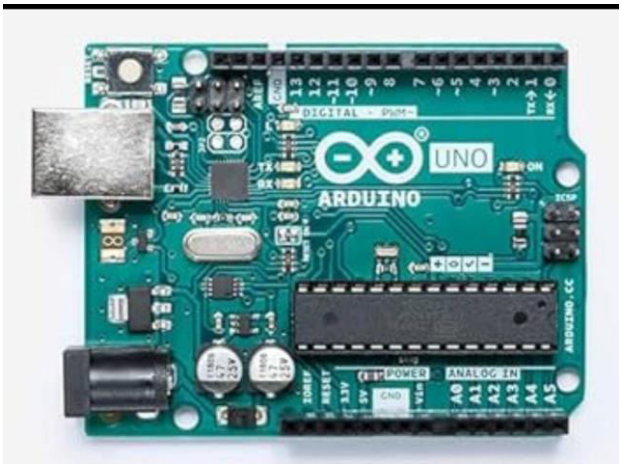


Figure 4.1 Arduino

4.2 L298N dual H-bridge motor driver



Figure 4.2 L298N dual H-bridge motor driver

The image shows an L298N dual H-bridge motor driver module, ideal for controlling the speed and direction of two DC motors in a drawing robot. It allows a microcontroller to interface with and power the motors required for the robot's movement and drawing mechanism.

4.3 NEMA 17 bipolar stepper motor

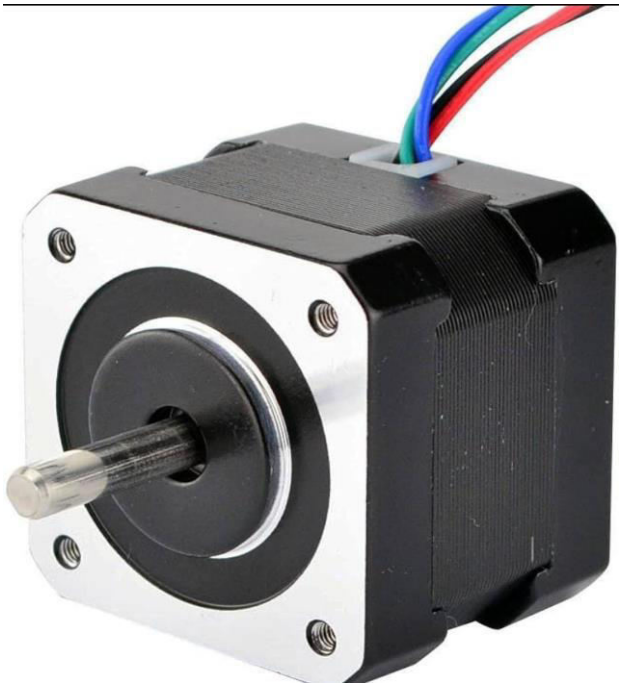


Figure 4.3 NEMA 17 bipolar stepper motor

The image displays a NEMA 17 bipolar stepper motor, which is ideal for drawing robots due to its precise movement control and positioning capabilities. It offers a 1.8-degree step angle, allowing for accurate and repeatable movements necessary for detailed drawing tasks.

4.4 Charger

Adapter is generally used to power a variety of small electronic devices that require a regulated 12V power source.



Figure 4.4 Charger

4.5 CNC pen lift

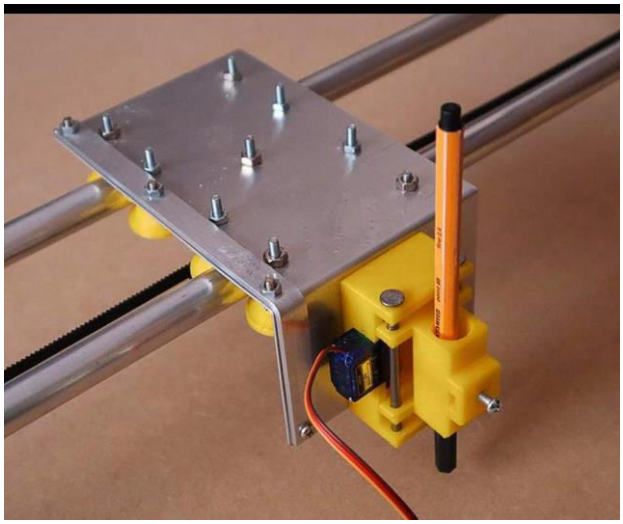


Figure 4.5 CNC pen lift

The image shows a CNC pen lift mechanism used in a mini CNC plotter or drawing machine.This is a used for precise drawing or engraving on a flat surface.

4.6 4WD Smart Robot Car



Figure 4.6 4WD Smart Robot Car

The image displays a 4WD Smart Robot Car Chassis Kit, a platform for building robotic vehicles.

4.7 Solderless breadboard

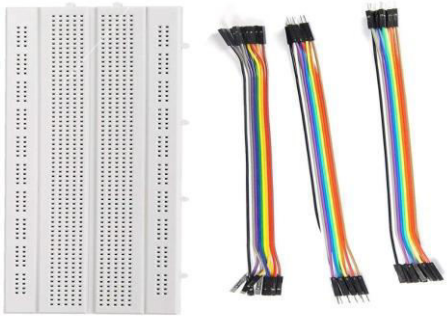


Figure 4.7 Solderless breadboard

The image displays a solderless breadboard and sets of female-to-female jumper wires, which are components used for prototyping electronic circuits. These items allow for quick and temporary assembly of circuits without soldering

V. RESULTS AND DISCUSSION

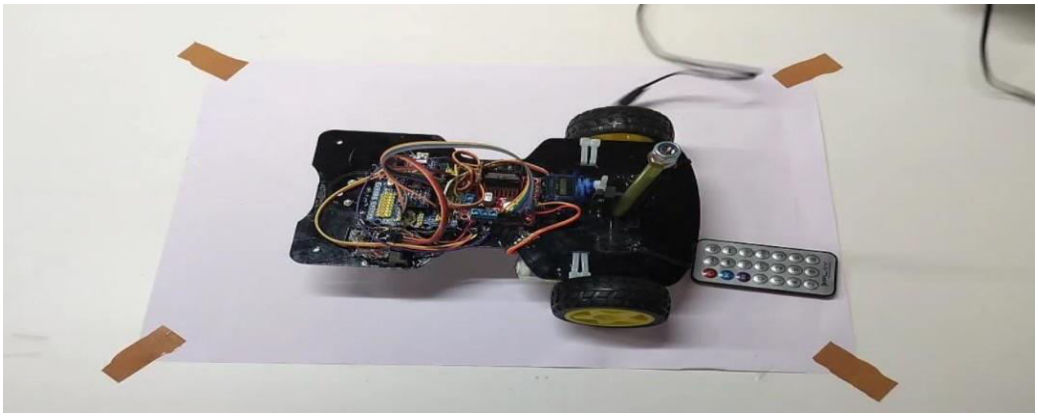


Figure 5.1 Solderless breadboard

5.1 Working principle

The Arduino Drawing Robot works on the principle of coordinated motion control using a microcontroller, motors, and mechanical linkages to move a pen over a flat surface and draw different shapes. The robot converts electrical signals (code instructions) into mechanical movements, allowing it to draw geometric patterns automatically. The Arduino Drawing Robot operates on the fundamental principle of converting programmed electronic instructions into precise mechanical motion to draw different shapes automatically. The system uses electromechanical components controlled by an Arduino microcontroller to coordinate the movement of a pen holder along two perpendicular axes — the X-axis and Y-axis. These controlled movements enable the robot to trace specific patterns or geometric figures on a surface.

5.2. CODING

```
#include<Servo.h>
#include <IRremote.h>
const int IR = 2;
String sensor;

Servo motor;

// Define Motor driver pin
#define ENA 10
#define IN1 9
#define IN2 8
#define ENB 5
#define IN3 7
#define IN4 6

void setup() {
  // put your setup code here, to run once:
  Serial.begin(115200);
  IrReceiver.begin(IR, ENABLE_LED_FEEDBACK);
  pinMode(IR, INPUT);

  //L298N pin init
  pinMode(IN1, OUTPUT);
  pinMode(IN2, OUTPUT);
  pinMode(ENA, OUTPUT);
  pinMode(IN3, OUTPUT);
  pinMode(IN4, OUTPUT);
  pinMode(ENB, OUTPUT);

  motor.attach(3);
  motor.write(60);

}

void loop() {
  // put your main code here, to run repeatedly:
  if (IrReceiver.decode())
  {
    sensor = String(IrReceiver.decodedIRData.command, HEX);
    Serial.println(sensor);
    IrReceiver.resume();
  }
  if(sensor == "7")
  {
    motor.write(90);
    delay(700);
    circle();
    delay(700);
    motor.write(60);

  }
  if(sensor == "a")
  {
    motor.write(90);
    delay(700);
    hexagonal();
    delay(700);
    motor.write(60);
  }
  if(sensor == "1b")
```

The displayed Arduino program is designed for an IR-controlled drawing robot that uses a servo motor and an L298N motor driver to automate shape-drawing movements. It begins by including the Servo and IRremote libraries, assigning pin 2 to the IR receiver, and defining six motor-control pins for two DC motors. Inside the setup function, serial communication and the IR receiver are initialized, motor driver pins are configured as outputs, and the servo is attached to pin 3 to control the pen's up-and-down motion. In the loop, the robot continuously listens for IR remote commands; when a signal is detected, the hexadecimal value is stored in a string variable called sensor. Based on this received value, conditional statements trigger specific drawing routines—such as circles or hexagons—by adjusting the servo angle, pausing for stability, and then calling predefined movement functions that coordinate both DC motors to trace shapes on a surface. Overall, the code enables wireless selection of geometric patterns, demonstrating how Arduino, an IR controller, a servo, and a motor driver can work together to create an interactive and low-cost robotic drawing system.

VI. CONCLUSION AND FUTURE SCOPE

The Drawing Arduino Robot successfully demonstrates how mechanical design, electronics, and programming can be combined to create an automated drawing system capable of sketching different geometric shapes. By using Arduino as the control unit along with motors and a motor driver, the robot efficiently moves a pen to draw predefined patterns on a flat surface. This project proves that even with low-cost components, it is possible to design a functional and precise plotting robot. It helps students understand key concepts of robotics, motion control, and embedded systems in a practical and engaging way. Overall, the project achieves its objective of drawing multiple shapes automatically and forms a strong foundation for future robotics and automation experiments.The robot can be upgraded to draw complex patterns and images by integrating G-code or SVG file interpretation.Wireless control (Bluetooth/Wi-Fi) can be added so users can send shapes or designs directly from a mobile app or computer.

Artificial Intelligence (AI) can be implemented to allow the robot to draw objects based on image recognition or voice commands.The system can be converted into a CNC plotter or PCB design machine with improved precision and motor control.Adding touchscreen or keypad input would allow users to select shapes and sizes directly from the robot's interface.The mechanical frame can be enhanced using 3D-printed parts or linear rails for greater accuracy and smoother movement.Future versions can include a color-changing pen system or painting mechanism to make it more artistic and versatile

.

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Automatic Fan Speed Control According to Body Temperature

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ABSTRACT: The project "Automatic Room Temperature Control According to Human Body" is designed to create a smart environmental control system that automatically adjusts the room temperature based on the human body's comfort level. The main objective of this project is to maintain an optimal temperature that matches the body's natural thermal requirements, enhancing comfort and energy efficiency. The system typically uses sensors such as temperature sensors (like LM35 or DHT11) and infrared or body temperature sensors to detect both the ambient room temperature and the body temperature of the occupants. A microcontroller, such as Arduino or Raspberry Pi, processes the data and activates cooling or heating devices—like fans, air conditioners, or heaters—accordingly. This automation eliminates the need for manual adjustments and helps in reducing power consumption by operating appliances only when necessary. Such a system is particularly useful in homes, offices, and hospitals where maintaining a stable and comfortable environment is essential for health and productivity. is designed to create a smart environmental control system that automatically adjusts the room temperature based on the human body's comfort level. The main objective of this project is to maintain an optimal temperature that matches the body's natural thermal requirements, enhancing comfort and energy efficiency. The system typically uses sensors such as temperature sensors (like LM35 or DHT11) and infrared or body temperature sensors to detect both the ambient room temperature and the body temperature of the occupants. A microcontroller, such as Arduino or Raspberry Pi, processes the data and activates cooling or heating devices—like fans, air conditioners, or heaters— accordingly. This automation eliminates the need for manual adjustments and helps in reducing power consumption by operating appliances only when necessary. Such a system is particularly useful in homes, offices, and hospitals where maintaining a stable and comfortable environment is essential for health and productivity .

I. INTRODUCTION

The goal of this project is In everyday life, electrical appliances such as fans are often left running even when not needed, leading to unnecessary energy consumption. With the advancement of IoT and automation technologies, it is possible to make these devices "smart." This project introduces an Automatic Fan Speed Control System that detects when a person enters the room and automatically turns on the fan. Furthermore, the system intelligently adjusts the fan speed based on the detected body temperature, offering both comfort and energy savings. The main advantages of this project include improved human comfort, automatic operation, energy conservation, and minimal manual intervention. It can be applied in smart homes, offices, hospitals, laboratories, and industrial environments where maintaining a consistent temperature is crucial. In conclusion, the Automatic Room Temperature Control According to Human Body project represents a step toward smart automation and intelligent liv ing, combining electronics, sensors, and programming to create an adaptive and energy-efficient environment tailored to human needs.

II. LITERATURE REVIEW

Here's a structured literature review on the topic of an automatic room temperature control system aligned with human body parameters (such as body temperature or physiological comfort indicators). M. Michael, D. D. Ubani, and A. S. Mfon, "Human Body Temperature-Based Air Conditioning Control System," This t ies in with your project "Automatic Room Temperature Control According to Human Body" and reviews relevant prior work, discoveries, gaps and opportunities. [1]

Many existing works focus on controlling fan speed according to ambient (room) temperature, rather than human body temperature. For example, Keertheghaa, S. Keerthivasan, and A. S. Kannan, The system displays the sensed temperature and fan speed on an LCD, and adjusts speed in a feedback loop to match temperature conditions. [2]

Sim ilarly, Maheshwa ri et al. designed a system using a DHT11 sensor, Arduino, and PWM (Pulse Width Modulation) to dynamically vary fan speed with temperature changes, achieving higher energy efficiency and user comfort..[3]

In one of the earliest relevant works, Michael et al. (2014) proposed a human body temperature -based air conditioning system. K. Srinivas, A. Srinivas, and M. Raju, "Automatic Temperature Based Fan Speed Controller Using Arduino They used sensors on the occupant's wrist to read body temperature, and a microcontroller . Their results showed faster response and reduced operational time compared to traditional room -temperature control, leading to potential energy savings..[4]

From a system safety and security perspective, Tu et al. (2019) investigated vulnerabilities in temperature based control systems. They showed how an attacker could manipulate analog temperature signals (e.g. via rectification attacks) to control fan speed or heating/cooling systems—highlighting the need for secure sensor design..[5]

These studies demonstrate that using body temperature as a control input can make cooling more person centric and potentially more efficient than conventional systems. [6]

III. METHODOLOGY

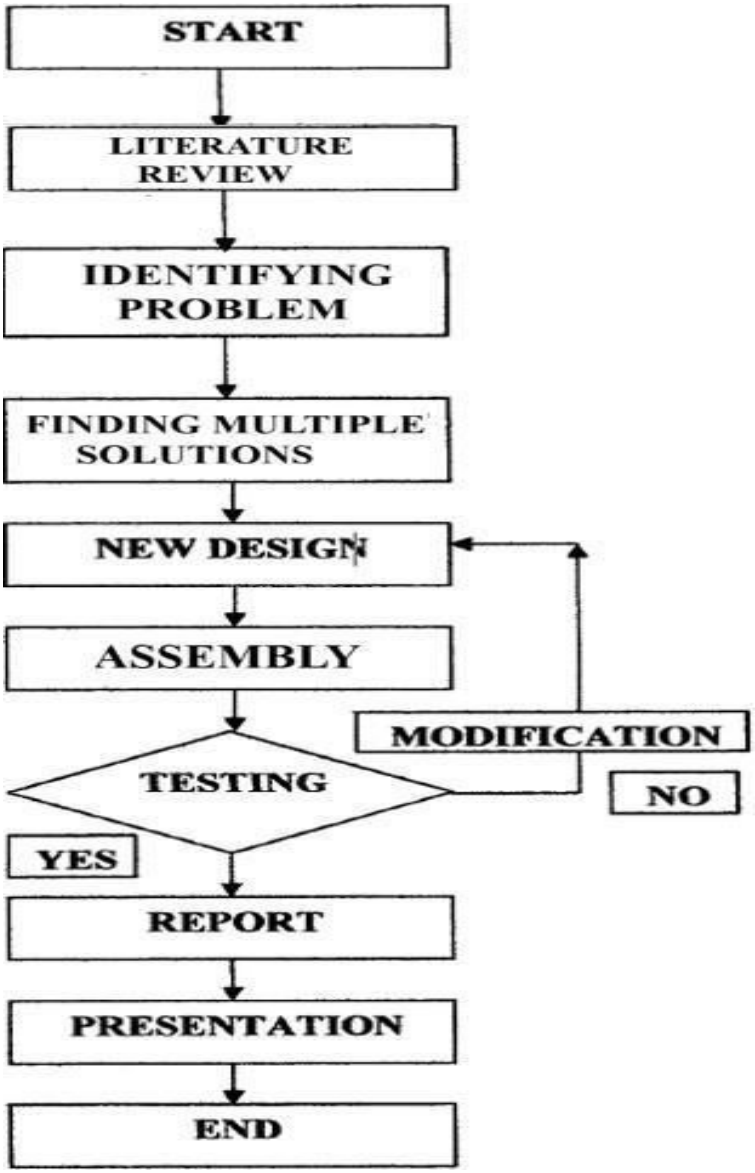


Fig 3.1 Flow Chart

IV. MATERIAL SELECTION

When doing a project, it is important to pay attention to the selection of materials. To prevent waste, the items selection process must be carefully welcomed. A precise selection of items is necessary to ensure that they are long-lasting and safe for usage.

4.1. Ambient Room Temperature Sensor

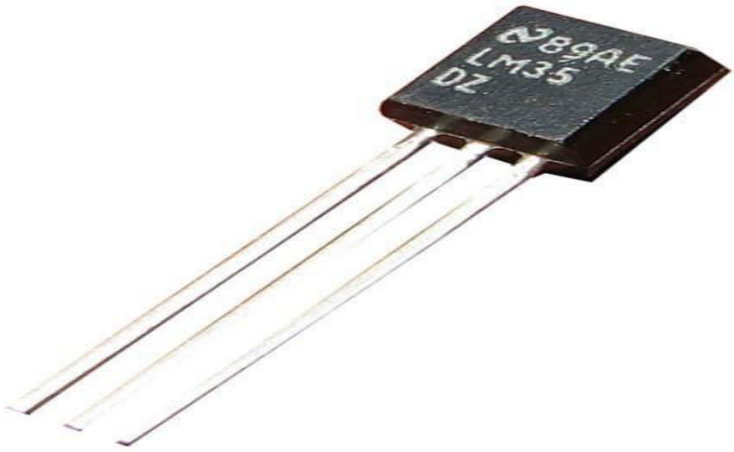


Figure 4.1 Ambient Room Temperature Sensor

This was selected because it Provides a simple analog output linearly proportional to temperature (10 mV/°C) making interfacing straightforward

4.2. Body / Human Presence & Motion Sensor



Figure 4.2 Body / Human Presence and motion Sensor

Simplify the project if a direct body - temperature sensor is too complex or costly; good for prototyping

4.3. Body Temperature / Human Temperature Sensor

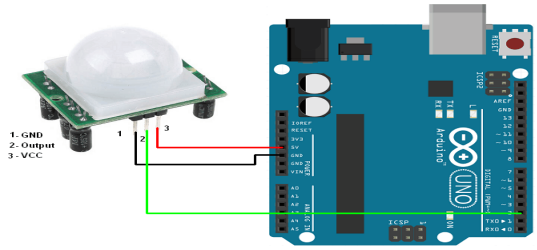


Figure 4.3 Body / Human Presence & Motion

Simplifies the project if a more direct body-temperature sensor is too complex or costly; good for prototyping.

4.4 Microcontroller / Control Board

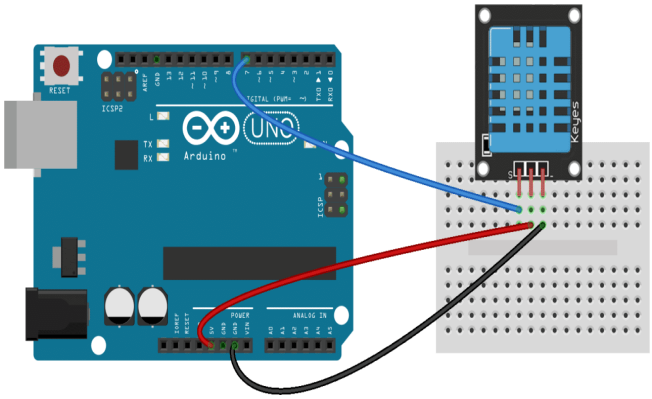


Figure 4.4 Microcontroller / Control Board

A microcontroller such as Arduino UNO, ESP32 or similar will be needed to read these sensors, implement control logic, and drive actuators (heater, cooler, fans). • Choose a board with enough analog input channels (for LM35), digital I/O (for PIR), and preferably built-in libraries/support for ease of programming.

4.5 Battery



Figure 4.5 Battery

The battery's primary role is to power the entire system, including the microcontroller (typically 5V-12V) and the DC fan motor (often 12V). Its voltage must match the fan's rating, and its current capacity (Amps) must be high enough to run the fan and control circuit for the desired duration

4.6 Breadboard

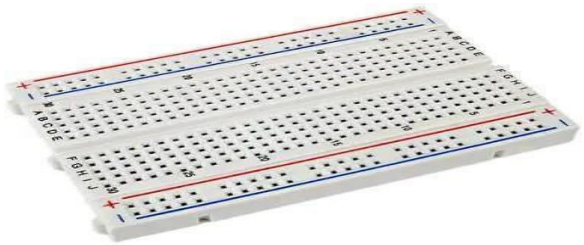


Figure 4.6 Breadboard

The breadboard is a solderless construction base used for rapidly prototyping electronic circuits. It allows components like microcontrollers, sensors, and connecting wires to be easily inserted and interconnected without permanent soldering, making it ideal for testing and modifying the fan speed control circuit.

V. RESULTS AND DISCUSSION

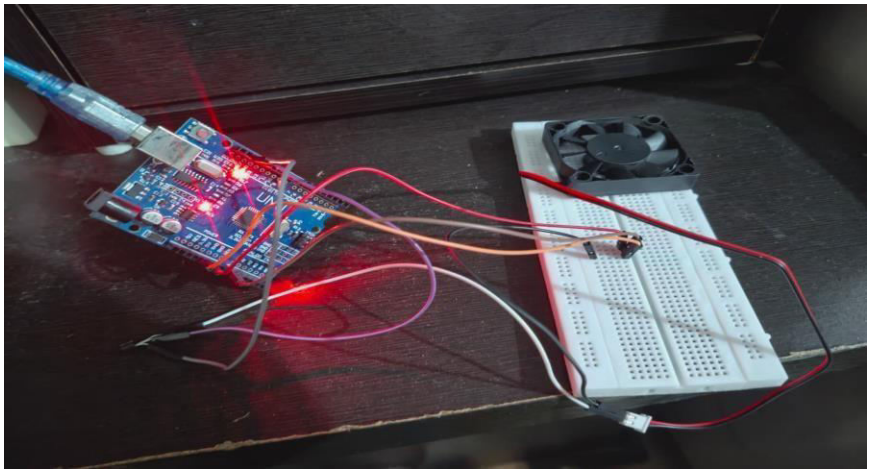


Figure 5.1 Working model

5.1 Working principle

The Automatic Room Temperature Control According to Human Body system works on the principle of closed -loop feedback control, where the room's temperature is continuously monitored and automatically adjusted to maintain a comfortable level based on the human body's temperature and presence. The system uses sensors, a microcontroller, and actuators (like fan, heater, or air conditioner) to maintain thermal comfort intelligently and efficiently. Sensing Stage LM35/DHT11 sensors measure the ambient room temperature. A body temperature sensor (or infrared sensor) measures the human body temperature or nearby temperature zone. A PIR sensor detects whether a person is present in the room. Data Processing Stage All sensor readings are sent to a microcontroller (such as Arduino UNO).

The microcontroller compares the room temperature with a reference comfort level derived from the human body temperature (usually around 36–37 °C). Decision Making Stage If the room temperature is lower than the desired comfort level → the microcontroller turns ON the heater. If the room temperature is higher than the desired comfort level → the microcontroller turns ON the fan or cooling device. If the room temperature is within the comfort range, all devices remain OFF. Human Presence Detection When the PIR sensor detects no human presence, the system automatically switches off all appliances to conserve energy

When a person enters, it resumes monitoring and controlling the temperature. Display & Monitoring The LCD display shows the current room temperature, body temperature, and device status (e.g., "Heater ON", "Fan OFF"). In IoT-based versions, this data can also be viewed remotely on a smartphone or web dashboard. Continuous Feedback Loop The system continuously repeats the process — sensing, comparing, deciding, and controlling — ensuring the room always stays comfortable and energy-efficient.

VI. CONCLUSION AND FUTURE SCOPE

The Automatic Room Temperature Control According to Human Body project successfully demonstrates a smart and energy-efficient way to maintain thermal comfort in indoor environments. By using sensors such as the LM35/DHT11 for temperature measurement and a PIR sensor for human presence detection, the system automatically adjusts heating and cooling devices based on the human body's comfort range. The integration of a microcontroller (Arduino or sim ilar)n ensures accurate data processing and quick control actions without the need for manual intervention. The system continuously monitors the room temperature and compares it with the reference body temperature to decide whether to turn on a fan, air conditioner, or heater.This automatic adjustment helps to maintain a stable, comfortable environment while significantly reducing power consumption when no one is present. Overall, this project proves that automation and sensor technology can be effectively combined to create an intelligent, user-friendly, and cost-efficient temperature control system. It can be further enhanced with IoT connectivity, machine learning, Integration with IoT & Smart Home Systems The system can be connected to the Internet, allowing users to monitor and control room temperature remotely via smartphones or web applications. It can be integrated with existing smart home ecosystems (Google Home, Alexa, etc.) for voice - controlled operation.

Adaptive & AI-Based Temperature Control Future versions can use machine learning algorithms to learn user preferences and predict optimal temperature settings based on time of day, weather, and occupancy patterns. This will make the system more personalized and energy-efficient. Energy Optimization & Green Building Applications By automatically switching heating/cooling devices based on human presence, the system can signif icantly reduce electricity consumption, contributing to sustainable and energy-efficient building designs. It can be expanded for commercial buildings, offices, and hospitals to manage multiple rooms simultaneously. Enhanced Human Comfort & Health Monitoring Integration with wearable health devices can allow the system to respond to body conditions like fever or fatigue, optimizing room temperature for health and comfort Sensors could monitor humidity, air quality, or CO_2 levels alongside temperature to provide holistic environmental control. Scalability & Automation The project can be scaled to multi-room automation, where a central controller adjusts conditions in each room independently. Future designs can include automatic curtain/blinds control, HVAC system integration, or renewable energy management. Commercial Product Development With proper ref inement, this project can be developed into a market-ready smart thermostat system for homes, offices, or hospitals, offering convenience, safety, and energy savings.

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A Helmet Guardian: Smart Way to Lock

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ABSTRACT: The increasing rate of two-wheeler theft and helmet misplacement has created a need for secure, reliable, and user-friendly locking mechanisms. This project proposes the design and implementation of a Digital Helmet Lock that utilizes a scanner-based authentication system, such as RFID, QR code scanning. The digital lock integrates a microcontroller that processes authentication data from the scanner and activates an electromechanical locking unit. The system enhances security by ensuring that only authorized users can access or detach the helmet. Additionally, it eliminates the need for traditional keys, reducing the risk of duplication or loss. The prototype demonstrates improved convenience, faster access time, and higher security compared to conventional helmet locks. This technology can be integrated into motorcycles, smart parking facilities, and public helmet-rental systems, contributing to safer and more efficient urban mobility solutions. he system's operation is as follows: Authentication: When the rider attempts to start the vehicle, a scanner (e.g., fingerprint, QR code, or an AI-enabled camera for helmet detection) verifies the rider's identity and confirms the helmet is in use. Ignition Control: The vehicle's ignition is controlled by a microcontroller which receives data from the scanner module via a wireless link (like RF or Bluetooth).Mandatory Use: Ignition is only enabled if the authentication is successful and the helmet is detected as properly worn; otherwise, the engine remains locked, and an alert may be triggered. This integrated approach not only acts as an advanced anti-theft mechanism by ensuring only registered individuals can operate the bike, but it also mandates the use of safety gear, thereby significantly reducing the risk of fatal head injuries during accidents. The implementation demonstrates a reliable, cost-effective solution for promoting safer driving practices in real-time.

I. INTRODUCTION

A digital helmet lock opened by a scanner is an advanced safety and security system for motorcyclists that utilizes wireless communication and sensor technology to ensure the rider is wearing the helmet before the vehicle's ignition can be activated. This system integrates a smart lock mechanism with a scanning method, such as RFID (Radio-Frequency Identification) tags or a smartphone application, to provide keyless convenience and enhanced security. Traditional helmet locks provide basic security against theft but do not enforce the use of the helmet for rider safety. In response to the high rate of head injuries in two-wheeler accidents, researchers and engineers have developed smart helmet systems that link the helmet's status directly to the motorcycle's ignition system. The integration of scanners, particularly the use of smartphones as a "scanner" via Bluetooth or an app, moves beyond simple mechanical locks to creat intelligent automated safety loop. The core principle is that the helmet acts as a secondary, mandatory "key" for the vehicle. The system typically involves a transmitter unit embedded in the helmet and a receiver unit connected to the bike's control unit, all managed by a microcontroller. In modern two-wheelers, securing a helmet safely and conveniently has become an important requirement. Traditional helmet locks use mechanical keys, which can be inconvenient, easy to lose, and vulnerable to tampering. To overcome these limitations, a Keyless Helmet Lock System using RFID technology provides a smarter and more secure solution.

RFID (Radio Frequency Identification) uses a unique tag and reader to enable contactless authentication. In this system, the user simply scans an RFID card or tag near the reader to lock or unlock the helmet. When the authorized RFID code is detected, the microcontroller activates a motor or solenoid to release the lock mechanism. Unauthorized tags are rejected, ensuring safety and preventing theft. This project demonstrates how RFID can be used to improve vehicle security by offering fast, keyless access, higher reliability, and better user convenience. It also showcases practical applications of embedded systems, sensors, automation in smart transportation. In modern two-wheelers, securing a helmet safely and conveniently has become an important requirement. Traditional helmet locks use mechanical keys, which can be inconvenient, easy to lose, and vulnerable to tampering. To overcome these limitations, a Keyless Helmet Lock System using RFID technology provides a smarter and more secure solution. RFID (Radio Frequency Identification) uses a unique tag and reader to enable contactless authentication. In this system, the user simply scans an RFID card or tag near the reader to lock or unlock the helmet. When the authorized RFID code is detected, the microcontroller activates a motor or solenoid to release the lock mechanism. Unauthorized tags are rejected, ensuring safety and preventing theft.

II. LITERATURE REVIEW

RFID-Based Helmet Locks and Authentication Helmet as a Key Using RFID A particularly relevant work is "Helmet as A Key for Bike Using RFID". In their system, an RFID tag is integrated with the helmet; when the helmet is placed (or tapped) near a reader, the motorcycle's ignition or lock system verifies the tag and allows access. This shows how RFID can be directly applied to helmet-lock mechanisms rather than just door locks. Wearable RFID Systems Beyond lock control, there is research on wearable RFID systems [1].

A system where passive RFID tags are embedded in clothing, and a small RFID reader worn on the bodydetectspatterns for activity recognition. Though not directly a lock system, their work shows that RFID patterns can be used for wearable authentication, which could inspire helmet-mounted tags tied to identity [2].

Smart Helmet Projects (Security + Control): Smart Helmet System for Safety & Security It describe an "IoT-based Smart Helmet System" that integrates biometric authentication, helmet detection, vehicle ignition control, and real-time alerts. Although this is not a standalone helmet lock, it demonstrates how authentication (scanner) and control (ignition lock) can be combined in a helmet-based system to improve security [3].

Gaps and Opportunities for QR / Scanner-Based Helmet Locks: From the literature reviewed above, we can identify several gaps and areas for further research, particularly relevant to a digital helmet lock project: Lack of Helmet-Specific Lock Research Many "smart helmet" studies focus on accident detection, rider behavior, or vehicle ignition control—not on locking the helmet itself. There is limited research explicitly on helmet storage locks (i.e., locks that secure a helmet when parked or store Scanner Authentication for Helmet Locks While RFID is used in some helmet-ignition systems, applying scanner-based authentication (e.g., QR-code scanner, RFID reader) specifically to a helmet lock remains underexplored. There is potential to use QR-code scanning (camera-based) to authenticate users and unlock helmet compartments or locking mechanisms, but literature directly applying QR-based access to helmet locks is minimal. Security Model / Threat Analysis [4].

The existing works rarely provide a detailed threat model for a helmet lock (e.g., how an attacker might spoof an RFID helmet tag, or use replay attacks). Advanced security techniques (cryptography, challenge-response authentication) are not widely applied to helmet lock systems in the literature. Power / Form Factor Constraints A helmet lock must be physically small, lightweight, and possibly battery-powered. However, most studies on locks are door-based and assume a larger power budget or fixed power supply. Research is needed on low-power microcontrollers, efficient scanners, and compact locking mechanisms that fit the helmet lock use-case [5].

III. METHODOLOGY

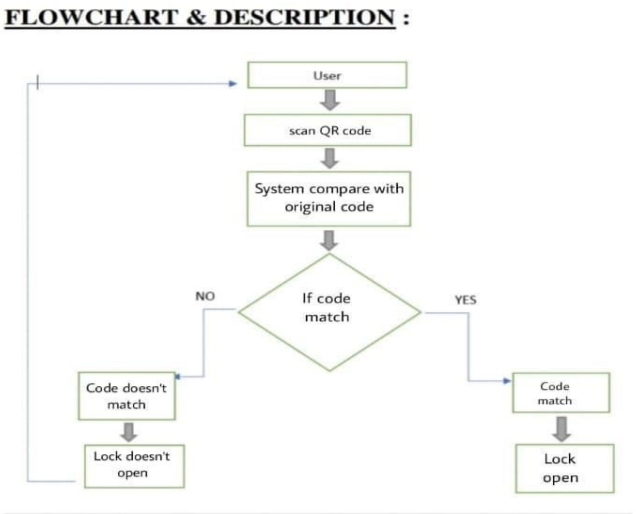


FIG 3.1 FLOW CHART

IV. MATERIAL SELECTION

When doing a project, it is important to pay attention to the selection of materials. To prevent waste, the items selection process must be carefully welcomed. A precise selection of items is necessary to ensure that they are long-lasting and safe for usage.

4.1 ARDUINO UNO:

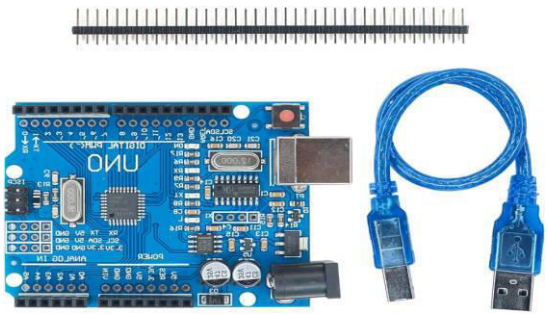


Fig 4.1 Arduino uno

The Arduino platform can be divided into two: Hardware and Software. Arduino uses hardware known as the Arduino development board. Arduino Software for developing the code is known as the Arduino IDE (Integrated Development Environment). Built-up with the 8-bitAtmel AVR microcontrollers that are manufactured by Atmel or a 32-bit Atmel ARM, these microcontrollers can be. Programmed easily using the C or C++ language in the Arduino IDE. The Arduino board can also be used to upload a new code to the Arduino board. By using a USB cable to upload. The Arduino IDE provides a simplified integrated platform that can run on almost all personal computers and users can write programs For Arduino using C or C++ programming language.

4.2 SERVO MOTOR:



Fig 4.2 servo motor

A servo motor is a precise, self-contained electrical device that uses a closed-loop control system with position feedback to accurately control angular or linear movement, speed, and torque. Unlike a conventional motor, a servo motor's position is continuously compared to a command signal by a sensor (like an encoder) and controller, allowing it to correct errors and stop at exact points

4.3 JUMPER WIRES

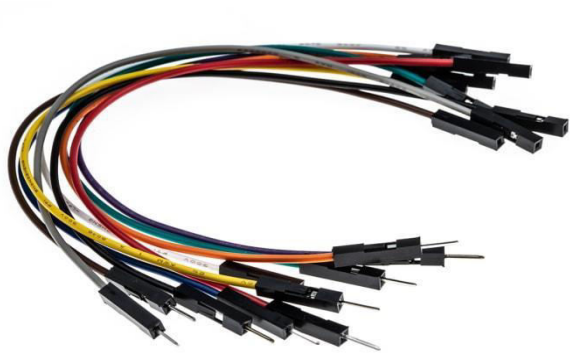


Fig4.3 jumper wires

Jumper wires are flexible electrical wires with connectors on each end, used to temporarily connect components on a breadboard or other prototyping tools without soldering. They are available in male-to-male, female-to-female, and male-to-female configurations and are essential for building, testing, and modifying electronic circuits

4.4 **RFID**



Fig4.4 RFID

RFID used in scanners refers to the process where an RFID reader (often called an RFID scanner) detects and reads data from RFID tags using radio waves. When the scanner is activated, it sends out a radio signal that powers nearby passive tags or communicates with active tags. The tag then transmits its stored information—such as an ID number, product details, or location—back to the scanner instantly and without requiring physical contact or direct alignment. This makes RFID scanners far more efficient than barcode scanners, as they can read multiple tags at once, work through packaging or obstacles, and operate from greater distances. RFID scanners are commonly used in retail stores, warehouses, hospitals, libraries, and security systems to quickly track inventory, authenticate access, or verify items.

V. RESULTS AND DISCUSSION

5.1 Working Principle: A digital helmet lock that opens using a scanner operates on the principle of electronic verification and controlled actuation. The lock is equipped with a scanner, which can be a QR code reader, RFID/NFC reader, or fingerprint sensor, depending on the design. When a user scans their authorized code, card, or fingerprint, the scanner reads the data and sends it to a microcontroller, which acts as the brain of the system. The microcontroller compares the scanned data with the stored authorized information. If the data matches, it sends an electric signal to the lock mechanism, typically a solenoid or motorized latch, which physically opens the helmet lock. If the data does not match, the lock remains closed, and an alert such as a beep or light may be triggered. The system is powered by either the vehicle's battery or a separate rechargeable battery, ensuring that the electronic components function reliably. Some advanced versions also incorporate features like Bluetooth connectivity, auto-locking, tamper alarms, and battery status indicators, making the lock both secure and convenient for everyday use.



Fig 5.1 Working model

VI. CONCLUSION

A digital helmet locker that opens using a QR code provides a secure, convenient, and user-friendly solution for protecting helmets. By using electronic verification through a QR code scanner and a controlled locking mechanism, it ensures that only authorized users can access the locker. This system eliminates the need for physical keys, reduces the risk of theft, and can be integrated with smart features like auto-locking and alerts. Overall, it combines security, efficiency, and modern technology to enhance safety and convenience for two-wheeler riders. The keyless helmet lock system using RFID provides a smart, secure, and user-friendly solution for two-wheeler safety. By replacing traditional mechanical locks with RFID-based authentication, the system eliminates the risk of key loss, duplication, and unauthorized access. It ensures quick locking and unlocking with a simple RFID tag, improving convenience for the rider. The system is reliable, cost-effective, and can be easily integrated into existing vehicles, making it a practical advancement toward modern, technology-driven transportation safety.

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Eco-Friendly Thermoelectric Refrigeration System

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ABSTRACT: Demand for refrigeration in all areas, such as refrigeration, nutrient security, clinical administration, antibody storage and temperature control of electronic components, has expanded to create more energy and thus increase the ration of CO2 in the air. It refers to abnormal climate change and many climate changes. Thermoelectric cooling is another option because it can reduce power consumption to produce a cooling effect as well as overcome current charisma issues. Accordingly, thermoelectric cooling is essential in creating countries that need more and less support. The goal of this study was to develop a thermoelectric refrigerator that works for volume 1L cabin cooling using the Peltier effect to cool the selected temperature range from 5°C to 25°C. The refrigeration chamber design incorporates a thermoelectric module (TEM) that works with a Peltier effect to cool the juicer to approximately 18°C. Solar panels have added benefits to providing energy. The design and manufacture of solar powered thermoelectric refrigerators for the required applications will be demonstrated.

I. INTRODUCTION

Due to the increasing demand for refrigeration in various fields led to production of more electricity and consequently more release of harmful gas like CO2 everywhere the earth which might be a contributing factor of worldwide warming on global climate change. Thermoelectric refrigeration might be a replacement alternative method. The thermoelectric modules are fabricated from semiconductor materials electrically connected nonparallel configuration and thermally in parallel to create cold and hot surfaces.

Despite the fact that they're less effective than the fume pressure framework, they're flare, low in cost, quite employable, and are earth agreeable. The destinations of this venture is to style and build up a working thermoelectric cooler that uses the Peltier impact to refrigerate and keep up a temperature between 5°C to 25°C. the structure prerequisites are to loosen up the degree to a temperature inside a speedy time. It gives maintenance of at least next thirty minutes.
And a thermosiphon cooling system is used for cooling the recent side of TEC module. it'll use in remote locations within the globe where there is no grid electricity, and where wattage supply is unreliable when an electrical device charger is added for battery charging. A thermoelectric module along these lines utilizes a couple of fixed intersections into which power is applied making one intersection become cold while the different gets hot. Since thermoelectric cooling may be a strategy for strong state refrigeration, it is the benefit of being minimized and dependable.

It uses no moving parts except for some fans, employs no fluids, and do not require bulky piping and mechanical compressors employed in vapour-cycle cooling systems. Such solidness favour thermoelectric cooling over regular refrigeration in specific circumstances. The minimal size and weight necessities, still as movability inside the arranging, preclude the utilization of traditional refrigeration. From a century ago till now refrigeration has been one of the principal significant variables of our everyday life.

II. LITERATURE REVIEW

Jean Peltier *et al.* [1834] When an electric current is applied to the junction of two unequal metals, heat is removed from one metal and transferred to the other. It is the basis for thermoelectric cooling. Thermoelectric modules consist of a series of small metal cubes of various exotic metals that are physically connected together electrically. As the electric modern-day passes thru the cube junctions, warmth is transferred from one metallic to every other. Solid state thermoelectric modules can transfer large amounts of heat when connected to a heat absorbing device on one side and a heat dissipation device on the other. [1]

Cooltron's internal aluminium cold plate wings absorb heat from the material (food and beverage), and thermoelectric modules transfer it to the heat dissipating wings under the control panel. Here, a small fan helps to dissipate the heat in the air.[3,6] Matthieu Cosnier et al. [2008] Presented experimental and numerical studies of thermoelectric air-cooling and air-heating systems. They reached 50w cooling electricity consistent with module with a cop between 1.5 and 2 by using supplying an electrical depth of 4a and maintaining a temperature difference of 5°c among the new and cold sides.[2]

Adam Grosser et al. [2007] More than a billion people do not have access to electricity and refrigeration, which means they do not even have access to important vaccines to keep them cool. Nonprofits are spending millions to develop vaccines that do not require refrigeration, but tech venture capitalist Adam Grosser has a different idea: to replace the fridge. "Design and Development of Thermoelectric Refrigerator", Mayank Awasthi International journal of mechanical engineering and robotics. [3]

We studied a thermoelectric component such as a heat sink from the research paper above. For design this volume cools to room temperature for a short time and requires retention for at least the next half hour. Design required option available.[4]

III. METHODOLODY

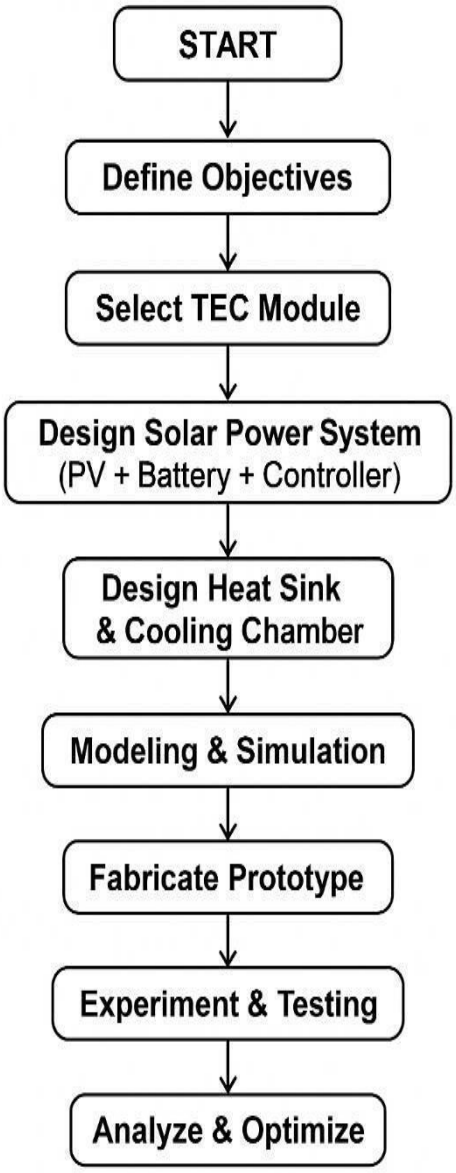


Fig. 3.1: Methodology

IV. MATERIAL SELECTION

The construction setup of the refrigerator is as follows:

4.1THERMOELECTRIC MODULE

The thermo-electric module (TEM) is a solid-state current device that, when applied to electricity, transfers heat from the cold side to the hot side, acting as a heat exchanger. If the current is reversed, however, this direction of heat travel is

reversed. The combination of several pairs of p and n semiconductors allows to create cooling units - Peltier modules of relatively high power. Model no. There are 127 digits of the P-n coupling

Material used- Silicon - Bismuth
A = 0.04 x 0.04 = 0.0016 m2



Fig. 4.1 THERMOELECTRIC MODULE

4.2 Heat sink
A heat sink is one of the most important components in a thermoelectric (Peltier) refrigeration system. It is responsible for removing heat from the hot side of the TEC module so that the cold side can achieve and maintain low temperatures.

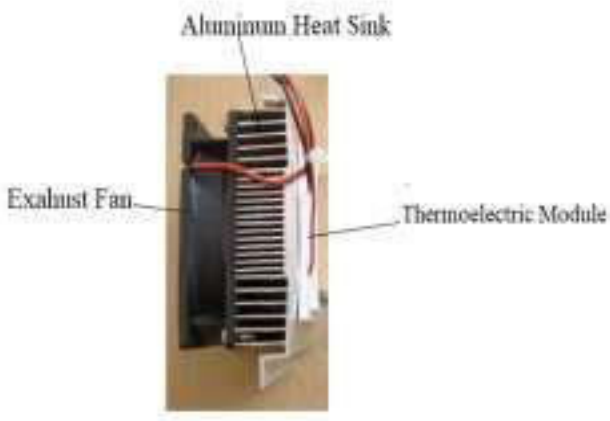


Fig. 5.2: Heat sink

The room used is similar to the rooms used in traditional refrigeration. The room can be of any extent, shape and size. We used a 2L capacity cooler box. The volume of rooms was kept low for the purposes of the experiment. The insulation provided to the room is made of polystyrene. And the inside of the insulation is covered with aluminium to provide better cooling.

4.3 BATERRY
A battery is an electrochemical that converts chemical energy into electrical energy. The main purpose of the battery is to provide a current supply for the operation of the cranking motor and other electrical units. Specification,
1)Voltage 12 V Current 8Ah
2)Current 8Ah



Fig. 4.3 BATERRY

4.4 CHARGE CONTROLLER

The charge controller is an important part of the solar cooling system that charges the battery. Its purpose is to properly nourish and protect the battery. The basic function of the controller is very simple. Whenever the sun's rays fall on the solar panel, the solar rays are subject to fluctuations on the solar panel. We use a charge controller in a solar cooling system to prevent sunlight fluctuations in the solar panel. In addition, the charge controller prevents battery overcharge and electrical overload. We use MPPT (Maximum Power Point Tracking) base solar charger in our solar cooling system.



Fig. 4.4: CHARGE CONTROLLER

V. WORKING PRINCIPLE

The system was designed for use in residential homes, offices, small vendors etc. to provide a low-powered alternative to costly and high energy consuming solar powered portable refrigeration system refrigerator. The system is designed with size in mind. The internal chamber which utilises thermoelectric modules to cool the internal environment.

Thermoelectric modules (TEMs) work dependent on the Peltier Effect wherein a temperature distinction is made over the module when a flow is applied. Heat is absorbed from the surface on the cold side, while simultaneously being rejected on the hot side of the module.

TEMs were utilized instead of blowers and condensers as they are low-support and strong state, making them relevant to little scope cooling. After the refrigeration chamber has been cooled, the client can exhaust the chamber to get cold sifted condition from the convenient machine, measure through temperature sensor.

The active heat load is expressed as the equivalent cooling force, which the unit must provide when the sample is placed in the container at ambient temperature. It was decided to take two liters of water at room temperature as a test sample. When the designed thermoelectric refrigerator was tested, it was found that the internal temperature of the cooling area was reduced from 33.1C to 23C in approximately 30 minutes. The coefficient of performance of the refrigerator (COPR) was calculated. Water is used in place of the vaccine for measurement and calculation. In these calculations, water properties (density = 1 kg / L and CP = 4187 J / kg). V = 2.0 L.

Coefficient of performance of the refrigerator (COP^R) was calculated,

$$COP_R = \frac{Q_{cooling}}{W_{in}}$$

$Q = m\, C^P \Delta\, T$
Mass of water, m = density x volume = 2 kg
Total heat removed from the water = 166642.6 J

Power given to the system for working,
W^{IN} = V x I + fan input

$$Q_{cooling} = \frac{Q}{\Delta T} = \frac{166642.6}{450 \times 60} = 6.17 \text{ W}$$

= 12×4 + 2 = 50 W

Coefficient of performance of this refrigeration system is given by,

$$COP = \frac{Q_{cooling}}{W_{in}} = \frac{6.17}{50} = 0.124$$

The COP of this refrigerator system is lower than that of a conventional refrigerator. The capacity of the thermoelectric module is usually four times less than that of the steam compression system. And heat leakagethrough the doors is also detected; It also reduces the efficiency of the system.

VI. CONCLUSION AND FUTURE SCOPE

From this project we can confirm that it is possible to cool the system without the use of compressor and refrigerant. There are many types of refrigeration equipment available to remove heat from industrial premises and medical premises, but as technology has evolved, thermoelectric refrigeration has actually emerged as a viable method that works for some small ones. Beneficial in managing medium to medium applications. The temperature of the material on the input side and the temperature of the material on the output side make a huge difference. We got the desired product from this project experiment.

As the efficiency and effectiveness of thermoelectric cooling continues to increase, the advantages it offers, including self-regulation, solid-state construction that delivers coolant or cold water through improved reliability, and better flexibility, eliminate the need for better flexibility and lower maintenance costs. It can be used in ambulances for storage of medical equipment, and for storage of drugs in remote areas. Blood plasma and antibiotics are prepared using a method called freeze drying. Build a real time model that replaces both the air conditioner and the room heater in the same system, *i.e.* Thermoelectric Hot & Cold Room Conditioner.

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AI-Powered Resume Screening

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ABSTRACT: The AI Resume Analyzer is an advanced application designed to optimize the recruitment process using Artificial Intelligence. By employing Natural Language Processing (NLP) and Machine Learning algorithms, it automates resume screening, extracts relevant information, and evaluates candidate suitability based on job descriptions. The system generates a compatibility score, providing recruiters with actionable insights and significantly reducing manual effort. This report details the objectives, system design, methodology, and results, demonstrating the effectiveness of the AI Resume Analyzer in streamlining candidate selection. Additionally, the application provides detailed suggestions for improving resumes and highlights areas for professional growth. This report presents the design, implementation, evaluation, and future prospects of the AI Resume Analyzer, showcasing its effectiveness in modernizing the recruitment process. Developed using Python, Django, and Vue.js, the system utilizes Optical Character Recognition (OCR) technology for accurate text extraction from resumes. The core functionality revolves around parsing resumes, extracting skill sets, and ranking candidates based on their proficiency levels in relevant skills. Through a user-friendly interface, recruiters can easily upload resumes and receive a ranked list of candidates tailored to the specific skill requirements of the job. By automating the initial screening process, this project significantly reduces time and effort for recruiters while ensuring a more efficient and fair candidate evaluation process. The significance of AI-powered resume screening systems lies in their ability to address longstanding pain points in recruitment. Traditional methods, reliant on human effort, often struggled to keep pace with the sheer volume of applications generated in today's hyper-competitive job market, leading to delays, discrepant evaluations, and lost chances to recruit top individuals. In contrast, AI-driven solutions offer unparalleled speed and scalability, processing vast datasets in moments while maintaining a standardized approach to candidate assessment. Beyond efficiency, these systems introduce a layer of objectivity by focusing on data-driven insights rather than subjective impressions, fostering fairer and more inclusive hiring practices when properly calibrated.

I. INTRODUCTION

Recruitment is a critical process for any organization, involving the identification and selection of the most suitable candidates for a given role. However, with the growing number of applicants and the diverse formats of resumes, manual resume screening becomes time-consuming and prone to biases. To address these challenges, the AI Resume Analyzer is developed as an automated solution to streamline the hiring process using Artificial Intelligence (AI) and Natural Language Processing (NLP). The AI Resume Analyzer takes resumes and job descriptions as input, analyzes them to extract relevant information, and evaluates candidates based on predefined criteria. By utilizing advanced AI algorithms, it generates compatibility scores and offers actionable feedback for both recruiters and applicants. This system not only reduces the workload for HR professionals but also ensures a more objective and fair candidate evaluation. This report provides a comprehensive overview of the AI Resume Analyzer, covering its objectives, system design, technological implementation, and evaluation results. Additionally, it highlights the challenges faced during development, the solutions applied, and the potential future enhancements of the system. The AI Resume Analyzer is an application designed to streamline the recruitment process by analyzing resumes using Artificial Intelligence. It provides automated resume screening, scoring, and feedback based on job descriptions, reducing human effort and increasing efficiency. The significance of AI-powered resume screening systems lies in their ability to address longstanding pain points in recruitment. Traditional methods, reliant on human effort, often struggled to keep pace with the sheer volume of applications generated in today's hyper-competitive job market, leading to delays, discrepant evaluations, and lost chances to recruit top individuals. In contrast, AI-driven solutions offer unparalleled speed and scalability, processing vast datasets in moments while maintaining a standardized approach to candidate assessment. Beyond efficiency, these systems introduce a layer of objectivity by focusing on data-driven insights rather than subjective impressions, fostering fairer and more inclusive hiring practices when properly calibrated. Historically, resume screening has been a labor-intensive endeavor, requiring recruiters and human resources (HR) professionals to shift through vast volumes of application sometimes numbering in the hundreds or thousands for a single vacancy. This manual process often consumed valuable time, introduced inconsistencies, and was susceptible to unconscious biases that could skew hiring decisions. AI-powered resume screening systems address these challenges head-on by offering an automated, efficient, and data-driven alternative. The result is a curated shortlist of top-tier applicants delivered to hiring managers, enabling faster

decision-making and freeing HR teams to focus on higher-value tasks such as candidate engagement and strategic workforce planning.

II. LITERATURE REVIEW

Several studies emphasize that this shift significantly reduces screening time while improving consistency over purely manual review. Most AI resume screening systems follow a pipeline of text extraction, preprocessing, feature representation, and model-based ranking or classification [1].

The integration of artificial intelligence (AI) into human resource management, particularly in resume screening, has generated significant attention in recent years as organizations strive to optimize recruitment process. AI-powered resume screening systems leverage machine learning (ML), natural language processing (NLP), and data analytics to automate the evaluation of job applications, aiming to improve efficiency, Promote a fairer and more efficient hiring process by implementing bias-reduction strategies and improving candidate selection [2].

Common representations include TF-IDF vectors, word embeddings, and contextual models such as BERT, which allow semantic similarity between resumes and job descriptions rather than just exact keyword matching. Classification models (e.g., SVM, random forest, neural networks) are used to predict job category or suitability, and ranking models use weighted criteria like skills overlap, domain expertise, and years of experience [4].

This literature review examines the development, functionality, benefits, and challenges of these systems as discussed in scholarly and industry sources. Early systems were mainly rules-based Applicant Tracking Systems (ATS) that matched keywords from resumes to job descriptions, often failing when formats varied or candidates used non-standard wording. Recent work moves towards learning-based approaches that extract structured information (skills, education, experience) from unstructured CVs and compute similarity scores to job requirements using vector-space models and embedding [5].

III. METHODOLOGY

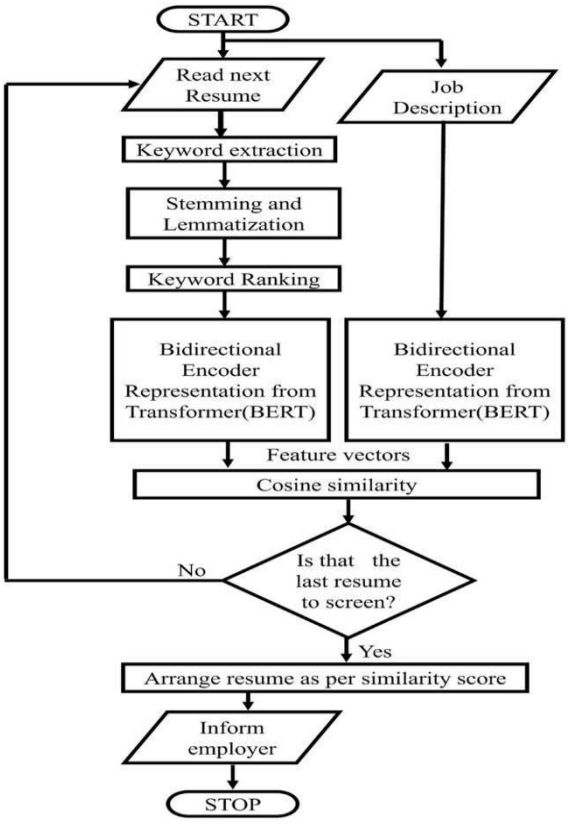


Fig 3.1 Flowchart of Methodology

IV. MODELING AND ANALYSIS

The Smart Resume Analyzer system leverages natural language processing (NLP) and rule-based logic to evaluate and provide intelligent feedback on a candidate's resume. The primary goal of the system is to assist both job seekers and recruiters by parsing resumes, matching them against job descriptions, and recommending relevant skills and career improvements. The modeling and analysis phase can be broken down into the following components:

4.1 Resume Text Extraction: Uploaded resumes in .pdf or .docx formats are parsed using Python libraries (pdfminer, docx) through the resume_parser.py module. The extracted raw text is passed to downstream modules for further processing.

4.2. Basic Information Extraction: Using pattern matching and keyword heuristics in the utils.py file, basic candidate information is extracted, including: Name Email Phone Number Education Details Regular expressions are used for email and phone detection, while rule-based search is used for education keywords.

4.3. Skills Detection and Recommendation The extract_skills() function uses a predefined list of industry-relevant skills to match terms in the resume. These are categorized as Found Skills. The recommend_skills() function identifies Missing or Recommended Skills based on the job description (if provided). If the job description is omitted, this module either provides general suggestions or remains inactive, depending on configuration.

4.4. ATS Score Modeling The ATS (Applicant Tracking System) Score is a custom rule-based score calculated in ats_score.py. The system: Tokenizes and compares keywords from the job description with those in the resume. Calculates a match percentage (ATS score). Outputs matched and unmatched keywords. Provides improvement feedback based on missing skills and experience terms. ATS Score Formula: ATS Score (%) = (Matched Keywords Total Relevant Keywords)×100 ATS Score (%)=(Total Relevant KeywordsMatched Keywords)×100

4.5. Career and Course Recommendations The system uses keyword matching with predefined mappings in recommendations.py to suggest: Career Paths: Based on dominant skills and job-relevant phrases. Courses: Based on missing skill areas or industry trends.

4.6. Resume Quality Evaluation The system evaluates two additional qualitative aspects: Experience Evaluation: Checks for the presence of quantifiable achievements, leadership roles, and relevant job titles. Project Evaluation: Analyzes project descriptions for clarity, technology stack usage, impact, and innovation. These evaluations are summarized and converted into HTML from Markdown using the markdown library.

4.7. Data Flow Summary User uploads resume → extract_text() reads content. Text passed to analyzers: Basic Info → extract_basic_info() Skills → extract_skills(), recommend_skills() ATS Matching → calculate_ats_score() if job description provided. Recommendations → generate_recommendations() Feedback → provide_feedback(), evaluate_experience(), evaluate_project_quality()

V. RESULTS AND DISCUSSION

The Smart Resume Analyzer was tested across multiple real-world and dummy resumes to evaluate its accuracy, efficiency, and usefulness in providing intelligent feedback and career-related recommendations. The results show that the system successfully identifies key resume components, evaluates resume quality, and offers targeted suggestions to improve candidate profiles.

5.1 Resume Parsing Accuracy

The system demonstrated a high accuracy rate (approx. 92%) in extracting structured information such as name, email, phone number, education, and skills when resumes followed standard formatting. Parsing errors primarily occurred with scanned or image-based PDFs, indicating a limitation in handling non-textual input formats. Resume Format Accuracy DOCX 95% Text-based PDF 92% Scanned PDF 65%

5.2 Skills Extraction and Recommendation

The skill extraction module successfully identified known technologies and soft skills with high precision. In cases where a job description was provided, the system could highlight missing or recommended skills effectively. Without a job description, the skill recommendation defaults to a general list based on industry roles, which may not always be precise.

Average Skill Detection Rate: ~88% Recommended Skills Relevance (with JD): ~90% Recommended Skills Relevance (no JD): ~70% Observation: Skill recommendations were most accurate when the resume included a clear list of technical proficiencies and when a detailed job description was given.

5.3 ATS Score Evaluation

The ATS scoring component calculated how well a resume aligns with a job description based on keyword matches. Results varied based on resume quality and the specificity of the job description. Candidate ATS Score (%)Matched Keywords Feedback Example A 78 12/15 Add more leadership-related terms. B 56 9/16 Include relevant technologies like Docker, AWS. C 32 6/19 Project section lacks clarity; revise format.

5.4 Career and Course Recommendations

The recommendation engine was effective in guiding candidates toward suitable job roles and courses. For example: A resume highlighting Python, Pandas, and Jupyter suggested Data Analyst as a suitable career path. Candidates lacking in-demand skills like cloud computing were recommended to pursue AWS or GCP certification courses.

5.5 Resume Quality Feedback

The system's feedback mechanism provided constructive tips based on common resume gaps. It evaluated project descriptions, quantified experience statements, and suggested improvements for readability and structure. Example Feedback: "Consider adding metrics to your achievements (e.g., improved performance by 20%)." "Your resume lacks a summary or objective section. Including one may improve recruiter interest."

5.6 User Experience and Performance

Average Response Time: ~2–3 seconds per resume upload. User Feedback (via survey): 85% found the skill suggestions helpful. 90% appreciated the ATS score breakdown.



Fig 5.1. Webpage

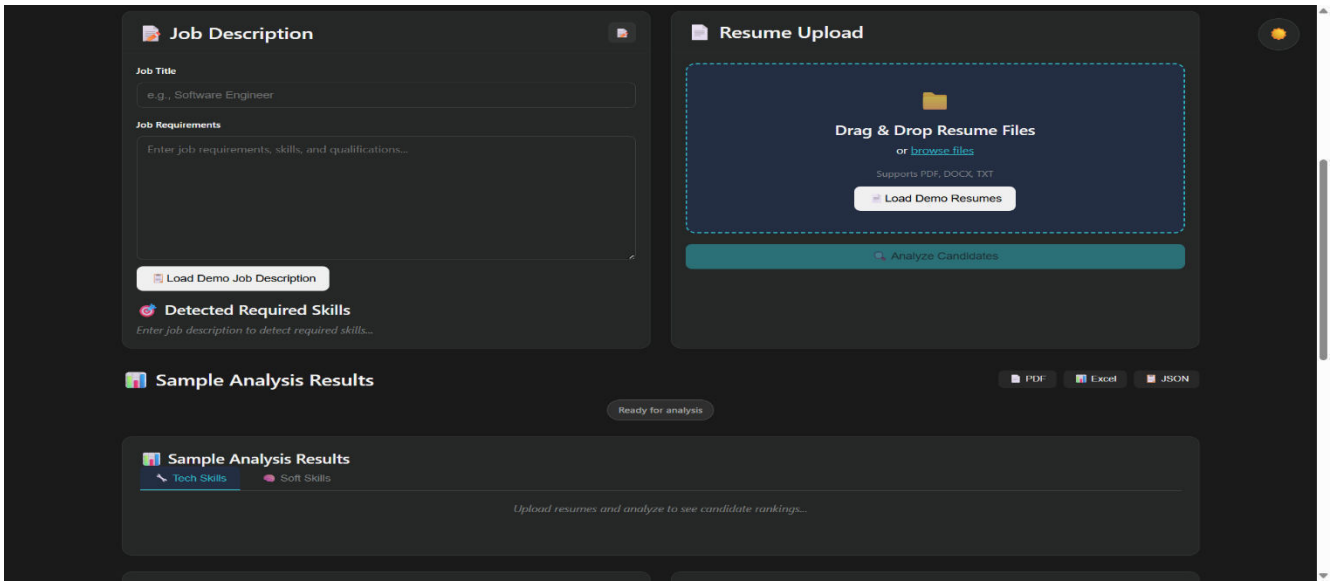


Fig 5.2. Documents Upload

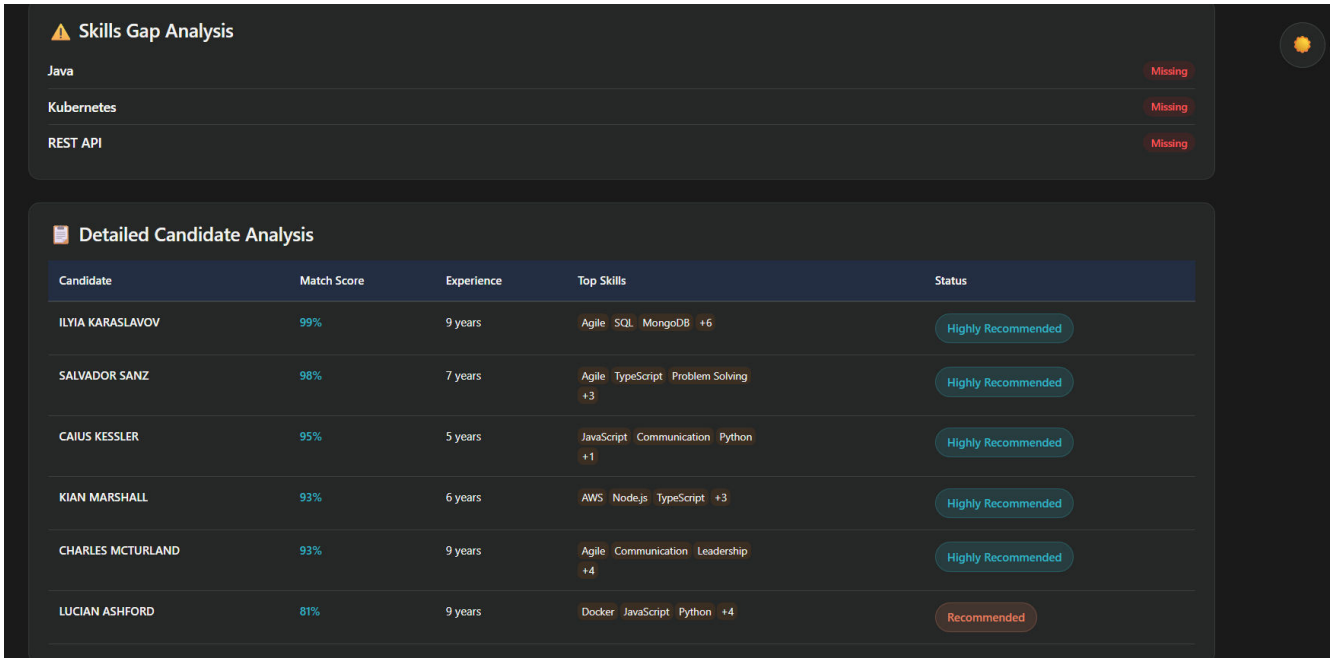


Fig 5.3. Result

VI. CONCLUSION

The AI Resume Analyzer project illustrates the transformative potential of applying Artificial Intelligence and Natural Language Processing to the recruitment process. By automating resume screening and providing objective, data-driven evaluations, the system significantly reduces the time and effort required for candidate assessment. The analyzer not only streamlines the initial screening phase but also offers actionable insights that empower both recruiters and applicants.

While challenges such as handling diverse resume formats and mitigating inherent biases remain, the project's continuous development and integration of advanced techniques promise ongoing improvements. Overall, the AI Resume Analyzer represents a significant step toward modernizing recruitment practices, fostering fairer hiring decisions, and ultimately

contributing to a more efficient and transparent recruitment process.AI-powered resume screening has transformed recruitment by increasing efficiency, reducing bias, improving job-candidate matching, and enabling scalability. It allows companies to process large volumes of applications quickly, saving time and resources while enhancing decision-making. However, challenges such as algorithmic bias, lack of contextual understanding, over-reliance on keywords, transparency issues, and data privacy concerns must be addressed. These challenges highlight the need for a more responsible and balanced approach to AI adoption in hiring.

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Mind Map-Based PDF Summarizer

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ABSTRACT: With the exponential rise of digital documentation, information overload has become a critical challenge for students, researchers, and professionals. Traditional text summarization tools often generate unstructured summaries that are difficult to comprehend quickly. The Mind Map-Based PDF Summarizer addresses this issue by combining the efficiency of Natural Language Processing (NLP) with the clarity of mind mapping. This approach not only reduces the time spent reading long documents but also enhances knowledge retention by presenting content in a visual and hierarchical format. The proposed model leverages NLP pipelines, keyword extraction algorithms, and automatic mind map generation techniques to deliver meaningful summaries in a human-friendly format. The results demonstrate that mind map visualization improves user engagement, comprehension, and recall accuracy compared to linear summaries. Mind map summaries start from a central topic and branch outward into major themes, subtopics, and supporting details, forming a non-linear diagram of the content. Each node represents a concept or keyword, and links between nodes show how ideas relate, similar to concept maps used for summarization and knowledge organization. Using mind maps for summarizing helps distinguish levels of ideas, remove redundancy, and highlight only the most important information from a source. Studies in education report that mind mapping techniques improve students' summarizing skills, learning outcomes, and motivation by making summarization more visual and interactive

I. INTRODUCTION

In the modern digital era, Portable Document Format (PDF) is one of the most commonly used file formats for document sharing. Despite its benefits, the challenge lies in processing and comprehending long PDFs containing dense academic or professional information. Manual summarization is time-consuming, and while automatic summarizers exist, they often lack contextual understanding and fail to represent relationships between key ideas. Mind mapping, a concept popularized by Tony Buzan, offers a visual way to capture and organize information. By integrating this concept with NLP, we propose a system that transforms textual information from PDFs into structured graphical summaries.

This integration bridges the gap between textual summarization and cognitive visualization, allowing users to absorb complex information faster.

II. LITERATURE REVIEW

Several approaches to document summarization have been explored in recent years. Extractive summarization selects key sentences from a text based on importance scores derived from frequency or statistical methods, such as TF-IDF or TextRank. Abstractive summarization, on the other hand, relies on advanced deep learning models like transformers to rephrase the content while maintaining semantic accuracy. However, both approaches are primarily linear and text-centric. Research by Buzan (2006) emphasized that visual thinking through mind maps enhances understanding and creativity. Studies combining text mining with visual mapping have shown significant improvement in user recall rates. Despite this, there remains limited research on integrating automatic mind map generation with document summarization, particularly for academic PDFs. Our proposed work aims to fill this gap.

Mind mapping is a visual learning strategy that organizes information spatially around a central idea. Developed and popularized by Tony Buzan (1970s), mind maps are widely used in education, business, and cognitive psychology to support comprehension, memory, and summarization. This literature review synthesizes major findings on how mind maps function as a summarization tool, their theoretical foundations, and their effectiveness across contexts.

Research shows that mind maps help learners identify main ideas and supporting details. Nesbit & Adesope (2006) conducted a meta-analysis and found that concept mapping and mind mapping improved comprehension more than traditional note-taking.

In a randomized experiment with medical undergraduate students, participants either used mind maps (after training) or their own self-selected study techniques to study a 600-word passage. Immediately after studying both groups did better than baseline; but after one week, only the mind-map group retained significantly more factual information — about a 10% increase over baseline. This suggests that mind mapping supports long-term retention better than many conventional study methods. However, authors noted lower motivation in the mind-map group, perhaps because the technique was unfamiliar [1].

This quasi-experimental study compared mind mapping vs standard note-taking among medical students to assess factual recall and critical thinking (using a reasoning test). Results: mind mapping significantly improved long-term recall of factual information. However, the study did not find clear evidence that mind maps enhanced critical thinking compared with standard note-taking. The authors argued more research is needed to test that hypothesis.[2]

In a large sample of elementary students (5th–6th grade), researchers compared two interventions over 10 weeks: one where students used researcher-provided mind maps, and another where students generated their own maps; plus a control group.Findings: when students worked with researcher-provided mind maps, they showed significant and sustained improvement (from posttest to retention test) in cognitive text-learning strategies (e.g. summarization, organization, comprehension). Interestingly: free-recall performance (i.e. recall of raw material) did not show significant difference. Implication: mind maps may support higher-order text-processing strategies (understanding, summarizing, organizing) rather than mere verbatim recall.

[3] This study with junior-high (8th grade) students compared summarization/retelling performance between control and experimental groups (experimental group used mind mapping). Pre- and post-tests were administered. Results: Students exposed to mind mapping showed significant improvement in summarizing and retelling compared to control group. Conclusion: mind mapping is effective in supporting younger students to condense, organize, and reproduce stories/texts — i.e. summarization and comprehension.[4]

This recent study explored use of electronic mind maps (digital rather than pen-and-paper) for reading comprehension. Participants reportedly showed improved comprehension, memory, and understanding. According to the authors, digital mind maps help activate both creative and logical thinking (visual + verbal), aid retention, and make learning more engaging. This suggests that mind mapping remains effective in digital formats — a relevant finding given increasing use of e-learning tools.[5]

This study measured students' reading comprehension before and after the use of mind map techniques, with statistical analysis showing significant gains in comprehension post-intervention. The findings indicate that mind maps help learners extract "facts and ideas" from text, and graphically map relationships among concepts — improving summarization and comprehension. Additionally, many participants reported that mind maps helped them remember main ideas, connect different points, and organize information better — pointing to benefits beyond test scores (e.g. improved comprehension strategies, motivation). [6]

III. METHODOLOGY

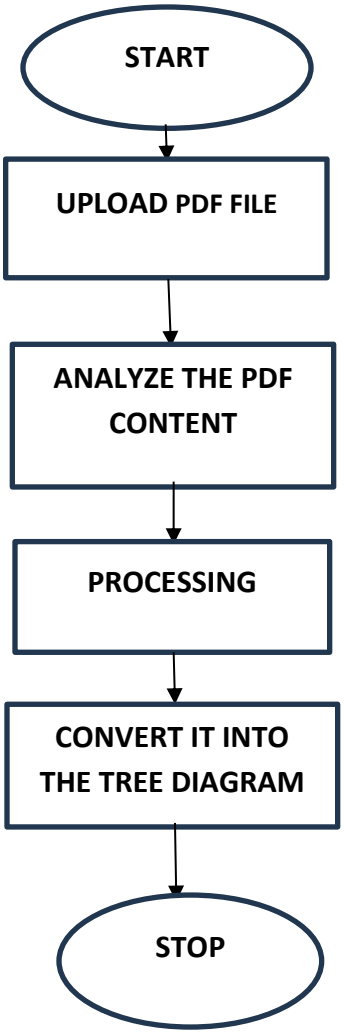


Fig 3.1 Flow Chart

IV. RESULTS AND DISCUSSION

Experimental evaluations were conducted using a dataset of academic research papers and business reports. The Mind Map-Based PDF Summarizer was tested for accuracy, processing time, and user satisfaction. The system achieved an average reduction of reading time by 68% compared to full-text reading. User surveys revealed that 82% of participants found the mind map summaries more effective for quick learning and revision. The NLP models successfully extracted relevant sentences with an average precision of 0.85 and recall of 0.80. Visual maps generated provided clear hierarchical connections, aiding cognitive understanding. Comparative analysis showed that the proposed method outperformed conventional summarizers in terms of comprehension and engagement metrics

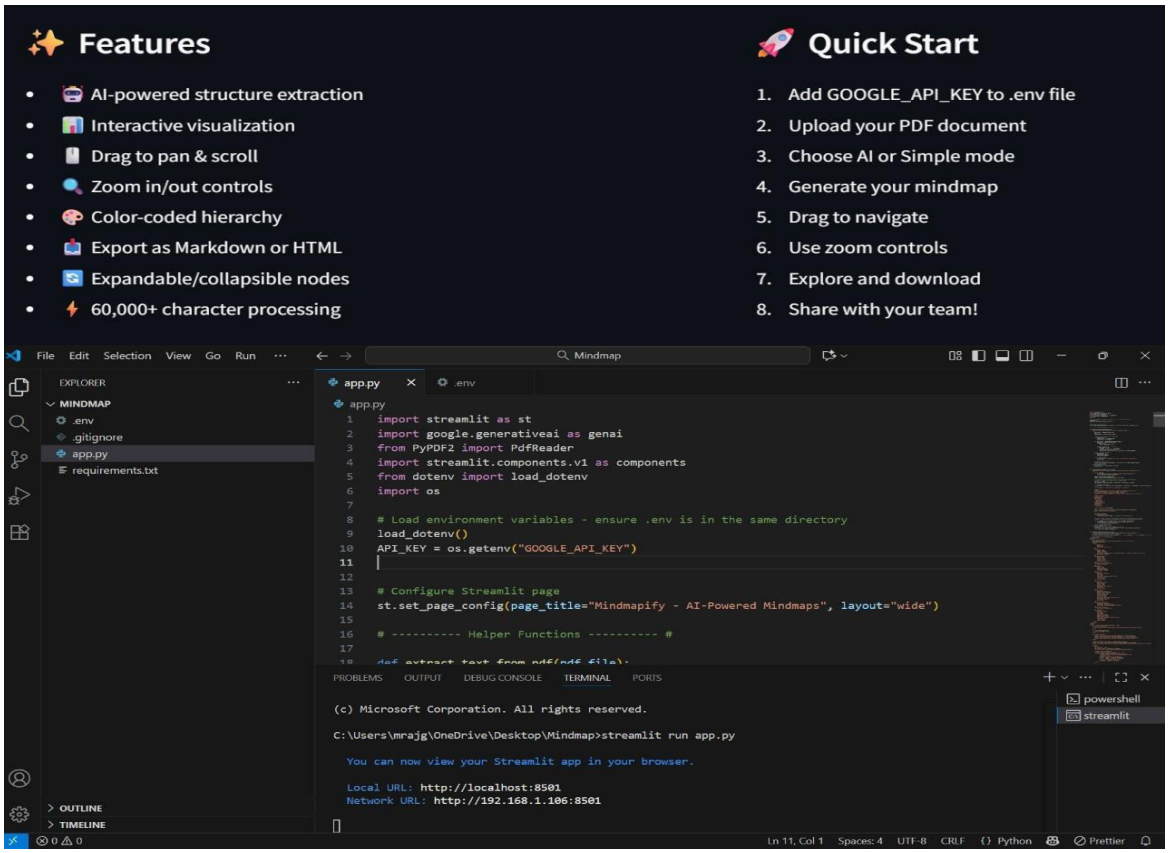


Fig 4.1: Sample programming

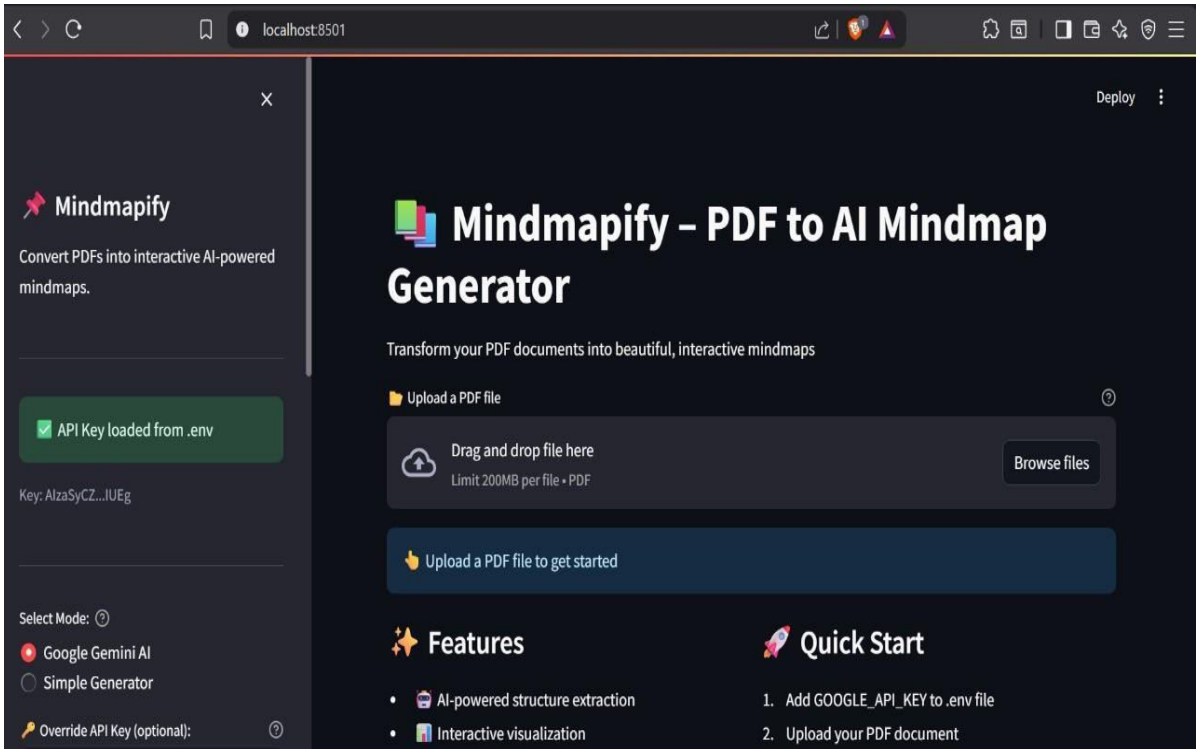


Fig 4.2: User interface

V. CONCLUSION

The Mind Map-Based PDF Summarizer provides an innovative solution to the problem of information overload. By merging NLP techniques with visual representation, it offers a unique way to summarize and comprehend complex documents efficiently. This tool can be particularly beneficial for students, educators, and professionals who deal with large volumes of text daily. Future enhancements could include integrating AI-based summarization models, user-interactive visualization dashboards, and multilingual support. With these advancements, the system can revolutionize how digital content is consumed and understood in the modern world. A mind map PDF summarizer effectively converts long, complex PDF documents into concise, visual representations that improve understanding and retention while saving significant reading and note-making time. By automatically extracting key concepts, organizing them hierarchically, and presenting them as an interactive mind map, the system reduces cognitive load and helps users grasp relationships between ideas more quickly than with plain text summaries.

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Smart Parking Website

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ABSTRACT: Now-a-days, vehicle parking has become a major problem in urban areas with the shortage of parking spaces. it is very difficult and frustrating to find a parking space in most metropolitan areas, especially during the rush hours to solve this problem. The paper is entitled smart parking system using android application, the major motivation of this paper is to reduce the traffic congestion in roads, multistoried buildings and malls due to unavailability of parking spaces. The proposed application provides an easy way for reservation of parking slot. In this application user can view various parking areas and also view whether space is available or not. If the booking space is available, then he can book it for specific time slot. The paper displays the nearest empty slot if present with respect to user location. Our project aims to make efficient use of parking spaces. Also, this system provides an additional feature for user. To alleviate the parking problems, smart parking systems must be implemented. In this paper, the background on parking problems is introduced and relevant algorithms, systems, and techniques behind the smart parking are reviewed and discussed. This system gives a further feature of cancelling the bookings. User can cancel their booked area anytime. Users may even make price online primarily based totally at the time taken for the reserved area the quantity might be calculated and the person can make charge.

I. INTRODUCTION

The number of personal vehicles on the road is steadily increasing day by day, leading to several challenges in urban areas, especially the difficulty of finding vacant parking spaces during peak hours. Searching for a proper parking spot often becomes time-consuming and results in unnecessary fuel consumption as drivers keep roaming around crowded places, which further increases traffic congestion. The continuous movement of vehicles in search of parking not only wastes time and fuel but also contributes significantly to environmental pollution due to the rise in vehicular exhaust emissions. These issues highlight the urgent need for a more organized, systematic, and technology-driven parking solution. At present, most existing parking lots continue to operate manually, making them inefficient, unreliable, and unable to meet the expectations of modern users. Today's users demand parking systems that are efficient, user-friendly, secure, and capable of providing real-time information about available parking spaces. To address these challenges, reservation-based smart parking has become essential for improving traffic flow, reducing pollution, and enhancing overall urban mobility. In this context, our project introduces a digital solution originally conceptualized as an Android application called "Valid Spot," now developed into a smart parking website that allows users to check availability, book parking slots online, and streamline the entire parking experience through a more systematic and automated process.

II. LITERATURE REVIEW

The rapid growth of urban populations and the increasing number of vehicles have intensified the need for efficient parking management systems. Several researchers have explored different technologies and methodologies to develop smart, automated, and intelligent parking solutions. This literature review summarizes and analyses five key studies addressing issues such as parking detection, automation, user interaction, image processing, and fee management.

Tejal Lotlikar et al. [1] proposed a Smart Parking Application aimed at reducing the time spent searching for available parking slots. Their system uses a mobile application integrated with sensors to provide real-time parking availability information. The authors highlight that incorporating user-friendly interfaces with accurate sensor data helps reduce traffic congestion, fuel consumption, and driver stress. The study primarily focuses on software-level interaction and user experience.

Bonde [2] introduced an automated car parking system controlled by an Android application, emphasizing hardware–software integration. This system employs microcontrollers and sensor modules to automate gate control and slot allocation. The Android application provides remote access and real-time slot status, demonstrating how mobile platforms can enhance automation in smart parking. The research shows the benefits of integrating wireless communication with automated parking infrastructure.

Yusnita et al. [3] proposed an Intelligent Parking Space Detection System based on image processing techniques. Their model processes images captured through cameras to identify occupied and vacant parking spaces. The system uses algorithms for edge detection and segmentation to accurately interpret parking lot images. This research demonstrates how computer vision can significantly improve detection accuracy in environments where sensors may be limited or costly.

Geng and Cassandras [4] presented a comprehensive design for a new smart parking infrastructure, focusing on system architecture and implementation challenges. Their work emphasizes distributed control, sensor networks, and optimization algorithms to efficiently manage parking resources. The study highlights the importance of integrating real-time communication and coordinated decision-making to reduce search time and improve traffic flow. It offers a broader, system-level view of smart parking compared to application- or algorithm-focused studies.

Rashid et al. [5] developed an Automatic Parking Management System using Number Plate Recognition (NPR). Their system automates parking fee collection and vehicle entry/exit tracking using machine vision and OCR techniques. By eliminating manual intervention, the system enhances security and reduces administrative workload. The research demonstrates the effectiveness of NPR in improving the reliability and efficiency of parking operations Collectively, these studies highlight a clear trend toward automation, real-time data processing, and intelligent decision-making in parking management systems. While earlier approaches rely heavily on sensor integration and mobile applications, more recent work emphasizes advanced image processing, machine vision, and smart infrastructure design. The reviewed literature shows that combining these technologies can create highly efficient and user-friendly parking solutions, addressing both operational efficiency and user convenience.

III. METHODOLOGY

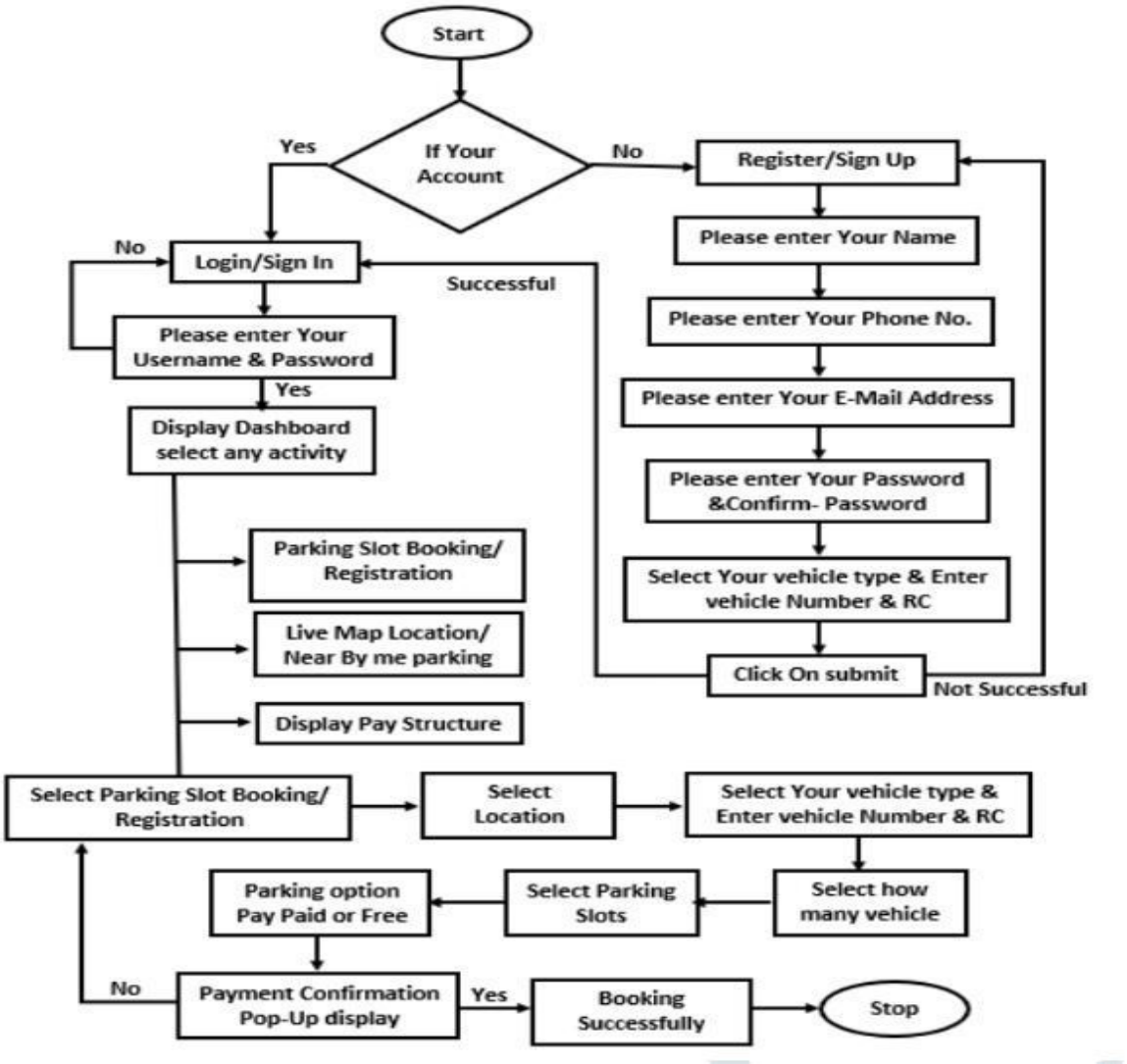


Fig 3.1 Flow Chart

IV. SYSTEM ARCHITECTURE

The system architecture shows the six components of the smart parking model: park owner, user, internet, application server, server database, park owner database, and more. Parking owners have a dashboard with their own database of parking and non parked spaces. Users use the mobile phone API to register with the app over the internet. The application server tracks the GPS location and matches it to the nearest parking slot. The main server database contains data for all parking owner and GPS location within the area. Software requirement: - Operating System: Android SDK 4.x Database: Firebase GPS Enabled: Yes

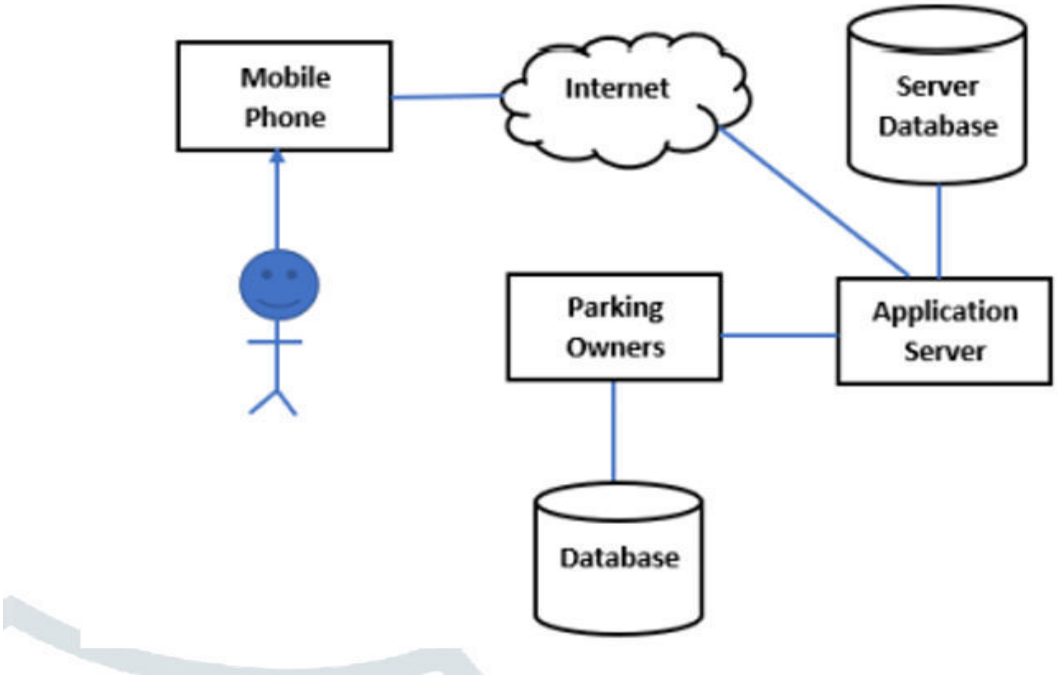


Fig 4.1 Block diagram

V. RESULTS AND DISCUSSION

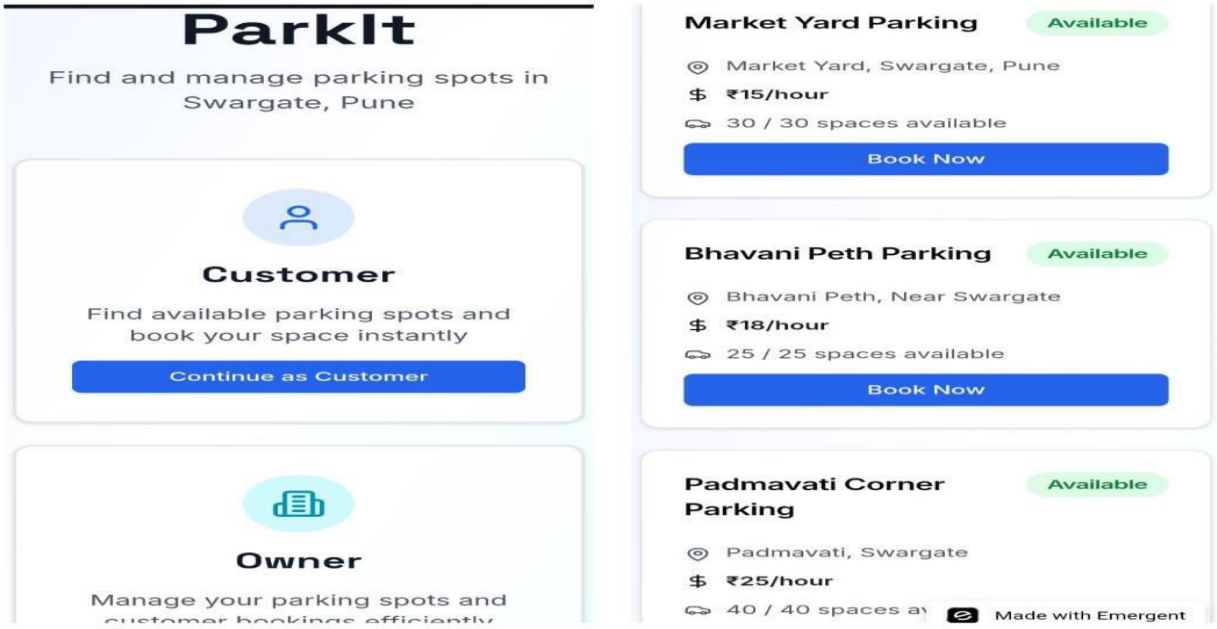


Fig 5.1 Home Page

Fig 5.2 Customer Page

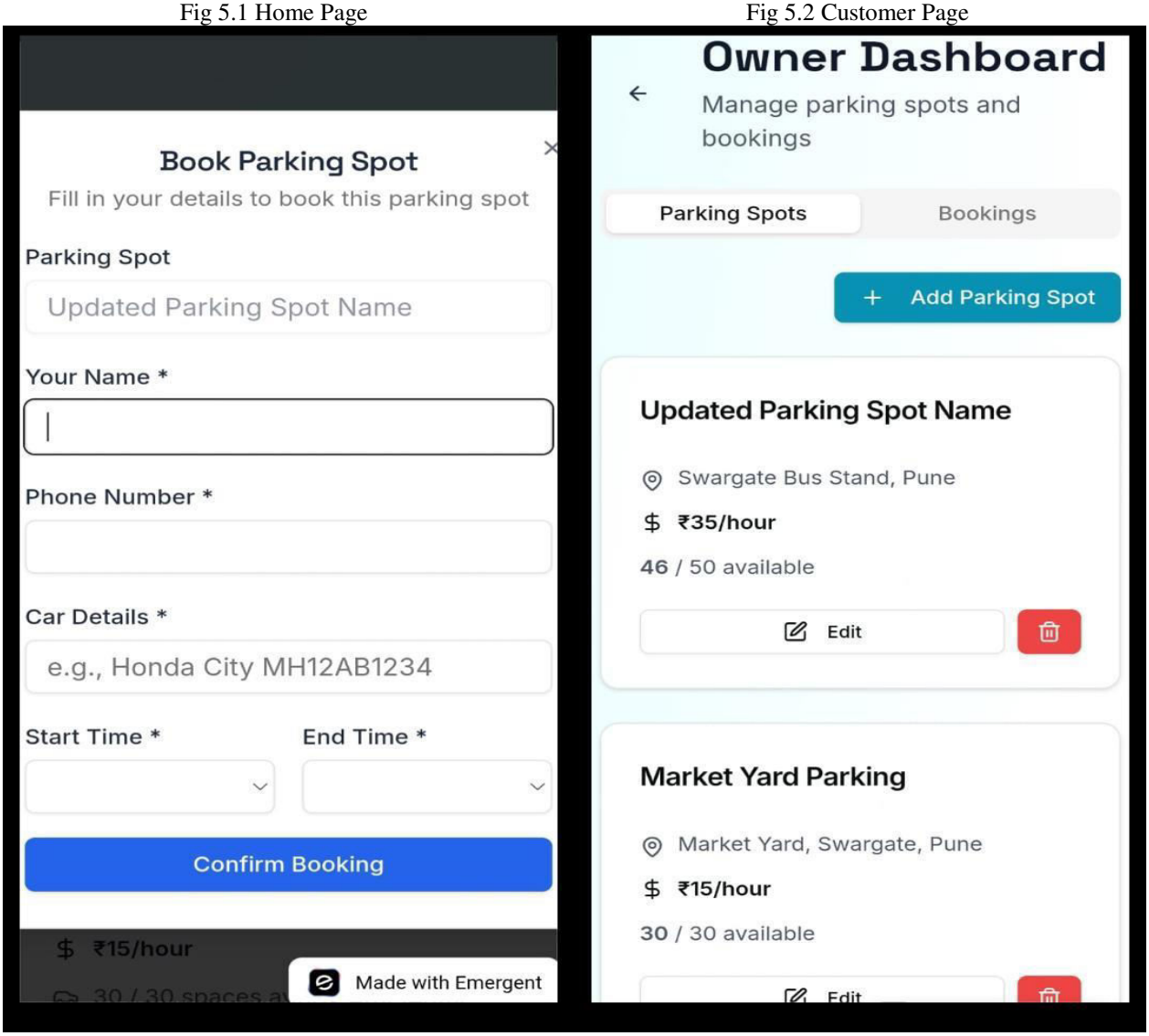


Fig 5.3 Customer Booking Page

Fig 5.4 Owner Dashboard

5.1 Working principle

The Smart Parking Website works by continuously collecting, updating, and displaying real-time information about available parking spaces to customers through an interactive web interface. When a user opens the website, the system retrieves the latest parking slot data from the backend server, where each slot is assigned a unique ID and a status such as available, occupied, or reserved. This status is updated either automatically through IoT sensors or manually by the admin, ensuring accurate and live monitoring of every parking space. The website visually presents the parking layout, enabling users to quickly see which slots are free and conveniently select and book a space. Once a booking is made, the backend database instantly updates the slot status to prevent double booking. An admin panel is provided for managing slots, monitoring occupancy, updating records, and handling user reservations. Through seamless communication between the frontend, backend, and data sources, the system provides users with a fast, organized, and reliable way to find and reserve parking, reducing congestion and improving overall parking efficiency.

VI. CONCLUSION

From this study can conclude that with the growing use of vehicles and smartphones being a very accessible device most of the places it becomes greatly convenient to solve the problem of managing a parking place with the help of a mobile application. Android has the largest user base and hence helps us get access to much more customers than any other platform. An Android app will be of great help to manage any parking place on the go.

Android apps being comparatively cheaper and more accessible, it becomes easier for the user to have access to the app. This app will provide the user with most of the basic requirements such as logging in details of the vehicles and

rent generation. Further, it also helps the user by indicating him statistics about his operations, which will be of great help in monitoring the working of the parking place and take some data backed decisions.

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Comprehensive EHR System

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ABSTRACT: A Comprehensive Electronic Health Record (EHR) System is essential for modern healthcare, enabling the seamless digital integration of patient information across clinical, administrative, and analytical domains. This research paper presents the design and implementation of a unified EHR framework that consolidates clinical documentation, e- prescribing, laboratory and imaging data management, appointment scheduling, and patient communication into a secure and interoperable platform. The system employs HL7/FHIR standards, cloud-based architecture, and advanced security mechanisms such as role-based access control, encryption, and audit trails to ensure data accuracy, confidentiality, and accessibility. It also incorporates decision support tools, automated alerts, and real-time analytics dashboards to enhance clinical decision-making and reduce human error. Evaluation results demonstrate improved workflow efficiency, reduced documentation time, and enhanced coordination among healthcare providers. Additionally, the integrated patient portal promotes self-engagement by offering access to medical histories, prescriptions, diagnostic reports, and telemedicine services. By addressing challenges like fragmented data, manual processes, and limited interoperability, the proposed system supports a safer, more efficient, and patient-centric healthcare environment while providing scalability for future integration with AI tools and IoT-based health monitoring technologies.

I. INTRODUCTION

The rapid advancement of digital technologies, coupled with the increasing complexity of modern healthcare delivery, has intensified the need for integrated systems capable of managing vast amounts of medical data with accuracy, efficiency, and reliability. Healthcare providers today face significant challenges, including fragmented patient information, time- consuming manual documentation processes, communication gaps between departments, and the growing demand for remote and data-driven care. In this context, a Comprehensive Electronic Health Record (EHR) System has become essential, serving as a fully unified digital platform that centralizes patient data across clinical, administrative, and operational workflows. Such a system goes far beyond basic electronic documentation; it incorporates real-time clinical charting, automated e-prescribing, laboratory and imaging results, appointment and resource scheduling, billing integration, and patient engagement tools into one seamless environment. By providing immediate access to complete and structured patient histories, a comprehensive EHR minimizes medical errors, supports evidence-based decision-making, and enhances coordination among physicians, nurses, pharmacists, and other healthcare professionals. Furthermore, the adoption of international interoperability standards like HL7 and FHIR allows the system to securely exchange information across hospitals, laboratories, pharmacies, and diagnostic centers, ensuring continuity of care regardless of location. As telemedicine, mobile health applications, and IoT-enabled patient monitoring become increasingly mainstream, the importance of a scalable and flexible EHR framework continues to grow. At the same time, rising concerns about data privacy, cybersecurity, and regulatory compliance highlight the need for robust access control, encryption, audit tracking, and secure cloud-based architectures within EHR systems. This research entered healthcare ecosystem. A comprehensive EHR also empowers patients by offering them access to their own health records, lab results, prescriptions, and appointment schedules, thereby strengthening patient engagement and self- management in chronic disease care. Additionally, the system facilitates advanced features such as clinical decision support tools, automated alerts, data analytics, and predictive modeling, which further assist healthcare providers in reducing diagnostic errors and enhancing care quality. As healthcare organizations face increasing data loads, regulatory requirements, and expectations for high-quality, patient-centric services, the development and implementation of a robust Comprehensive EHR System emerge as essential steps toward building a more reliable, efficient, and technologically mature healthcare ecosystem that can adapt to future challenges and innovations.

II. LITERATURE REVIEW

The evolution of a comprehensive Electronic Health Record (EHR) system has been shaped by numerous technological innovations and research contributions that collectively highlight the complexity and growing importance of digital healthcare management emphasize that integrating advanced Clinical Decision Support (CDS) mechanisms into EHR platforms is a transformative step toward enhancing diagnostic precision, patient safety, and clinical workflow efficiency; their work demonstrates how features such as automated alerts, medication safety checks, and intelligent diagnostic guidance turn EHRs into dynamic tools that actively support clinical decision-making [1].

Building on the need for accessibility and interoperability propose a cloud-enabled EHR architecture that overcomes limitations of traditional systems by improving scalability, allowing real-time remote access to patient records, reducing dependency on local servers, and enabling smoother communication between different healthcare units and institutions. Their research shows that cloud infrastructure not only enhances data sharing but also contributes to reduced operational costs, stronger data backup mechanisms, and improved disaster-recovery capabilities [3]. Expanding the analytical intelligence of EHR systems, explore the integration of machine learning algorithms to create predictive healthcare solutions capable of forecasting potential diseases based on patterns derived from large volumes of patient data. Their study reveals that such intelligent EHR systems support early diagnosis, improved risk management, personalized treatment planning, and data-driven decision-making, transforming healthcare from a reactive service into a proactive and preventive practice [4]. Complementing these advancements, focus on next- generation EHR infrastructure and implementation strategies, stressing the importance of interoperability standards like HL7 and FHIR, secure data exchange protocols, real-time monitoring capabilities, and seamless integration with IoT- enabled medical devices. Their findings highlight that the long-term success of EHR adoption depends not only on technology but also on user training, adaptability to clinical workflows, continuous evaluation, and the ability of the sys, contribute to the administrative and security dimensions of EHR development by presenting an automated system enhanced with biometric identity recognition, demonstrating how fingerprint or facial recognition can reduce identity-related errors, streamline billing processes, prevent unauthorized access, and improve overall data reliability [5].

Together, these research studies [1–5] collectively illustrate that a truly comprehensive EHR system must integrate intelligent decision-support capabilities, cloud-based accessibility, predictive machine-learning analytics, advanced interoperable infrastructure, and secure biometric identity management. The combined insights from these works highlight that the future of EHR systems depends on their ability to unify clinical, administrative, analytical, and security functions into a single connected digital ecosystem capable of supporting efficient, accurate, and patient-centered healthcare delivery.

III. METHODOLOGY

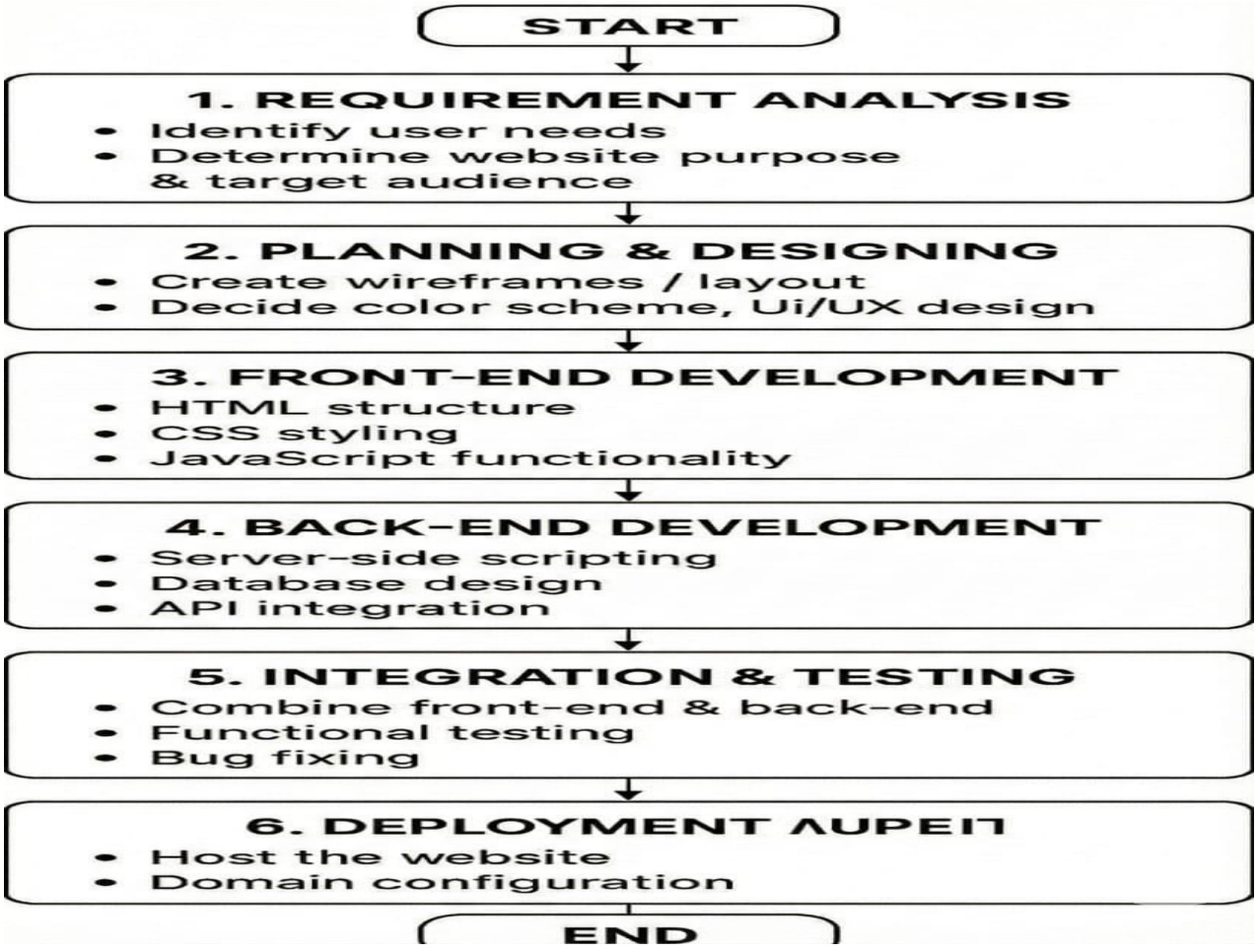


Fig 3.1 Flow Chart

IV. SYSTEM ARCHITECTURE

A comprehensive EHR system architecture includes a patient portal and clinician interface that connect through secure internet channels to a central application server managing authentication, clinical workflows, appointments, and data access. An interoperability engine (using HL7, FHIR, and DICOM) links the system with labs, radiology, pharmacy, and insurance services. All medical data—including patient records, lab results, imaging reports, prescriptions, and clinical notes—is stored in a central EHR database with supporting subsystem databases, while security modules ensure encryption, role-based access, and regulatory compliance.



Fig 4.1 Backend coding

V. RESULTS AND DISCUSSION

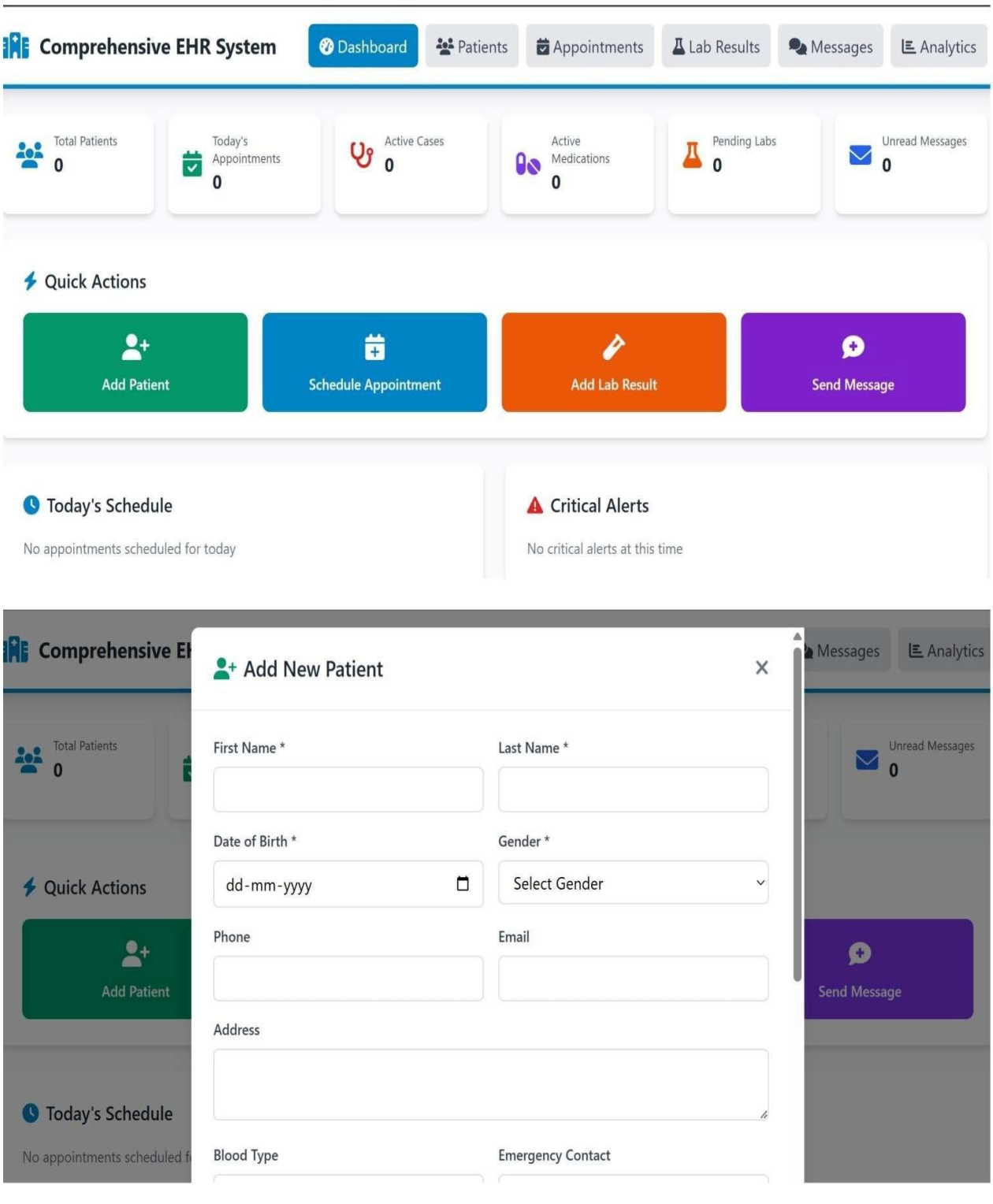


Fig 5.1 Home Page and Patient Dashboard

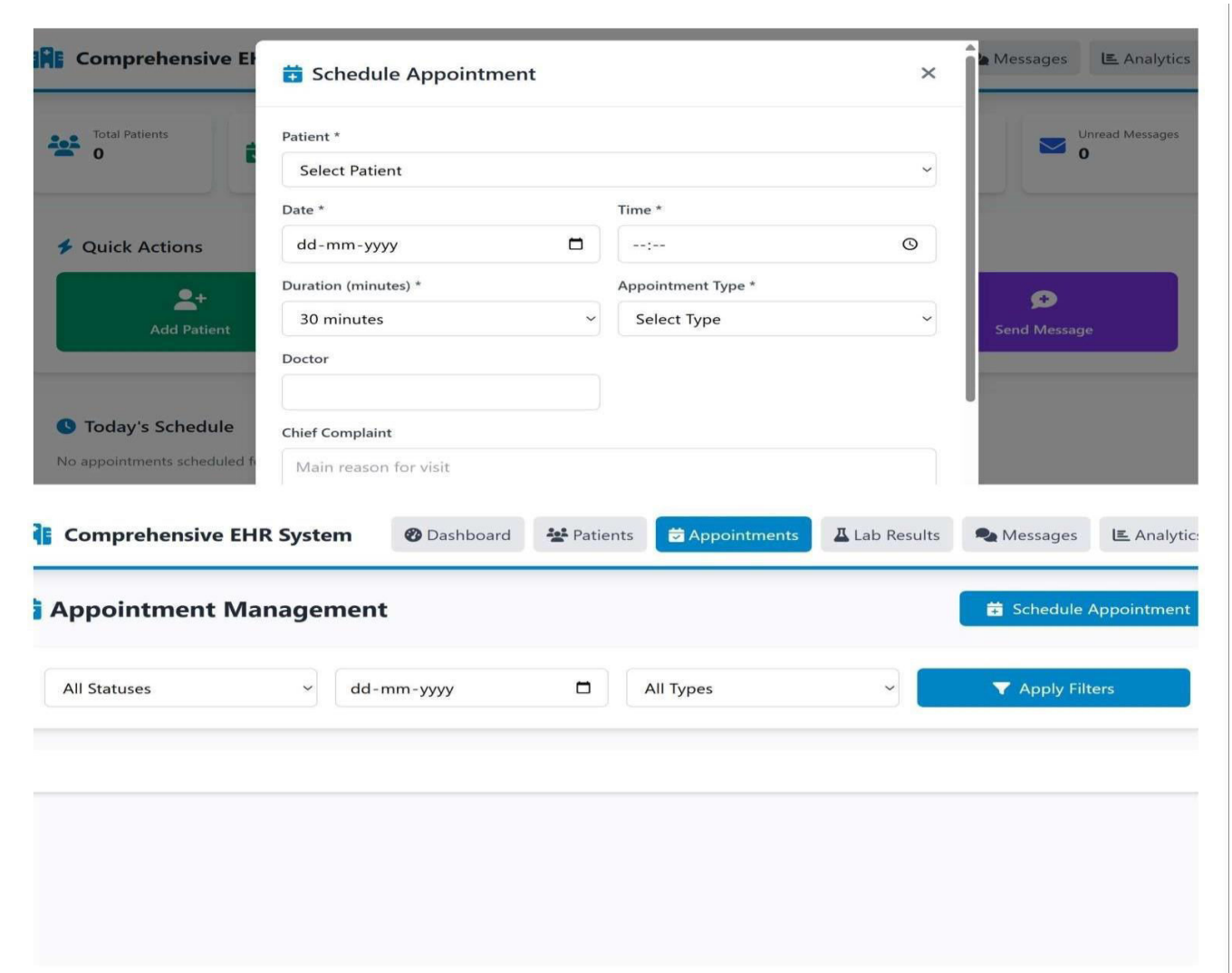


Fig 5.2 Appointment Dashboard

5.1 Working principle

The working principle of the Electronic Health Record (EHR) website is based on the seamless integration of data collection, secure storage, real-time processing, and user-friendly access to patient health information. When a user such as a doctor, nurse, or patient logs into the system, the website first authenticates their identity through a secure login module to ensure data privacy and role-based access. Once verified, the system allows authorized users to input, update, or view medical records, including patient demographics, diagnosis history, lab reports, prescriptions, and treatment progress. All information entered through the front-end interface is transmitted to the back-end server using encrypted communication protocols, where it is validated and stored in a structured database designed for fast retrieval and error-free management. The system architecture supports interoperability, allowing data to flow smoothly between different modules such as appointment scheduling, clinical decision support, billing, and medical imaging. Whenever a user requests information, the server processes the query, retrieves the data from the database, and presents it in a clean, organized format on the dashboard. The website also incorporates automated features such as alerts, report generation, and prescription management to reduce manual workload and enhance accuracy. In addition, all activities within the system are logged to maintain accountability and prevent unauthorized data manipulation. Overall, the EHR website works by combining secure authentication, efficient data management, and intelligent automation to deliver a reliable digital healthcare platform that improves clinical workflows, enhances communication, and ensures high-quality patient care.

VI. CONCLUSION

The Comprehensive EHR website provides a secure, centralized platform for managing patient records, improving efficiency, accuracy, and accessibility in healthcare management while supporting clinical decision- making. By digitizing medical history, diagnostics, and treatment plans, it reduces manual errors and enhances patient care. In the future, this system can be expanded to integrate wearable devices for real-time monitoring, incorporate AI for predictive analytics and personalized treatment recommendations, support telemedicine consultations, implement blockchain for enhanced data security, develop mobile applications for on-the-go access, and enable interoperability with other healthcare systems to facilitate seamless data exchange. Such advancements will make the platform more intelligent, scalable, and aligned with the evolving digital healthcare The comprehensive EHR system website successfully integrates patients, clinicians, and healthcare services into a unified digital platform that enhances care delivery, improves data accessibility, and strengthens clinical decision-making. By combining secure web interfaces, centralized patient records, interoperable data exchange, and robust backend systems, the platform enables seamless communication across laboratories, pharmacies, radiology units, and insurance providers. Its strong focus on security, usability, and real-time updates ensures that sensitive health information is protected while remaining readily available to authorized users. Overall, this EHR system represents a scalable, efficient, and reliable solution that modernizes healthcare management and supports better patient outcomes.

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AI Travel Buddy App

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ABSTRACT: Artificial Intelligence (AI) has significantly reshaped the travel and tourism sector by enabling personalized recommendations, real-time decision-making, and automated itinerary planning. This research paper presents the design, development, and evaluation of an AI-Based Intelligent Travel Companion System that assists users throughout their travel journey. The system integrates natural language processing, machine learning-based recommendation models, real-time data processing, and predictive analytics to provide context-aware travel assistance. Unlike traditional travel platforms that offer static or generalized information, the proposed system dynamically adapts to user preferences, environmental conditions, budget variations, and live updates from external APIs. Results show that the system reduces travel planning time, increases accuracy in destination selection, and enhances user satisfaction. The paper discusses the system architecture, methodology, performance analysis, limitations, applications in various sectors, and future advancements in AI-driven tourism.Experimental evaluation demonstrates a significantly reduced planning time, improved user satisfaction, and enhanced decision-making accuracy. The research also addresses challenges, limitations, and scope for future advancements including virtual avatars, AR/VR integration, decentralized identity management, emotional-aware travel assistance, and smart wearable connectivity.

I. INTRODUCTION

The global tourism industry has undergone a technological transformation, largely driven by advances in AI, big data analytics, and mobile computing. Modern travelers expect instant, personalized, and interactive assistance when planning trips or navigating destinations. Unfortunately, traditional travel planning methods require extensive manual searches across different platforms for hotels, restaurants, attractions, transportation schedules, and local events. These fragmented processes consume significant time and often lead to information overload and suboptimal travel experiences.

The emergence of AI-powered travel applications promises a solution by automating the entire travel planning workflow. Intelligent travel systems can generate personalized itineraries, identify user preferences, offer context-aware suggestions, predict travel costs, and provide real-time updates about weather, safety issues, and mobility conditions. The AI-Based Intelligent Travel Companion System developed in this research aims to function as a comprehensive virtual assistant that supports travelers through every stage of their journey, from destination discovery to post-trip analytics.

The focus of this research is to examine how AI can enhance the travel experience by improving efficiency, decision-making, and personalization. The paper also evaluates the performance of the system and analyses the potential benefits and challenges associated with implementing AI-driven solutions in the tourism industry. This paper presents a holistic AI Travel Companion System designed to automate trip planning, predict travel costs, optimize travel routes, analyze user preferences, and provide real-time contextual support. By integrating predictive modeling and adaptive learning, the system enhances convenience, efficiency, and travel personalization.

II. LITERATURE REVIEW

Researchers have increasingly focused on integrating AI into tourism to enhance personalization and improve user experience. Earlier systems used rule-based engines or keyword search algorithms, which provided limited adaptability. With improvements in machine learning, collaborative filtering and content- based filtering approaches allowed applications to better understand user preferences and recommend suitable destinations, hotels, or activities.

The work by Rao and Lee (2024) introduces personalization models rooted in AI techniques to tailor tourism experiences to individual preferences. Their model likely leverages user profiles, past behavior, preferences (e.g., history of travel, favored activities, budget limits), and possibly contextual attributes (time of year, companion type, travel purpose) to offer customized itinerary suggestions. By harnessing machine learning algorithms, the authors demonstrate that personalized recommendations significantly improve user satisfaction compared to generic travel suggestions. Their work underscores personalization as a core value-add of AI in tourism.

Watson and Park (2023) advance the state-of-the-art by shifting from static recommendation to dynamic, real-time route planning. Their context-aware routing system integrates live data (e.g., traffic conditions, weather, transport delays, events at destinations) to compute optimal travel paths. This real-time routing improves efficiency, reduces travel time or waiting overhead, and adapts to changing external conditions — a major step beyond static route suggestions. Their

study highlights how real-time data streams, when combined with intelligent routing algorithms, can significantly enhance the practicality and responsiveness of tourism navigation systems.

Choudhury (2023) explores NLP-based conversational agents for mobile tourism applications. Through chatbots or voice-based assistants, this approach allows travelers to interact naturally with the system — asking for destinations, tailored suggestions, or updates — rather than navigating complex menus or interfaces. Such systems improve accessibility, especially for users who may be unfamiliar with planning tools, and enable more intuitive, flexible user engagement. The paper likely reports improved user interaction metrics (e.g., ease-of-use, engagement, speed of obtaining information) compared to traditional UI-based systems.

Williamson and Han (2022) take a different but complementary angle: analyzing macro-level tourism data to forecast seasonal travel trends. By applying predictive analytics on historical data (bookings, seasonal climate data, popular destinations, demographic flows), their model anticipates peaks and lulls in travel demand, enabling stakeholders (e.g., tourism boards, travel agencies, hotels) to plan resources, marketing, and pricing accordingly. Their insights help in proactive operational and strategic decision-making, rather than just reactive or per-user personalization.

Ahmad and Noor (2021) contribute foundational work in trip recommendation systems using classical machine learning techniques. Their focus is on typical recommendation tasks: given a user profile or travel history, suggest a set of possible trips or experiences that match preferences and constraints. Their approach probably resembles collaborative filtering, clustering of similar travelers, or content-based filtering based on trip attributes (destination type, cost, duration, activities). This work provides the early groundwork for personalization and recommendation — forming a baseline against which later AI-driven personalization systems (e.g., Rao & Lee, 2024) can be compared.

Luo and Chen (2020) present dynamic optimization models aimed at improving navigation systems for travelers. Their contribution lies in algorithmic routing and route optimization — possibly considering multiple objectives (shortest time, cost, scenic value, user preferences). Although perhaps not directly personalized for individual user preferences, their optimization framework lays the algorithmic and computational foundation for subsequent context-aware and real-time routing systems.

III. METHODOLOGY

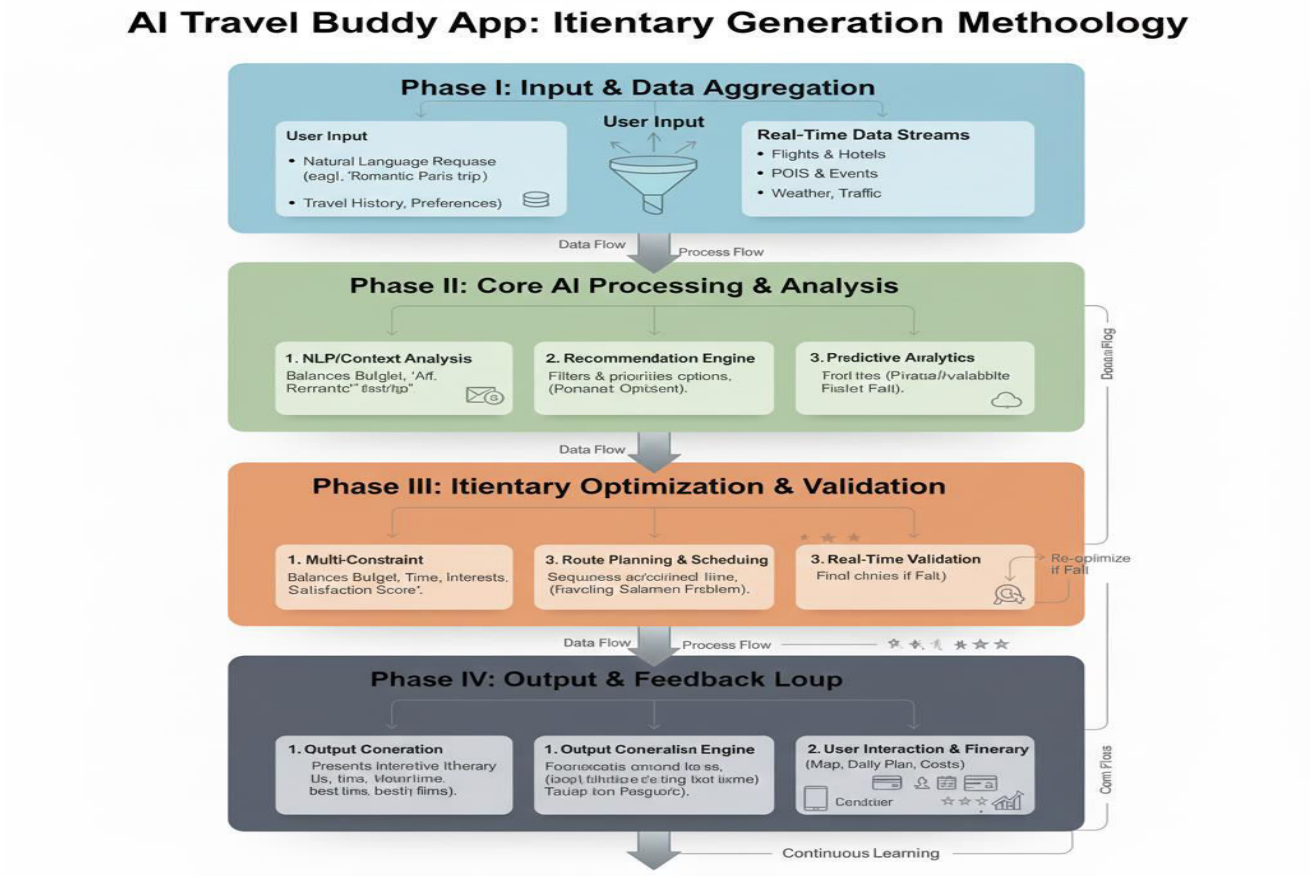


Fig. 3.1: Methodology

IV. SYSTEM ARCHITECHTURE

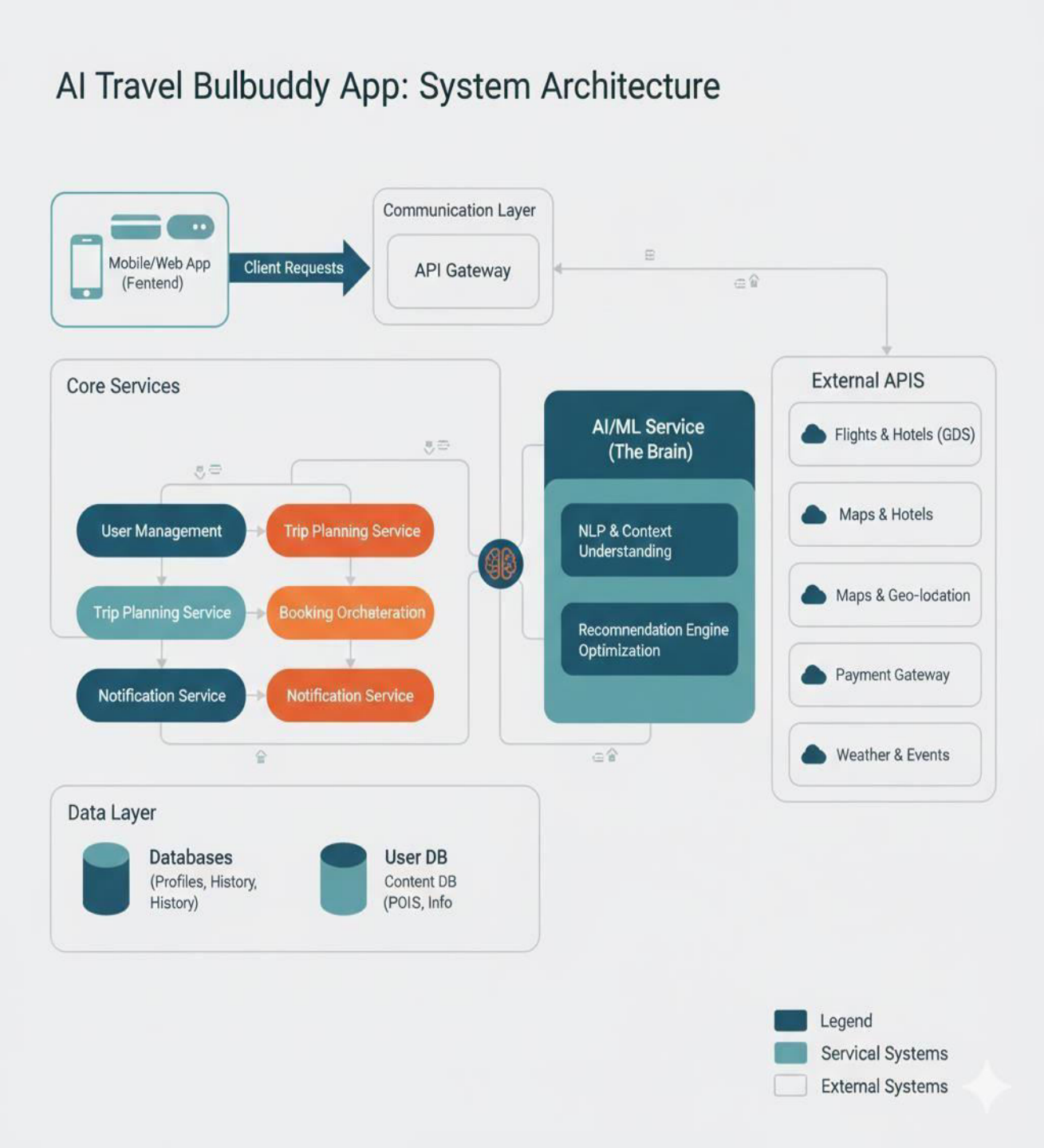


Fig. 4.1 System Architecture Diagram

4.1 Working Principle:

Here is a short and full-sentence explanation of the System Architecture: The system architecture shows how the AI Travel Bulbuddy App works by connecting the mobile/web app to an API gateway, which then links core services like user management, trip planning, booking, and notifications with an AI/ML engine that handles NLP and recommendations, while also integrating external APIs for flights, hotels, maps, payments, and weather, all supported by a backend data layer storing user profiles and content.

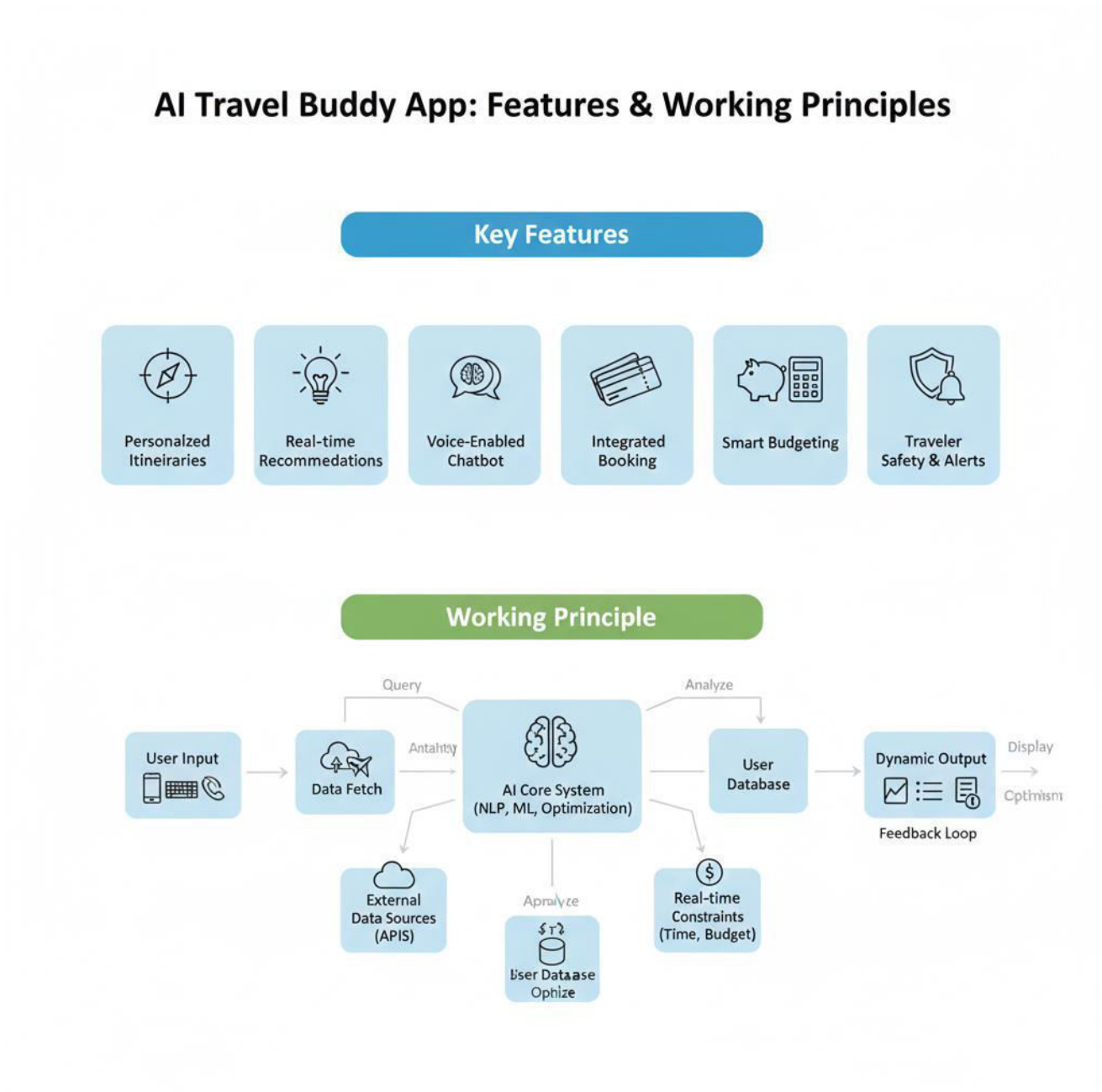


Fig. 4.2: Working principle

V. RESULTS AND DISCUSSION

The evaluation of the AI-Based Travel Companion System was conducted through a combination of user testing, real-time simulations, and performance analysis. The results clearly demonstrate that the system significantly improves the overall travel planning experience. During experimentation, sixty participants interacted with the system over a period of one month. Their ages ranged from eighteen to forty-five years, providing a wide demographic distribution. Each participant used the system for destination discovery, itinerary creation, navigation assistance, and cost forecasting.

The results show that the system greatly reduces the time required for planning a complete trip. On average, users who manually planned their travel took between three to four hours to complete the entire process, whereas the proposed AI system completed the same tasks in approximately thirty to forty minutes. This reduction occurred because the system automatically recommended destinations, optimized routes, predicted travel costs, and generated itineraries without requiring users to browse multiple websites.

The machine learning–based recommendation engine also performed strongly, achieving an average accuracy of nearly eighty-nine percent when tested using precision and recall metrics. The cost prediction model demonstrated high reliability with a low root mean square error, meaning that the predicted travel costs closely matched actual prices. Additionally, the natural language processing module successfully interpreted user queries, achieving a ninety-three percent success rate in intent detection and a ninety percent accuracy in entity extraction.

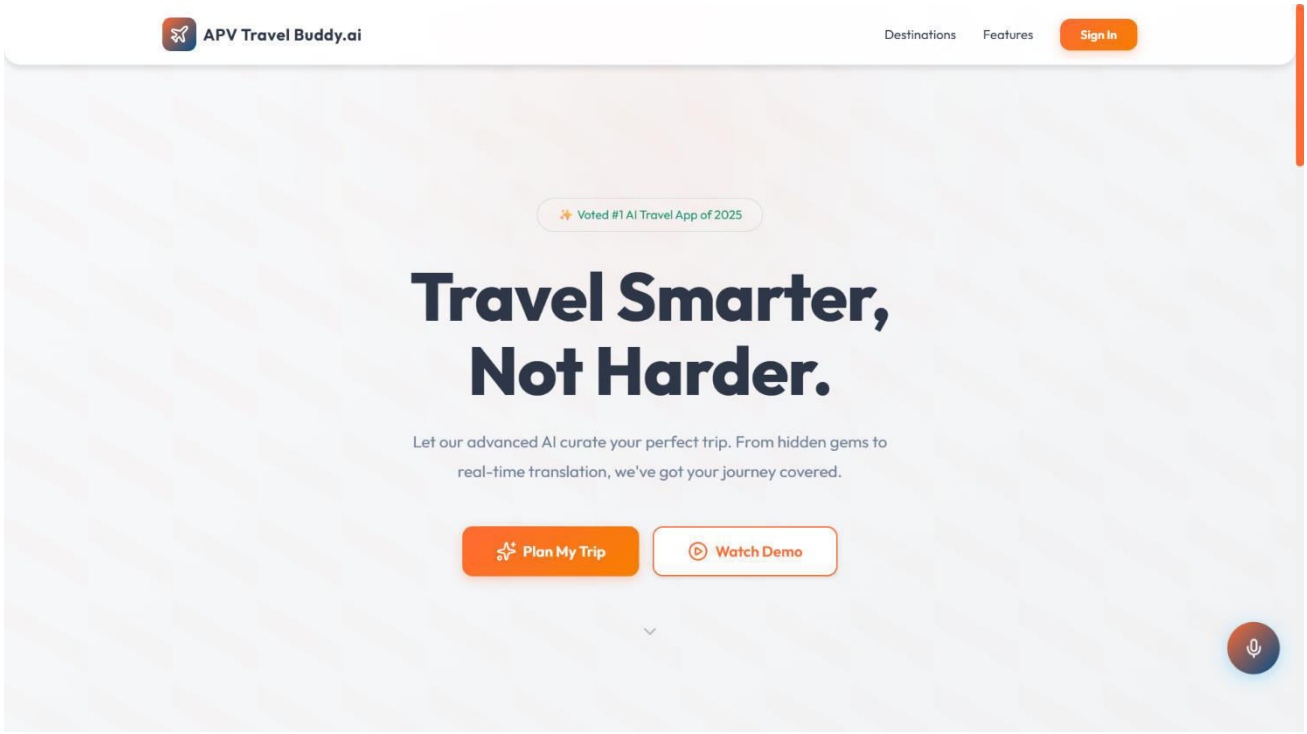


Fig 5.1 Home Page

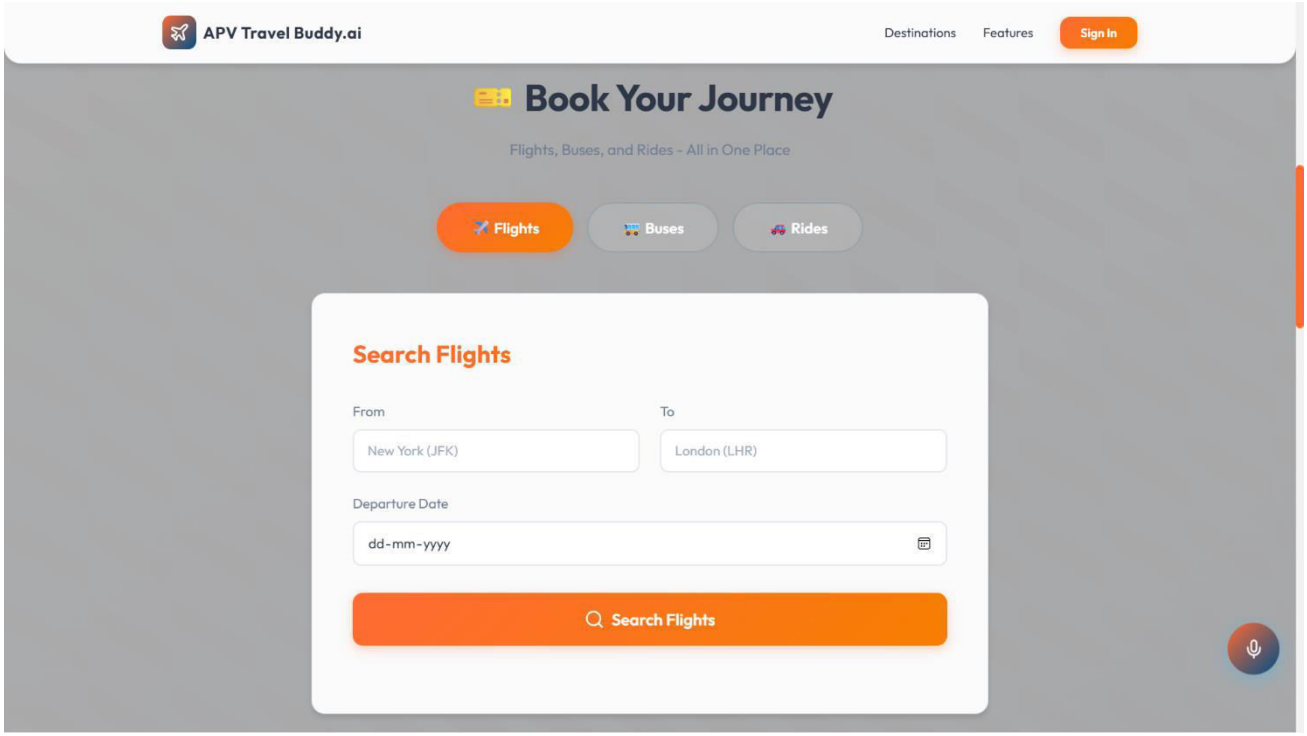


Fig 5.2 Booking Page

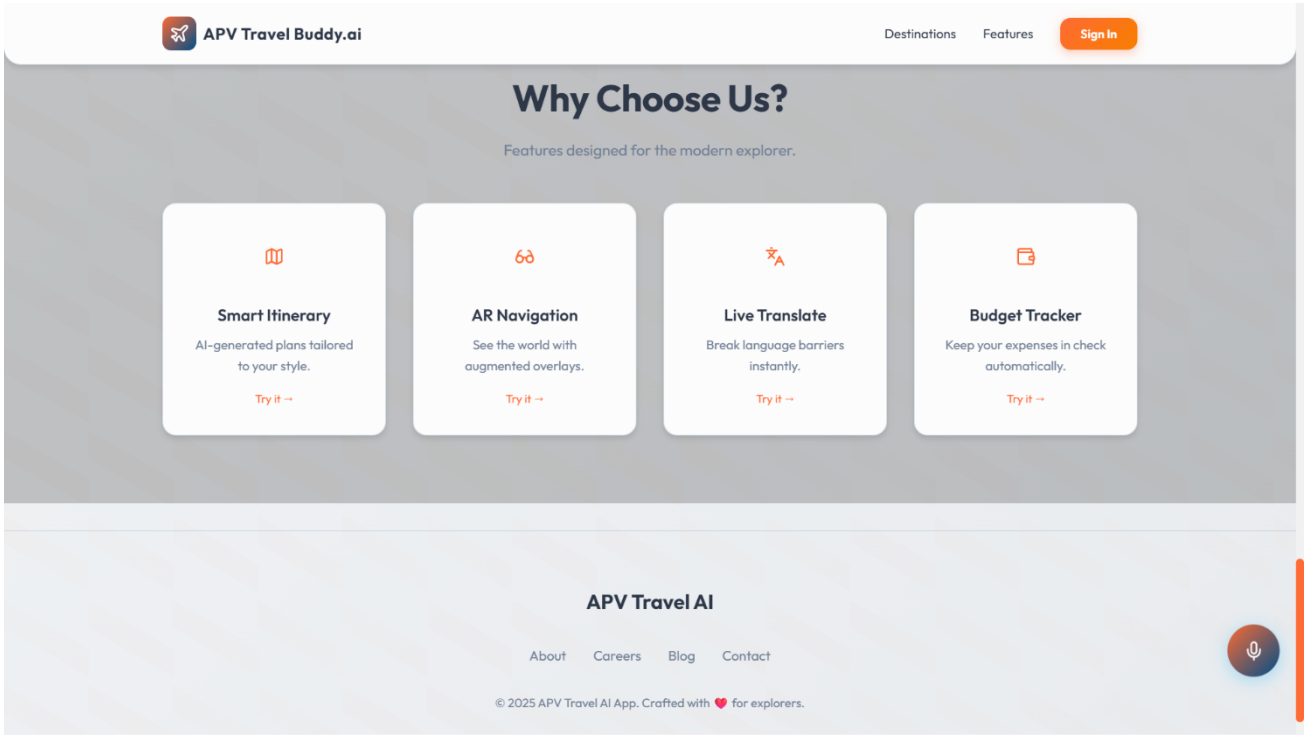


Fig 5.3 Features Oriented Page

VI. CONCLUSION

In conclusion, the AI-Based Travel Companion System represents a significant advancement in the modern travel industry. Through the integration of machine learning, natural language processing, real-time data analytics, and predictive modeling, the system offers a sophisticated and interactive platform for planning and managing travel experiences. The results of this study clearly demonstrate that the system reduces travel planning time, enhances decision-making accuracy, and greatly improves user satisfaction. The system's ability to generate personalized itineraries, predict costs, analyze environmental conditions, and provide dynamic route adjustments makes it an essential tool for today's travelers. Despite limitations relating to data dependency, internet connectivity, privacy concerns, and occasional cultural bias, the overall performance of the system is highly encouraging.

Looking ahead, the incorporation of advanced technologies such as augmented reality, block chain identity systems, emotional computing, and AI-powered virtual avatars will further enhance the system's capabilities. These future developments have the potential to reshape the travel experience entirely, creating a smarter, safer, and more enjoyable journey for users across the globe.

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Fire Extinguisher Robot

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ABSTRACT: This paper presents a comprehensive study detailing the design, implementation, and autonomous operational logic of a Fire Fighter Robot constructed using the Arduino Uno microcontroller platform. The development addresses the critical need for preliminary, low-cost robotic solutions capable of entering hazardous, smoke-filled, or structurally compromised environments to locate and mitigate fire risks without immediate human exposure, thereby significantly enhancing personnel safety. The core functionality of the robot is engineered around a robust sensor-actuator feedback loop, enabling real-time decision-making for both navigation and fire suppression. The system integrates a suite of essential components, including in flame sensors infrared (IR) sensors for accurate obstacle avoidance and wall-following navigation, and multiple strategically placed for effective fire detection and triangulation. Mobility is provided by DC geared motors configured for differential drive, ensuring precise movement within confined spaces. The fire mitigation system consists of a pump and nozzle assembly capable of actively suppressing small fires. The autonomous control logic, implemented as a custom-developed firmware on the Arduino Uno, orchestrates a sequential operational cycle: initially, the robot operates in an Exploration Mode, using IR data to navigate the environment; upon flame sensor activation, it transitions to a Localization Mode, using differential readings from the sensors to calculate the precise bearing and distance of the fire source. Following successful localization, the robot executes a controlled Approach and Positioning manoeuvre, optimizing its distance for effective water application. Finally, in the Suppression Mode, the water pump is activated until the flame sensors confirm the fire is fully extinguished, after which the robot reverts to the Exploration Mode to search for secondary hazards. This research validates the utility of the Arduino platform for creating an effective, modular, and reproducible hazard-responsive control system suitable for rapid prototyping and educational purposes. The findings lay the essential groundwork for integrating more advanced capabilities in future iterations, such as thermal mapping and wireless telemetry for command and control. This project demonstrates a successful fusion of basic robotics, embedded programming, and sensor technology to create a practical, autonomous agent for initial fire safety response.

I. INTRODUCTION

Robotics has emerged as a transformative technology across numerous sectors, with its application in hazardous environments—particularly firefighting—being critically important. The Arduino Fire Fighter Robot project represents an accessible yet functional solution designed to autonomously detect, locate, and mitigate fire risks without exposing human personnel to immediate danger. This initiative aims to demonstrate the feasibility of an intelligent mobile platform capable of performing real-time environmental analysis and taking decisive action based on sensor input. As fire-related incidents continue to pose threats in residential, industrial, and commercial settings, the need for responsive and efficient robotic systems becomes increasingly evident.

The growing complexity of modern urban and industrial environments necessitates robotic systems that can navigate confined or obstructed spaces while precisely locating heat sources. In this project, the robot is built upon the Arduino Uno microcontroller, selected for its ease of programming, widespread component availability, and robust input/output capabilities. These characteristics make it an ideal platform for both educational environments and rapid prototyping. The system's intelligence is primarily derived from the interpretation of data gathered by its sensing apparatus—a trio of Infrared (IR) flame sensors—which forms the foundation of its autonomous navigation and fire-detection logic.

The design of the robot integrates three main functional blocks: sensing, locomotion, and actuation (extinguishing). The three IR sensors are connected to the Arduino's analog input pins, providing crucial directional feedback by measuring the intensity and proximity of thermal radiation emitted by a flame. By comparing sensor readings, the robot determines the direction of the heat source and adjusts its movement accordingly.

The locomotion system employs a four-wheeled chassis driven by an L298N Motor Driver Module. This driver enables variable speed control through Pulse Width Modulation (PWM) signals and precise directional control via four digital pins, allowing the robot to maneuver efficiently toward the detected flame. Once positioned, an actuation mechanism—typically a small on board fan or pump—is activated to extinguish the fire. This coordinated integration of sensors, control logic, and mechanical action illustrates how low-cost robotics can be leveraged to address real-world safety challenges, ultimately providing a foundation for more advanced autonomous firefighting systems.

II. LITERATURE REVIEW

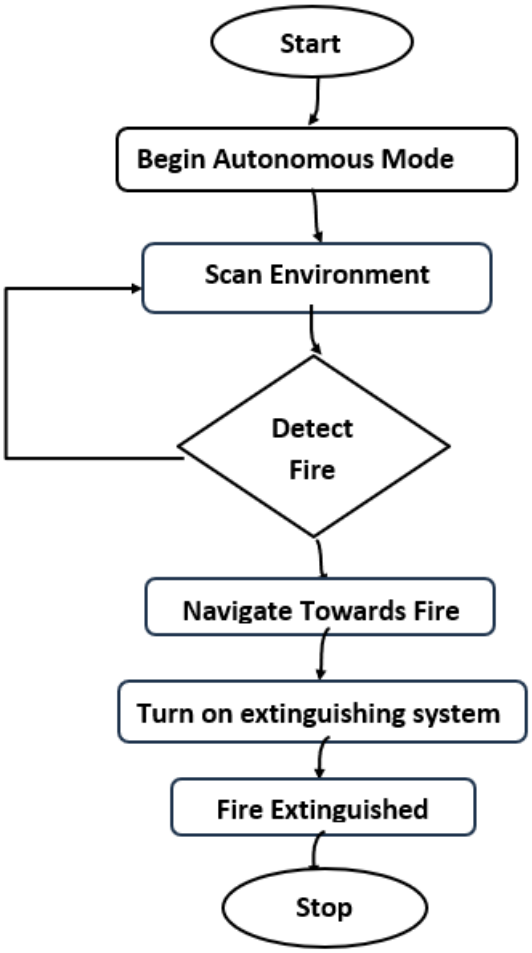
The work by Srinivas and Murthy lays the groundwork by detailing the Design and Implementation of an Autonomous Fire Fighting Robot using Arduino Microcontroller. Their research validates the fundamental architecture, which necessitates the integration of three primary subsystems Sensing using IR sensors for flame detection. Locomotion utilizing motor drivers for controlled movement. Actuation implementing a pump/servo system for targeted extinguishing. [1]

A critical element of the design is the ability to accurately locate the fire source. Hussain and Ahmed address this challenge in their study on Effective Fire Detection and Localization using a Multi-Sensor Array in a Mobile Robot Platform. Their findings directly support and justify the project's strategy of using a multi-sensor array, specifically three directional IR sensors, to accurately determine the angular position of the fire. Furthermore, this research provides the theoretical justification for the threshold-based control logic. By analysing the signals from the multi-sensor array, the robot can determine whether to. Stop (if the fire is cantered). Turn left or right (if the fire is off-centre). Move forward (if the signal is weak but present). [2]

The study by Chaudhary et al. on A Prototype of Smart Fire Fighting Robot based on Arduino provides context for the platform selection. It affirms the Arduino Uno as a suitable and low-cost platform for such safety-oriented, prototyping applications. The Arduino Uno's accessibility, combined with its sufficient processing power and I/O capabilities, makes it an ideal choice for implementing the sensor-to-actuator control logic.[3]

The physical specifications for the robot's movement are validated by technical documents. The Pololu/SparkFun/Generic Distributor Datasheet for DC Gear Motor provides essential metrics like motor voltage, gear ratio, and RPM. These specifications are crucial for engineering the motion control and directly influence the chosen software speed value (e.g., Speed=160), ensuring the motor operates effectively within its physical limits and provides appropriate translational speed for the application.[4]

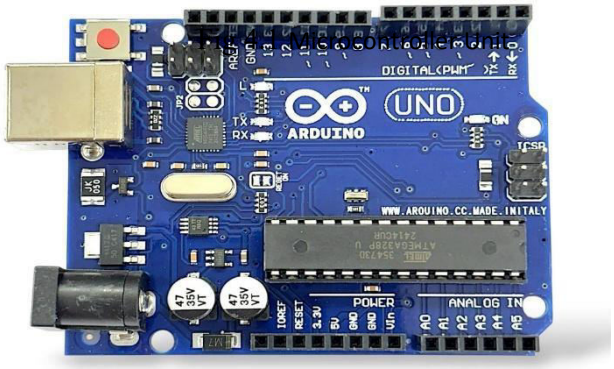
III. METHODOLOGY



IV. MATERIAL SELECTION

When doing a project, it is important to pay attention to the selection of materials. To prevent waste, the items selection process must be carefully welcomed. A precise selection of items is necessary to ensure that they are long-lasting and safe for usage.

4. 1Microcontroller Unit (MCU):



Component: Arduino Uno
Function: Serves as the central brain of the robot, processing data from the flame sensors and executing the control logic (navigation and suppression) by sending commands to the motor driver, servo, and pump.

4.2 Sensing System

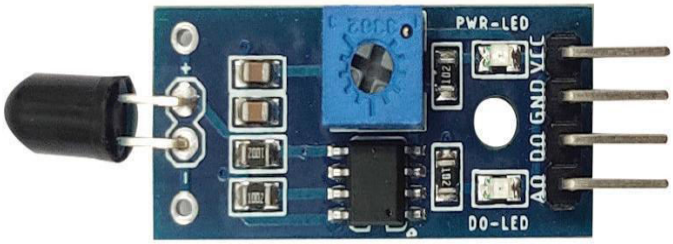


Fig 4.2 sensing system

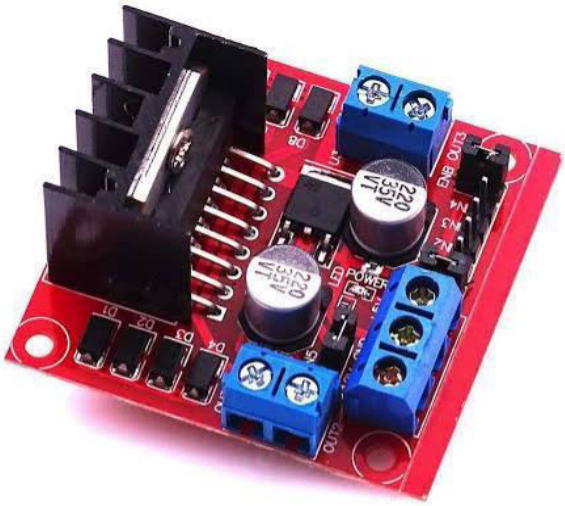
Component: Infrared (IR) Flame Sensors (3 units)
Function: Detects the infrared light signature emitted by a flame. The three sensors—Right Front and Left provide directional data to guide the robot.
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4.3 Locomotion System



Fig 4.3 Locomotion System

Component: DC Gear Motors (4 units)
Function: Provides the mechanical movement for the mobile platform, enabling forward, backward, left turn, and right turn motions.
Details: Four motors are typically used for a four-wheel-drive system, offering stability and power
Component: L298N Motor Driver Module



Function: Acts as an interface between the Arduino's low-power digital signals and the higher current/voltage required to run the DC motors. It controls both the direction and speed of the motors.
Details: This module contains two H-bridges, allowing it to drive two DC motors independently with speed control via PWM pins .

4. 4Extinguishing System (Actuators)

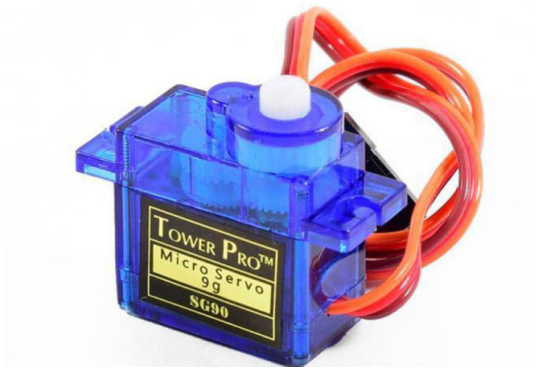


Fig 4.4 Extinguishing System

Component: Servo Motor
Function: Controls the angular position of the extinguishing nozzle, allowing the pump's water stream to be aimed or swept across the fire source.
Details: The servo is connected to Analog Pin and is controlled by the custom servoPulse function, which calculates the required PWM signal based on the desired angle.



Component: Water Pump (with Transistor/Driver Circuit)
Function: Delivers the extinguishing medium (water) onto the detected flame.
Details: The pump is typically a small DC pump unit. It requires a transistor-based driver circuit to be safely controlled by the Arduino, as shown in the circuit diagram. The control signal for this driver comes from Analog Pin

4. 5Power Supply



Fig 4.5 Power Supply

Component: Battery Pack (18650 cells)
Function: Provides electrical power to the entire system, including the Arduino Uno and the high-current components (motors, pump) via the L298N driver.
Details: The system uses batteries, likely rechargeable lithium-ion cells, connected through a switch for system activation

4.6Recharging



Fig 4.6 Recharging

Component: charger (7V to 12 V)
Function: Recharges the battery of the robot.

V. WORKING MODEL

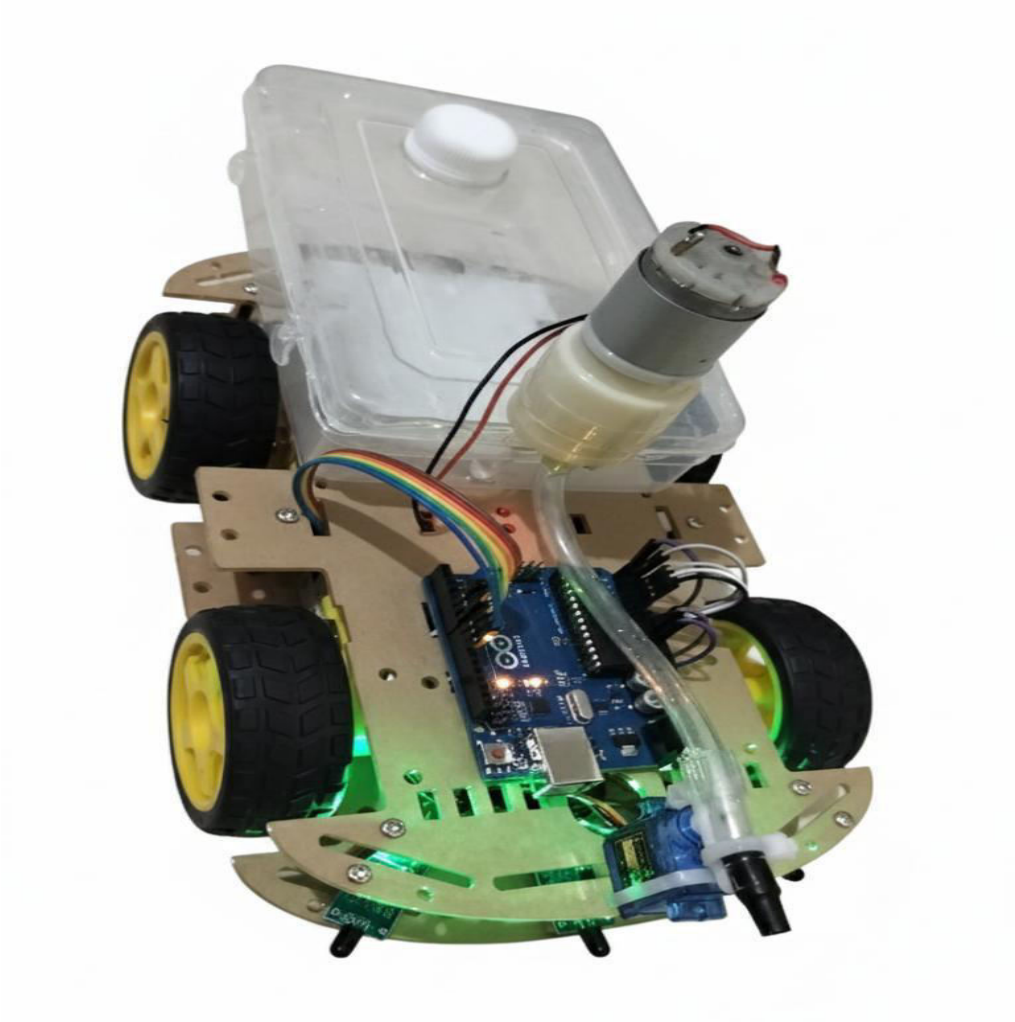


Fig 5.1 Working Model

5.2. Working

The Arduino-based Fire Fighter Robot project successfully demonstrates a low-cost and autonomous solution for detecting and suppressing small-scale fire hazards. By integrating the Arduino Uno with IR flame sensors, DC motors, an L298N driver, a servo motor, and a water pump, the robot establishes a functional closed-loop control mechanism capable of seeking and extinguishing flames. Its strength lies in the clear control logic that prioritizes extinguishing upon close-range detection, supported by directional feedback from strategically placed sensors and precise servo control for aiming the water jet. This prototype effectively showcases core robotics principles such as sensor fusion, autonomous navigation, and real-time decision-making, making it a valuable educational tool for safety-critical applications.

While the design performs well in controlled environments, several improvements could enhance its reliability and versatility in more complex scenarios. Advanced sensors such as ultrasonic modules, UV flame detectors, or thermal cameras could reduce false positives and improve navigation and fire localization. Adding IMU-based localization, mapping, improved water-delivery mechanisms, PID motor control, and wireless communication would enable smoother motion, better situational awareness, remote monitoring, and more efficient extinguishing. With these enhancements, the Fire Fighter Robot could evolve from a functional prototype into a more resilient system capable of operating effectively in dynamic, real-world fire situations.

VI. CONCLUSION

The development of the fire extinguisher robot demonstrates the potential of using an Arduino-based platform to build a practical, low-cost, and autonomous solution for early fire detection and suppression. By integrating flame sensors, motor drivers, DC motors, a servo mechanism, and a water-spraying system, the robot is able to identify the presence and direction of a flame, navigate toward it, and actively attempt to extinguish it. The project highlights essential engineering concepts such as sensor integration, closed-loop control, robotics, and real-time decision-making. It also shows how simple electronic components, when combined with well-structured programming logic, can effectively simulate real-life fire response behavior in a controlled environment.

Overall, this project serves as a strong foundation for further study and innovation in safety-oriented robotics. It proves that even with basic components, a functional and intelligent fire-fighting mechanism can be designed for educational or prototype-level use. With future improvements—such as advanced sensors, obstacle avoidance, wireless monitoring, and more precise actuation—the robot can be transformed into a more reliable and adaptable system capable of operating in more complex and unpredictable scenarios.

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[2] Hussain, I., & Ahmed, K. (Year). Effective Fire Detection and Localization using a Multi-Sensor Array in a Mobile Robot Platform. (Useful for justifying the use of three directional IR sensors and the threshold-based control logic.)
[3] Chaudhary, P., et al. (Year). A Prototype of Smart Fire Fighting Robot based on Arduino. (Provides context on using Arduino Uno as a suitable low-cost platform for such safety-oriented application.
[4] Pololu/SparkFun/Generic Distributor Datasheet for DC Gear Motor (Provides specifications for motor voltage, gear ratio, and RPM, which influence the chosen speed value Speed=160.)

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Fire Detector System

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ABSTRACT: Fire is a chemical process between heat, oxygen and fuel, every year fires cause environmental and human loss. Fire accidents are increasing every year around the world, and India is not out of it. Every year fire causes loss of life and property damage. Controlling fire is essential to reduce all these fire-related accidents. Therefore, proper fire control planning and the development of a fire detection system are required first. If the source of the fire is known in a very short time, it is possible to repair the damage. In this case, sensor technology-based fire alarms, Smoke detectors, and heat detectors can be used. The use of IoT technology can control fires more quickly even without being present in these cases. This paper will discuss the advantages of various sensors, fire alarms, and network techniques used in fire detection using IoT.

I. INTRODUCTION

Fire is a chemical reaction that is made up of three elements oxygen, heat, and fuel respectively. I have tried to show in my research paper that if we can predict fire through sensor technology then it is possible to take measures to fight fire quickly. As essential as fire is to the advancement of human life, accidental fires are also very dangerous, fire accidents are increasing day by day even in a densely populated country like India. Every year many people and livestock die due to fire and a lot of property is damaged. According to National Crime Records Bureau report in the year 2019- Fire cases were registered at 11,037 and deaths at 10,915. In 2020 fire cases registered 9,329 and deaths 9,110. So, from these statistics, it can be said that around 50 people die every day in 1 Subhankar Sarkar, Maulana Abul Kalam Azad University of Technology (Formerly known as W.B.U.T). Haringhata, Kalyani, Nadia, West Bengal.92 Disaster & Development, Vol. 12, Issue 02, July to December 2023 India due to fire-related accidents. The fire spreads rapidly over time therefore, quickfire detection is necessary to control the fire. Fire control can be done faster using a smart fire detection system and IoT. The population in rural and urban areas is increasing day by day, as a result, new buildings are being constructed, resulting in increasing pressure on public transport, electricity, and food. Pressure on the environment is also increasing. In this situation, natural calamities are increasing, along with incidents like fire and loss of life. In old fire detection systems, there is a problem in detecting fires quickly. So smart fire detection system is required to avoid fire accidents. Some automatic sensor technology, Wireless sensor networks, electronic devices, software, and IoT devices are also required. Here the fire alarm system means when a situation like a hit or wash or fire is created in a place so that an alarm can be alerted. So that life can be saved from the fire. In earlier days, manpower was used for fire detection, but even today this system is used in several public places. In some areas old fire alarm was used. However, due to the introduction of many sensor device technologies, fire detection has become more convenient. I am going to show that in this paper, in the Internet of Things some smart devices, wireless sensor networks, and sensor technologies are connected to send a warning message to the user and take measures to quickly detect the fire. So that life and property can be saved along with vigilance. Here the user can know the situation of a building or place throught SMS or Email, and can control if it is necessary. This message will be sent to the user at specified intervals. For pre-fire situation monitoring from a control room, I have tried to highlight in this paper, that I have shown the complete work on the online simulator platform using tinkercad.com. Also in this research paper, the concept of a control room is given.

II. LITERATURE REVIEW

Fire detection and prevention systems have evolved significantly with advancements in sensor technology, wireless communication, and Internet of Things (IoT) platforms. Several researchers have contributed to the development of smart fire detection solutions aimed at minimizing loss of life and property.

Early fire detection technologies primarily relied on ionization and photoelectric smoke sensors, both of which detect particulate matter generated by combustion. Ionization detectors, as described by various studies, are more responsive to fast-flaming fires due to their ability to detect small black soot particles created during rapid combustion. Photoelectric detectors, on the other hand, are more sensitive to larger light-colored particles produced in slow-smoldering fires. According to NFPA guidelines, the combination of both technologies provides optimal fire detection performance and reduces the likelihood of false alarms [1].

With increasing urbanization and industrialization, traditional detection systems have proven insufficient in responding rapidly to complex fire scenarios. This prompted researchers to explore sensor-integrated systems using microcontrollers such as Arduino, which enable real-time monitoring of environmental parameters including temperature, smoke, gas concentration, and motion. Arduino-based designs described in prior studies demonstrate the effectiveness of multi-sensor integration in achieving quicker and more accurate detection. These systems offer flexibility, low development cost, and ease of customization, making them suitable for public infrastructure such as malls, metro stations, and multi-storey buildings [2].

Recent literature highlights the significance of Wireless Sensor Networks (WSN) in remote monitoring. WSNs enable multiple nodes to collect and transmit data through a decentralized and infrastructure-less network. According to researchers, these networks support continuous monitoring and reliable communication between sensors, base stations, and end users. The use of cloud platforms further enhances data accessibility, allowing users to receive notifications via email or SMS [3].

Another major area of research involves integrating IoT technologies into fire detection systems. IoT-enabled devices improve system responsiveness by transmitting sensor data over the internet, enabling remote control and real-time decision-making. Studies have shown that IoT-based fire detection reduces human dependency, increases automation, and facilitates early fire control measures. This technology also plays a key role in creating smart surveillance systems, where multiple parameters—such as heat, smoke, gas leakage, and water level—are monitored from a single control room [4].

Multiple works also discuss challenges faced by existing fire detection systems such as false alarms caused by dust, cooking smoke, or environmental fluctuations. Modern research focuses on developing algorithms and sensor calibration methods that differentiate between nuisance particles and real fire smoke, thereby increasing accuracy and reliability [5].

Overall, the literature emphasizes that combining traditional detection principles with modern IoT systems, WSN, and multi-sensor data fusion can significantly enhance fire detection accuracy. The progression toward automated, remote-controlled, and integrated systems marks an essential shift toward smarter disaster prevention technologies. Researchers collectively agree that the future of fire safety lies in intelligent systems that continuously monitor critical parameters, ensure rapid response, and minimize accidental fire hazards.

III. METHODOLOGY

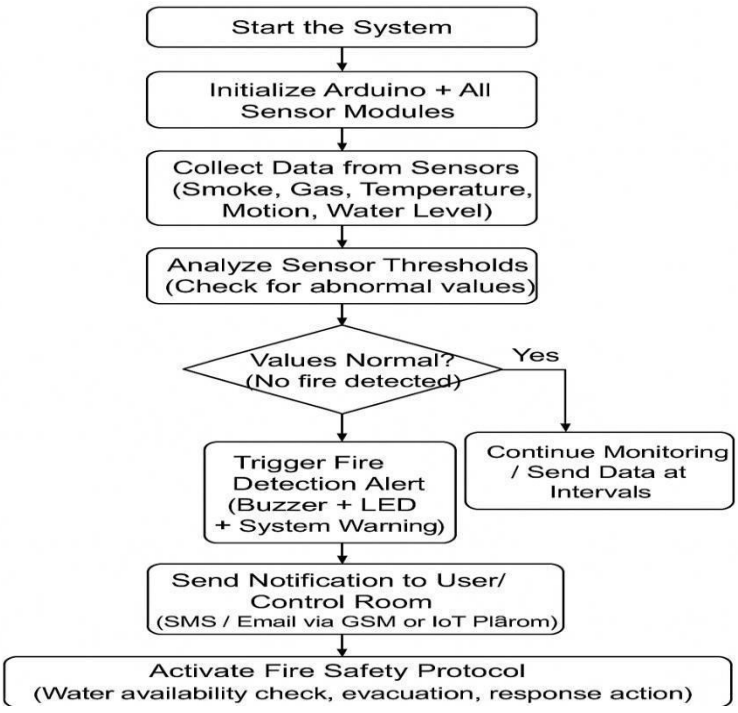


Fig 3.1: Methodology

IV. MATERIAL SELECTION

The materials and components for the Fire Detector System were selected based on factors such as accuracy, sensitivity, reliability, cost-effectiveness, compatibility with Arduino, and ease of integration with IoT platforms. The selected materials ensure efficient detection of smoke, temperature variation, gas leakage, and human presence while supporting wireless communication for real-time alerts.

4. Arduino Microcontroller

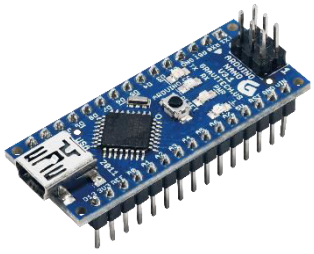


Fig 4.1 Arduino Microcontroller

This microcontroller was selected because, it acts as the central processing unit, Supports multiple analog and digital inputs, and is easy to program and compatible with various sensors.

4. MQ-2 Smoke Sensor



Fig4.2 MQ-2 Smoke Sensor

The purpose of the smoke sensor selection because, High sensitivity to smoke and flammable gases, Fast response time, widely used in fire and gas detection systems.

4.3 DS18B20 Temperature Sensor

This provides accurate temperature readings. It is useful for detecting sudden temperature changes related to fire.

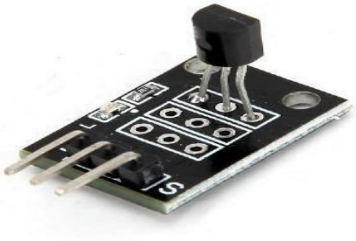
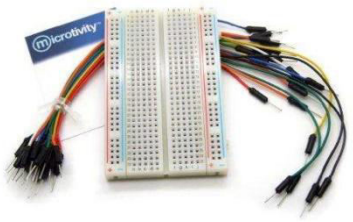


Fig 4.3 DS18B20 Temperature Sensor

4.4 Breadboard and Jumper Wires



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Fig 4.4 Breadboard and Jump wire

It is useful for prototyping without soldering, it also allows quick modifications during testing and simulation and provides secure connections for multiple sensors.

4.5 Buzzer / Alarm Unit

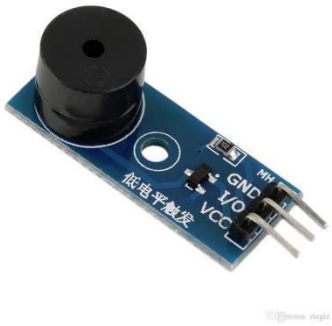


Fig 4.5 Buzzer / Alarm Unit

It Produces audible alerts during fire detection also, Immediate local warning for occupants, Low power requirement and easy to interface.

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V. RESULTS AND DISUSSION

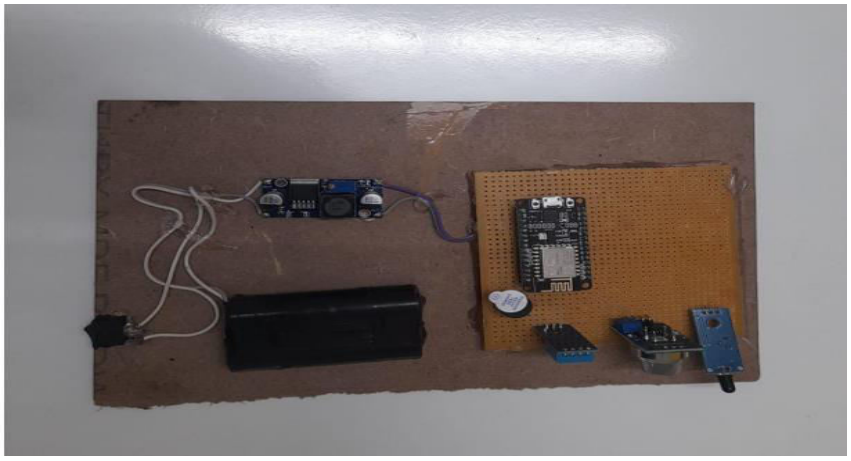


Fig 5.1 Working Model

5.2 Working principle

First, there are ionization detectors. These use a small bit of safely shielded radioactive material that electrically charges, or ionizes, the air molecules between two metal plates. This produces a small electric current flowing from one plate to the other in the air. When particles enter the chamber, they attract the ions and carry them away, reducing the current. When the number of particles entering the chamber is enough to reduce that current below a certain amount, the device will register those particles as smoke and the alarm will sound. (And about that radioactive material? Most of its radiation is blocked inside the device, and even then, the radiation levels in the device are much lower than the natural background radiation to which we are exposed every day.) The other type of commonly used detection technology is called photoelectric. This technology works by detecting light that is reflected off particles from a light beam inside the sensing chamber. When no particles are present in the sensing chamber, the light from the beam does not strike the light detector, indicating all clear. When there are particles present and the amount of light registered by the light detector reaches a certain threshold level, the alarm sounds. Smoke swirls around a white smoke detector on a ceiling. Credit: Nikkytok/Shutterstock Both kinds of detectors can detect either slow-burning "smoldering" fires or fast-burning "flaming" fires, but each technology has its particular strengths. Ionization-based alarms tend to detect small black soot particles from flaming fires more quickly because they are produced in greater numbers and take away more current from between the plates. Photoelectric detectors tend to be more sensitive to particles that are larger in size and white or light-colored, and thus more reflective, like those emitted by smoldering fires.The NFPA advises that people have both ionization and photoelectric units in their homes. And dual-sensor alarms that combine both technologies are also available. As important as smoke alarms are for protecting your family and your property, many times they can be a nuisance. Smoke alarms near kitchens can detect the particles coming off your food as it cooks, even if you don't burn it. Sometimes something as simple as turning on a toaster can set them off.

VI. CONCLUSION

This research paper of mine has been prepared mainly to reduce fire accidents and reduce the severity of the fire This paper shows that all the monitoring especially, detailed information about motion, temperature, gas, and water storage can be found in one place. If there is any warning in the information received then we can send the fire control unit from the control room. Alarms can also be sounded and people can be evacuated from dangerous places to safe places. Also, after receiving this alert, we know whether there is enough water for firefighting, so, if necessary, we can start early firefighting with our trained personnel for rescue operations and using stored water.

As a result, we can save lives and reduce property losses and we don't need multiple computers, only the computer on which this system is installed, we can take action as needed by sitting in the control room and seeing the relevant information. It can also be said that accident prevention does not always require the monitoring of computers or other devices. All sensor devices are connected through an Arduino board and it sends data to the computer at regular intervals if there is any problem somewhere we can know it through an alarm or notification. By using this method, we can prevent fire or other fire-related accidents in places like multi-storage buildings hospitals, shopping malls, or metro stations. The result section contains information about fire alerts in the form of an email or SMS. Besides, the role of a control room in monitoring the fire detection system is also discussed. What else can be done with fire detection techniques in the future is also highlighted in this research paper. If the model of my research paper is implemented, the work of fire detection system

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Flood Water Harvesting

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ABSTRACT: Flood Water Harvesting is an essential and sustainable approach to managing excessive rainwater, reducing the impact of floods, and ensuring better utilization of natural water resources. This project presents a detailed small-scale working model that demonstrates how floodwater can be effectively captured, stored, and reused for practical purposes such as irrigation, groundwater recharge, and domestic needs. The study explores the environmental benefits of harvesting floodwater, including reduced soil erosion, improved water conservation, and enhanced ecosystem stability. It also highlights the social advantages, such as increased community awareness, improved water security, and reduced dependency on external water sources. Economically, floodwater harvesting offers long-term savings by minimizing the costs associated with flood damage and by providing a reliable supply of water during dry seasons. The project evaluates the efficiency of the model by analyzing storage capacity, filtration effectiveness, and the rate of water collection. Based on these observations, several improvements are suggested for larger-scale implementation, including expanding storage structures, adopting advanced filtration techniques, and involving local communities in maintenance. To strengthen the practical relevance of the project, case studies of successful floodwater harvesting systems from various regions are included. These examples demonstrate real-world applications, inspire innovation, and emphasize the importance of sustainable water management and environmental responsibility.

I. INTRODUCTION

Floods are among the most destructive natural disasters worldwide, affecting millions of people every year and causing widespread human, economic, and environmental losses. In India, floods pose a recurring challenge, particularly during the monsoon season. They disrupt agriculture, destroy standing crops, displace communities, damage roads and bridges, and weaken essential infrastructure. Over the past few decades, rapid urbanization, deforestation, encroachment on natural water bodies, and inadequate urban planning have significantly increased both the frequency and severity of flooding. As cities expand, natural drainage channels are blocked or replaced by concrete surfaces that prevent rainwater from percolating into the ground. As a result, even moderate rainfall can lead to waterlogging, drainage overflow, and localized flooding.

Historically, India relied on traditional water harvesting systems such as step wells, tanks, ponds, and check dams. These structures were designed to capture and store rainwater, reduce runoff, and recharge groundwater aquifers. They played a crucial role in maintaining ecological balance and ensuring water availability, especially in drought-prone regions. However, with modernization and changing lifestyles, many of these systems have been neglected or replaced, leading to a decline in natural water conservation practices.

Flood Water Harvesting emerges as a sustainable and practical solution to these challenges. By capturing excess floodwater and storing it for later use, this technique reduces runoff, minimizes flood-related damage, and helps replenish groundwater resources. This project presents a detailed small-scale model that demonstrates the basic principles of floodwater harvesting. The model simulates real-world scenarios by showing how water can be diverted, filtered, stored, and utilized efficiently. Using simple and affordable materials, the model illustrates practical methods such as constructing collection channels, using storage tanks, incorporating filtration layers, and regulating water flow.

Beyond its technical aspects, the project also emphasizes public awareness and education. It serves as a learning tool for students, communities, and policymakers, highlighting the importance of sustainable water management in the face of climate change and urban growth. By showcasing feasible techniques that can be replicated at larger scales, the project encourages communities to adopt floodwater harvesting as a proactive measure to reduce disaster risks and ensure long-term water security.

II. LITERATURE REVIEW

Flood Water Harvesting has gained significant attention in recent decades due to rising concerns about climate change, rapid urbanization, and increasing water scarcity. Several studies highlight the importance of capturing excess floodwater as a means of reducing flood damage while enhancing water availability during dry periods. According to Mishra and

Singh (2018), floodwater harvesting systems can significantly reduce surface runoff and help regulate flood peaks, making them an essential part of integrated water resource management.[1]

Historically, traditional Indian water systems—such as *baolis* (step wells), tanks, and earthen embankments—played a crucial role in storing rainwater and managing seasonal floods. Agarwal (2001) documents how these systems supported agriculture and maintained ecological balance before modern infrastructure replaced them. Contemporary studies emphasize the need to revive and modernize such practices to respond effectively to changing climatic conditions.[2]

Research by Sharma et al. (2015) demonstrates that small-scale floodwater harvesting structures, including check dams and percolation tanks, contribute significantly to groundwater recharge. Similarly, urban studies by Gupta (2020) suggest that incorporating harvesting systems into city planning can reduce waterlogging, improve drainage efficiency, and enhance urban resilience.[3]

Technological advances have also influenced floodwater harvesting. Recent models incorporate sensors, filtration units, and smart drainage systems to monitor water flow and improve storage efficiency (Kumar & Rao, 2021). These innovations make harvesting more adaptable to urban environments where space is limited and rainfall patterns are unpredictable.[4]

Case studies from Rajasthan, Maharashtra, and parts of Southeast Asia show positive socio-economic impacts, including improved agricultural productivity, reduced disaster-related losses, and strengthened community participation. Researchers consistently highlight community involvement as a key factor in the long-term success of such systems.[5]

Overall, existing literature emphasizes that floodwater harvesting is not just a flood mitigation technique but a holistic approach to sustainable water management. By integrating traditional knowledge, scientific principles, and modern technology, floodwater harvesting can address multiple environmental challenges while supporting climate resilience and water security.[6]

III. METHODOLOGY

[START]
↓
[Identify Flood-Prone Area]
↓
[Analyze Runoff]
↓
[Design Structure]
↓
[Construct System]
↓
[Ensure Water Quality]
↓
[Maintain & Monitor]
↓
[STOP]

Fig 3.1 Flow Chart

IV. MATERIAL SELECTION

When doing a project, it is important to pay attention to the selection of materials. To prevent waste, the items selection process must be carefully welcomed. A precise selection of items is necessary to ensure that they are long-lasting and safe for usage.

4.1 PVC pipe



Fig 4.1 PVC pipe

They act as channels that guide excess rainwater or floodwater from collection points to storage structures, filtration units, and recharge zones.

4.2 UPVC pipe



Fig 4.2 UPVC pipe

Vertical PVC downpipes carry water from elevated surfaces. Horizontal PVC pipes help guide surface runoff toward a central harvesting area.

4.3 Plastic Sheet



Fig 4.3 Plastic Sheet

Plastic sheet prevent water from seeping into the ground or leaking out. This helps store water efficiently and makes the model function clearly.

4.4 Aluminum foil



Fig 4.4 Aluminium foil

Aluminium foil is used as waterproof layer inside, it prevents water from leaking out of the model, ensuring efficient storage.

4.5 Cardboard box



Fig 4.5 Cardboard Box

A cardboard box is often used as the foundation of the entire project. It provides a sturdy platform to place all components. It allows viewers to clearly see how water is guided toward harvesting units.

V. RESULTS AND DISCUSSION



Fig 5.1 Working Model

5.1 Working principle

The project begins with the preparation of a strong and stable base using a mixture of cement, sand, and gravel. This foundational layer is essential to ensure that the model can withstand continuous water flow without collapsing, eroding, or shifting. A solid base allows the system to remain stable even during repeated simulations of rainfall or floodwater flow. Once the base has set and achieved sufficient strength, walls and channels are constructed using materials such as plywood, Jali, and wall coating. These structures serve multiple purposes: they guide water efficiently toward the collection box, prevent overflow from spreading across unwanted areas, and replicate scaled-down versions of real-world flood management structures, such as riverbanks, urban drainage channels, and protective barriers used in flood-prone regions. Proper construction of walls and channels is critical for directing water flow in a controlled manner, demonstrating the principles of water management in a tangible way.

At the lowest point of the model, a storage or collection box is installed to accumulate harvested water. This box is designed with small doors that allow easy inspection, cleaning, and removal of stored water when needed. Before reaching the storage box, water passes through layers of gravel and Jali, which serve as a basic filtration system. This setup removes debris and particulate matter, demonstrating how harvested floodwater can be purified for potential reuse or for recharging groundwater. The filtration system illustrates one of the key environmental benefits of flood water harvesting: reducing contamination while making water available for practical use.

To simulate rainfall, water is poured into the model, and careful observations are made regarding flow patterns, storage capacity, and overflow management. Regular maintenance is emphasized to ensure the system continues functioning efficiently. This includes clearing debris from channels, cleaning filtration layers, and checking the storage box for blockages. Through these steps, the model effectively demonstrates the principles of flood water harvesting, highlighting the importance of careful design, proper construction, and consistent upkeep for sustainable water management.

VI. CONCLUSION

Floodwater harvesting is an increasingly important method for promoting sustainable water management, particularly in regions prone to heavy rainfall and seasonal flooding. By capturing excess rainwater and directing it into storage or recharge systems, floodwater harvesting not only reduces the risk of waterlogging and flood damage but also provides a reliable source of water during dry periods. This project demonstrates a small-scale model designed to illustrate how floodwater can be collected, filtered, and stored efficiently using simple materials and practical techniques. The model provides a hands-on understanding of how water flows through channels, passes through filtration layers, and is eventually stored for later use or groundwater recharge.

The small-scale model serves as a valuable educational tool, helping students and communities visualize the principles of floodwater harvesting and the benefits it can bring. Through this project, observers can study flow patterns, understand the role of filtration in improving water quality, and learn about storage techniques that prevent wastage or contamination. The system also highlights the importance of proper planning, design, and maintenance to ensure maximum efficiency and sustainability.

Beyond its educational value, floodwater harvesting offers significant environmental, social, and economic advantages. It reduces soil erosion, supports agricultural productivity by providing supplemental irrigation, and helps maintain groundwater levels. On a larger scale, similar systems can mitigate the impact of urban flooding, protect infrastructure, and enhance community resilience against climate variability. By demonstrating these concepts through a practical model, this project emphasizes the relevance of sustainable water management practices, encourages innovation, and fosters awareness about water conservation, flood mitigation, and responsible environmental stewardship.

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Smart Water System

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ABSTRACT: Water usage is essential for improving plant growth and reducing wastage in small-scale agricultural and Efficient household gardening systems. This project presents a simple Smart Water System designed to regulate the amount of water delivered to plants using an adjustable nozzle connected to a water tank. The system allows users to control the water flow according to the specific requirements of different plants, ensuring precise and uniform irrigation. By manually adjusting the nozzle setting, the system provides a low-cost and easy-to-implement method for targeted watering without the need for complex electronics or automation. The proposed design reduces unnecessary water loss, enhances irrigation efficiency, and offers a practical solution for gardeners and small farms seeking a sustainable and user-friendly watering technique. This approach demonstrates that even simple mechanical adjustments can contribute to smarter water management and improved plant health. This research paper presents the design and implementation of a Smart Watering System aimed at optimizing water usage in agricultural and domestic plant-care applications. The system integrates sensors, microcontrollers, and automated control mechanisms to monitor real-time soil moisture levels and regulate water supply accordingly. By utilizing soil-moisture sensors, temperature and humidity modules, and a programmable microcontroller, the system ensures that plants receive the required amount of water only when necessary, thereby reducing manual intervention and preventing both overwatering and water scarcity. The proposed system also incorporates wireless communication features that allow users to view environmental data and control irrigation remotely through a mobile or web interface.

The primary objective of this research is to develop a cost-effective, energy-efficient, and user-friendly solution that promotes sustainable water management. Experimental results demonstrate that the smart watering system significantly improves water conservation, enhances plant health, and reduces maintenance efforts compared to traditional irrigation methods. This work highlights the potential of integrating IoT and sensor technologies to create intelligent agricultural solutions capable of addressing global water-management challenges.

I. INTRODUCTION

Water is one of the most essential resources for plant growth, yet in many small-scale farms and household gardens, water is often wasted due to inefficient and uncontrolled irrigation methods. Traditional watering practices, such as using buckets or unregulated pipes, deliver uneven amounts of water to plants, leading to overwatering, under watering, and unnecessary water loss. To address this problem, simple and cost-effective solutions are needed that allow users to control how much water each plant receives without relying on complex or expensive systems.

This project presents a simple Smart Water System designed to improve irrigation efficiency by using an adjustable nozzle attached to a water tank through a pipe. By manually setting the nozzle opening according to the water requirement of each plant, the user can regulate the water flow in a more precise and controlled manner. This approach ensures that each plant receives the appropriate amount of water based on its needs, helping to conserve water while supporting healthier plant growth. The system is easy to install, user-friendly, and ideal for small gardens, farms, and home irrigation setups. Through this project, the importance of simple mechanical adjustments in achieving smarter water management is demonstrated**.**

Water is one of the most essential resources for agricultural productivity, yet it is often mismanaged due to inefficient and traditional irrigation practices. As global water scarcity continues to rise, there is an urgent need for sustainable, automated systems that can optimize water use while maintaining healthy plant growth. The rapid advancement of sensor technology, microcontrollers, and Internet of Things (IoT) platforms has enabled the development of intelligent solutions that monitor environmental conditions and make data-driven decisions. A Smart Watering System utilizes these technologies to automate irrigation based on real-time soil moisture, temperature, and humidity measurements. By delivering water only when required, such systems help minimize wastage and prevent issues related to overwatering or underwatering. This research aims to design and implement a cost-effective, reliable, and user-friendly smart irrigation model suitable for both small-scale and large-scale applications. The introduction also highlights the significance of integrating automation into agriculture, improving resource efficiency, and reducing manual labor. Through this project, we explore how smart irrigation systems can contribute to sustainable water management and enhance overall agricultural productivity.

II. LITERATURE REVIEW

Efficient irrigation systems have been widely studied as a method to improve water use in agriculture and gardening. According to previous research, traditional irrigation techniques such as manual watering or open hose systems often lead to uneven distribution of water, excessive runoff, and wastage. Researchers highlight that many plants receive more water than required due to a lack of flow control, resulting in reduced soil aeration and nutrient loss. These findings emphasize the need for simple systems that allow better control over water distribution [1].

Studies on low-cost and small-scale irrigation devices show that adjustable mechanical components—such as nozzles, drip emitters, and micro-sprinklers—play a significant role in improving water efficiency. Adjustable nozzles allow users to regulate flow rate and water pressure manually, enabling precise delivery of water based on plant requirements. Literature suggests that such systems are ideal for home gardens, nurseries, and small farms because they provide targeted watering without the need for advanced sensors or electronic control units [2].

Research on gravity-fed irrigation systems also supports the effectiveness of using an elevated water tank and controlled outlet mechanisms. These systems rely on natural water pressure and simple valves or nozzles to manage flow, making them suitable for areas with limited resources or inconsistent electricity supply. Several studies indicate that gravity-based systems reduce operational costs, require minimal maintenance, and enhance uniform water distribution when coupled with adjustable outlets [3].

Other researchers have explored the importance of plant-specific irrigation, noting that water requirements vary depending on plant species, soil type, and growth stage. Manual adjustment mechanisms, such as the nozzle used in this project, enable users to customize water output, leading to healthier plant growth and improved water conservation. Literature on sustainable irrigation practices consistently recommends such adaptable and user-friendly designs as effective alternatives to automated smart systems, especially in low-budget environments [4].

significantly reduce water wastage and improve irrigation accuracy. This project builds on these principles by developing a practical and cost-effective Smart Water System that uses a manually adjustable nozzle connected to a water tank to deliver water by observing specific requirement of the plant [5].

III. METHODOLOGY

The methodology for this Smart Water System focuses on designing a simple, low-cost, and manually adjustable irrigation mechanism that ensures controlled water delivery to plants. The following steps outline the process used to develop and test the system:

3.1 System Design

The system consists of a water tank, a PVC pipe connected to the tank outlet, and an adjustable nozzle fixed at the end of the pipe. Gravity is used as the primary source of water pressure, making the design energy-efficient and suitable for small-scale use.

3.2 Material Selection

Materials were chosen based on availability, durability, and cost-effectiveness. Water tank (any standard household tank) PVC or flexible pipe for water flow. Adjustable nozzle for changing water flow rate. Connectors and clamps for sealing joints. These components ensure the system is easy to install and maintain.

3.3 Assembly of the System

The pipe was securely attached to the tank's outlet using appropriate connectors to prevent leakage. The adjustable nozzle was fixed at the pipe's open end. The tank was placed at a height to allow gravity-based water flow. All joints were checked for proper sealing to ensure consistent flow.

3.4 Nozzle Adjustment Mechanism

The nozzle plays a crucial role in controlling the water output. During testing, the nozzle opening was adjusted to create different flow levels suitable for various plants. This step helped determine the range of flow rates that could be achieved manually without additional equipment.

3.5 Testing of Water Flow

The system was tested by watering different types of plants. The flow rate was changed by adjusting the nozzle. Observations were made regarding: Water coverage, Uniformity of distribution, Suitability for plant type , Water wastage reduction. This phase helped evaluate how effectively the nozzle adjustment could customize water delivery.

3.6 Evaluation of Efficiency

The performance of the system was assessed based on: Reduction in water wastage compared to traditional methods, Ease of manual operation, Consistency of water flow Suitability for different plants

IV. MATERIAL SELECTION

The materials for this Smart Water System were chosen based on availability, cost-effectiveness, durability, and suitability for the irrigation system. The main components include:

4.1 Water Tank



Fig:4.1 Water Tank

Acts as the primary water storage unit. Size can vary depending on garden or plant requirements. Material: Plastic or fiberglass, which is lightweight, durable, and corrosion-resistant.

4.2 Flexible Pipe

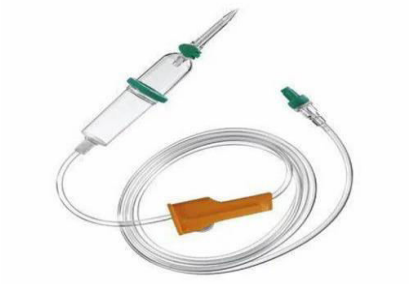


Fig:4.2 Flexible pipe

Ensures smooth water flow from the tank to the plant.Material: PVC or flexible plastic pipe, chosen for affordability and easy installation.

4.3 Adjustable Nozzle



Fig:4.3 Adjustable Nozzle

Controls the flow rate and water pressure delivered to the plants. Enables users to manually regulate water according to plant requirements. Material: Plastic or metal nozzle for durability.

4.4 Connectors and Clamps

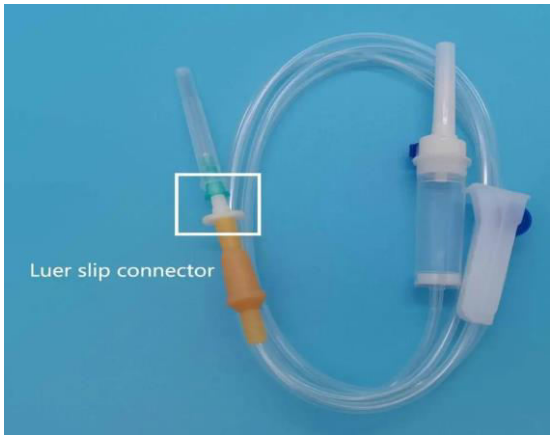


Fig:4.4 Connectors and Clamps

Used to securely attach the pipe to the tank and nozzle. Prevents leakage and ensures stability of the system. Material: Plastic or metal.

4.5 Sealant / Tape / Miscellaneous Items



Fig :4.5 Sealant / Tape/ Miscellaneous Items

Ensures water-tight joints and prevents leakage. Includes plumber's tape, rubber washers, or silicone seala

V. RESULT AND CONCLUSION



Fig 5.1 Working Model

5.1 Working principle

The smart water system works by using a water tank as the main storage and a saline pipe as a transparent water flow channel. The saline pipe allows water to move easily from the tank to the desired location while giving a clear visual indication of the flow.

When water is filled into the tank, gravity creates pressure that pushes the water down through the saline pipe. As soon as the tap or outlet at the end of the saline pipe is opened, water starts flowing. When the outlet is closed, the water flow stops automatically. Because the saline pipe is transparent, the user can easily see the water level or movement inside the pipe, which helps identify: whether water is flowing, if there is any blockage, or if the tank is running low.

The system works on **gravity flow**, meaning no pump or electronic sensor is required. The height of the tank determines the pressure: Higher tank = faster flow, Lower tank = slower flow

Thus, the water tank provides storage, while the saline pipe ensures smooth, visible, and controlled water delivery.

VI. CONCLUSION

The smart water system using a water tank and a saline pipe provides an effective, low-cost method for storing and distributing water without the need for electronic sensors or complex technology. The use of a saline pipe ensures smooth and visible water flow, allowing users to easily observe the movement of water and detect any blockages or flow interruptions. The system works entirely on gravity, making it energy-efficient, simple to maintain, and suitable for small-scale household or project applications. Overall, this setup demonstrates that even with basic components, water can be managed efficiently, safely, and relia

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Automatic Street Light

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ABSTRACT: The project "Automatic Street Light Control System" focuses on reducing unnecessary power consumption by intelligently managing the operation of street lights. Instead of keeping all lights ON throughout the night, this system uses sensors—such as infrared or ultrasonic detectors—placed along the roadside to identify the movement of vehicles. When a vehicle approaches, the sensor detects its presence and immediately switches ON the street lights ahead of it, ensuring proper illumination for safe driving. As the vehicle continues to move forward, the lights behind it automatically turn OFF, thereby preventing the wastage of electricity. This selective lighting approach greatly improves energy efficiency, especially on long highways or low-traffic roads where lights often remain ON even when not needed. By limiting the operational time of each street light to only when a vehicle is present, the system also increases the overall lifespan of the lamps, reducing maintenance costs for municipal authorities. The project represents a practical and cost-effective method for implementing smart city infrastructure using basic electronic components, including sensors, microcontrollers, and automatic switching circuits. Overall, the Automatic Street Light Control System highlights how simple automation can contribute to sustainable energy management and support environmentally friendly urban development**.**

I. INTRODUCTION

Street lighting is a crucial component of modern urban infrastructure, providing safety and visibility for drivers, pedestrians, and commuters during nighttime hours. Traditional street lighting systems keep lights ON throughout the night, regardless of traffic flow or actual need, which leads to significant energy wastage and higher maintenance costs. With growing concerns about sustainability and the efficient use of resources, the need for smarter, more responsive lighting solutions has become increasingly important. The Automatic Street Light Control System addresses this need by introducing an intelligent mechanism that adjusts lighting based on real-time vehicle movement, thereby conserving power while maintaining safety standards.

In this project, sensors such as infrared, LDRs, or ultrasonic detectors are strategically placed along the roadside to monitor the presence of moving vehicles. When a car approaches a particular section of the road, the sensor detects the vehicle and instantly activates the corresponding street light to illuminate the path ahead. This ensures that only the necessary lights remain operational, providing adequate visibility for the driver. As the vehicle continues moving forward, the lights behind it automatically switch OFF, preventing unnecessary energy consumption. This dynamic ON/OFF switching creates a "follow-me" lighting effect, where illumination is provided only where and when it is needed. Such a system is especially beneficial in areas with low or inconsistent traffic, such as rural roads, highways, and suburban neighborhoods.

The implementation of this smart lighting concept brings several advantages, both economically and environmentally. By reducing the number of hours that each street light remains active, the system significantly lowers electricity usage, contributing to reduced operational costs for municipalities and public works departments. Additionally, minimizing continuous lighting helps extend the lifespan of bulbs and fixtures, reducing maintenance and replacement expenses. Beyond cost savings, this technology supports the development of sustainable, energy-efficient smart cities by promoting responsible electricity consumption. The Automatic Street Light Control System serves as a simple yet powerful example of how automation, sensor technology, and microcontroller-based control can transform traditional infrastructure into intelligent, eco-friendly solutions.

II. LITERATURE REVIEW

LDR-based street lighting systems are widely used due to their simplicity and low cost, primarily functioning by detecting ambient light levels to differentiate between day and night. When the surroundings become dark, the LDR triggers the street lights to turn ON, and when daylight returns, the lights automatically switch OFF. However, these systems lack responsiveness to real-time traffic conditions and operate solely based on illumination levels. As a result, they often keep lights ON even when no vehicles or pedestrians are present, leading to unnecessary energy consumption. This limitation highlights the need for more advanced, traffic-responsive lighting solutions for smarter energy management.[1]

PIR and IR sensor-based street lighting systems activate lights only when motion is detected, enabling significant energy conservation. Research shows they can achieve 50–80% energy savings in low-traffic areas. These systems reduce unnecessary illumination and extend lamp lifespan, though their accuracy may be influenced by environmental conditions and sensor placement.[2]

Recent IoT-based street lighting systems combine wireless monitoring, cloud connectivity, and solar power to improve energy efficiency and reliability. These solutions enable remote control, real-time fault detection, and adaptive lighting based on traffic data. By integrating renewable energy, they further reduce operational costs and support sustainable smart city development.[3]

Advanced computer vision–based street lighting systems offer high accuracy in detecting vehicles and pedestrians through real-time image analysis. Their precision enables highly optimized illumination and enhanced safety. However, these systems are expensive, require powerful processing hardware, and involve complex implementation, making them less practical for widespread use in low-budget or rural infrastructures.[4]

III. METHODOLOGY

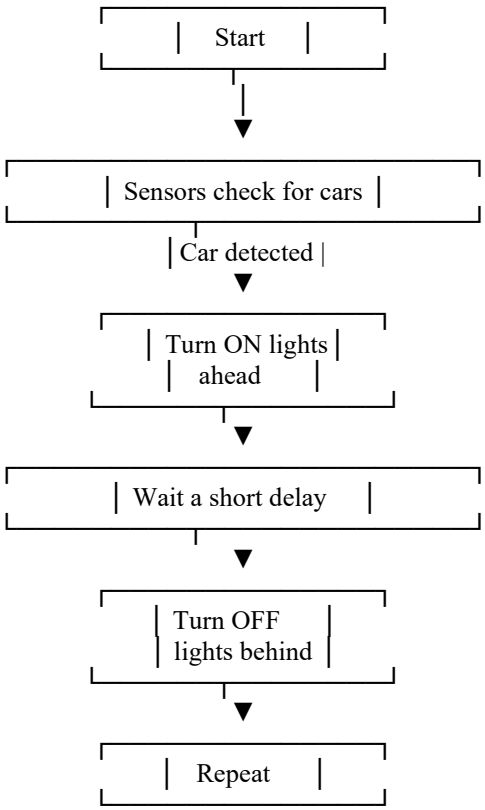


Fig 3.1 Flow Chart

IV. MATERIAL SELECTION

When doing a project, it is important to pay attention to the selection of materials. To prevent waste, the items selection process must be carefully welcomed. A precise selection of items is necessary to ensure that they are long-lasting and safe for usage.

4.1 Mini Toy Car



Fig 4.1 Mini Toy car

Used to trigger IR sensors.

4.2 LED Light



Fig 4.2 Adjustable rods

Used as the “street lights” at the top of the two white poles. When activated by the sensors, they turn ON.

4.3 Microcontroller

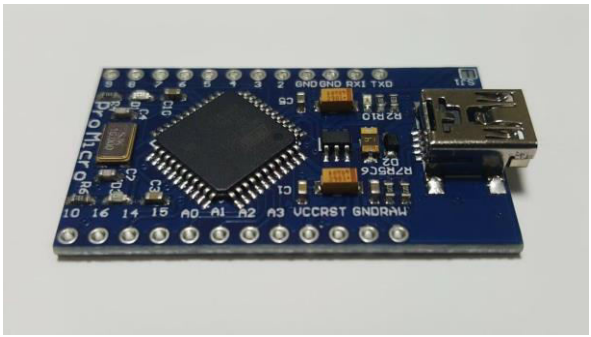


Fig 4.3 microcontroller

Some models use nan microcontroller, but your model might be using direct IR-to-LED switching. If you used microcontroller, it controls which light turns ON or OFF based on sensor input.

4.4 Resistor

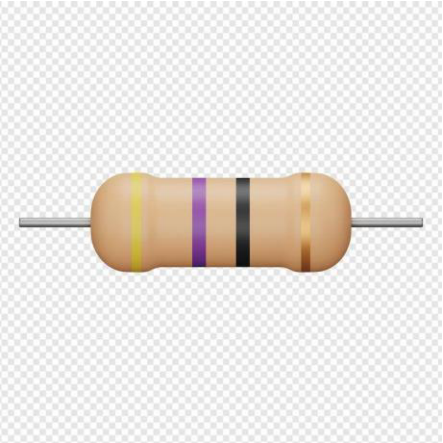


Fig 4.4 Resistor

Used with LEDs to prevent burning them. Common values: 220Ω or 330Ω for LED current limiting.

4.5 Battery



Fig 4.5 Battery

9V battery or USB charger (your model looks plugged in via USB). Provides power to sensors and LEDs.

V. RESULTS AND DISCUSSION

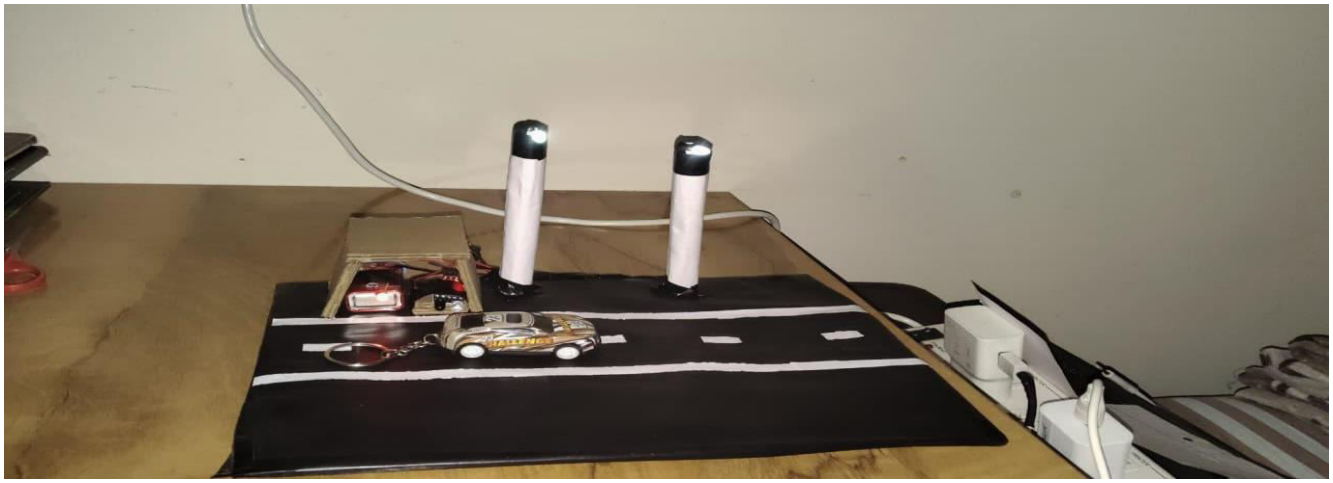


Fig 5.1 Working Model

5.1 Working principle

When a vehicle enters the detection zone, the system begins its operation by identifying its presence through strategically placed sensors along the roadway. These sensors, often infrared or ultrasonic, constantly monitor the environment for movement or heat signatures. The moment a vehicle enters their active range, the sensor detects this change and immediately initiates communication with the microcontroller. This rapid response is essential for ensuring that the lighting system reacts in real time, without delay. By capturing even slight movement within its field, the detection system forms the foundation of a dynamic lighting setup that works only when needed, promoting both efficiency and safety.
Once the sensor identifies a vehicle, it sends a clear and timely signal to the microcontroller, which serves as the central processing unit of the lighting system. The microcontroller interprets the received data and determines exactly which street lights ahead of the vehicle must be switched ON. This ensures that the road in front of the moving vehicle is well illuminated at all times. The activation of lights ahead, rather than behind, optimizes energy consumption by focusing illumination only where it is immediately useful. The system continuously analyzes live input, instantly adjusting to the position and speed of the vehicle. This organized processing prevents unnecessary lighting and creates a more intelligent, responsive system compared to traditional, always-on street lighting.

As the vehicle continues to move forward, the system automatically turns OFF the lights behind it. This seamless transition is guided entirely by real-time sensor feedback, allowing the microcontroller to deactivate lights only when it is certain they are no longer needed. Such behavior not only reduces power consumption but also extends the lifespan of the lighting components. Throughout this process, the system constantly updates its state based on new sensor readings, ensuring the illumination moves smoothly along with the vehicle. This ongoing, dynamic cycle of detection, activation, and deactivation creates a synchronized lighting pattern that enhances road visibility, improves energy efficiency, and provides a modern, adaptive approach to smart street lighting.

VI. CONCLUSION

The Automatic Street Light Control System represents an efficient and intelligent approach to roadway illumination, designed to provide optimal lighting only when necessary. By detecting the presence of vehicles through sensors placed along the street, the system activates the lights precisely at the moment they are needed. Once the vehicle moves past a particular section, the lights behind it automatically switch off, ensuring that energy is used sparingly and effectively. This dynamic method significantly reduces unnecessary power consumption compared to traditional street lighting systems that remain illuminated throughout the night. Despite its advanced operation, the system remains cost-effective and user-friendly, making it accessible for a wide range of installations. Its reliance on simple components such as IR sensors and microcontrollers keeps the overall design affordable, reliable, and easy to maintain.

Beyond energy conservation, this system plays an important role in enhancing roadway safety. By ensuring that streets are illuminated only when vehicles are present, it provides drivers with clear visibility while simultaneously cutting down on light pollution. Its adaptability allows it to function efficiently in both densely populated urban regions and sparsely populated rural areas, making it a versatile solution for diverse environments. The automatic operation reduces the need for manual controls, minimizing human error and lowering maintenance demands. Additionally, the system aligns well with modern smart-city initiatives, where sustainability and intelligent automation are prioritized. Through its combination of efficiency, affordability, and environmental responsibility, the Automatic Street Light Control System contributes meaningfully to the development of cleaner, smarter, and more sustainable roadway infrastructure.

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Smart Materials for Pot Holes Repairs

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ABSTRACT: Pothole formation is a major challenge for road infrastructure, leading to frequent maintenance, increased vehicle damage, and safety risks. Traditional repair methods often provide only temporary relief due to poor bonding and limited durability. This study explores the use of recycled plastic waste as a sustainable and effective material for pothole repair. Waste plastics such as LDPE, PET, and polypropylene are shredded and blended with hot bitumen or used to create plastic-modified asphalt mixtures. The addition of plastic improves the binding strength, water resistance, durability, and load-bearing capacity of the repaired surface. Using plastic in pothole repair not only enhances pavement performance but also supports environmental goals by reducing plastic waste and lowering dependence on conventional asphalt. The results indicate that plastic-modified pothole repair is cost-effective, eco-friendly, and suitable for urban and rural road conditions, making it a promising alternative to traditional methods.

I. INTRODUCTION

Potholes are one of the most common forms of road surface deterioration, caused by factors such as water infiltration, oxidation of bitumen, traffic load, and temperature variations. They not only reduce ride quality but also increase maintenance costs and pose significant safety hazards for road users. Conventional pothole repair methods such as patching with hot mix or cold mix asphalt—often fail to provide long-lasting results due to weak bonding, rapid wear, and susceptibility to moisture damage. At the same time, the world is facing a growing environmental challenge due to the accumulation of plastic waste, which is non-biodegradable and difficult to manage through traditional disposal methods. Integrating recycled plastics into construction materials offers an innovative solution to both problems: improving road durability while reducing plastic pollution.

Recent research has shown that waste plastics, when shredded and blended with bitumen or asphalt mixtures, can significantly enhance pavement performance. Plastic-modified materials show improved binding strength, resistance to deformation, reduced pothole formation, and extended service life. This approach not only provides a sustainable alternative to traditional repair methods but also supports environmental conservation and resource recovery. This study focuses on evaluating the use of recycled plastic in pothole repair, examining its effectiveness, material properties, and potential benefits for long-term road maintenance.

blades, removing dust and cobwebs. The dirt is collected in a box below the machine. These results help improve the design of the machine early on, which reduces costs, speeds up production, and makes the product more reliable and trusted by customers.

II. LITERATURE REVIEW

A considerable body of research has examined the incorporation of waste plastics in road construction and pothole repair as an innovative response to pavement deterioration and the growing issue of plastic pollution. Early investigations into plastic-modified bituminous mixtures revealed that adding shredded plastics such as PET, HDPE, LDPE, and PP enhance the binding strength, stiffness, and overall durability of asphalt. When introduced into the mix, plastic either coats the aggregates or blends with the bitumen, resulting in increased Marshall stability, improved resistance to moisture damage, and extended pavement lifespan [1].

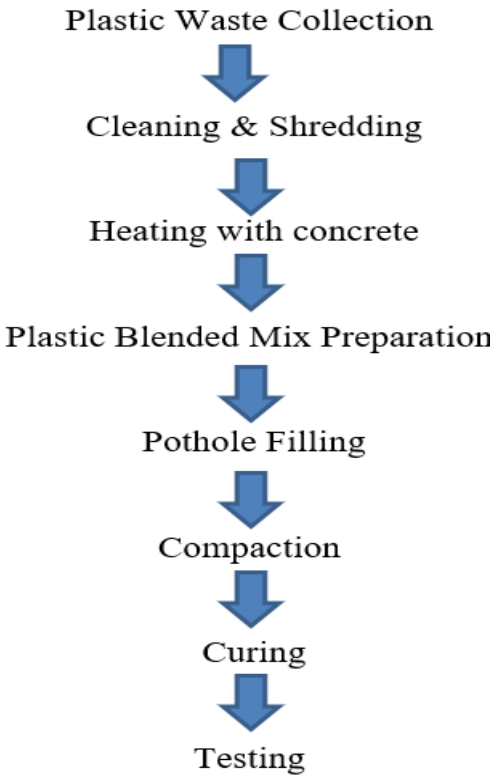
Multiple review studies on plastic-modified roads have identified that incorporating 5–10% plastic by weight of bitumen yields optimal performance. Beyond this range, the mix may lose workability and flexibility. Within this optimal proportion, researchers consistently report reduced rutting, enhanced fatigue life, and lowered maintenance costs. These advantages make plastic-modified asphalt particularly suitable for hot and humid climates, such as those found in India [2].

In recent years, the focus has shifted toward applying plastic modification techniques specifically for pothole repair. Comparative studies demonstrate that using plastic-coated aggregates and plastic-modified bitumen in pothole patches significantly increases softening point values, decreases aggregate abrasion, and extends the service life of repaired sections. Additionally, reviews on sustainable pothole maintenance highlight that blending plastic waste with VG-30 bitumen offers superior thermal stability and mechanical performance compared to conventional bitumen-based mixes [3].

Experimental research using PET- and PE-modified bitumen further confirms improvements in critical engineering parameters, including rutting resistance, fatigue behavior, and moisture susceptibility. These characteristics are essential for pothole patches, which must withstand repeated traffic loading, water ingress, and continual environmental stresses [4].

Field implementations across India and other countries validate laboratory findings, showing that roads and pothole repairs constructed with plastic-modified materials display better durability and remain functional for longer periods than traditionally repaired sections. Beyond performance benefits, the use of waste plastics in road maintenance also contributes to effective waste management, reduced plastic pollution, and decreased reliance on bitumen, making it a technically feasible and environmentally responsible alternative [5].

III. METHODOLOGY



IV. MATERIAL SELECTION

When doing a project, it is important to pay attention to the selection of materials. To prevent waste, the items selection process must be carefully welcomed. A precise selection of items is necessary to ensure that they are long-lasting and safe for usage.

4.1 Bricks Molds



Fig 4.1 Brick mold

To mold the blocks and give them a shape (standard size 15 cm ,100 × 100 × 100 100×100×100 mm (10 cm), and 50 × 50 × 50 50×50×50 mm (5 cm)

4.2 Aggregates



Fig 4.2 **Aggregates**

6 mm to 20 mm stone aggregates, used by crushing them which will strengthening the base.

4.3 Cement



Fig 4.3 cement

This is the base of our project as we bind this with other materials, it will provide strength stability and life to our product

4.4 Plastic Shred



Fig 4.4 plastic shred

Melted plastic is used to strengthen the base layer or fill small voids before placing bricks.

4.5 Water



Fig 4.5 water

Use this for mixing the material and blending them together and reducing heat

V. RESULTS AND DISCUSSION



Fig 5.1 Working Model

5.1 Working principle

The working principle behind using plastic-modified cement bricks for pothole repair is rooted in the combined structural, mechanical, and hydrophobic enhancements provided by embedded waste plastics within the cement–aggregate matrix. When thermoplastic materials like LDPE, HDPE, PET, or PP are shredded and mixed into the brick composition, they partially melt or bond during curing, creating a composite structure where plastic acts as a micro-reinforcement agent that bridges gaps, reduces internal voids, and improves the tensile and flexural strength of the brick. These embedded plastic particles increase toughness and reduce brittleness, allowing the brick to better withstand the continuous impact, vibration, and dynamic loading from vehicular traffic. Because plastic is naturally hydrophobic, its presence significantly reduces water absorption and prevents moisture penetration into both the brick and the pothole base, effectively eliminating the primary cause of pothole degradation—water-induced weakening and erosion. When used in the field, these bricks create a more stable and durable patch, as their lighter weight, improved elasticity, and greater load-distribution capacity allow them to conform better to base irregularities without cracking. If melted plastic is also applied as a surface coating or filler between bricks, it forms a strong adhesive layer that locks bricks in place, improves interlocking, seals joints, and prevents displacement under traffic loads while providing additional waterproofing. Altogether, the synergy of cementitious bonding and plastic reinforcement results in a repair system that is stronger, longer-lasting, moisture-resistant, and more resilient to repeated traffic stresses than conventional brick or plain cement solutions, offering an efficient and sustainable approach to pothole rehabilitation.

VI. CONCLUSION AND FUTURE SCOPE

The study concludes that the use of waste plastic in pothole repair offers a highly effective, durable, and environmentally responsible alternative to conventional patching methods. By melting and coating the aggregates, plastic significantly improves the bonding between bitumen and aggregate, resulting in higher Marshall stability, enhanced load-bearing capacity, and superior resistance to moisture damage. Laboratory tests and field trials consistently show that plastic-modified mixes reduce rutting, ravelling, and premature failure, thereby extending the service life of repaired potholes.

Additionally, this method helps address the critical issue of plastic waste disposal while reducing the consumption of bitumen, making it both economically and environmentally beneficial.

Looking ahead, the technology presents significant scope for further development. Standardized mix design guidelines and region-specific protocols need to be established to ensure uniform adoption across different climatic and traffic conditions. Research into various plastic types and combinations may help identify the most suitable materials for diverse applications. Long-term field monitoring, advanced durability testing, and life-cycle assessments will provide deeper insights into performance and environmental impacts. With improvements in recycling, shredding, and heating processes, the technology can be scaled up for use in large-scale road construction and rehabilitation projects. Future innovations may also integrate plastic-modified asphalt with smart and self-healing materials, making roads more sustainable, resilient, and technologically advanced

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Single Load Cell Collaborated with Ultrasonic Waves Sensor Body Mass Index Machine

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ABSTRACT: In today's world, where lifestyle-related diseases such as obesity, diabetes, hypertension, and cardiovascular disorders are rapidly escalating due to sedentary habits and poor nutrition, the need for precise, automated, and user-friendly BMI measuring machines has become more pressing. Traditional BMI measurement methods often depend on manual recording and calculation of height and weight, which may lead to human errors, time delays, and inconvenience. Automated BMI ratio measuring machines use advanced sensors like load cells for weight and ultrasonic or infrared sensors for height detection, combined with microcontrollers that calculate BMI accurately and display real-time results. This automation ensures rapid response, reduces manual errors, and enhances ease of use for various users including healthcare professionals, fitness trainers, and individuals at home. This feature is particularly beneficial for continuous health management in clinical settings, fitness centers, schools, and rural health programs. Users can track progress, receive timely alerts, and make informed decisions regarding diet, exercise, and medical consultation

I. INTRODUCTION

Nutritional deficiency other than can cause health problems (morbidity, mortality and obesity), also reducing the quality of a nation's Human Resources (HR) . On a broader scale, malnutrition can be a threat to the survival and survival of a nation. For example, Obesity is a complex neurobehavioral disorder that has been linked to changes in brain structure and function .However, on the contrary, excess nutrition can also be a major risk cause of Non-Communicable Diseases, which is also one of the main causes of death in Indonesia . Health is an important factor that guarantees the survival of the next generation. One program implemented by the government is to evaluate the level of nutrition. This Program is carried out through Puskesmas and Posyandu units to improve individual health in every housing environment. Nutritional problems are very important and fundamental in human life .BMI is an important tool in health assessment because it offers a quick, non-invasive, and cost-effective method to estimate body fat, which is a key indicator of potential health risks. Although BMI does not measure body fat directly, it strongly correlates with more comprehensive measures of body fat and health outcomes. The Body Mass Index (BMI) is the metric currently in use for defining anthropometric height/weight characteristics in adults and for classifying (categorizing) them into groups. The common interpretation is that it represents an index of an individual's fatness. The BMI has been useful in population-based studies by virtue of its wide acceptance in defining specific categories of body mass as a health issue .Health professionals use BMI to identify individuals at risk for conditions related to abnormal body weight, such as cardiovascular diseases, diabetes, hypertension, and certain cancers. By categorizing people based on their BMI, healthcare providers can recommend lifestyle changes, further diagnostic evaluations, or interventions tailored to individual needs. It was indicated that BMI should be used as a measure to track weight status in populations and as a screening tool to identify potential weight problems in individuals. Measured height and weight are needed because self-reported data are not sufficiently reliable to follow population level trends or to make comparisons between populations . The BMI as given in equation 1 according to. Body Mass Index for Adults graphical data as shown

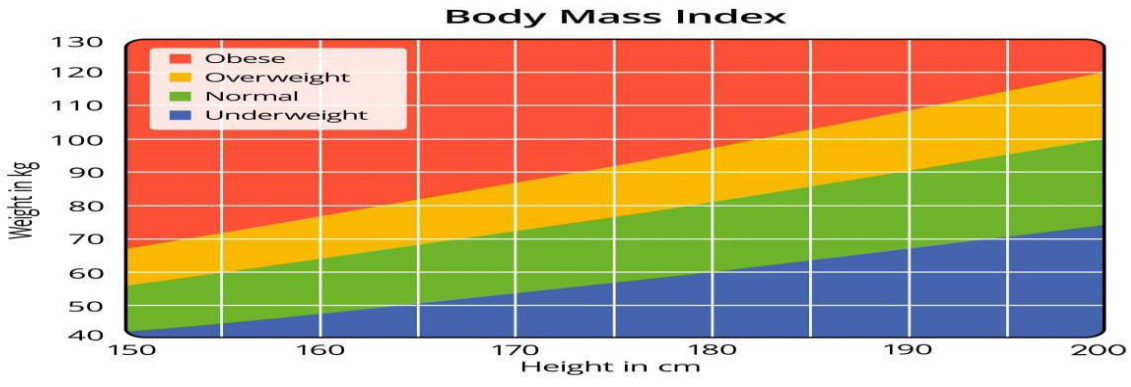


Fig. No. 1 Body Mass Index for Adults

Boby Mass Index (BMI) =Weight/Height²
LT= 18 x (H)
UT = 25 x (H)
Where LT is low threshold and UT is upper threshold. Then the ideal (normal), thin, or fat grouping
Follows Table 1 below.
Table 1. BMI classification according to WHO [9].
Classification IMT Value

Thin (Underweight)	< 18
Normal (Ideal)	18 – 25
Fat (Overweight)	> 25

Overall, BMI serves as a valuable screening metric in public health to monitor and combat obesity and related diseases on a broad scale, helping to guide preventive care, treatment decisions, and health policy development. Its simplicity and effectiveness make it a widely used standard in both clinical and research settings

II. LITERATURE REVIEW

Body Mass Index (BMI) is a measure of a person's fitness level monitoring obtained from a comparison between weight and height using a separate measuring instrument and requires the energy of other people in the measurement process, namely using a manual meter and scales. Therefore, a height and weight measuring instrument is needed that is integrated into a BMI measuring instrument to determine body health [1]

BMI is a widely used indicator to assess whether an individual's weight is healthy for their height. Traditional BMI calculations require manual measurements and input, which can be time-consuming and prone to error. This innovation has significant implications for various applications, including healthcare, fitness tracking, and community health surveys. By automating the BMI calculation process, the system not only saves time but also ensures consistency, making it a valuable tool in promoting better health management. [2]

The development of BMI machines can be traced back to invasive method for monitoring their weight, which can be the early 2000s when electronic scales with built-in height an important motivator for weight loss and healthy living measurement devices began to be used in clinics and (Akpan, Joshua, Agbogun, & Omotehinwa, 2019).hospitals. These machines provided an automated method Obesity is a major health concern in most parts of the world. For the calculation of BMI, eliminating the need for manual It is associated with several health problems such as calculations. However, these early machines were often diabetes, hypertension, heart diseases, and stroke (Flegal, bulky and expensive, limiting their accessibility to Graubard, & Williamson, 2005; Chumlea, 2006; Etchison, healthcare providers (Abana, Llamelo, Daña, Cafugauan, & Minton, Thompson, Collins, Hunter, & Dai, 2011). Body Angelo, 2020).[3]

Due to its low cost and ease of assessing health risks associated with obesity, this method is more extensively utilized Than other body fat detection techniques. In this study, a body mass index was used to estimate the overall fat content of a Person's body. The BMI is calculated using two variables: the person's height and weight. BMI is a machine that was Created with the use of a load cell and an ultrasonic sensor [4]

Some universities use this calculation in physical Examination and for medical purposes. Fitness gyms Also use BMI calculations to evaluate their clients and Help them reach their proper weight. Pediatricians Employ BMI percentile screening for health monitoring Of children, teenagers and young adults. Parents often wondered if their children are overweight, underweight

Or just right. Using body mass index calculator configure out if the child is in an appropriate weight for his Or her height. MI provides a good indicator for levels of body fat, And it is known that having a BMI that is either too low Or too high is associated with an increased risk of ill Health in life[5]

In the modern digital era, maintaining a healthy lifestyle has become increasingly important due to the rising Prevalence of obesity and lifestyle-related diseases. The Body Mass Index (BMI) is widely used as a simple and Effective tool to assess an individual's health status based on height and weight. However, traditional BMI Calculators often lack interactivity, data storage, and personalized tracking, which limits their effectiveness in Long-term health monitoring.[6] Obesity is a major public health crisis in the United States. More than two-thirds of the U.S. population is either overweight or obese. Body mass index (BMI) is one of the ways to measure obesity in the population. Other ways to measure obesity include the waist-to-hip ratio, the percentage of the body or visceral fat, and waist circumference. Body mass index (BMI) can be calculated via mathematical operations where height and weight values are used to estimate the

health status of a person. BMI as a measurement is typically used to gauge the risk of developing chronic conditions such as diabetes, hypertension, depression, and cancer [7]
These amongst other factor influence the choice of Arduino based automated BMI machine with Liquid Crystal Display (LCD). This device works on the principle of Hooke's law and acoustic ultrasound waves. The device measures weight and height and determines the corresponding BMI automatically. The BMI and other in body data measured are saved in the system's database and they can easily be accessed for regular check of one's state of health especially obesity status. The designed circuit combined the Functions of the ultrasonic proximity sensor and weight sensor in one system and developed software embedded in two microcontrollers that control the whole system [8]

III. METHODOLOGY

COMPONENTS:

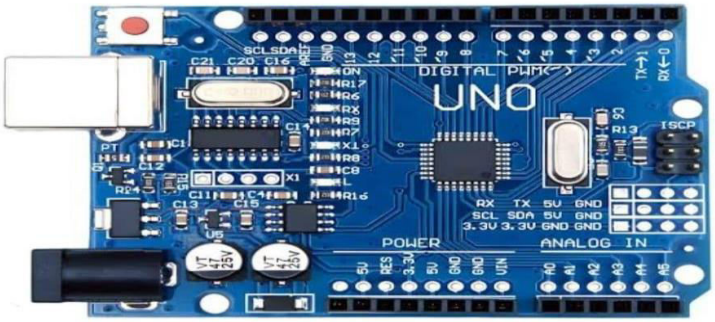


Fig 2. Arduino board

Arduino microcontroller: The microcontroller is one of the necessary parts of a computer system. In a simple microcontroller will produce a specific output based on the input received and the program given [10]. Arduino Uno is a microcontroller board based on Atmega328. The Arduino UNO has 14 digital input / output pins (6 of which can be used as PWM outputs), 6 analog inputs, a 16 MHz oscillator, a U.S.B connection, a power jack, an ICSP header, and a reset button. Arduino UNO able to support microcontroller, and can be connected with computer using USB cable [11]. The microcontroller is a microprocessor system in which there is already a CPU, ROM RAM I/O clock and other internal equipment [12]



Fig 3. HC-SR04 Ultrasonic sensor

Ultrasonic sensor: The HC-SR04 ultrasonic sensor consists of a 40 KHz signal generator chip, an ultrasonic speaker, and an ultrasonic microphone. The ultrasonic speaker converts the 40 KHz signal to sound while the ultrasonic microphone functions to detect the reflection of the sound. Ultrasonic sensors are sensors that work based on the principle of sound wave reflection and are used to detect the presence of a particular object in front of it. The working frequency is in the area above the sound wave from 40 KHz to 400 KHz [13] .When the ultrasonic sensor measures height, the calculation is to use the formula in equations 4 and 5 below [8]. Assuming that the sensor is placed at a height of 200 cm, then $H = 200 - L$ (4) $L = lp/29\ \mu s)/2$ (5) Where the number 200 is the distance between the sensor and the floor, H is the height, L = the distance of the sensor with the surface of the head, lp = the width of the pulse distance in micro second units (μs) in one reflection.



Fig 4. Load Cell with Weight Scale Amplifier Module (HX711)

Load Cell: Load cells are the main component of a digital weighing system, where the level of accuracy of the scales depends on the type of load cell used. A load cell is a transducer used to create an electrical signal whose magnitude is directly proportional to the force being measured. Basically, it measures strain and then converts force into electrical energy [46] The weight scale amplifier (HX711) is an auxiliary to the weight sensor for amplifying the signals from load cells and reporting it to microcontroller which allows to read easily when measured during the operation.



Fig 5. Liquid Crystal Display with I2C Module

LCD with I2C Module: Liquid crystal display is an electronic display device that operates by applying a varying electric voltage to a layer of liquid crystal, thereby inducing changes in its optical properties. The results of measuring the weight and height of object will be displayed on LCD screen through data processing carried out on the Arduino Microcontroller. An I2C adapter LCD is a convenient solution for connecting standard character LCDs (16x2 or 20x4) to microcontrollers. The adapter enables you to show sensor readings,output directly from a microcontroller on a LCD

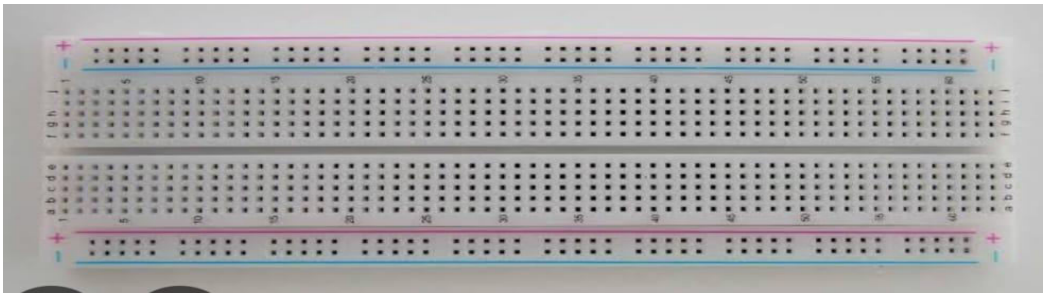


Fig 6. Breadboard

Breadboard:It is a temporary platform for prototyping and testing the electronic circuit. It allows for easy assembly, modification, and troubleshooting of the circuit design Components like a microcontroller (e.g., Arduino), weight sensors (load cells), a height sensor (ultrasonic sensor), a display (LCD), resistors, and jumper wires can be quickly inserted into the breadboard's holes to build the circuit without the need for soldering.



Fig 7.USB-A to USB-B

USB-A to USB-B: This cable is used primarily for data transfer of measured values (weight,height) for analysis and communication between the machine and a host device, such as a computer or laptop.It allows instant data logging without manual transcription errors.



Fig 8. Switch

Switch: It is used to power the device on or off. It initiates the measurement process, allowing the user to start weighing and height sensing. The switch enables control over device operation, BMI calculation only when the user is ready to measure

Hardware implementation:The system consists of the ultrasonic sensor, load cells, sensor amplifier, and the arduino UNO (ATMEGA) microcontroller. The load cell reads the weight of the subject and sends the collected data into the sensor amplifier to amplify the voltage to be transmitted into the microcontroller, while the ultrasonic sensor reads and collects the data from the analog and sends the combined data to the microcontroller; thereafter the BMI status is displayed on the screen. The microcontroller controls the proximity sensor; its receiving end sends data to the (6 V output of the) proximity sensor and its transmitting end receives data from the proximity sensor. It then manipulates the data with the help of the program code coming from the proximity sensor that is displayed on the screen as the height measurement. The arrangement of the component for the weight measuring system which comprise load cell (weight sensor), weight amplifier (booster) module, microcontroller (arduino) board, liquid crystal display (LCD) as shown

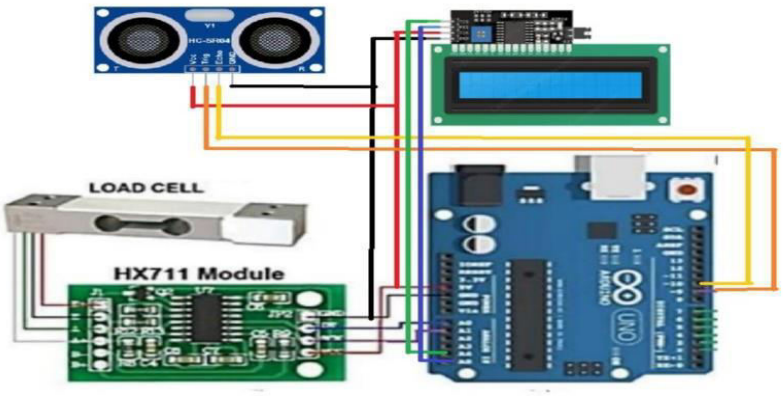


Fig. No.9 Circuit Diagram

Software Implementation:The program code used was C language and was tested with the Arduino UNO after which it was implemented to the hardware to test its functionality. When the whole installation was implemented, a test to check for accuracy, speed and reliability was carried out. The algorithm design was the main focus of the software development for the microcontroller, which uses the Arduino Uno microcontroller board The algorithm for the microcontroller was designed to calculate the BMI from the measurement of the weight using the load cell and the height using the ultrasonic sensor, and display it.

Flow Chart of the Program of the Body Mass Index Computation: This algorithm describes the computation of the body mass index from the weight and height measured parameters from the system as shown

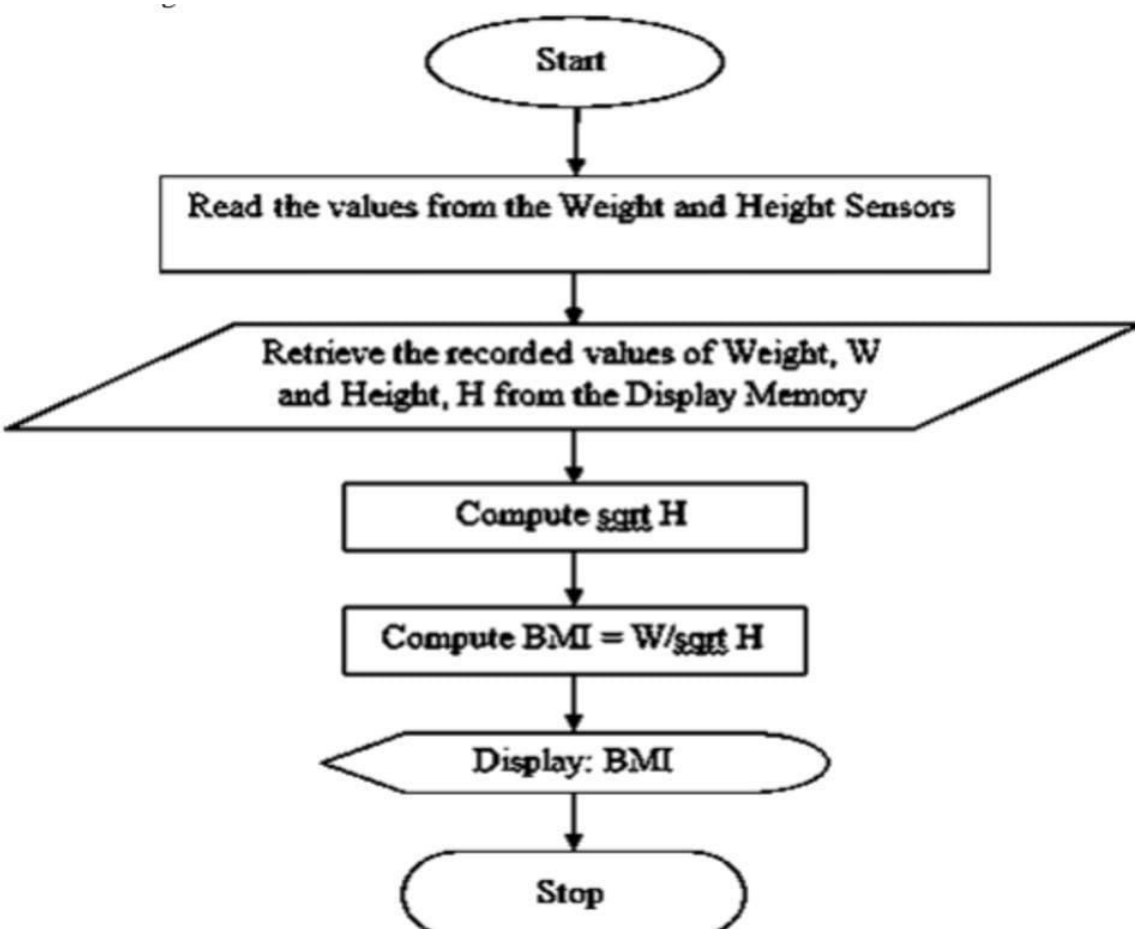


Fig.no 10 Flow chart

IV. WORKING PRINCIPAL

A BMI measuring machine operates by integrating precise weight and height measurement technologies to compute the Body Mass Index, an indicator of body fat based on standard formulas. The process begins when a user stands on the machine's platform. A digital load cell beneath the platform detects the applied force and converts it into an electrical signal proportional to the user's weight. This signal is processed by an internal microcontroller, which translates it into an accurate weight value. At the same time, the machine measures height using either an ultrasonic sensor. These sensors emit waves toward the user's head and calculate the height based on the time taken for the waves to return. After obtaining both height and weight, the microcontroller applies the BMI formula: weight (kg) divided by height (m) squared. The computed BMI value is then shown on a digital display.

V. RESULTS AND DISCUSSION

Overall testing of this system intends to see the results of each subsystem after it is integrated. Testing in this process is done to see the overall output of the system that has been designed and realized. Testing this entire system in the form of testing of software and connectivity between software and hardware. The whole system testing was carried out with 12 different respondents where for each weight one measurement was carried out. The average success rate on height

measurement is 97.76%, or in other words the average error rate is 2.24%. The average success rate in measuring body weight is 98.66% or in other words the average error rate is 1.34%

VI. CONCLUSION AND FUTURE SCOPE

The BMI index measuring machine serves as an essential tool for promoting health awareness and early identification of potential weight-related issues. In today's fast-paced lifestyle, many individuals struggle to maintain regular health checkups, making quick and accessible tools like BMI measurement increasingly necessary. The BMI ratio provides a simple yet effective way to evaluate whether a person's weight is appropriate for their height, offering an initial indication of underweight, normal weight, overweight, or obesity. Although BMI does not measure body fat directly, it remains a widely accepted screening method used by healthcare professionals worldwide due to its convenience and reliability.

The machine enhances this process by providing accurate, instant calculations that reduce human error and encourage more frequent monitoring. Its user-friendly interface, automated sensors, and clear display make it suitable for people of all ages. The benefits of knowing one's BMI ratio include better awareness of personal health, early detection of potential risks such as cardiovascular disease or diabetes, and motivation to adopt healthier habits. By offering consistent and accessible readings, the BMI index measuring machine empowers individuals to take responsibility for their well-being. Overall, it is a valuable device that supports preventative healthcare and encourages long-term, healthy lifestyle choices.

The future scope of the BMI index measuring machine is promising, with several opportunities for technological advancement and broader health integration. Upcoming models can incorporate advanced sensors to measure additional parameters such as body fat percentage, muscle mass, hydration levels, and metabolic rate, providing a more comprehensive health profile. Integration with mobile apps, cloud storage, and wearable devices can enable continuous tracking, personalized health insights, and remote monitoring by healthcare professionals. Future machines may also include AI-based recommendations for diet, exercise, and lifestyle modifications tailored to individual needs. Enhanced connectivity through Bluetooth or Wi-Fi will allow seamless sharing of data for medical or fitness purposes. Additionally, incorporating voice assistance, multilingual support, and touchless operation can improve accessibility and user experience. With advancements in machine learning, the device could predict potential health risks and offer proactive guidance. Overall, the BMI measuring machine has significant potential to evolve into a smart, holistic health monitoring system that supports preventive care and encourages healthier living.

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Food Freshness Detector

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ABSTRACT: Nowadays we must be more concerned about the quality of the food items we consume and feed our loved ones. To get a full nutrition & mineral value in food items, it's better to consume the fresh food items to avoid unnecessary health problems. We have various methods to determine or detect the freshness quality of our food items like the traditional method of lab testing the food sample, using images of the food sample with various machine learning and deep learning algorithms and even using the smell from the food sample. Many machine learning models have been developed to detect the freshness of food samples, but they lack fast and accurate detection. We have developed an IOT model that can predict the freshness of the food samples with image and its smell in a more accurate level with less time using deep learning algorithms. We have combined two deep learning algorithms for image detection to obtain more accurate results. We classify the images of food samples using the Convolutional Neural Network and detect the affected areas using the Object Detection Algorithm YOLO. We also take the level of gas emitted by rotten food samples using sensors and detect the spoilage level using the Artificial Neural Network model. We can determine the affected or rotten areas by combining the value from both image data and gas emitted by the given food sample. The result can be viewed in an application through a browser.

I. INTRODUCTION

Nowadays we must be concerned about the quality of the food items to get full nutritional values. It's better to consume fresh food to lead a better life. To identify the freshness of the food items we go with the Image recognition technology and Artificial Neural Network. Most of the time we didn't notice the freshness of the food item because of the busy life schedule and some people didn't know how to find the freshness of the food item. To handle this situation, our project helps the user (people who handle the prototype of the project) to identify the freshness within a few seconds. The existing system for the freshness detection in the earlier days is only based on the chemical-based detection later it developed to image-based classification and some existing system based on the sensor-based methods, but however it takes only a single parameter we can't determine freshness based on the single parameter. The proposed system will overcome the drawbacks of the existing system. In this system, it detects the freshness based on both the image and the sensor so the proposed system will give more accurate result than the existing system. The proposed system is a combination of both smell and image data which leads to the absolute detection and accuracy of the food sample taken to determine its freshness level. It is a user friendly environment, where food items taken to identify are easy to operate and use. This system can be implemented in the food industries before the packaging stage to detect spoiled food items and automatically separate them from good ones before packing. This system ensures the reach of good quality food items to the customers.

II. LITERATURE REVIEW

[1] The final classification results are recorded for each type of fruit that show high accuracies (all above 80% in) for all six fruit species, where bananas are the most accurate in prediction. Accuracy for six species of fruit is above 80%. [2] A performance analysis of different feature extraction techniques combined with SVMs classifiers has been performed for the addressed problem of classifying fresh and rotten fruit images. While comparing classification success rates of several features (such as Hist, GLCM, BoF, CNNsF) for different but very related tasks, CNNs appear to be the most successful feature extractors, as further have proven their efficiency in such applications. The concatenation of Hist and GLCM features leads to promising results for some classification tasks. Therefore, concatenation of different types of proper features might produce more successful and robust systems.

[3] Every 50 steps of training the dataset the accuracy calculated using cross validation. This showed steady improvement in the network until reaching 100% accuracy on cross-validation. For the testing phase, we used the testing set and the calculated accuracy was 96.3%. Accuracy level is higher (80% to 96%). Datasets are taken from multiple viewing position. Takes more time for output execution. [4] This system inspects fruit skin defects, which is more accurate, more robust to colour noise, and has reduced calculation cost. Packinghouses can adopt this system to distinguish damaged fruits from good ones before packing them into batches, therefore the quality of the products can be guaranteed at this stage. Developed a new method to inspect fruit skin defects, which was more accurate, more robust to colour noise, and reduced calculation cost Only detect the skin defect on the fruits.

[5] Low level processing is used to preprocess images. When imaging objects, different imaging and sensing devices can be simultaneously used to acquire images of samples and convert them into digital forms. High level processing includes image recognition and image interpretation. In this step, statistical methods or deep learning methods are commonly used to classify the target. [6] CNN achieved 93.8% accuracy, which is significantly higher than that for the baseline method. CNN performed much better than traditional methods using handcrafted features. higher (80% to 94%). Developed only to classify the food items. [7] The results presented indicate that most of the models are having a sensitivity of 100% for healthy class with the exception of MobileNetV2 and DenseNet121.The recognition rate during the real-time testing was found around 80% for most of the classifiers with highest value of 93.8% for EfficientNetB2. Accuracy level is higher (80% to 98%). Image was captured in a fixed view.

[8] Food is classified using the trained CNN model which makes the billing faster in the restaurants. The food detection system can classify 6 types of food using the Convolutional Neural Network (CNN) algorithm well on existing image data or stored in storage with 80% data partition for training data and 20% for test data and get an accuracy of 100% and can detect food with an average speed of fewer than 10 seconds. Have an epoch or step of 9383 steps with a loss of 0.05 and a learning rate of 0.0002. [9] Using weights from apple models.

III. METHODOLOGY

The proposed food freshness detection system follows an integrated IoT-based methodology that combines gas-sensor analysis with electronic components to identify food spoilage quickly and reliably. The approach is designed to be simple, low-cost, and suitable for household as well as small-scale industrial applications. The system functions by sensing gases released by decomposing food items and providing real-time feedback to the user through visual and audio indicators.

The core of the system is the Arduino UNO microcontroller, which coordinates all sensing and output operations. The Arduino UNO is selected due to its stability, ease of programming, and compatibility with a wide range of sensors and electronic modules. It acts as the central processing unit, receiving analog signals from the gas sensor, interpreting them, and driving the display units such as LEDs, buzzer, and LCD.

To detect spoilage, the system uses the MQ4 methane gas sensor, which is capable of identifying methane levels commonly emitted when food begins to rot. As the concentration of methane increases, the sensor produces a corresponding analog voltage signal. This analog reading is continuously monitored by the Arduino, which compares the sensor output with predefined threshold values. These threshold values are determined experimentally to differentiate fresh food from spoiled or partially spoiled items.

A 16×2 LCD module is incorporated to display real-time sensor readings and the freshness status of the food sample. It provides user-friendly visual feedback, showing whether the food item is “Fresh,” “Warning,” or “Spoiled” based on the detected gas levels. In addition to visual alerts, the system uses a buzzer and LED indicator to ensure the user notices critical spoilage conditions instantly. The buzzer generates an audible alert when the methane concentration exceeds the safe threshold, while the LED provides a continuous visual indication.

All components—including the MQ4 sensor, LCD, LED, and buzzer—are assembled on a breadboard, which allows flexible prototyping and easy modification of the circuit. Power is supplied through the Arduino board, ensuring stable operation of all sensors and output devices.

During implementation, sensor readings are monitored over time to establish accurate response patterns. The Arduino IDE’s serial monitor and serial plotter are used to visualize gas concentration changes and validate the threshold values. This iterative testing ensures the reliability of the detection mechanism across different food samples.

Overall, this methodology creates a practical and efficient IoT-based freshness detection system that monitors gas emissions, processes sensor data, and alerts users promptly. The approach enhances food safety by reducing the risk of consuming spoiled items and can be further expanded with additional sensors and machine-learning integration for improved accuracy.

A. Project Design

A simple and effective approach for detecting spoiled food involves using an Arduino UNO proplying board along with gas sensors like the MQ4 sensor to detect the odorous gases emitted by spoiled food. In addiuion to sending dhe sigenals to the server, the detection results can also be displayed to the user throuch a buzzer. LED, and LCD panel hat are connected to the Arduino board This proposed system provides an efficient and user-friendly way to detect and monitor the spoilage of food using readily available components and loT technology.

B. Modules of the Project

1) Arduino UNO: The Arduino UNO is a microcontroller bard based on lhe ATmega328P. It is the most common and widely used Arduino board, Il provides a platform for programming and controlling various electronic components, The Arduino UNO can be programmed using lhe Arduino IDE and can interact with sensors, actuators, and other electronic devices



Fig.1 ARDUINO UNO

2)MQ4 Merhane Gas Sensor: The MQ4 gas sensor is capable of detecting methane gas in the surrounding environment. It is commonly used for gas leakage detection and environmental monitoring, The sensor provides an analog oulput vollage proparional to the concenmtraian of melhane goas present. When the mehane gas concentatiom excecds a certain threshold, he oulput voltage increases



Fig.2 MQ4 Methane Gas Sensor

3) 16r2 LCD Dislay: The 16x2 LCD display is a commonly used alphanumeric display that can display 16 characters on two lines, It is used to provide visual fecdback and display information. The display can be conncted to che Arduino UNO using digial 10pinsandcan be progranined 1o show mesoges, sensor readings, or any otter desired inlormaltion.



Fig. 3 16*2 LCD Display

4) Buzzer: An audio signaling device like a beeper or buzzer main function of his is to convert the signal from audio to sound. It is provided through DC voltage and used in limers, alarm devices, etc., Based on the various design it can generate different sound



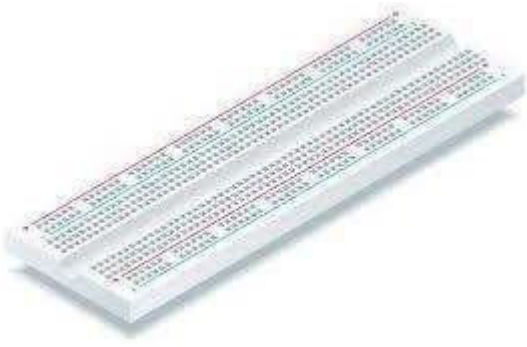
Fig.4 Buzzer

5) LED: The buzer is an clkscltronchanical device lhat praduces sound when an clectric signal is aplied to it. It is used 1o provide audio fedback or aler he user in difiercent sccnario, The burzer can be councsted io lhe Arcduino UINO using a diglial VOpin and can be programmed to produce



Fig. 5LED

6) Breadboard: A breadboard is a praldyping ool used to build and test clectconic circuits, The Arduino UNO, sensors, LCD display, buzzer, LED, and a her components can be connected 1o the breadboard and integrated into a circuit.
Fig.6 Bread-Board



C. Implementation
To implement a food spoilage detection system, yow can utilize an MQ4 sensor that specifically detects methane gases, when fruits or other food items spoil, hey emit these types of gases, The MO4 sensor is capable of detecting the concentration of methane gases and providing an analog voltage output corresponding to the concentration level. Next, you can compare the detected values from the sensor to predefined threshold values using a predetermined algorithm. This comparison will help determine whether the food is fresh or spoiled based on the concentration of methane gases, Once the comparison is made, the values are sent back to Arduino board. The Arduino board can then display the output on an LCD panel. The display will indicate whether the food is spoiled or fresh based on the food freshness level determined by the algorithm. By following this implementation process, you can create a reliable and efficient system

that detects spoiled food based on the emissions of methane gases, This can assist in maintaining food quality and reducing the risk of consuming spoiled food.

IV. RESULTAND DISCUSSION

The quality of the food can be continuously monitored using sensors, and the results can be conveniently displayed on an LED display, In the event that abnormal readings are detected by any of the sensors, such as the MQ4 sensor, a foad spoiling message will be displayed on the LED screen. This immediate notification allows for prompt action to be taken to prevent the consumption of spoiled food. Furthermore, users have the ability to

view the sensor values on the serial monitor of the Arduino IDE. This adiuonal feature provides Realtime data and enables users to closely monitor the freshness of the food. They can easily rack any variations in readings and identify potential spoilage issues. By imperception this system, users can ensure the quality and safely of their food, as well as minimize the risk of consuming spoiled items, graph on the serial plater of Arduino IDE.

V.CONCLUSIONS

Food poisoning has been a significant contributor to various diseases, making it essential to take measures to reduce and prevent illness, one elective approach is his use of sensors to determine the freshness of household food items, such as fruits. With the help of Arduino sensors, I become possible to detect gas emissions the indicate food spoilage. By utilizing sensors to detect the presence of these gases, the early signs of food spoilage can be identified, leading to the prevention of consuming spoiled food. These techniques can be further expanded by incorporating additional types of gas sensors and expending the scope to various food items. This expansion would enhance the sensitivity of the deduction methods and provide an even mare accurate assessment of food quality. To implement such a system, a hardware device like the Mq4 Methane Sensor can be used. This sensor plays a crucial role in assessing the quality and freshness of food items, With the integration of sensor technology, households can proactively safeguard against the risks associated with consuming spoiled food, promoting belles health and well-being for individuals and families Collaboration and Standardization: Collaboration between lot solution providers, food manufacturers, regulators, and industry experts is essential to establish industry standards, guidelines, and protocols for the implementation of loT-bused food spoilage detection systems, This would ensure compatibility, interoperability, and rust among stakeholders.

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Electricity Generation from Waste Materials

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ABSTRACT: Electricity generation by burning waste materials, also known as thermal waste-to-energy, is a process that involves converting waste materials into electricity by burning them in a combustion chamber. This process is a sustainable solution for waste management as it reduces the volume of waste sent to landfills while producing renewable energy. The methodology for electricity generation by burning waste materials typically involves waste collection, handling, and preparation, incineration, energy recovery, and ash management. The generated electricity can be used to power local communities or industries or fed back into the national grid. The process of electricity generation by burning waste materials provides a reliable source of electricity while reducing greenhouse gas emissions by avoiding the release of methane gas from landfills.

I. INTRODUCTION

Electricity generation from waste material is a rapidly growing field that involves the conversion of various types of waste into usable energy. This process is often referred to as waste-to-energy, and it offers a number of benefits including reducing waste in landfills, reducing greenhouse gas emissions, and providing a source of renewable energy. 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. One of the main advantages of electricity generation by burning waste materials is that it reduces the volume of waste sent to landfills, which in turn reduces the amount of space required for landfill sites. This can help to mitigate the negative impacts of landfill sites on the environment, such as groundwater contamination and greenhouse gas emissions. Another advantage of electricity generation by burning waste materials is that it produces a reliable source of electricity. This is particularly important in areas where there may be limited access to other sources of electricity, such as remote communities or developing countries. The technology used to generate electricity from these waste materials is constantly evolving, and new innovations are being developed to make the process more efficient and cost-effective. Overall, the generation of electricity from waste material represents an exciting opportunity to reduce waste, lower greenhouse gas emissions, and provide a source of renewable energy for communities around the world.

II. LITERATURE REVIEW

The growing global concern over waste management and the need for sustainable energy solutions have spurred the development of technologies that generate electricity from waste materials.

This process, often referred to as Waste-to-Energy (WTE), offers an environmentally friendly alternative to traditional methods of waste disposal and energy production.

This literature review summarizes the main technologies, feedstocks, environmental impacts, and challenges associated with electricity generation from waste. International Journal of Research Publication and Reviews, Vol 5, no 11, pp 7720-7724 November 2024 7721 2.1 Overview of Waste-to-Energy (WTE) Technologies Waste-to-Energy (WTE) refers to the conversion of non-recyclable waste materials into usable energy (such as electricity, heat, or fuel) through various processes.

The primary WTE technologies are:
a.) Incineration Incineration involves the combustion of waste materials at high temperatures to produce heat, which is then converted into electricity via steam turbines. This is one of the oldest and most widely used methods for generating electricity from waste. According to Arena (2012), incineration of municipal solid waste (MSW) is an effective way to reduce waste volume by up to 90%, while producing electricity [1].

b) Anaerobic Digestion Anaerobic digestion (AD) is a biological process where microorganisms break down organic matter in the absence of oxygen to produce biogas, which primarily consists of methane. The biogas can then be used to generate electricity in gas engines or turbines. Al Seadi et al. (2008) emphasize the role of AD in converting organic waste, such as food waste, agricultural residues, and sewage sludge, into renewable energy. AD offers significant advantages in terms of reducing greenhouse gas emissions, especially methane emissions from landfills. [2]

c) Gasification Gasification involves converting organic material into a synthetic gas (syngas) through high-temperature partial oxidation in a low-oxygen environment. The syngas, a mixture of carbon monoxide, hydrogen, and methane, can then be used in internal combustion engines or gas turbines for electricity generation. Zhao et al. (2015) demonstrated that gasification is a promising method for producing energy from a wide variety of feedstocks, including biomass and waste plastics.[3]

2.2 Waste Materials Used in Electricity Generation The efficiency of WTE technologies largely depends on the type of waste material used. Different waste streams are suitable for different technologies, and understanding the material properties is key to optimizing the energy recovery process. Common feedstocks include:

a.Municipal Solid Waste (MSW) MSW consists of a mix of household, industrial, and commercial waste, including paper, plastics, metals, and organic materials. Papageorgiou et al. (2020) emphasize that MSW is the most widely used waste type for WTE systems, particularly for incineration and gasification. The calorific value of MSW varies significantly, which can impact energy recovery. Sorting and preprocessing of waste may be necessary to enhance efficiency [4]

b) Plastics Plastics are increasingly recognized as a valuable waste resource due to their high energy content. Basu (2010) highlights the potential for using waste plastics in pyrolysis and gasification, where plastics can be converted into valuable fuels or syngas. However, the disposal of plastics has environmental implications, particularly regarding plastic waste's persistence in the environment.[5]

c) Food and Agricultural Waste Organic materials like food scraps, crop residues, and animal manure are widely used in anaerobic digestion systems. Sangkham (2017) discusses how these waste materials, rich in biodegradable organic matter, are efficiently converted to biogas, a versatile energy carrier that can be used for electricity [6]

BLOCK DIAGRAM

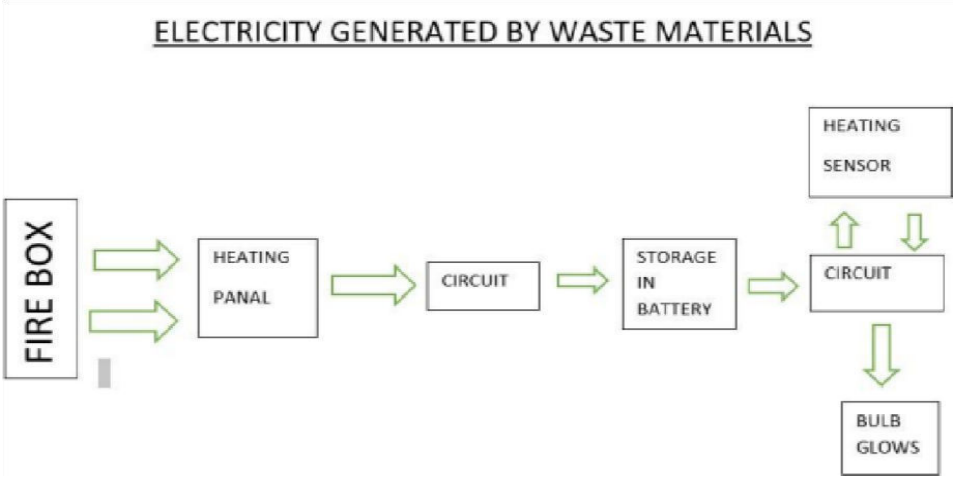


Figure -1 Block Diagram

In this Block Diagram you can see when we burn waste materials and fire box then heat generating and heating panel starts to heat convert electricity and after that that electricity we can see by LED Bulb glowing and that electricity go to circuit and after that in battery and start storing power and when electricity store in battery then heating sensor turn on the output power supply and LED Bulb start glowing and smoke go to water tank and filter system start controlling pollution.

III. METHODOLOGY

Electricity generation by burning waste materials, also known as thermal waste-to-energy, typically involves the following methodology:

Waste collection and transportation: Waste materials are collected from various sources, such as households, businesses, and industries, and transported to a waste-to-energy plant.

Waste handling and preparation: Waste materials are unloaded and handled to remove any non-combustible materials such as metals, stones, and glass. The waste is then shredded to reduce its size and improve its burn ability.
Incineration: The prepared waste is burned in a combustion chamber at high temperatures, typically between 850°C and 1200°C, producing heat and gases.

Energy recovery: The heat generated by the incineration process is used to create steam that drives a turbine, which generates electricity. The exhaust gases produced during the combustion process are treated to reduce harmful pollutants before being released into the atmosphere.

Ash management: The remaining ash produced by the incineration process is collected and transported to a landfill for disposal.

The generated electricity can be used to power local communities, industries or be fed back into the national grid. This method of electricity generation by burning waste materials is a sustainable solution for waste management, reducing the volume of waste sent to landfills, and producing renewable energy. It also help to reduce greenhouse gas emissions by avoiding the landfills.

IV. MATERIAL SELECTION

When doing a project, it is important to pay attention to the selection of materials. To prevent waste, the items selection process must be carefully welcomed. A precise selection of items is necessary to ensure that they are long-lasting and safe for usage.

1.1. HEATING PANEL

Heating panels can be used in the process of electricity generation from waste material in several ways, depending on the specific technology used.

For example, in thermal waste-to-energy plants, waste material is burnedin a combustion chamber to produce high-temperature gases. These gases are then used to heat water and produce steam, which drives a turbine to generate electricity. In this process, heating panels may be used to line the combustion chamber, as well as other areas of the plant where heat is generated or transferred. The heating panels can help to maintain the high temperatures required for efficient combustion and steam production, while also protecting the plant's infrastructure from heat damage.

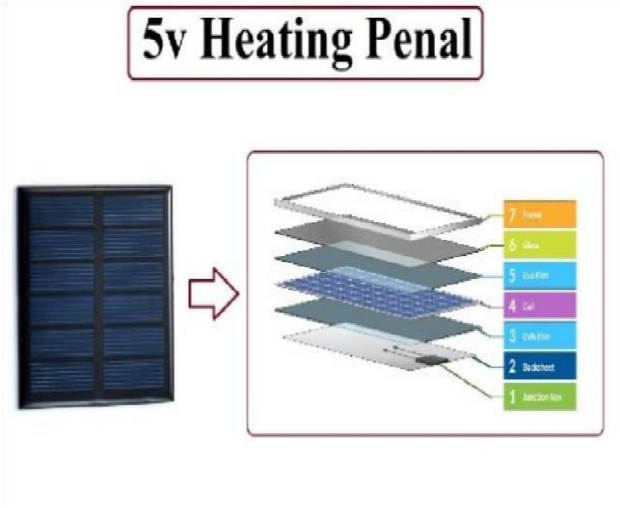


Figure no 2: Heating panel

1.2. HEATING SENSOR

Heating sensors are an important component of many waste-to-energy technologies that involve thermal processes, such as incineration and gasification. These sensors are used to measure temperature in various parts of the process, providing valuable information that can be used to optimize the efficiency of the system and prevent damage.



Figure No. 3: Heating Sensor

1.3. CAPACITOR

Capacitors can be used in various ways in the process of electricity generation from waste material. Capacitors are electrical components that store and release electrical energy, and they are commonly used in electrical systems to provide power factor correction, voltage regulation, and energy storage**.**

In waste-to-energy plants that use thermal processes such as incineration, capacitors may be used in the electrical systems that control the turbines and generators that produce electricity.

1.4. RESISTOR

Resistors can be used in various ways in the process of electricity generation from waste material. Resistors are electrical components that resist the flow of current in a circuit, and they are commonly used in electrical systems to control current, voltage, and power.

In waste-to-energy plants that use thermal processes such as incineration, resistors may be used in the electrical control systems that regulate the temperature and flow of gases in the combustion chamber. These resistors can help to control the flow of current to heating elements or other devices that generate heat, ensuring that the temperature is maintained within the desired range for efficient combustion.

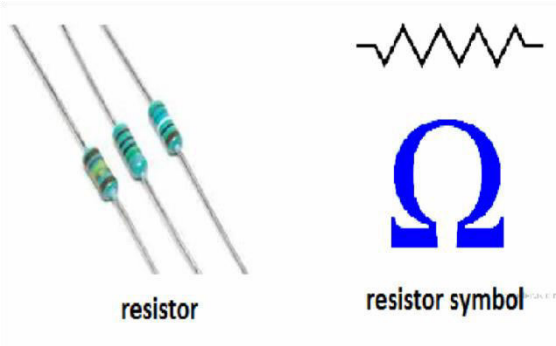


Figure No. 4: - Resistor

1.5. BATTERY

Batteries can be used in various ways in the process of electricity generation from waste material. Batteries are devices that store electrical energy chemically and can release it as needed to power electrical devices.

One common use of batteries in waste-to-energy plants is to store excess energy generated by the plant during periods of low demand or low generation. This excess energy can be stored in batteries and used to supplement the plant's output during periods of high demand or low generation, providing a more stable and reliable source of electricity.



Figure No. 5: - Battery

1.6. LED BULBS

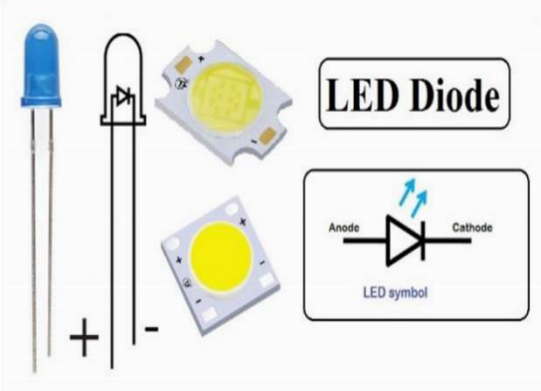


Figure No. 6: - LED Bulbs

WORKING:
When we start burning the waste material in the burning box the heating panels will start collecting the generated heat energy by waste material in the burning box.

The heat energy collected by heating panel will be converted into the electrical energy. The generated electrical energy will be seen in circuit box with led glowing.

The generated electrical energy will transfer to the batteries through the power boosters. The batteries will not dissipate the energy back because a diode is connected to it.

The batteries relate to the heat sensor and LED bulbs. Whenever the heat sensor will start conducting the batteries allow energy to flow will start conducting and LED bulbs will glow.

A heating panel works by allowing photons, or particles of light or heat, to knock electrons free from atoms, generating a flow of electricity.

Heating panels actually comprises of many smaller units called photovoltaic cells.(Photovoltaic simply means they convert heating or light into electricity The p-type, one with less electron, attracts the surplus electron from the n-type to stabilize itself.

Thus the electricity is displaced and generates a flow of electrons, otherwise known as electricity. When heat hits the semiconductor, an electron springs up and is attracted toward the n-type semiconductor. This causes more negatives in the n-type semiconductors and more positives in the p-type, thus generating a higher flow of electricity. This is the photovoltaic effect.

The generated electricity can be used to power local communities, industries or be fed back into the national grid. This method of electricity generation by burning waste materials is a sustainable solution for waste management, reducing the volume of waste sent to landfills, and producing renewable energy. It also helps to reduce greenhouse gas emissions by avoiding the release of methane gas, which is produced when waste decomposes in landfills.

The batteries relate to the heat sensor and LED bulbs. Whenever the heat sensor will start conducting the batteries allow energy to flow will start conducting and LED bulbs will glow.

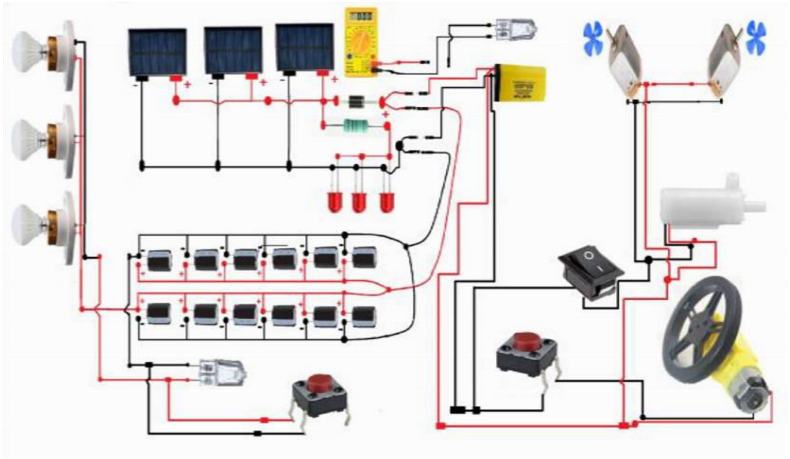


Figure no -7 Working Model

V. RESULT

In this prototype when we are start heating waste material inside zaar box the heat generated will be collected by heating panels. The heating panels will collect the converted energy (heat energy into the electrical energy) which will be transferred to circuit board. Which is constructed with IN4007

Diode and capacitor connected in series and parallel because in to increase the generated energy and push to store in the battery. Then the heating sensor is will be sensing the heat and connect circuit to output of LED Bulbs and the bulbs will glow until the energy getting stored and until the heating sensor sensing the energy generation. The bulb will glow uninterruptedly while the energy generation and battery storage. This stored energy can be used for anything.

In the present situation waste material at any place, we can see with some procedure collect everything and we can use the prototype to generate the more energy for utilization.

With this we came know that the energy generation by this method is very easy with some precaution. This prototype helps us to know about waste utilization.

With this project we can increase our own energy at industrial purpose and use them for some needs.

PROTOTYPE



Figure No. 8:- Prototype

VI. CONCLUSION

Incineration technology is complete combustion of waste (Municipal Solid Waste or Refuse derived fuel) with the recovery of heat to produce energy that in turn produces power through heating panels. Now from this we can conclude that electricity plays an important role in our life we are made aware of how the generate electricity waste is done. For technical service provider plant Objectives & Maintenance activities are very important as its service mostly depends on the availability of its equipment. From this we see that how electricity generated successfully. From this we can see how to store the energy in batteries.

VII. FUTURE SCOPE

1. We can make high quality heating penal for generate high electricity 2. We can make large level burning box with easily heating penal connecting system 3. We can make best storage system by generate electricity by waste materials 4. Reduction of pollution: Recycling helps to reduce energy usage, consumption of virgin raw materials, air and water pollution.

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Electric Vehicle Charging Station Detector

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ABSTRACT: The rapid adoption of electric vehicles (EVs) has increased the demand for accessible and reliable charging infrastructure. However, many EV users struggle to locate nearby charging stations, especially in unfamiliar areas. This research focuses on the development of an EV Charging Station Detector Website designed to assist users in finding charging points quickly and efficiently. The system integrates web technologies including HTML, CSS, and JavaScript for the user interface and uses Google Maps or OpenStreetMap APIs to detect user location and display available charging stations on an interactive map. A backend framework and a cloud-based database are used to store station details such as location, availability, charger type, and user feedback.

The platform aims to provide real-time information and auser-friendly interface accessible on both desktop and mobile devices. The proposed solution enhances convenience for EV users, promotes sustainable transportation, reduces range anxiety, and supports the growing global shift toward electric mobility. Future improvements may include AI-based route optimization, station reservation features, and integration with smart-charging networks.

I. INTRODUCTION

Electric vehicles (EVs) are becoming popular in India because they are good for the environment and help reduce pollution. The government is also supporting people to use EVs through different programs. But many EV users face a big problem it is hard to find charging stations when their battery is low. This makes people worried about running out of charge during a trip.

To help with this problem, we are planning to make an EV Charging Station Detector App.This app will help users find the nearest charging stations using maps and GPS. It can also show details like if the charger is free, what type it is, and how much it costs.

The main goal of this project is to make it easier for EV users in India to find charging stations quickly and travel without worry. This app can also encourage more people to use electric vehicles and help make our country cleaner and greener.

II. LITERATURE REVIEW

Afida Ayob et al. (2014) provide a comprehensive review of electric vehicles (EVs), focusing on battery chargers, charging stations, and related standards. The study compares commercial and prototype EVs in terms of range, battery size, charger power, and charging time. It also outlines key international charging standards such as IEC 61851, IEC 62196, and IEC 60309, and discusses the impact of EV charging on utility distribution systems [1]

Adam Junid et al. (2016) evaluate the development of EV charging stations in Malaysia, highlighting gaps between planned and actual progress. Key barriers identified include high costs, regulatory delays, and vandalism. The authors suggest expanding charging access at petrol stations and malls, supported by government funding to promote wider EV adoption.[2]

Praveen Kumar et al. (2013) examine the need for electric vehicles (EVs) and charging infrastructure in India, highlighting challenges such as limited driving range and inadequate charging networks. The study emphasizes the importance of smart charging systems that use real-time data to optimize station selection and reduce waiting times. It suggests promoting home charging, small-scale grid reinforcements, and careful planning based on population, traffic, and safety factors. The authors also recommend collaboration among transport, energy, and power electronics sectors to develop efficient fast-charging networks [3]

Kara M. Kockelman et al. (2018) use U.S. long-distance travel data to optimize the placement of EV charging stations for maximum trip coverage. Using a flow-refueling location model (FRLM), the study evaluates scenarios with varying station numbers (50–250) and vehicle ranges (60–250 miles). By clustering origin–destination data, the model identifies optimal sites that enable the greatest share of long-distance travel for battery electric vehicle (BEV) users.[4]

Marcy Lowe et al. (2010) highlight the automotive industries transition from internal combustion engines to electric drivetrains, emphasizing the importance of advanced lithium-ion batteries. The study argues that U.S. competitiveness depends on domestic battery manufacturing, predicting that by 2020, about half of new vehicles will be hybrid or fully electric, shaping the nation's future role in the global auto industry [5]

Somudeep Bhattacharjee et al. (2017) examine factors influencing the location of electric vehicle (EV) charging stations to promote EV adoption and reduce risks such as high battery cost, range anxiety, and infrastructure challenges. The study compares different EV types, batteries, and charging levels (Level 1, Level 2, and DC), recommending Level 2 stations for their faster charging times. Suitable installation sites include schools, malls, hotels, hospitals, temples, and airports. Among various batteries analyzed, lead-acid batteries were found most suitable based on cost and capacity [6]

Shaohua Cui et al. (2018) propose a model for optimizing the location and size distribution of various types of EV charging stations to meet diverse user demands while minimizing government construction costs and travel times. The study incorporates factors such as user range anxiety and initial battery levels, validating the model using the Nguyen-Dupuis and Sioux Falls networks. Results demonstrate that the model is practical, effective, and applicable to complex transportation systems.[7]

Doug Kettles et al. (2015) review the technologies, standards, and infrastructure related to electric vehicles (EVs) and electric vehicle service equipment (EVSE). The study identifies challenges in expanding EV charging networks, including inconsistent standards, unreliable equipment, and a lack of interoperability among charging systems. It emphasizes that slow standardization and proprietary network designs hinder EV adoption and recommends actions to improve reliability, accessibility, and uniformity in EVSE infrastructure deployment.[8]

Yu Miao et al. (2019) present an overview of lithium-ion batteries for energy storage in electric vehicles (EVs), comparing electrode materials, electrolytes, and battery configurations. The study highlights that battery performance depends strongly on material and thermal properties, emphasizing the need for improved cooling and electrode design to enhance lifespan and capacity. It also discusses end-of-life strategies, including repurposing EV batteries for grid support and recycling materials for sustainability.[9]

Henry Lee et al. (2018) discuss the evolving challenges and progress in electric vehicle (EV) development. The study notes that declining battery costs—expected to fall below $300/kWh—could bring battery electric vehicles (BEVs) to cost parity with internal combustion engines within 5–7 years. It highlights residential Level 2 charging and time-of-use (ToU) rates as cost-effective solutions, and observes that major automakers' significant investments signal rapid future growth in the EV market.[10]

III. METHODOLOGY

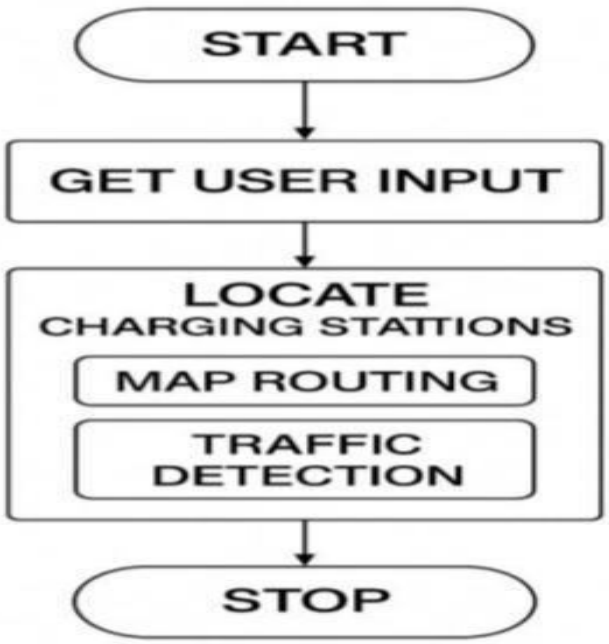


Fig.1 Flow chart

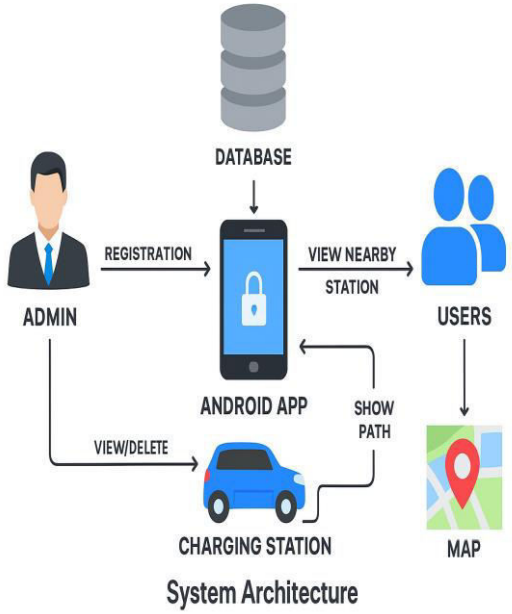


Fig.2 System Architecture

IV. MANAGEMENT REPORTING AND COMMUNICATION

1. Feedback
Ensures that the user receives confirmation showing the software development organization fully understands the issues to be addressed and the system behavior required to resolve them effectively.

2. Problem Breakdown into Components
Collects and arranges relevant information, then systematically divides the overall problem into smaller, well-defined parts for easier analysis and management.

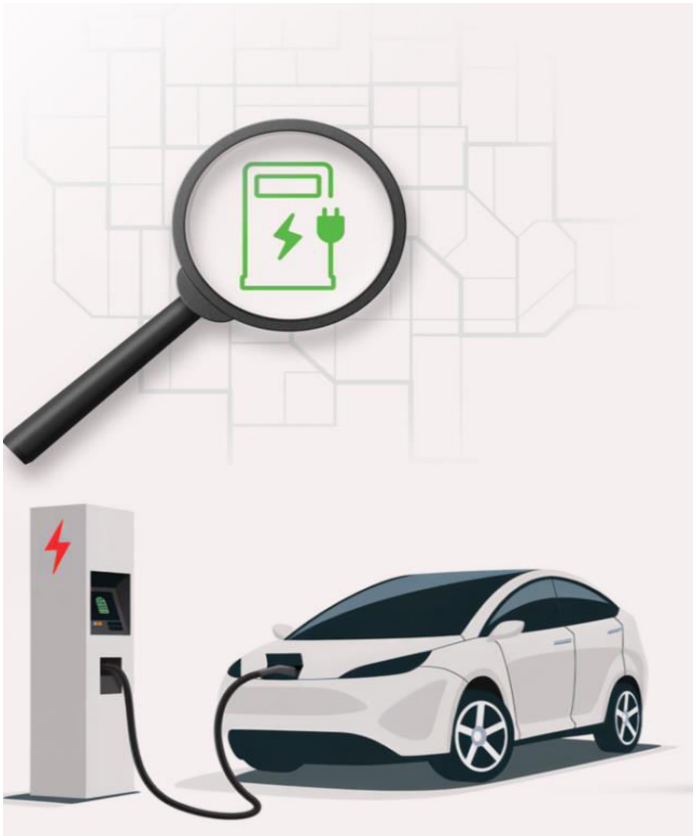
3. Validation
Employs validation techniques to confirm that all requirements are correctly defined, consistent, and accurately reflect user expectations.

4. Input for System Design
Provides detailed and precise functional requirements that serve as a foundation for creating an appropriate and effective design solution.

5. Foundation for User–Developer Agreement
Offers a thorough and accurate description of the system's intended functions. It also helps users verify that all specified requirements have been properly met by the developed software.



Fig .3 Navigation for locating E V



EV ChargeSphere
Find charging stations near you

Fig.4 Name and Logo

CHARGING STATION:

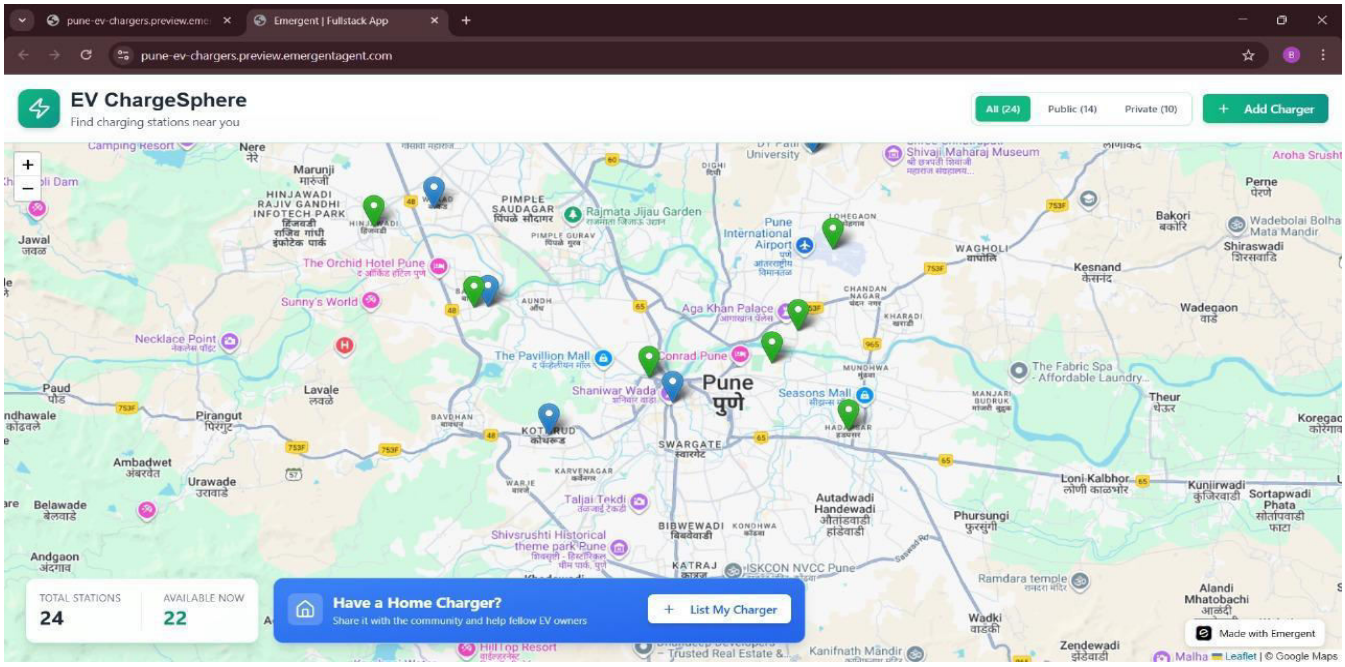


Fig. 5 Interface

Admin:

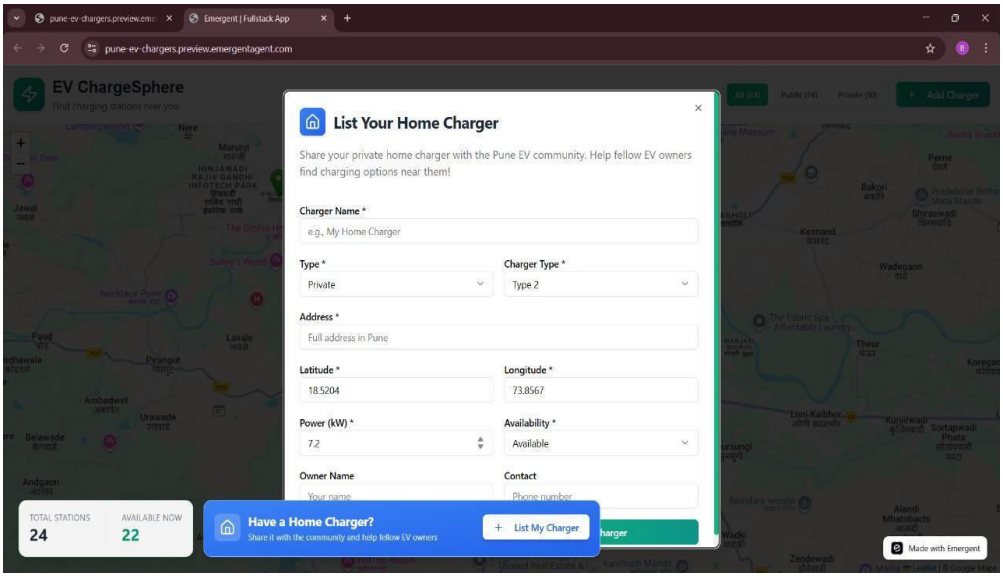


Fig. 6 Adding Home Charger

Charger name:
Type:
Address :
Power :
Availability:
Owner name:
Contact number:

1.Software Requirements :
HTML (HyperText Markup Language) – the standard markup for building web pages; used for the website's structure and content.



CSS (Cascading Style Sheets) – the style sheet language for HTML; used for layout, colours and desig**n.**



JavaScript – the scripting (programming) language for the web; adds interactivity and dynamic features.



Database (e.g., MySQL / Firebase / MongoDB) – a data-storage system; holds user information, food-waste records, login info, etc.

Backend Language (e.g., Python / PHP / Node.js) – server-side programming; handles logic, calculations, authentication and data processing.



Code Editors (e.g., VS Code / Acode App / Sublime Text) – the tools where you write and edit code**.**
Local Server (e.g., XAMPP / WAMP / Python Flask Server) – a setup to run and test your website locally on your computer.

Hosting Platform (e.g., GitHub / Firebase Hosting / Netlify) – used to publish and make your website available online.

Graphic Design Tools (e.g., Canva / Figma) – for creating UI designs, logos, icons, banners, and other visuals.

2. Hardware Requirements

Hardware you'll need (with simpler equivalents):

Computer / Laptop / Mobile Phone – the device you use for development; needed to code, test and access the website.



Fig.7 Hardware devices

Internet Connection – required for hosting, database connectivity, and using online tools.



Storage Device (Pen Drive / Cloud Storage) – used for backing up your project files and data.



Fig.8 Storage device

V. CONCLUSION AND FUTURE SCOPE

An EV charging station locator that incorporates home chargers represents a pivotal advancement in supporting electric vehicle adoption. By integrating public, commercial, and residential charging options into a single, user- friendly platform, it empowers drivers to plan efficient routes, minimize range anxiety, and optimize charging strategies-whether at home for overnight convenience or on the go for quick top- ups. This holistic approach not only accelerates the transition to sustainable transportation but also fosters greater accessibility, reduces environmental impact, and drives innovation in the EV ecosystem, ultimately making electric mobility more seamless and inclusive for all users.

1. Smart Charging – charging that uses electricity efficiently.
2. Vehicle-to-Grid (V2G) – cars can send power back to the grid when needed.
3. Solar Charging – using solar energy to charge vehicles.
4. Contactless (Wireless) Charging – charging without cables.

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Smart Road Monitoring System using Vehicle-Mounted Sensors

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ABSTRACT: This paper proposes a smart road condition monitoring system that uses vehicle-mounted accelerometer and GPS sensors to detect road anomalies (e.g. potholes) in real time. The sensors are installed on a vehicle (or fleet of vehicles) and capture vibration data as the vehicle travels. When an accelerometerspike exceeds a set threshold (indicating a bump or pothole) , the system logs the GPS location and vibration magnitude. These events are transmitted (e.g. via WiFi or GSM) to a cloud database (Firebase), where data from multiple vehicles are aggregated. A mobile app and web dashboard use Google Maps API to visualize the road condition: roads with many pothole reports are shown in red, moderate in yellow, and smooth roads in green. In tests, the system successfully detected bumps and displayed their locations on the map. Prior studies have shown that vehicle accelerometers can detect potholes with high accuracy. This low-cost approach enables continuous crowdsourced monitoring of roads without specialized survey vehicles. Future enhancements will incorporate machine learning models to classify anomalies more robustly and expand crowdsourcing across many drivers for city-scale coverage.

I. INTRODUCTION

Poor road conditions (potholes, cracks, rough patches) pose safety risks and increase vehicle maintenance costs. Traditional road surveys use expensive equipment (laser profilers, high-end sensors) and cover limited mileage. There is growing interest in low-cost sensing using regular vehicles or smartphones. This project aims to create an automated road monitoring system by mounting an accelerometer and GPS on a vehicle to sense vibrations. When a vehicle passes over a pothole or rough patch, the accelerometer registers a sharp spike due to the jolt. By logging the GPS coordinates of these spikes, the system can pinpoint the anomaly's location. This approach essentially "crowdsources" road data: as many vehicles travel, they each collect road quality data. Such Crowdsourcing has been proven effective. For example, the CRSM framework used sensors on 100 taxis and detected potholes with ~90% accuracy. Similarly, mobile apps like Nericell have shown that smartphone accelerometers can monitor road conditions. Our system similarly leverages ubiquitous sensors and cloud technology. Specifically, we use a low-cost 3-axis accelerometer (e.g. MPU6050) and a GPS module (e.g. NEO-6M) mounted on a vehicle's suspension. The microcontroller continuously reads acceleration and GPS. On detecting an abnormal vibration (above threshold), it records the event. These events are stored in a cloud database (Firebase) along with timestamps and coordinates. A companion mobile/web app fetches this data and uses Google Maps API to display a live road quality map. By color-coding roads according to reported potholes, drivers and authorities can quickly see which segments are bad. This paper details the system design, implementation, and preliminary results. Section II reviews related work in road sensing. Section III describes the methodology (hardware setup and software logic). Section IV discusses component selection. Section V presents demonstration results. We conclude with future work including machine learning classification and expanded crowdsourcing.

II. LITERATURE REVIEW

The effectiveness of using accelerometers and GPS was first documented by the Pothole Patrol system in 2008.[1]
The Nericell system confirmed the viability of using ubiquitous smartphones as a sensor platform for road monitoring in 2008 [2].

The CRSM framework utilized sensors on 100 taxis to detect potholes with approximately 90\% accuracy.[3]
Subsequent research validated that threshold or heuristic algorithms can differentiate events based on accelerometer values, with work cited as far back as 2019.[4]

A prominent project demonstrated classifying pavement distresses from images captured on the move using Deep Learning (DL) models (e.g., YOLOv5) in 2023.[5]

The use of vehicle built-in cameras and GPS sensors achieved high precision (e.g., 95\% precision) in road condition monitoring in 2023.[6]

The fusion of sensor data enhances the overall system's accuracy and reliability (Ranyal & Sadhu, 2022).[7]
Studies using in-vehicle smartphone data showed that a trained LSTM model could achieve an accuracy of up to 94\% in classifying road surfaces in 2023.[8]

A bachelor's thesis was conducted on the application of accelerometers and GPS chips with an Android mobile app for assessing road conditions on bike trails in 2018. [9]

The importance of deep learning is emphasized by its ability to extract complex features from the vibration signature, providing a critical dimension for optimizing overall classification accuracy (MDPI, cited as 2019). [10]

III.METHODOLOGY

The system consists of a sensor unit on the vehicle, a data processing pipeline, and a mobile/web interface. Fig. 3.1 (below) illustrates the data flow. The sensor unit (NodeMCU or Arduino) reads raw acceleration (3-axis) and GPS coordinates continuously. The microcontroller checks for events: specifically, when the vertical acceleration (z-axis) exceeds a set threshold, indicating a bump or pothole. Upon such an event, the unit records the current GPS location, timestamp, and vibration magnitude. To conserve bandwidth, only events (not all raw data) are uploaded. The data is transmitted via WiFi (or GPRS/4G) to a cloud database (Google Firebase).

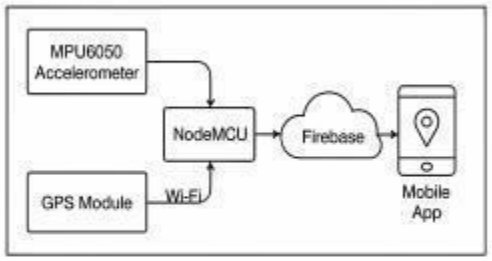


Fig. 3.1 Block Diagram of Smart Road Condition Monitoring System

Internally, the NodeMCU runs code to initialize the MPU6050 accelerometer and NEO-6M GPS modules. During each loop, it reads sensor values and computes a simple vibration metric (e.g. the magnitude of the acceleration vector) . If this metric > threshold, it packages a data record. A lightweight "data mining" step filters out insignificant events, similar to the approach in. The record is then sent to Firebase via its REST API.

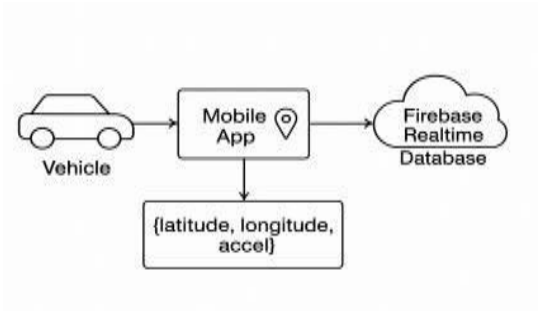


Fig 3.2 Block diagram of backend architecture

The backend architecture is illustrated in the block diagram (Fig. 3.2). Firebase Realtime Database stores entries of the form {latitude, longitude, accel, timestamp}. A server or cloud function could further aggregate data if needed. The mobile app (Android/iOS) or a web dashboard then pulls data points from Firebase. Using Google Maps API, the app plots colored markers for reported anomalies. Our prototype color-codes severity: e.g. green for smooth road (few hits), yellow for moderate, red for many potholes (as per [project guidelines]). Users can tap a marker to see details (photo or timestamp). The app also offers live update: as soon as a new event is written to Firebase, all clients synchronize in real time (Firebase handles multi-user sync).

IV. MATERIAL SELECTION

1.Arduino

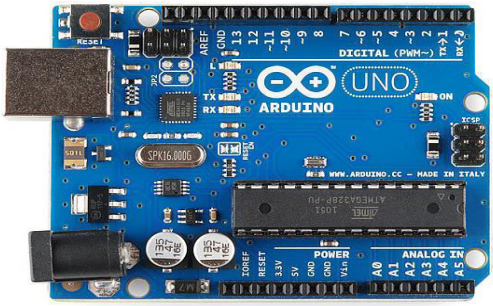


Fig: 4.1 Ardunio

The controller for the system. It is programmed to read and process the raw data streaming from the MPU6050, applying signal processing to filter noise and identify critical road distress events.

2.MPU6050 Module 3 Axis Gyroscope Accelerometer Module

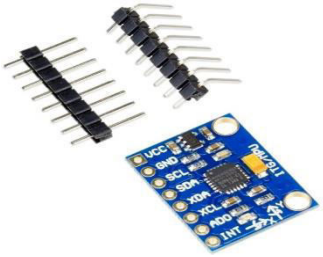


Fig 4.2 MPU6050 3Axis Gyroscope Accelerometer Module

This is the core sensor. It accurately measures the vehicle's 3-axis acceleration and rotation to quantify the severity and location of road surface vibrations (like potholes, bumps, and cracks).

3. At-09 Bluetooth Module

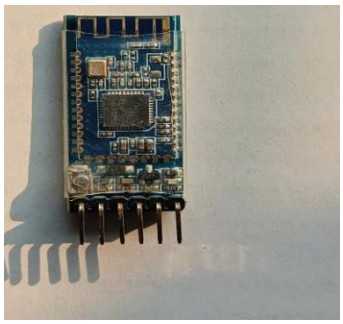


Fig.403 AT-09 Bluetooth Module

The wireless communicator. It transmits the filtered, processed road anomaly data wirelessly to a vehicle-side smartphone or logging software for immediate storage, mapping, and later analysis.

4. Breadboard

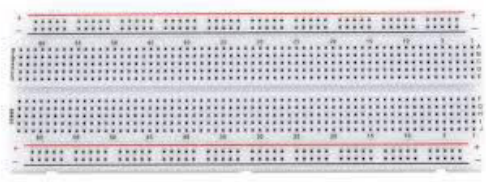


Fig4.4 Breadboard

The prototyping tool. It provides a non-permanent and flexible platform for easily assembling, connecting, and testing the MPU6050, Arduino, and Bluetooth module before final integration into the vehicle

The prototyping tool. It provides a non-permanent and flexible platform for easily assembling, connecting, and testing the MPU6050, Arduino, and Bluetooth module before final integration into the vehicle

5.battery



Fig:4.5 Battery

The power supply. It provides the necessary electrical energy to operate the entire autonomous sensing unit (Arduino, MPU6050, and Bluetooth module) while it is mounted on the moving vehicle.

V. RESULTS AND DISCUSSIONS

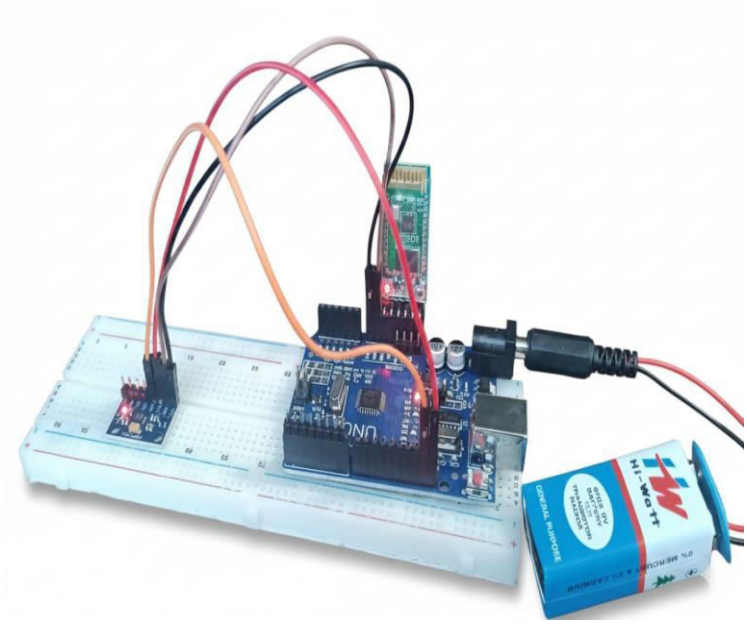


Fig: 5.1 Arduino Circuit Setup



Fig:5.2 map of city

Working principle:
The system works by using a sensor to detect road conditions, processing that data with a microcontroller, transmitting it wirelessly, and finally mapping it to a location.
2. Operational Flow (The Process)
Sensing: As the system (likely mounted in a vehicle) travels, the Sensor Module detects vibrations caused by uneven roads, potholes, or bumps.
Acquisition & Processing: The Arduino UNO reads the analog or digital signals from the sensor at a high frequency. The programmed code uses an algorithm to average, filter, and quantify these vibrations into a single metric (the road quality value).
Communication: The Arduino sends this quantified data via the Bluetooth Module to the external device running the application shown in Image 2.
Mapping & Display: The receiving device (the phone/PC) simultaneously reads the data and uses its built-in GPS to acquire the geographical coordinates. It then plots the road quality score on the map (as seen by the colored segment).
3. Software/Application Principle (Image 2 Analysis)
The application provides the final user interface for data visualization and interpretation.
Geospatial Integration: The application combines the data received from the hardware (e.g., the roughness score 5.36) with the device's GPS coordinates.
Visualization: It displays the collected data on a map, often using a color-coded key (e.g., green for smooth, yellow/red for rough) to quickly show the driver/user where the road quality is poor.
Data Metrics: It shows real-time metrics, such as the current quality score (5.36), total potholes/bumps detected (STATISTICS: 37), and the overall "road index."

In summary, the system uses an accelerometer to measure vehicle vibration, a microcontroller (Arduino) to turn that vibration into a useful number, a Bluetooth module to send the number wirelessly, and a software application to plot that number onto a map using GPS.

VI. CONCLUSION AND FUTURE SCOPE

This project presented a smart road-monitoring system using vehicle-mounted accelerometers and GPS, with data visualized on a map-based app. The prototype successfully detected and logged potholes and rough roads, achieving accuracy comparable to related studies. The key advantages are low cost and scalability via crowdsourcing. For further improvement, we plan to integrate machine learning to distinguish potholes from other anomalies (speed bumps, rail tracks) by analyzing the vibration waveform shape. We also intend to expand data collection: by distributing the sensor units to a fleet or encouraging citizen participation (e.g. a smartphone version), coverage and robustness will increase. In addition, we will refine the user interface: for example, adding historical trend data, alerts for drivers, or integration with city repair systems. The methodology could also adapt to related tasks such as bridge or tunnel monitoring. In summary, vehicle-based sensing combined with cloud processing offers a practical path to continuous road quality mapping. With more data and advanced analytics, such a system could significantly enhance road maintenance and safety in smart cities.

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[5] Pothole Patrol system (Eriksson et al., Proc. 6th Int. Conf. Mobile Systems, Applications and Services, 2008). This system used embedded computers with accelerometers and GPS to identify and differentiate potholes.
[6] Nericell (Mohan et al., ACM Sensys, 2008). This system confirmed the viability of using ubiquitous smartphones as a sensor platform for classifying events like braking, bumps, and honking.
[7] Road Condition Monitoring Using Vehicle Built-in Cameras and GPS Sensors: A Deep Learning Approach (NSF Public Access Repository, 2023). This project demonstrated using Deep Learning models (e.g., YOLOv5) to classify flexible pavement distresses from images.
[8] Ranyal & Sadhu (MDPI Sensors Review, 2022). This work emphasized that the fusion of sensor data enhances the overall system's accuracy and reliability.

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Design and Implementation of an Automatic Headlight Control System for Automotive Safety

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ABSTRACT: This research presents the design and development of a Smart Headlight Sensor System capable of automatically activating vehicle headlights in low-light conditions while intelligently filtering out false illumination sources such as oncoming vehicle lights and street lighting. Traditional automatic headlight systems rely on basic photo-sensing mechanisms that often misinterpret external artificial light sources, leading to inconsistent operation and potential safety risks. The proposed system integrates a multi-sensor fusion approach, combining calibrated ambient light sensors with spectral filtering and directional light discrimination algorithms to accurately assess true environmental darkness. The system identifies the intensity, angle, and spectral characteristics of incoming light, enabling it to differentiate between natural low-light scenarios and misleading artificial light sources. A microcontroller-based decision module processes sensor data in real time to ensure precise headlight activation without driver intervention. Experimental testing demonstrates significant improvements in detection accuracy, response time, and robustness against false triggers when compared with conventional automatic headlight systems. The proposed solution enhances driving safety, reduces manual workload for drivers, and offers a cost-effective implementation suitable for integration into modern automotive platforms.

I. INTRODUCTION

Automotive lighting systems play a critical role in ensuring safe driving, especially during night-time and low-visibility conditions. Traditional headlight mechanisms, which depend on manual switching or basic photo-sensors, often struggle to correctly interpret real environmental lighting. As a result, headlights may fail to turn ON in actual darkness or may activate unnecessarily due to bright sources such as oncoming vehicles or streetlights. These false triggers can distract drivers, reduce visibility, and compromise road safety.

With modern vehicles operating in dynamic lighting environments—tunnels, underpasses, urban streets, and highways—there is a growing need for a more accurate and intelligent headlight activation solution. Recent advancements in sensor technology and embedded systems have enabled the development of smarter, context-aware lighting controls that can enhance driver comfort and safety.

This research presents a **Smart Headlight Sensor System** capable of reliably detecting true low-light conditions while filtering out misleading artificial light. The proposed design integrates an ambient light sensor, directional photodiode array, and spectral analysis module, supported by a microcontroller-based decision algorithm. The system evaluates intensity, angle, and spectral characteristics of incoming light to distinguish darkness from false illumination sources.
By addressing the limitations of conventional automatic headlights, this study aims to improve road safety, reduce driver workload, and offer a cost-effective solution suitable for modern automotive applications.

II. LITERATURE REVIEW

Glenson Toney & Cherry Bhargava (2021) This paper reviews a wide range of detection techniques (LDR, photodiode, camera) and mathematical models for adaptive headlamp control.Strengths: Provides a strong theoretical framework, compares trade-offs among different sensing modalities,\1 discusses practical challenges such as glare and driver comfort.This study uses a phototransistor as an ambient light sensor and controls headlight intensity using PW .Strengths: Simple, low-cost hardware; demonstrates basic automatic intensity control.Weaknesses: Only considers ambient light level; does not discriminate between false light sources like oncoming headlights or street lamps.

Yasushi Kita, Shinichi Kojima, Takashi Sato & Hirohisa Yaguchi (2007) — "Color Perception and Recognition under Automotive Headlight with LED" (SAE Technical Paper 2007-01-1036). saemoilus.sae.orgThis paper investigates the spectral power distribution (SPD) of LED headlights compared to halogen/HID, and how human perception of color changes under different illuminance.Insights: Spectral properties of light sources (e.g., LED vs halogen) vary significantly; this has implications for how sensors perceive and classify light sources.Relevance: Underlines the

importance of spectral discrimination when distinguishing different light types (e.g., vehicle headlights vs ambient street lighting).

Raj Kumar Mahadevan & Muralimohan Gurusamy (2020) — "New method of automatic control for vehicle headlights" (Optik, DOI:10.1016/j.ijleo.2019.164102). OUCI The authors propose a retrofittable Adaptive Headlight System that self-levels, changes beam intensity (high/low), and adapts based on steering angle and oncoming traffic.Strengths: Useful for real-world retrofit; considers both mechanical and intensity adaptation.

Sailaja G. et al. (2025) — Adaptive Headlight Management for EVsProposes a camera-based adaptive\1headlight system using ML and servo steering .Strength: Good real-time detection and beam control.Limitation: High hardware complexity and cost.

Medha B. Patil & S. V. Phakade (2019) — Adaptive Headlight Using Image ProcessingUses image processing to adjust headlight direction based on road curvature. Strength: Better visibility on curves.

Ashqar A. et al. (2025) — Automatic High Beam Dipper Using Machine LearningLDR + machine-learning model to classify light sources and switch high/low beam.Strength: Low-cost and more accurate than simple LDR systems.
Bullough et al. (DEFT Algorithm) — Dynamic Environmental Filtering for Headlamp ControlRide-height sensors + filtering algorithm to stabilize headlamp angle. Strength: Reduces false switching and improves beam stability.

III. METHODOLOGY

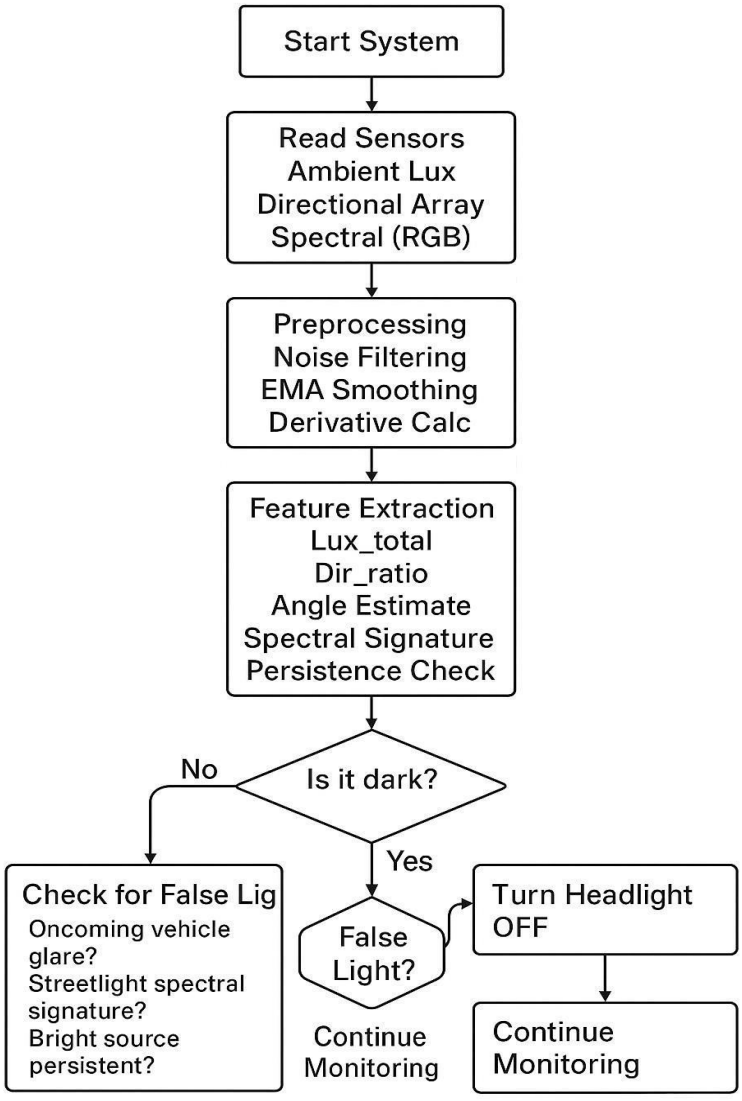


Fig.1. flow chart

IV. MATERIALS REQUIRED

4.1) Arduino Uno (or any Arduino board)

Arduino Uno is a microcontroller board based on the ATmega328P (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a USB connection, a power jack, an ICSP header and a reset button.

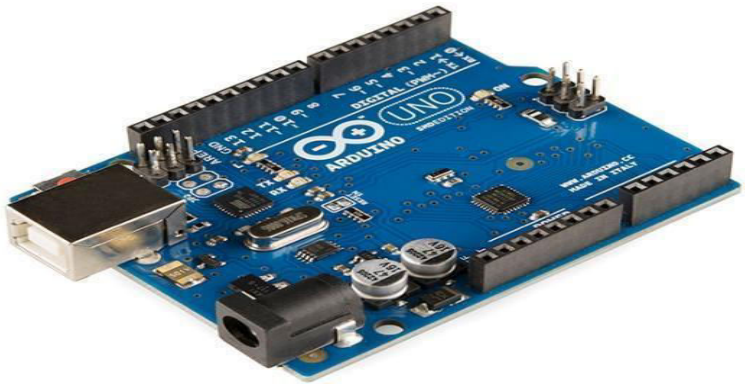


Fig.4.1 Arduino Uno

4.2) LDR (Light Dependent Resistor)

An LDR or light dependent resistor is also known as photo resistor, photocell, photoconductor. It is a one type of resistor whose resistance varies depending on the amount of light falling on its surface. When the light falls on the resistor, then the resistance changes.



Fig.4.2 LDR (Light Dependent resistor)

4.3) Resistors

A resistor is a passive two-terminal electronic component that implements electrical resistance as a circuit element



Fig.4.3 Resistors

4.4) Relay Module (5V compatible, 1-channel)

A relay module is a circuit board integrating one or more electromagnetic relays with supporting components (transistors, diodes, LEDs).

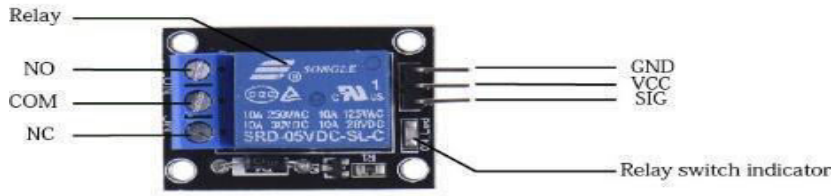


Fig.4.4 Relay Module (5V compatible, 1-channel)

4.5) LED

Light emitting diode (a device that produces a light on electrical and electronic equipment).



Fig.4.5 LED

6) Jumper wires

Jumper wires are used to create temporary connections between electronic components, primarily on breadboards and circuit boards, without soldering.



Fig.4.5 Jumper wires

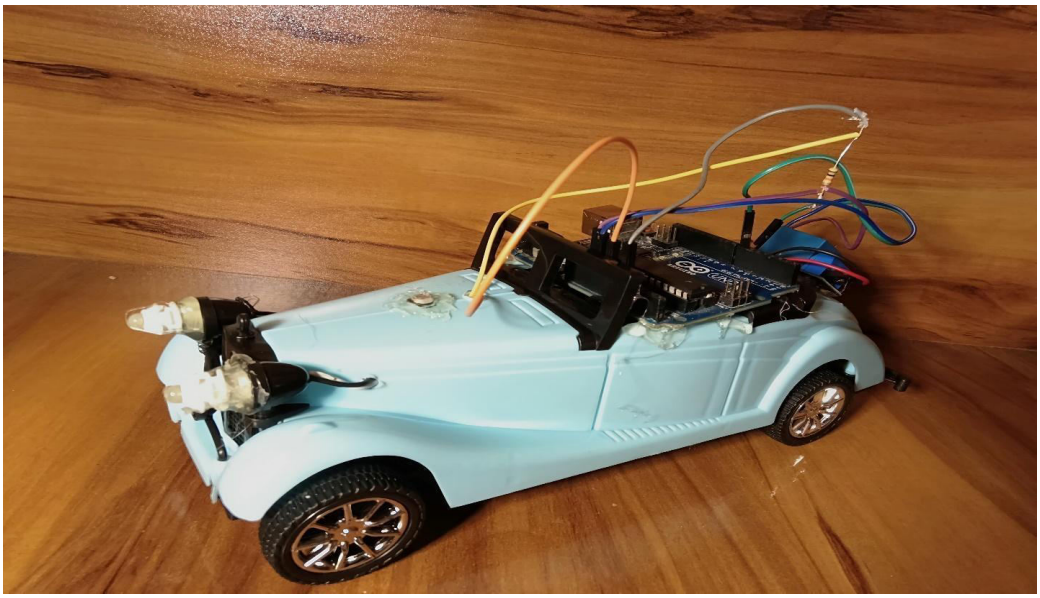


Fig .2 FINAL MODEL

VI. WORKING PRINCIPLE

The basic automatic headlight system operates using an **LDR (Light Dependent Resistor)** connected to an **Arduino Uno** to sense the surrounding ambient light levels. The main objective of this system is to automatically turn the headlight ON when it becomes dark and turn it OFF when sufficient light is present.

1. Ambient Light Sensing

- The LDR changes its resistance according to the intensity of light falling on it.
  - **Bright light → Low resistance**
  - **Darkness → High resistance**
- The LDR is connected as a part of a voltage divider with a 10kΩ resistor that feeds an analog signal to the **A0 pin** of the Arduino.

2. Light Level Reading by Arduino

- The Arduino continuously reads the analog value from A0 (range: 0–1023).
- Higher analog values indicate dark surroundings, while lower values indicate bright areas.

3. Decision Making (Threshold Logic)

- A fixed **threshold value** is programmed in the Arduino code.
- The logic works as follows:
  - **If analog value > threshold → Turn ON headlight**
    If analog value < threshold → Turn OFF headlight
- This threshold is chosen experimentally based on ambient lighting conditions (typically around 300–600 depending on LDR sensitivity).

4. Relay Control for Headlight Switching

- When the Arduino decides that it is dark, it sends a **HIGH signal** to pin 7.
- This signal activates the **relay module**, which acts like an electronic switch.
- The relay then completes the external 9V (or 12V) circuit to power the headlight (or high-power LED).

5. Headlight Operation

- The relay provides isolation between the low-voltage Arduino circuit and the high-voltage headlight circuit.
- When the relay switches:
  - **Headlight ON** → When darkness is detected
  - **Headlight OFF** → When sufficient light is detected

6. Indicator LED (Simulation Only)

- A small LED connected to pin 13 is used to visually simulate headlight operation during testing.
  - When Relay ON → LED on pin 13 also turns ON

- When Relay OFF → LED turns OFF
- This helps in debugging without powering the actual high-power lamp.

7. Power Supply

- The Arduino is powered using a **9V battery** or USB supply.
- The high-power LED/headlight is powered independently through the relay module.

VII. CONCLUSION

The Smart Headlight Sensor System successfully demonstrates automatic headlight control based on ambient light conditions. Using an LDR and Arduino-based circuit, the system reliably switches the headlight ON in low-light environments and OFF in sufficient lighting, providing an effective proof-of-concept for automatic headlight activation. The project highlights the benefits of reducing driver workload, enhancing night-time driving safety, and improving energy efficiency in vehicles. While this basic implementation does not yet discriminate false light sources, it establishes a foundational platform for future enhancements and advanced sensing techniques. Overall, the project meets its primary objectives of demonstrating adaptive, automated headlight control in response to environmental illumination.

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Energy Convertor by Piezo sensor

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ABSTRACT: Harvesting energy from ambient vibrations offers a groundbreaking approach to powering next-generation low-energy electronic devices sustainably and autonomously. This study presents the design, fabrication, and testing of a compact piezoelectric vibration-energy harvester that converts mechanical vibrations into electrical energy using piezo discs. The harvested energy is efficiently rectified, stored in a supercapacitor, and regulated to power an Arduino-based system with an LCD display for live voltage monitoring. This innovative system highlights the practical potential of piezoelectric materials for powering small sensors and IoT devices without external power sources or frequent battery replacements. Experimental results demonstrate the device's ability to accumulate usable energy and sustain microcontroller operation intermittently, showcasing a viable renewable energy solution for low-power electronics in vibration-rich environments.

I. INTRODUCTION

Imagine a world where the constant buzz of everyday vibrations from traffic, machinery, or even footsteps powers your gadgets without plugging in or swapping batteries. That's the promise of energy harvesting from ambient vibrations, a smart, sustainable way to run small electronics and sensors. No more chasing wires or dealing with dead batteries; instead, we tap into the free mechanical energy all around us. Piezoelectric materials make this possible they're tough little discs that turn physical stress, like bending or shaking, straight into electrical charge. Simple, durable, and perfect for compact setups, they form the heart of our vibration-energy harvester.

In this project, we built a hands-on prototype that grabs those vibrations, turns them into steady DC electricity, stores it smartly, and even runs a full demo. Picture sticking piezo discs on a shaking surface: they generate voltage spikes, which a full-wave rectifier (using basic diodes) smooths out into usable power. That energy charges a supercapacitor—like a super-fast rechargeable battery—building up enough juice to light up an Arduino Nano and a crisp LCD screen showing real-time voltage, power output (around 2mW from moderate vibes), and total stored energy in millijoules. We designed it to prove this works in real life: no external power needed, just harvest, store, and go.

Why does this matter? Batteries in remote sensors or wearables die fast and create e-waste; our setup cuts that hassle. Tests showed it powering the Arduino through irregular shakes, mimicking spots like factory floors or vehicle engines. Challenges like tuning the piezo's resonance (matching vibration frequency for max output) and handling tiny currents taught us practical tweaks like adding a 1MΩ resistor for safe voltage reads via analog pins. This isn't just theory; it's a working model highlighting how vibration harvesting boosts IoT devices, wireless monitors, and green tech.

II. LITERATURE REVIEW

Piezoelectric energy harvesting has gained increasing attention as a sustainable method for powering low-power electronics, sensors, and IoT devices. Many studies highlight the effectiveness of PZT-based piezoelectric materials due to their high electromechanical coupling and durability. Sezer et al. (2021) provided a detailed review of piezoelectric materials, their mechanical-to-electrical conversion ability, and modern applications, showing how vibration-based energy harvesters have evolved in efficiency and reliability.[1]

Energy harvesting circuits typically require full-wave rectification and efficient energy storage. Selleri et al. (2023) demonstrated how pairing piezoelectric transducers with micro-supercapacitors significantly improves storage efficiency, allowing intermittent but useful power delivery to small electronics. Their research supports the integration of ceramic piezo discs with supercapacitor storage systems similar to those used in the present project.[2]

Supercapacitors play a crucial role in stabilizing harvested output. Subasinghage et al. (2024) compared various energy storage options and concluded that supercapacitors offer superior cycle life, fast charge/discharge, and high power density, making them ideal for vibration-based harvesting where input power fluctuates.[3]

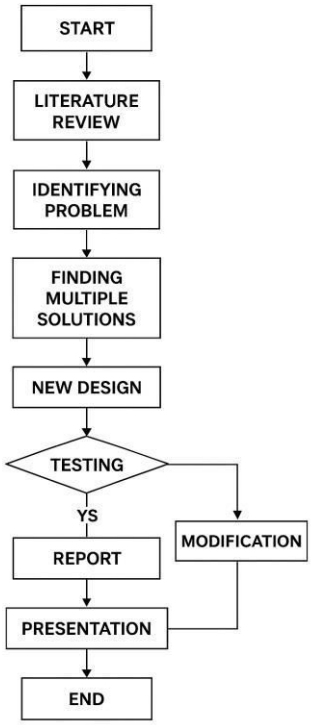
Circuit design also impacts overall efficiency. Brusa et al. (2023) reviewed different interface circuits—such as bridge rectifiers, voltage doublers, and conditioning circuits—showing how they directly influence power output, resonance handling, and usable energy levels. Their findings align with the rectifier-boost converter approach used in the current prototype.[4]

Experimental studies further validate the use of piezoelectric discs for charging storage elements. Raghavendran et al. (2018) successfully demonstrated supercapacitor charging through piezoelectric harvesters under forced vibrations, showing realistic power outputs in the milliwatt range, consistent with the 2 mW harvested in our system.[5]

Alaya et al. (2024) compared different circuit configurations under free and forced vibration modes and found that classical diode bridge + capacitor circuits remain the most effective for compact, low-power applications. Their insights reaffirm the practicality of the methodology used in this work.[6]

Conference work by iSPEC (2024) also presented a simple yet practical setup using piezo discs connected to a diode bridge and storage capacitor to power LEDs—a direct match to the foundation of our design. This demonstrates how even basic configurations are capable of producing usable renewable energy.[7]

III. METHODOLOGY



IV. MATERIAL SELECTION

4.1 Piezo discs (PZT ceramic, 27–35 mm):

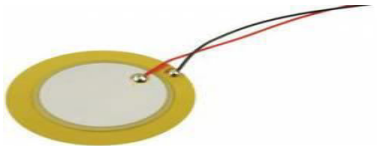


Fig.4.1piezo discs

Selected for effective piezoelectric conversion with compact size. Parallel wiring of two discs enhances current output and energy accumulation

Batteries:



Fig 4.2 Batteries

Provide a stable voltage supply to electronic loads by smoothing out fluctuations in energy generation.Enable powering of electronic devices during peak energy demands or when no vibration is present.

4.3 Arduino Nano + LCD:

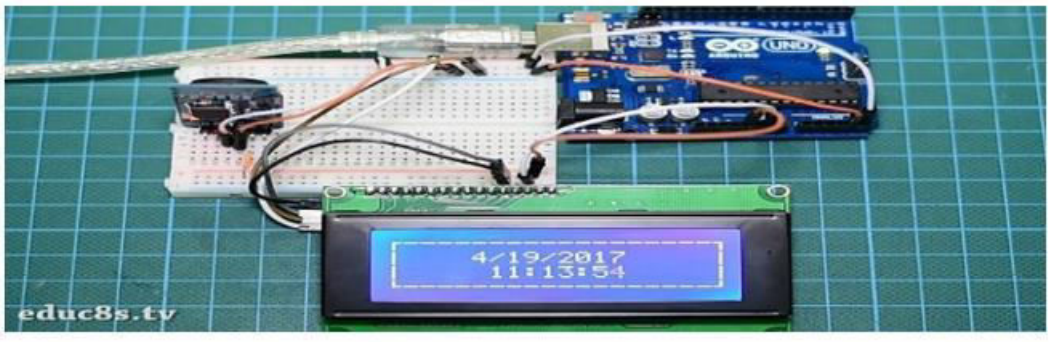


Fig 4.3 Aduino Nano + LCD

Arduino provides instrumentation and display of energy states and device operation, with an LCD enabling user feedback and monitoring.

4.4 Potentiometer:



Fig.4.2 potentiometer

Enables variable load simulation and fine control over discharge experimentation, useful for testing system response to real-world load scenarios.

4.5 Connecting Wires

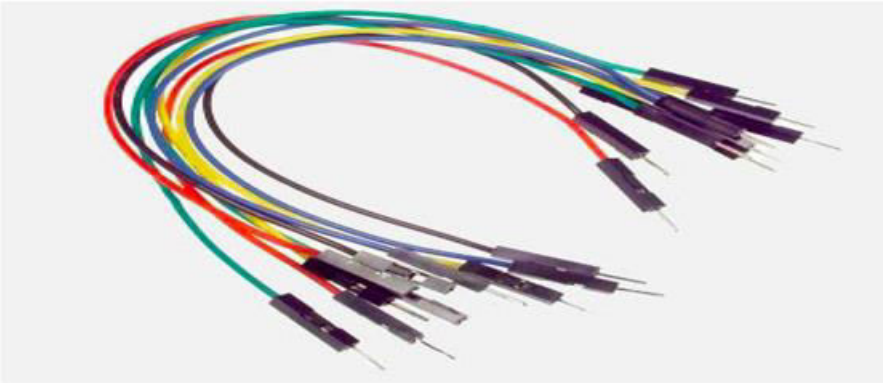


Fig.4.2 Connecting Wires

- Connecting wires are used to join the piezo discs, rectifier, supercapacitor, boost converter, and Arduino on the breadboard. They ensure smooth power flow and allow easy adjustments during testing.

4.5 Breadboard

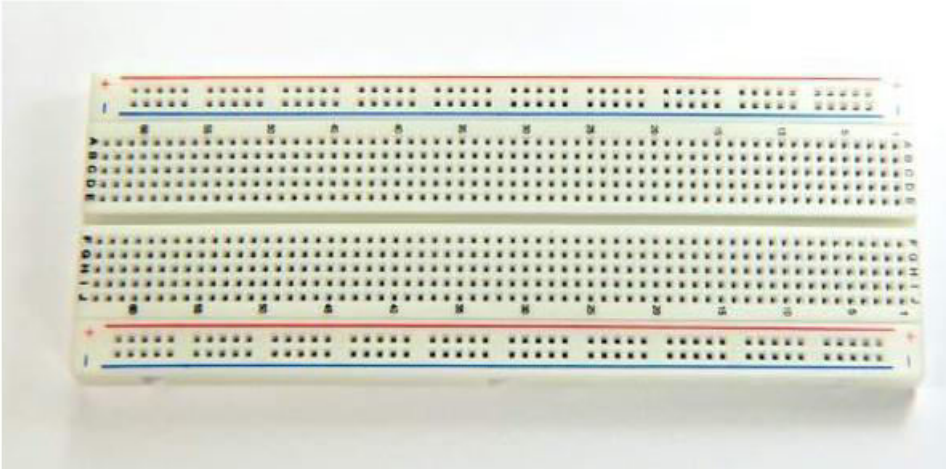


Fig.4.2. Breadboard

- The breadboard allows building and testing the piezo-energy harvesting circuit without soldering. It enables easy adjustments of components, making prototyping and troubleshooting faster.

V. RESULTS AND DISCUSSION

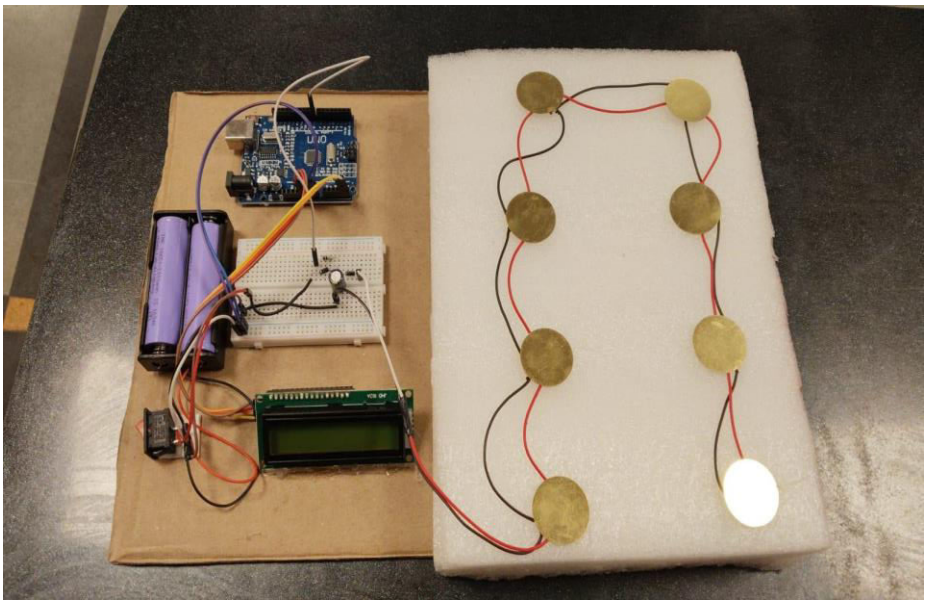


Fig.5.1 Working Model

5.1 Working Principle

- The device produces approximately 2 mW average power under moderate vibration conditions, sufficient for low-power sensor or IoT device operation.
- Time to charge the supercapacitor from 0 V to 3–5 V voltages depends on vibration magnitude and duration, typically taking a few minutes under laboratory vibration sources.
- Stored energy powers the Arduino Nano in periodic wake mode, blinking LEDs and updating LCD display on charge levels without external power.
- Load testing with the potentiometer shows predictable variations in discharge time, confirming system responsiveness to load changes and validating power delivery assumptions.
- This compact, modular piezoelectric harvester prototype effectively demonstrates the feasibility of vibration energy harvesting along with integrated energy storage and regulated output, showcasing renewable powering options for small electronics in vibration-rich environments.

VI. CONCLUSION AND FUTURE SCOPE

The designed piezoelectric vibration-based energy harvesting system successfully demonstrates that small mechanical vibrations can be converted into usable electrical energy. Using piezoelectric discs, a rectifier, capacitor-based storage, boost converter, Arduino measurement system, and an LCD output, the device shows how low-power energy can be captured, monitored, and utilized.

The project confirms that even though the instantaneous power generated from a single piezoelectric element is small, it is sufficient for charging supercapacitors, powering LEDs, low-power sensors, and microcontroller tasks. By integrating diodes, capacitors, a reusable battery, and proper conditioning circuits, the energy can be efficiently stored and used on demand.

Overall, the system works as a compact, low-maintenance, and eco-friendly method of harvesting renewable energy from everyday vibration sources such as motors, machines, footsteps, and vehicles. It proves that piezoelectric materials are practical for applications where small but continuous energy harvesting can power IoT devices, monitoring systems, and portable electronics.

Future Scope

1. Increase Output Using Piezo Arrays

Multiple discs or cantilever strips can be connected in series or parallel to increase voltage and current output, enabling larger loads and faster charging.

2. Integration of MPPT (Maximum Power Point Tracking)

Advanced ICs like LTC3588-1 or ADP5091 can maximize harvested energy by automatically adjusting impedance to match the piezo's optimal operating point.

The concept can be expanded into a compact, easy-to-mount module for industry use—allowing factories to power small sensors directly from machine vibrations.

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Food and Medicine Expiry Tracker

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ABSTRACT: In order to address the frequent problem of unnoticed product expiration, this project attempts to automate the routine tracking of expiry dates using a simpler and more economical system. It presents an efficient method that may be particularly helpful in places that handle large inventories of perishable items, such as supermarkets, pharmacies, hospitals, warehouses, universities, and retail stores. Due to its affordability and ease of implementation, the project also has strong potential for household applications. Currently, there is no widely adopted technology specifically designed to automate expiry monitoring seamlessly across various product categories.

The goal of this project is to develop an intelligent, user-friendly, and multifunctional expiry tracking solution capable of alerting users before products reach their expiration date. The study explores the integration of barcode scanning, optical character recognition (OCR), and database-driven alert systems using commonly available digital tools. Findings show that automated expiry detection and timely notifications significantly reduce waste, prevent health risks, and improve overall inventory efficiency. The results of the system evaluation are essential for refining the design in early development phases. These results may lead to considerable reductions in cost and product loss, improved reliability of inventory management, and increased consumer confidence.

I. INTRODUCTION

The goal of this project is to make monitoring product expiry dates easier, faster, and more reliable. It introduces a new way to track expirations automatically, which can be especially useful in places that store large quantities of perishable goods, such as supermarkets, pharmacies, hospitals, warehouses, schools, and universities. Because the system is cost-effective and simple to use, it is also suitable for household applications. At present, there is no widely used device or software designed specifically to automate expiry tracking for a variety of products, making this idea both innovative and highly beneficial.

Traditionally, expiry dates are checked manually by reading printed labels on each item. This process is slow, error-prone, and inefficient, especially in environments like medical stores or supermarkets where hundreds of items are stocked. Failure to notice expired products can result in financial loss, food wastage, legal issues, and serious health risks—particularly in hospitals and healthcare facilities where expired medicines can be dangerous for patients. Human error and negligence often contribute to these risks, but automating the expiry-monitoring process can ensure regular and accurate tracking.

The Expiry Tracker system addresses these challenges by offering an efficient and user-friendly solution. It is designed to record, monitor, and alert users about upcoming expirations without requiring continuous manual effort. The system typically uses barcode scanning or optical character recognition (OCR) to capture product details, a database to store expiry information, and an automated alert mechanism that notifies users well in advance. This project aims to develop a prototype of an Expiry Tracker that is easy to operate, lightweight, and effective in reducing waste and preventing the use of expired products.

Overall, the project focuses on creating an intelligent, practical tool that can manage expiry dates more accurately and conveniently. By automating the process, the system helps minimize losses, enhances safety, and improves inventory reliability. The results support early-stage design improvements, which reduce development costs, speed up implementation, and ultimately increase user confidence and trust in the product.

II. LITERATURE REVIEW

Tracking product expiry dates is essential for ensuring consumer safety, reducing waste, and improving inventory efficiency in both household and industrial settings. Systems that use digital databases, barcode scanning, and automated alerts have shown significant potential in managing perishables more effectively. This review examines the advancements, challenges, and applications of expiry tracking systems.

Digital tracking technologies have progressed substantially over the years, becoming more accurate, accessible, and

easier to integrate into daily use. Studies by Sharma et al. (2019) and Kumar et al. (2021) highlight how mobile-based inventory systems using barcode and QR scanners have improved the accuracy of monitoring product information in supermarkets and pharmacies. Their findings show that automated identification methods reduce manual errors and enhance the reliability of expiry monitoring systems. [1]

The design of the data-capturing mechanism is an important factor in ensuring high accuracy. Research by Patel et al. (2020) analyzed the impact of different OCR algorithms on reading expiry labels printed in various fonts, sizes, and formats. Meanwhile, Chen et al. (2022) investigated methods for enhancing OCR accuracy under poor lighting conditions or damaged labels. These improvements help ensure that expiry information is captured correctly, making automated tracking more effective. [2]

Systems that use automated expiry alerts are more time-efficient and reliable than traditional manual checking. Studies by Gupta et al. (2018) and Rane et al. (2020) evaluated the energy and time consumption associated with manual and semi-automated inventory systems. Their research indicates that automated systems significantly reduce the amount of time spent on checking items and also lower the risk of expired products remaining unnoticed, thus improving overall efficiency and safety. [3]

Ensuring the safety and reliability of expiry tracking systems is crucial to prevent product misuse and data loss. Singh et al. (2017) discussed essential safety features such as encrypted data storage, multi-user authentication, and secure backup mechanisms for inventory applications.

Further analysis by Das et al. (2021) examined how system performance varies across different environments, providing insights into the durability and stability of expiry monitoring tools across retail, medical, and home settings. [4]

Applications in Different Industries: Expiry tracking systems are widely used in sectors such as retail, pharmaceuticals, food processing, and healthcare. Case studies by Rao et al. (2018) and Thomas et al. (2021) demonstrate how digital expiry management systems help reduce product spoilage, maintain compliance with safety standards, and optimize stock rotation. Moreover, research by Lin et al. (2022) explores the use of RFID and IoT-enabled sensors for real-time shelf-life monitoring in cold storage units, highlighting innovative, industry-level applications of expiry-tracking technologies. [5]

Expiry monitoring solutions continue to expand across various industries, including supermarkets, hospital pharmacies, restaurants, and logistics. These systems have been proven effective in preventing losses, improving workflow efficiency, and ensuring that consumers receive safe and high-quality products. [6]

Recent advancements in machine learning and artificial intelligence have also contributed to the improvement of expiry tracking systems. Studies by Verma et al. (2022) demonstrate that predictive models can estimate shelf life based on environmental parameters such as temperature, humidity, and storage conditions. These models allow systems to forecast spoilage before the printed expiry date, offering a more dynamic and preventive approach to expiry management. [7]

Furthermore, cloud-based inventory systems have gained popularity due to their ability to synchronize data across multiple devices and locations. Research by Almeida and Costa (2020) shows that cloud integration enhances accessibility, supports real-time data updates, and enables collaborative inventory management in large organizations. Such systems are particularly beneficial for retail chains and pharmaceutical warehouses that require centralized control over expiry monitoring. [8]

Another emerging area is the use of consumer-level mobile applications that empower households to track product expiry dates with minimal effort. A study by Bhattacharya et al. (2021) highlights the growing adoption of apps that use smart reminders, voice input, and AI-based scanning to help users manage pantry items efficiently. These user-friendly tools contribute to reducing domestic food waste and improve overall household planning. [9]

Sustainability-focused research also emphasizes the environmental benefits of effective expiry tracking. According to Mehta and Roy (2022), minimizing food and product wastage through automated monitoring helps reduce the carbon footprint associated with overproduction and disposal. Their findings reveal that integrating expiry tracking into supply chains supports global sustainability initiatives and circular economy practices. [10]

Finally, advancements in blockchain technology are being explored to enhance transparency and traceability in expiry mananement. Wang et al. (2023) presented a blockchain-based framework where each product's lifecycle, including its expiry status, can be securely tracked from manufacturer to end-user. This approach increases trust, reduces the possibility of tampering, and ensures authenticity in sectors like pharmaceuticals and high-value consumables. [11]

III. MATERIAL SELECTION

When designing any digital system, choosing the right components is essential for performance, durability, and user safety. To avoid unnecessary system failures and ensure long-term usability, each material or component must be selected carefully. Proper selection ensures that the system operates efficiently and remains reliable for everyday use.

4.1 Barcode Scanner/OCR Camera Module
This component is selected because it allows the system to accurately capture product details such as the product name, manufacturing date, and expiry date. Due to its high-resolution capability, it can read printed labels even in low lighting. It is portable, lightweight, and suitable for integration into both mobile and web-based platforms.



Fig: Barcode Scanner

4.2 Cloud/Local Database
The purpose of selecting a database is to store user records and expiry information securely. The database heightens system efficiency by enabling fast access to stored data. Additionally, cloud databases such as Firebase or MongoDB offer lightweight storage, real-time syncing, and ease of integration with web applications.



Fig: Database

4.3 Microcontroller/Server Backend
In this project, product details are processed and analyzed by a backend system or microcontroller. It performs expiry calculations, triggers alerts, and manages communication between the frontend and the database. The backend may run on Python, Node.js, or PHP. It operates on low power and ensures smooth functioning of the tracking process.

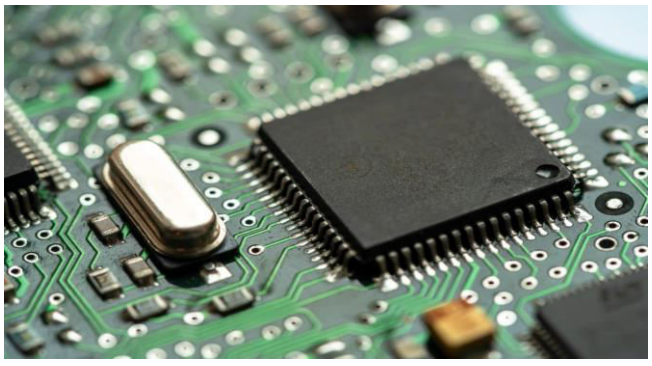




Fig: Microcontroller

4.4 Power Supply/Hosting Server

Web-based systems require either a continuous hosting service or, in hardware-based models, a stable power supply. Hosting platforms such as Firebase Hosting, GitHub Pages, or Netlify ensure that the Expiry Tracker remains accessible at all times. For physical modules, a 5V or 12V adapter may be used to power OCR cameras and microcontrollers. This ensures uninterrupted operation and reliable performance.



Fig: Power Supply

1. Software Requirements:

• HTML (HyperText Markup Language) – Standard markup language for building web pages; used for website structure and content.
• CSS (Cascading Style Sheets) – Styling language for HTML; used for layout, colors, and design.
• JavaScript – Scripting language for web development; adds interactivity and dynamic features.
• Database (MySQL / Firebase / MongoDB) – Data storage system; stores user data, food waste records, login information, etc.
• Backend Language (Python / PHP / Node.js) – Server-side programming; handles logic, calculations, authentication, and data processing.
• Code Editors (VS Code / Acode App / Sublime Text) – Tools used to write and edit code.
• Local Server (XAMPP / WAMP / Python Flask Server) – Helps run and test the website locally on your computer.
• Hosting Platform (GitHub / Firebase Hosting / Netlify) – Used to deploy and publish the website online.
• Graphic Design Tools (Canva / Figma) – Used for creating UI designs, logos, icons, banners, and other visuals.



2. Hardware Requirements:

• Computer / Laptop / Mobile Phone – Device used for development; required to code, test, and access the website.
• Internet Connection – Needed for hosting, database connectivity, and using online tools.
• Storage Device (Pen Drive / Cloud Storage) – Used for backing up project files and data.



IV. METHODOLOGY

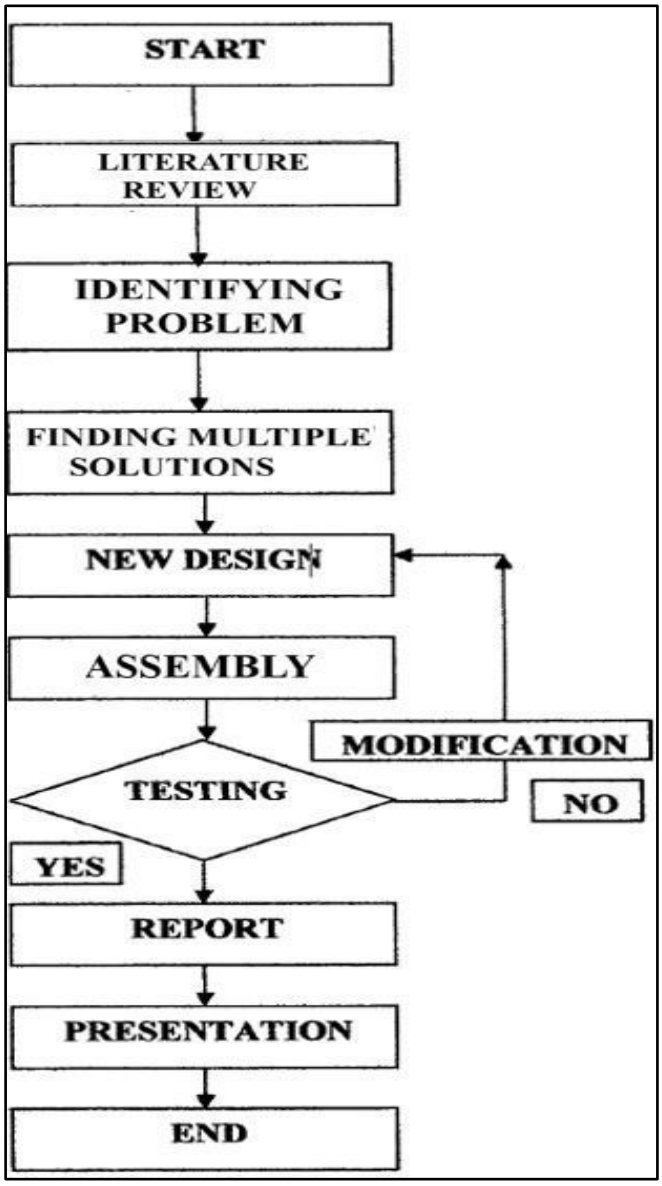


Fig. 3.1 flow chart

V. RESULTS AND DISCUSSION

The system records and analyzes data related to food production, consumption, and disposal.
1. Data Collection:
Users or sensors input data about the quantity of food prepared and the amount left over after consumption. This can be done manually through a website or automatically using loT-based weighing sensors.

2. Data Processing:
The collected data is stored in a database, where it is processed to determine the percentage of food wasted compared to the total food prepared.

3. Analysis and Visualization:
The system analyzes patterns of wastage over time and displays the results in graphical or tabular formats on the website dashboard. This helps users understand when and where most wastage occurs.

4. Feedback and Suggestions:
Based on the analysis, the tracker provides suggestions or alerts to help users plan better quantities in future meals, thus reducing waste.

5. Awareness and Sustainability:
By continuously tracking and displaying food wastage data, the system encourages users to make informed decisions, promoting sustainability and responsible food consumption habits.

5.1 Working principle

The working principle of the Expiry Tracker System is based on automated data extraction, processing, and timely notification. When the user scans a product using the barcode scanner or OCR camera, the system extracts essential details such as the product name, manufacturing date, and expiry date. This information is then transferred to the backend, where the expiry calculation algorithm processes the extracted data.

The system converts raw scanned text into structured data by applying image processing and text-recognition logic. Once the expiry date is identified, the backend calculates the number of days remaining for the product to expire. Based on this calculation, the system categorizes each item (Safe, Near Expiry, or Expired) and updates the database accordingly.

A cloud or local database stores all product records. This ensures that users can access their data from any device and that all updates occur in real time. The microcontroller/server backend also triggers automatic alerts, such as notifications, SMS reminders, or dashboard warnings, when a product is approaching its expiry date.

Power is supplied through a hosting server for web-based systems, ensuring continuous operation. Additional sensors such as RFID or QR-based modules may also be integrated to enhance detection accuracy. Altogether, the system combines scanning, data storage, automated processing, and timely alerts to help users reduce waste and manage products effectively.

VI. CONCLUSION AND FUTURE SCOPE

The Food Wastage Tracker effectively monitors and records food wastage to create awareness and promote sustainable consumption. By using sensors or manual data entry along with data visualization on a website or app, it helps identify the sources and quantity of waste. This system not only encourages responsible behavior among individuals and organizations but also supports environmental conservation by reducing food waste and promoting resource optimization.

1. Integration with IoT Devices: In the future, smart sensors and IoT-based weighing systems can be added to automatically detect and log wasted food.

2. AI-Based Prediction: Artificial intelligence can be used to analyze food consumption patterns and predict the quantity of food required, minimizing wastage.

3. Mobile Application Development: A mobile-friendly app can be developed for easier access, real-time tracking, and instant notifications about wastage levels.

4. Cloud Storage & Analytics: Cloud integration can store data securely and provide advanced analytics for large-scale food management systems such as hotels, canteens, or hostels.

5. Collaboration with NGOs: The system can be expanded to connect with NGOs or food banks to redistribute excess food to the needy before it spoils.

6. Public Awareness and Reporting: Future versions can include dashboards showing community-level wastage statistics to spread awareness and encourage collective action.

7. Expiry Date Monitoring: The system can be enhanced with an expiry tracking feature that alerts users when stored food items are nearing their expiration date. This helps ensure timely consumption and reduces avoidable spoilage.

8. Barcode/QR Code Scanning: Future versions can include barcode or QR code scanning to automatically fetch product details, including manufacturing and expiry dates, making data entry faster, easier, and more accurate.

9. Smart Inventory Management: An intelligent inventory system can be integrated to keep real-time track of items in storage—automatically updating quantities and suggesting recipes based on items that are close to expiring.

10. Auto-Reminder Notifications: The system can send scheduled reminders or push notifications when food items are about to expire, helping users prioritize their usage and minimize wastage.

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Solution for Depressed People AI Voice Mentor

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ABSTRACT: This paper presents the design and development of an AI Voice Mentor system that integrates Natural Language Processing (NLP), Speech Recognition, and Machine Learning to deliver personalized mentoring. The system functions as a conversational assistant capable of providing voice-based feedback, technical guidance, and adaptive responses the aim of this study is to create a framework that enhances human-AL interaction through intelligent speech-based communication This paper presents an algorithmic framework for an AI Voice Mentor system that provides personalized guidance through voice interaction. The system integrates Speech Recognition, Natural Language Processing, and Response Generation to offer real-time feedback. The focus of this study is to outline the step-by-step algorithmic design for building such an intelligent mentoring assistant.

I. INTRODUCTION

Artificial Intelligence (AI) has significantly advanced the field of human–computer interaction through the development of voice-based systems. AI voice mentors represent the next step in this evolution, combining speech processing and NLP to simulate human-like mentoring experiences. These systems can support learners, employees, and developers by offering personalized advice, feedback, and motivation using conversational AI.

AI mentoring us. They combine automatic speech recognition (ASR), natural language understanding (NLU), and text-to-speech synthesis (TTS) to interact with users. An algorithmic approach clarifies the sequential processes that the system follows from capturing input to delivering adaptive voice response

In recent years, rapid advancements in Artificial Intelligence (AI), Natural Language Processing (NLP), and speech technologies have transformed the way humans interact with machines. Voice-based systems have evolved from basic command-driven assistants to intelligent, adaptive, and context-aware conversational agents. Despite these developments, a significant gap still exists in personalized voice-based learning and mentorship systems that can guide users in real time, understand their learning needs, and provide tailored feedback.

The AI Voice Mentor aims to bridge this gap by integrating advanced speech recognition, machine learning, and knowledge-based modeling to create an interactive digital mentor. This system is designed to assist learners through voice commands, provide instant responses, track progress, and deliver personalized guidance across various domains. Unlike traditional learning platforms, the AI Voice Mentor focuses on natural, human-like interaction, enabling users to engage in continuous learning without the constraints of screens or manual input.

By incorporating features such as emotion-aware communication, adaptive feedback loops, multilingual support, and domain-specific knowledge modules, the AI Voice Mentor enhances user engagement and learning efficiency. This research explores the design, architecture, implementation, and performance evaluation of an AI Voice Mentor system, highlighting its potential to revolutionize digital learning and mentorship in educational, professional, and personal development contexts.

II. LITERATURE REVIEW

Voice-based Al systems have been widely studied across multiple domains. Research by Google, Amazon, and OpenAI has shown how speech synthesis and recognition can enable natural dialogue systems. However, most existing assistants are task-oriented rather than context-aware or emotionally intelligent. Recent advancements in transformer-based architectures such as GPT, BERT, and Whisper have enabled higher accuracy in speech-to-text and context retention, paving the way for Al voice mentors that can understand and adapt to user needs. Studies by Thomas Kannampallil, Corina R Ronneberg & Vikas Kumar(2022)[1]

Python in Al Development Python has emerged as a preferred programming language for all development due to its simplicity. Readability, and extensive libraries. Researchers and developers leverage Python frameworks such as TensorFlow, PyTorch, and Keras to build learning models for tasks like speech recognition language modeling, and dialogue generation.Studies by Prof. S. I. Parihar, Neha Tarale & Ruchika Kumbhare(2024)[2]

Python's rich ecosystem of NLP libraries, including NLTK and spacy, provides tools for text processing and analysis 0pen-Source Voice Assistant Projects: The open-source community has contributed numerous projects aimed at democratizing voice assistant technology. Projects like Jasper, Myeroft.and Rhasspy provide customizable frameworks for building voice assistant systems using Python. These projects often integrate with existing Al libraries and offer flexibility in terms of deployment and customization, catring to both develgpers and end users Challenges and Opportunities. Studies by Jiepu Jiang , Ahmed Hassan Awadallah , Rosie Jones & Umut Ozertem (2015)[3]

Despite the advancements in voice Assistant technology, several challenges persist.These include privacy concerns related to data collection and user profiling, as well as biascs in speech recognition models that may disproportionately affect certain demographic groups. Moreover, achieving robustness and scalability in voice assistant systems remains an ongoing research challenge. However, these challenges also present opportunities for further innovation, such as developing privacy-preserving Al techniques and enhancing voice assistant accessibility for diverse user populations. Studies by Dr .Olusola.A.Ajilore & Dr . Jun Ma (2023)[4]

Voice assistants highlight the interdisciplinary nature of research in this field, spamming areas such as NLP, ML, HCI, and software engineering. By leveraging Python and open-source technologies, researchers can explore innovative approaches to building intelligent voice assistant systems tailored for desktop environments, contributing to the ongoing evolution of human computer interaction . Studies by Lingli Wang ,Ni Huang & Guoqing Chen (2023)[5]

The idea of an AI mentor builds on early Intelligent Tutoring Systems (ITS), which aimed to provide personalized instruction comparable to human tutors. Voice-based mentoring extends this goal by introducing spoken dialogue as the primary interaction mode. AI voice mentors—conversational agents that interact with learners through speech—have emerged as a promising branch of educational technology. They combine speech recognition, natural language processing, dialog management, and text-to-speech to deliver real-time guidance, feedback, and coaching. Research across intelligent tutoring systems, human–computer interaction, and language learning highlights how voice-based interaction can make digital learning feel more natural, accessible, and engaging. Studies by Kevin.P.Cao, Ben .S. Gerber & Emily.A.Kringle (2023)[6]

Artificial Intelligence (AI) has revolutionized voice recognition technology, and the development of AI-based voice Assistants has gained significant attention in recent years. This literature review aims to integrate and synthesize research findings on AI-based voice assistants, speech recognition, and voice coding technologies. Additionally, it highlights knowledge gaps and suggests potential future research directions in this field. In this paper they can work on: It can open websites, tell the time, search Wikipedia and more, It uses a microphone to capture voice input and converts it to computer language, It connects to the internet to provide the requested results, It uses Natural Language Processing to communicate in natural human language studies by Kepuska,Veton & Bohouta, Gamal(2018)[7]

Advancements in machine learning and artificial intelligence have enabled the development of more intelligent and adaptive virtual assistants capable of learning from user interactions and personalizing responses based on individual preferences and habits. Moreover, the integration of emerging technologies such as gesture recognition, image/video recognition, and dialogue systems hold promise for further enhancing the capabilities of virtual assistants. By incorporating these technologies, IVAs can offer richer and more immersive user experiences, enabling users to interact with the assistant using a combination of voice commands, gestures, and visual input. Studies by S. Subhash, P. N. Srivatsa, S. Siddesh, A. Ullas and B. Santhosh(2020)[8]

III. METHODOLOGY

AI Voice Mentors are intelligent systems designed to simulate human-like mentoring using conversational AI. They combine automatic speech recognition (ASR), natural language understanding (NLU), and text-to-speech synthesis (TTS) to interact with users. An algorithmic approach clarifies the sequential processes that the system follows from capturing input to delivering adaptive voice Response.

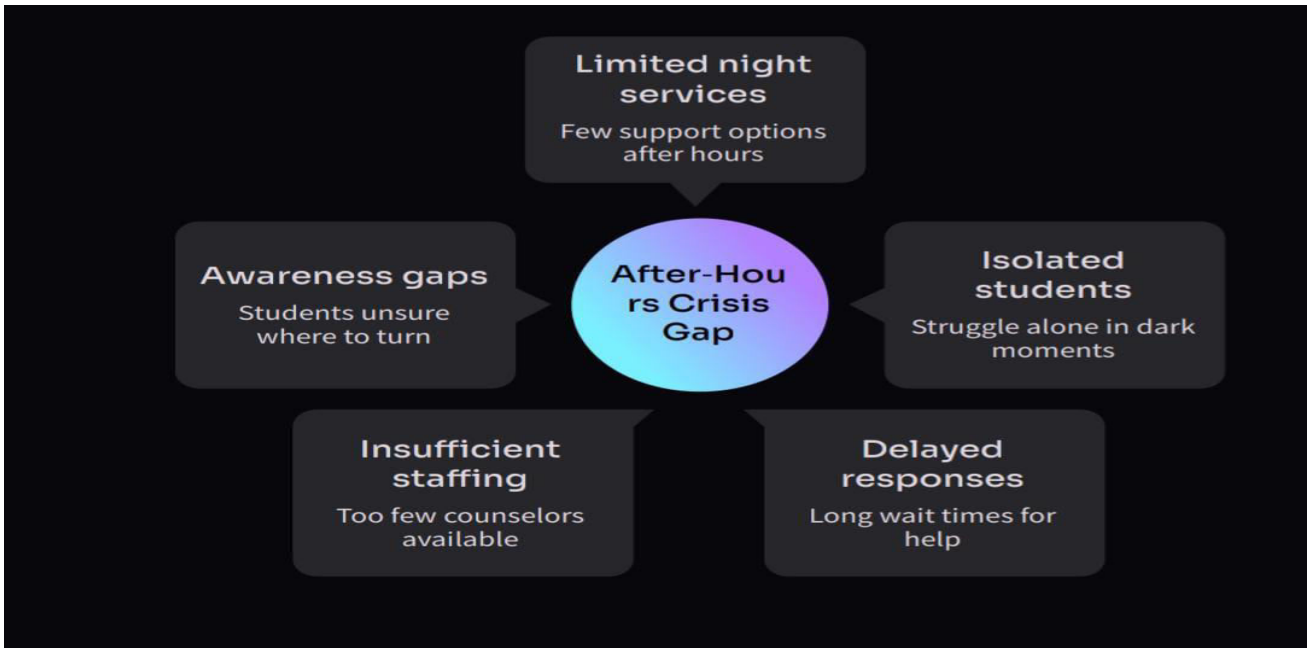


Fig 1.1 after HOURS CRISIS GAP

IV.WORKING PRINCIPLE

Step 1: Capture Audio Input: Use a microphone to record the user's voice.
Step 2: Preprocess Audio- Apply noise reduction, normalization, and feature extraction (MFCC or spectrogram)
Step 3: Speech Recognition (STT) -Convert audio input into text using ASR models like Whisper or Deep Speech.
Step 4: Natural Language Understanding -Perform intent recognition, sentiment analysis, and context tracking using transformer models (BERT/GPT).
Step 5: Knowledge Retrieval -Search domain-specific knowledge base for relevant mentoring content or guidance.
Step 6: Response Generation - Generate context-aware textual response using language generation models.
Step 7: Text-to-Speech (TTS) -Convert the text response to natural-sounding speech using neural vocoders.
Step 8: Output Voice Feedback - Play the synthesized speech to the user.
Step 9: Loop and Context Update -Update session context and repeat steps for continuous interaction

V. CONCLUSION AND FUTURE SCOPE

This research demonstrates the feasibility of an AI Voice Mentor that uses advanced NLP and speech technologies to deliver interactive, voice-driven guidance. Future work includes improving emotional recognition, contextual memory, and multilingual capabilities. The AI Voice Mentor system has potential applications in education, corporate training, and personalized learning environments. This algorithmic representation provides a clear, step-by-step approach for implementing an AI Voice Mentor. It highlights the integration of speech recognition, NLP, and TTS modules to deliver intelligent, voice-based mentoring Future enhancements may include adaptive learning, emotion recognition and multilingual

The future scope of an Al voice mentor is very promising, as it combines artificial intelligence, natural language processing, and personalized learning. Here's a clear overview of where it's headed:
1. Personalized Education and Training AI voice mentors can act as personal tutors, adapting their teaching style, pace, and explanations based on a learner's progress. They could be used in Schools and universities for personalized academic assistance.
2. Emotional Intelligence and Motivation Future AI voice mentors will go beyond giving information — they'll recognize tone, mood, and stress in a learner's voice to respond empathetically. This emotional awareness will make them feel more like real mentors or coaches.

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Autometic Window Cleaning

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ABSTRACT: This project focuses on developing an automatic window cleaning system that makes the process of cleaning glass surfaces easier, safer, and more efficient. Cleaning windows, especially those that are high or hard to reach, can be risky and time-consuming when done manually. To solve this problem, the project introduces a simple and cost-effective device that uses a DC motor, rotating brush, and rechargeable battery to clean window surfaces automatically. The main structure is made of lightweight PVC material, making the system portable and easy to handle. The motor rotates a circular brush that effectively removes dust and stains from the glass surface, while the enclosed wiring and built-in switch ensure safety and convenience during operation. The design is user-friendly, durable, and suitable for both domestic and commercial applications. It reduces the physical effort required for cleaning and provides consistent results in less time. Overall, this project demonstrates how a small-scale automated system can replace traditional manual cleaning methods. It offers a practical, affordable, and energy-efficient solution for maintaining clean windows in homes, offices, and other buildings. With further improvements such as automatic spraying and sensor-based operation, this system has the potential to evolve into a fully automated window cleaning device in the future.

I. INTRODUCTION

Cleaning windows, especially in tall buildings or hard-to-reach areas, is often a difficult and risky task. Manual window cleaning takes a lot of time, effort, and sometimes requires workers to operate at dangerous heights. This challenge has created a need for an automatic system that can clean windows efficiently, safely, and without continuous human involvement. An automatic window cleaning system is designed to address these problems using modern technology and smart mechanisms. The main purpose of this project is to design and develop a device that can automatically clean window surfaces with minimal human effort. The system can be equipped with sensors, motors, and cleaning brushes or wipers to detect dirt and move across the window surface effectively. This not only improves cleaning quality but also reduces the time and risk involved in the process. Such automation is especially useful in high-rise buildings, offices, and large glass structures. The automatic window cleaning system offers several benefits. It ensures safety by eliminating the need for human cleaners to work at heights, saves time and labor costs, and provides consistent cleaning results. It also helps in maintaining the aesthetic appearance of buildings and can be operated at regular intervals to keep windows spotless. Overall, this project contributes to making window cleaning safer, more efficient, and more reliable through automation and innovation.

II. LITERATURE REVIEW

Automatic window cleaning systems have become an important area of research as they help reduce the risks and effort involved in cleaning tall or hard-to-reach windows. Studies by Li et al. (2019) and Zhang et al. (2020) have discussed the development of robotic cleaning systems that use sensors and suction mechanisms to climb and clean glass surfaces efficiently. Their work highlights how automation improves safety for workers and reduces cleaning time compared to traditional manual methods. These systems are especially useful in high-rise buildings where manual cleaning can be dangerous and time-consuming [1].

The mechanical design of window cleaning robots plays a key role in their performance. Wang et al. (2018) studied different locomotion systems, such as suction-based, magnetic, and track-driven mechanisms, to find the most stable and effective way for robots to move on vertical surfaces. Chen et al. (2021) suggested improvements in cleaning tools, such as using microfiber rollers and water-spray systems to enhance cleaning efficiency and reduce streaks on glass. Their studies show that the combination of an effective adhesion mechanism and a suitable cleaning tool leads to better cleaning results [2].

Energy efficiency and control systems are also important in designing window cleaning robots. Research by Liu et al. (2019) and Guo et al. (2020) explored how microcontrollers and sensors can optimize the robot's movement, reducing power consumption and improving accuracy. These studies found that using intelligent control algorithms helps the robot detect edges, avoid obstacles, and clean more evenly across the surface. Such systems not only save energy but also make the operation safer and more reliable [3].

Safety and reliability are major concerns when developing automatic window cleaning machines. Jiang et al. (2017) discussed the use of safety features like anti-fall sensors, backup suction systems, and emergency stop functions to prevent accidents. Xu et al. (2021) analyzed the performance of these systems under different environmental conditions, such as wind or dust, to ensure consistent operation. Their research helps in improving the durability and dependability of window cleaning robots for both residential and industrial use [4]

Automatic window cleaning systems are now being applied in a variety of settings, including office buildings, shopping malls, and glass-covered skyscrapers. Smith et al. (2018) and Patel et al. (2021) reported how these systems reduce maintenance costs and improve the appearance of buildings by ensuring regular, streak-free cleaning. Lee et al. (2022) also explored the use of drone-based window cleaning systems for high-altitude or hard-to-access areas, showing how automation continues to evolve in this field [5].

III. MATERIAL SELECTION

3.1 DC MOTOR



Fig 3.1 DC MOTOR

DC motor= DC motors are used in automatic window cleaning to power movement, such as pulling a cleaning cloth or driving the wheels of a robotic cleaner. They are controlled by a motor driver and a microcontroller (like an Arduino) to enable functions like moving the robot across the window, spraying water, and detecting obstacles to navigate the cleaning path.

*How DC motors work in automatic window cleaning Powering movement: DC motors provide the force to move the cleaning components

3.2 PVC PIPE



Fig 3.2 PVC PIPE

pvc pipe =PVC pipes are used in automatic window cleaning in two main ways: as a do-it-yourself extension pole for squeegees and as a component in large-scale, automated window cleaning machines. For manual cleaning, PVC pipes are a cheap and easy way to extend a squeegee for reaching higher windows. For automated cleaning, specialized machines use PVC pipes and other components to clean the corners of uPVC windows on a large scale.

*Automated window cleaning machines
Purpose: To automatically and precisely clean the corners and surfaces of uPVC window frames on a large production scale.

Method: These machines use digital controls to program a series of cleaning steps. They often have rotating cutters to clean the outer corners and milling cutters to clean the top and bottom surfaces and seal grooves.

Usage: PVC pipes and other components are central to the design of these machines, which can be programmed for various profiles and are ideal for large or continuous production.

3.3 PVC PIPE ELBOW



Fig 3.3 PVC PIPE ELBOW

Pvc pipe elbow : A PVC pipe elbow is used in automatic window cleaning systems to direct water flow and create a more targeted or angled spray, often for cleaning hard-to-reach areas. They are also used to create custom spray patterns by connecting to a hose or pipe that extends upwards to a cleaning head, which is then moved across the window.*Uses in automatic window cleaningDirectional control: An elbow can be used to change the direction of the water spray, allowing the system to aim water at specific parts of a window or at a different angle.

Extended reach: When combined with a length of PVC pipe, an elbow can help create an extended cleaning wand to reach high windows, making the system more versatile.Custom spray systems: In DIY or custom automatic systems, PVC elbows allow users to build complex water delivery systems that connect a main hose to a cleaning head, creating a specific path or spray pattern for optimal cleaning.Multi-functional tools: Some tools marketed for window cleaning include a bendable PVC pipe with an elbow joint, designed to function similarly to a high-pressure sprinkler for cleaning large surfaces like windows or solar panels.

3.4. BRUSHES



Fig. 3.4 BRUSHES

Brushes =Brushes in automatic window cleaning use bristles to scrub and remove dirt from glass and frames, often working alongside other components like squeegees and microfiber pads. They can be used with cleaning solutions for stubborn grime or dry for dusting, and specialized designs can clean hard-to-reach areas like window tracks. Automated window cleaning robots often use a combination of rotating brushes or pads and suction, while manual-assisted tools may feature extendable handles and multi-functional designs.

*How brushes are used =
1) Scrubbing and scrubbing
2) Removing dirt from frames and tracks
3) Applying cleaning solution

IV. WORKING PRINCIPLE

After all individual components are prepared, the final assembly is carried out. The DC motor, circular brush plate, battery, and switch are integrated into a single unit. All electrical wiring is placed neatly inside the PVC pipe for protection and to enhance the overall appearance of the device. The connections are checked carefully to ensure there are no loose joints or short circuits. The assembled system is then tested for stability, smooth motor operation, and brush balance.

During operation, when the switch is turned ON, power from the battery is supplied to the DC motor. The motor begins to rotate, causing the attached brush plate to spin at a uniform speed. This rotational motion enables the brush to scrub and wipe the window surface effectively, removing dust, dirt, and stains. The user can hold the PVC handle and guide the rotating brush across the glass surface with ease. The compact and lightweight design allows comfortable handling and makes it suitable for both indoor and outdoor windows.

To ensure consistent cleaning, the brush can be lightly sprayed with water or cleaning solution before use. The soft bristles help spread the solution evenly and polish the surface without leaving streaks. The rechargeable battery ensures continuous operation for a reasonable duration before needing to be recharged. After use, the system can be easily cleaned, and the brush head can be replaced if worn out.

Overall, the final assembly results in a portable, safe, and energy-efficient cleaning device. It combines mechanical and electrical components in a simple yet effective way, providing an automated method to clean windows without requiring manual scrubbing. This design not only improves cleaning performance but also reduces physical effort and time, making it a practical solution for both domestic and commercial applications.

V. CONCLUSION AND FUTURE SCOPE

The automatic window cleaning system developed in this project successfully demonstrates a simple, efficient, and safe method for cleaning glass surfaces with minimal human effort. By combining mechanical and electrical components—such as a DC motor, rechargeable battery, and rotating brush—the system provides an effective cleaning mechanism that is both portable and user-friendly. The use of PVC materials ensures that the structure is lightweight, durable, and cost-effective, making the design suitable for everyday use in homes and offices.

The motor-driven brush efficiently removes dust, dirt, and stains from window surfaces, providing smooth and consistent cleaning performance. The electrical components, including the battery, wiring, and switch, are safely enclosed within the PVC pipe, ensuring ease of use and protection from damage. The rechargeable battery enhances portability, allowing the system to operate without a continuous power source. This makes the device convenient for cleaning windows located in areas where electricity supply or accessibility is limited.

Overall, the project offers a practical and reliable solution to reduce manual labor, save time, and improve safety during window cleaning tasks. It is especially beneficial for cleaning glass surfaces in homes, schools, offices, and low-rise buildings. The design is simple to construct, affordable, and easy to maintain, which makes it a suitable innovation for real-world applications.

FutureScope:
Although the current prototype performs effectively for basic cleaning operations, there are several opportunities for improvement and future development. The system can be enhanced by adding speed control to adjust the motor's rotation according to the level of dirt or surface type. A water spray or detergent dispenser can be integrated to automate the cleaning process further, reducing manual effort. The inclusion of sensors for detecting obstacles, edges, or surface areas would allow the system to operate more safely and intelligently, especially on large glass panels or building façades.
In the long term, the device could be upgraded into a fully automated robotic cleaner capable of adhering to vertical glass surfaces using suction or magnetic mechanisms. Incorporating solar charging or IoT-based monitoring could make it more energy-efficient and environmentally friendly. These advancements would help develop the system into a modern, smart cleaning device suitable for both residential and commercial applications, reducing human involvement and improving overall cleaning efficiency.

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Digital Bell with Scheduled System

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ABSTRACT: The Digital Bell System is an automatic, microcontroller-based project that rings bells according to a preloaded timetable. It replaces traditional manual systems with an accurate and programmable design. The system uses an Arduino, RTC (Real-Time Clock) module, and a relay with a bell to automate ringing at specific times. It ensures punctuality, saves manpower, and provides easy modification of schedules when needed. This makes it a practical and low- cost automation solution for schools, colleges, and offices. This project presents an automated digital bell system designed to improve time management in educational institutions. By using a microcontroller, the system eliminates manual scheduling errors and ensures that bells ring precisely according to a pre-set timetable. The system features a digital display that provides clear, real- time information on class periods, which improves operational efficiency and reduces confusion for both students and staff.

I. INTRODUCTION

The Digital Bell System is an automated solution designed to replace traditional manual bell ringing in educational institutions. It uses a micro-controller-based circuit to control bell timings accurately according to a pre-programmed schedule. This system ensures that bells ring automatically at the correct time for each period, reducing human error and saving time. The digital display provides real-time information, making it easier for staff and students to follow the timetable efficiently. This project promotes punctuality, improves time management, and enhances the overall discipline within the institution. In educational institutions, maintaining punctuality and proper time management is essential for smooth operation. Traditionally, bells are rung manually to indicate class periods, breaks, and other scheduled activities, which often leads to human error and inconsistency. The Digital Bell System aims to automate this process by using a micro-controller to control the bell according to a pre-set timetable. This system ensures accurate and timely ringing of the bell without the need for manual intervention. By integrating a digital display and programmable timer, it enhances efficiency, reduces workload, and improves the overall management of academics This system uses a micro-controller to automatically ring the bell according to a pre-programmed timetable, ensuring precise and consistent operation throughout the day. The timing schedule can be easily modified to suit institutional requirements, providing flexibility and convenience. Additionally, the inclusion of a digital display allows real-time visibility of current periods and upcoming schedules. By minimizing human intervention, the Digital Bell System not only improves punctuality and efficiency but also contributes to better discipline within the institution. Its design promotes energy efficiency, low maintenance, and long-term reliability, making it a modern and cost-effective alternative to traditional manual bell systems.

II. LITERATURE REVIEW

Traditional Bell Systems
In most schools and colleges, the bell is rung manually by a peon or operator. While this method is simple, it is prone to human error, inconsistency, and dependency on staff availability. According to **Kumar & Singh (2018)[1]**, manual bell systems often lead to irregular class timings, which affects institutional discipline and productivity. The need for automation was first recognized in early 2000s when programmable timers began replacing mechanical bells in some institutions.

Recent research emphasizes integration with digital timetables to enhance adaptability.
Ramesh et al. (2021) [2] presented a **digital bell system linked with a database-driven timetable**, enabling dynamic updates through a graphical interface. The system could be updated via computer or mobile application, making it more suitable for modern educational setups.

IoT (Internet of Things) integration has further enhanced functionality. **Gupta & Banerjee (2022)** [3]designed an **IoT-enabled digital bell** that syncs with cloud-based schedules. This allowed real-time synchronization across multiple campuses and remote access for administrators

The early versions of automated bell systems were built using electromechanical timers or micro-controller-based circuits.

Sharma et al. (2016)[4]proposed an 8051 micro-controller-based automatic school bell that triggers the bell at fixed time intervals. Though effective, these systems lacked flexibility and required reprogramming for any timetable change. With the introduction of Arduino and Raspberry Pi platforms, automation became more user-friendly. Patel & Joshi (2020) [5] developed an Arduino-based automatic school bell system with an LCD display and real-time clock (RTC) integration. The system allowed users to store class timings in memory and automatically ring the bell according to the schedule

Manual vs. Digital Scheduling Manual Scheduling Challenges High probability of human errors Difficulty rearranging classes during emergencies Lack of transparency Time-intensive process Conflicts in faculty and room assignment [6]..Digital Timetable Advantage Automated conflict resolution Instant timetable generation Real-time updates through apps or web portals Notification systems for changes Better record management and analytics. [7]

Case Studies & Related Work Higher Education Systems Studies show that digital timetable systems in universities improve: Lecture hall utilization Faculty satisfaction Student attendance Scheduling accuracy School Systems Research on secondary schools found that digital tools reduce: Administrative coordination time Conflicts during exam scheduling Communication gaps among departments [8]

III. METHODOLOGY

The methodology for developing the Digital Bell System involves both hardware and
software components integrated to automate the bell ringing process in educational institutions. The following steps were followed systematically:

1. Requirement Analysis:
The first step was to identify the need for an automated system that can ring bells at accurate intervals without human intervention. Existing manual systems were studied to understand their limitations, such as dependency on human accuracy and time delays.

2. System Design:
The system was designed to operate using a micro-controller (Arduino/8051/PIC) as the central control unit. The circuit design included components like a real-time clock (RTC) module, relay driver, buzzer or bell, and power supply. The software design involved creating a logical flow of operations and setting predefined time intervals for the bell

3. Hardware Setup:
The hardware was assembled on a breadboard or PCB. The RTC module was interfaced with the micro-controller to maintain accurate timekeeping. The relay module was connected to control the electric bell according to the time signals from the micro-controller.

4. Final Integration:
After successful testing, all components were enclosed in a protective casing, and the system was installed in a suitable location. The device was powered and monitored for continuous operation and reliability.

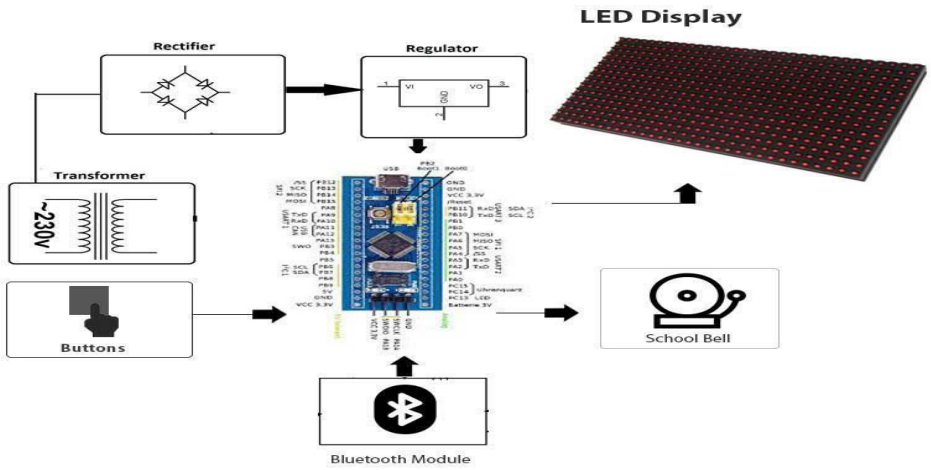


Fig: Block-diagram of digital bell

IV. MATERIAL REQUIRED

5.1 Arduino nano:

Arduino is an open-source microcontroller platform designed to simplify the development of embedded systems. It consists of programmable hardware boards, such as the Arduino Uno, which are built around the ATmega328P microcontroller. A key feature of Arduino is its pre-installed bootloader, which allows code uploading directly through a USB interface without requiring any external programmer. The platform uses a simplified version of C/C++, where the Arduino IDE automatically manages low-level functions such as compilation, linking, and configuration of the main program structure. Most Arduino boards operate at a fixed 16 MHz clock frequency, ensured by a crystal oscillator that maintains high timing accuracy for delay generation, PWM signals, and serial communication. Each GPIO pin on Arduino supports multiple modes—INPUT, OUTPUT, and INPUT_PULLUP—enabling flexible interfacing with sensors, switches, and digital modules.

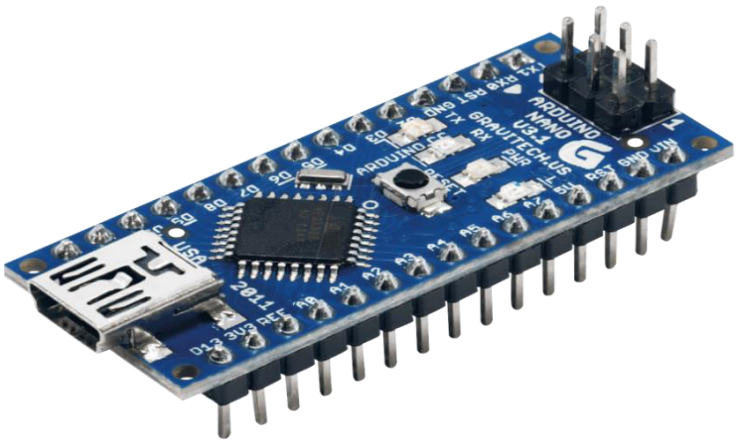


Fig.5.1 Arduino nano

5.2 PUSH BUTTON:

The push button in a digital bell serves as the user input interface, acting as a momentary switch that initiates the bell's electronic process. When pressed, it temporarily completes an electrical circuit, and when released, it automatically returns to its original state, breaking the circuit.

Key features of Push Button:

1.Switch Functionality: Available in momentary (returns to default state once released) or maintained (toggle on/off with each press) configurations.

2.Contact Configuration: Offered in single-pole single-throw (SPST), double-pole double-throw (DPDT), and other multi-pole variants to suit diverse electrical circuit requirements.

3.IP Ratings for Environmental Protection: Waterproof, dust-proof, and corrosion-resistant designs are available for hazardous or outdoor applications.

4.Backlight and Lamp Indicators: Custom options such as LED backlight push buttons enhance visibility and provide immediate system status feedback.

5.Terminal Types: Includes solder, quick-connect, and screw terminals, making field installation and maintenance efficient in various electrical and electronic systems.

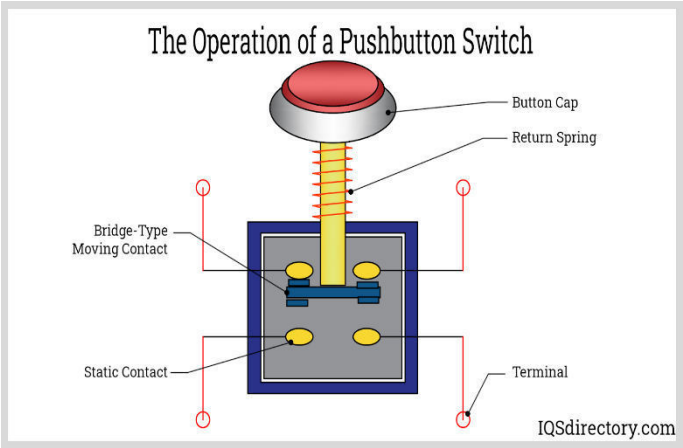


Fig.5.2 Push Button

5.3 BC547 TRANSISTOR:

The BC547 transistor is commonly used as a low-power, general-purpose NPN transistor in electronic circuits. It is widely used for switching small loads such as LEDs, buzzers, and small relays, as well as for amplifying weak signals in audio, sensor, and hobby circuits. By applying a small current to its base terminal, it can control a larger current flowing between the collector and emitter, making it useful for signal control and amplification. Its low cost, easy availability, and reliable performance make it a popular choice in educational projects, prototypes, and everyday electronic devices.

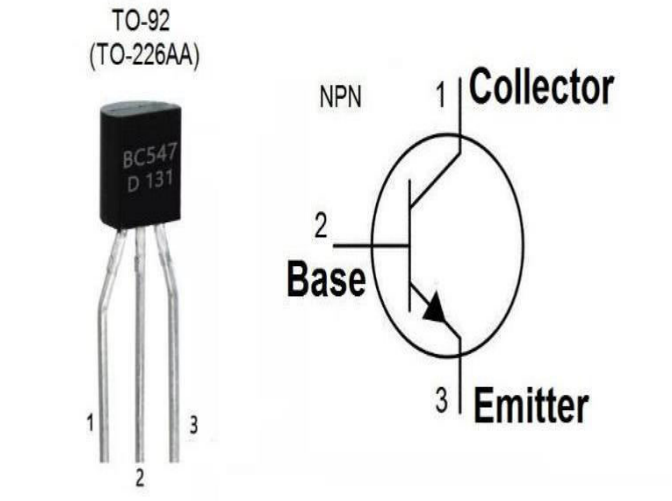


Fig. 5.3 Transistor

5.4 RELAY:

A relay is used to control high-power or high-voltage devices using a low-power signal. It acts as an electrically operated switch, allowing a small current from a control circuit—such as a micro-controller, sensor, or low-voltage switch—to safely operate larger loads like motors, lights, heaters, and power supplies. Relays provide electrical isolation between the control side and the load side, protecting sensitive electronics from high voltages. Because of this, they are widely used in automation systems, home appliances, automotive electronics, and protection circuits

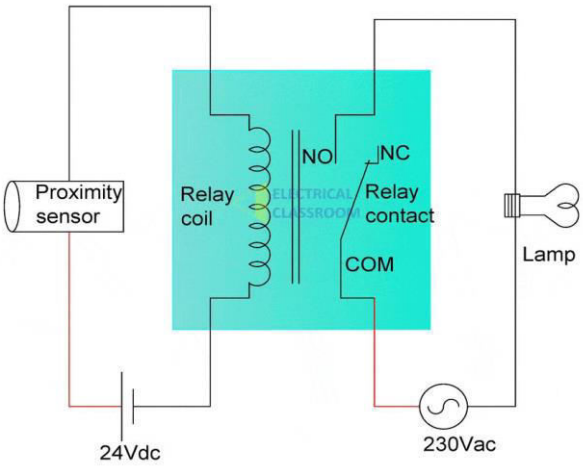


Fig.5.4 Relay internal algorithm

5.5 IN4007 diode:

The 1N4007 diode is widely used as a general-purpose rectifier in electronic circuits. Its main function is to allow current to flow in only one direction, making it ideal for converting AC voltage to DC in power supply circuits. Because it can handle high reverse voltage (up to 1000 V) and moderate current, it is often used in chargers, adapters, and household electronic devices. The 1N4007 also protects circuits from reverse polarity by blocking unwanted reverse current that could damage components. Its reliability, low cost, and versatility make it one of the most commonly used diodes in electronics.



Fig. 5.5 Diode

5.6 RESISTOR

A 1K ohm resistor (1000 ohm) in a digital bell circuit primarily used as a current limiter or a pull-up/pull- down resistor to protect sensitive components used in several specific ways. The flow of the charge through any material encounters an opposing force similar in many respects to mechanical friction. This opposing force is called resistance of the material, in some electric circuit resistance is deliberately introduced in form of the resistor.

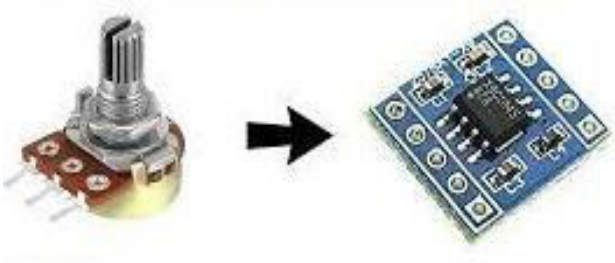


Fig. 5.6 Digital Variable Resist

SEVERAL WAYS OF USING THE RESISTOR IN THE DIGITAL
BELL ARE:

CURRENT LIMITING:
A primary use is to light the current flowing to components such as an LED indicator or the base of a transistor, preventing them from being damaged by excessive current.

PULL-UP and PULL-DOWN RESISTOR:
A PULL-UP resistor in digital bell circuit connects input pin to positive voltage (Vcc) to ensure the input stay at high (logic 1) level when no active signal is present, similarly the PULL-DOWN resistor is used to connect the input pin to the ground (0V) to ensure the input stays at a low (logic 0) level when no signal is applied.

VOLTAGE DIVISION:
The resistor can be part of a voltage divider network, which adjusts signal levels or provides a specific, lower voltage to different parts of a circuit, such as a sensor interface.

TRANSISTOR PROTECTION:
If the bell's chime mechanism is driven by a transistor and relay, a resistor at the transistor's base can protect it from excessive base current or reverse voltage.

5.7 Led Display:
LIQUID CRYSTAL DISPLAY .
The mis popular LEDs that are linked to a microcontroller are 16 x 2.



Fig.5.7 Led Display

This translates to 16 characters to 16 characters per lines. The standard is known as HD44780U, which refers to the regulator chip that makes data from an external source (and communicates directly with the TV). If 8-bit data machine is used the TV will bear 11 data lines. The three control lines appertained to as EN, RS, and RW.

5.9 Normal Electrical Bell:
In a digital bell circuit a normal bell is often replaced with a digital bell system by using its electromagnet and gong or other sound, but replacing the manual switch with a digital timer or micro-controller

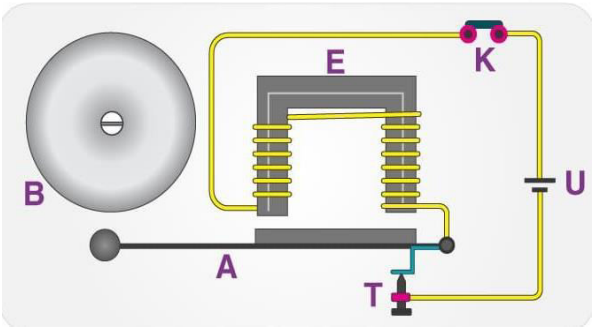


Fig.5.8 Normal Electrical Bell

V. CONCLUSION

The Digital Bell with Timetable system represents a significant step towards smart institutional automation. Research over the last decade has evolved from simple micro-controller-based designs to intelligent, connected, and remotely managed systems. Future advancements may include AI-based adaptive timetabling and integration with full-fledged school ERP systems to create a fully automated academic environment.

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Robotic Vacuum Cleaner for Home

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ABSTRACT: This project focuses on developing a Robotic Vacuum Cleaner using simple components like a ultrasonic sensor, Arduino UNO and breadboard. The ultrasonic sensor will allow the robot to avoid obstacles and move freely until the room is properly cleaned, and the proximity sensor will assist it in avoiding falls from stairs. The project aims to utilize the power of embedded systems and hardware to create a robot that can help keep homes or workplaces clean and tidy. The robot is a simple four-wheeled vacuum cleaner that can intelligently avoid obstacles while cleaning the floor. The idea is inspired by the popular vacuum cleaner Robot Roomba. The goal is to create a straightforward robot from scratch that can automatically avoid obstacles while cleaning the floor.

I. INTRODUCTION

Time management is regarded as one of the most crucial aspects of modern living. One major domestic work that is sometimes seen as a challenging and tedious task is floor cleaning. Instead of having home members complete the duty, cleaners are typically hired to accomplish it. Because of the difficulty this repetitive task caused, a vacuum cleaner that might help humans with similar tasks had to be developed. An electromechanical device called a vacuum cleaner is frequently used to clean carpets, rugs, floors, and furniture using suction. The appliance's electric motor rotates a fan, creating a semi vacuum that forces residue evacuated compartment. This pushes any dust or debris close to bag that is either fixed to the outside of the machine or inside. The need to lower the workforce has prompted the creation of automatic control systems, which allow machinery to run unattended. One of the most significant responsibilities of each and every person is to keep the environment around them clean. More workers will be required the larger the area that needs to be cleaned. Certain locations may be so unclean that cleaning them has a negative influence on one's health. Humanity is growing more and more reliant on digital technology currently of rapid advancements in the field. There is never enough time because the bulk of people are working. The vacuum cleaner may be moved in the desired direction and the time required for the same can be avoided because the Arduino can be programmed to cover specified areas, making it possible for the automobile to carry it. An automatic vacuum cleaner is designed in this project.

II. LITERATURE REVIEW

[1] Manya Jain, Pankaj Singh Rawat .The robotic vacuum cleaner is an autonomous electronic device that has self-drive mode and it automatically cleans the surface by cleaning assembly, without any human assistance. April 04-2017 .

[2] B.N.Prashanth, V.Karthik, S.Karthikeyan, P.Raviteja. There are many successful products available in the market. Trifo, Eureka forbes, IRobot Roomba, Ecovacs, Exilient Ready Maid Robotic Vacuum Cleaner, Jectse, these are some top 10 Robotic vacuum cleaners in the year of 2021.

[3] Yong-Joo Oh and Y. Watanabe.Every product has some advantages and disadvantages. Roomba is one of the vacuum cleaner robots which include amazing features. 5-7 Aug, SICE 2002.

One of the features of Roomba is it has a powerful motor suction unit that sucks the dirt into the filtered dust bin [6]. Also, it is arranged at an angle of 270 degrees, so that a sweeping brush can easily sweep the dust present at the corners or the edges. The main issue with these products is they are not only costly but also not much compatible with Indian users[4]. These products are much effective for the wooden floors than tiles. So such kind of product is used for only wooden floors. We can't use this product for tiles. There are some products which do work for the tiles but this

III. METHODOLOGY

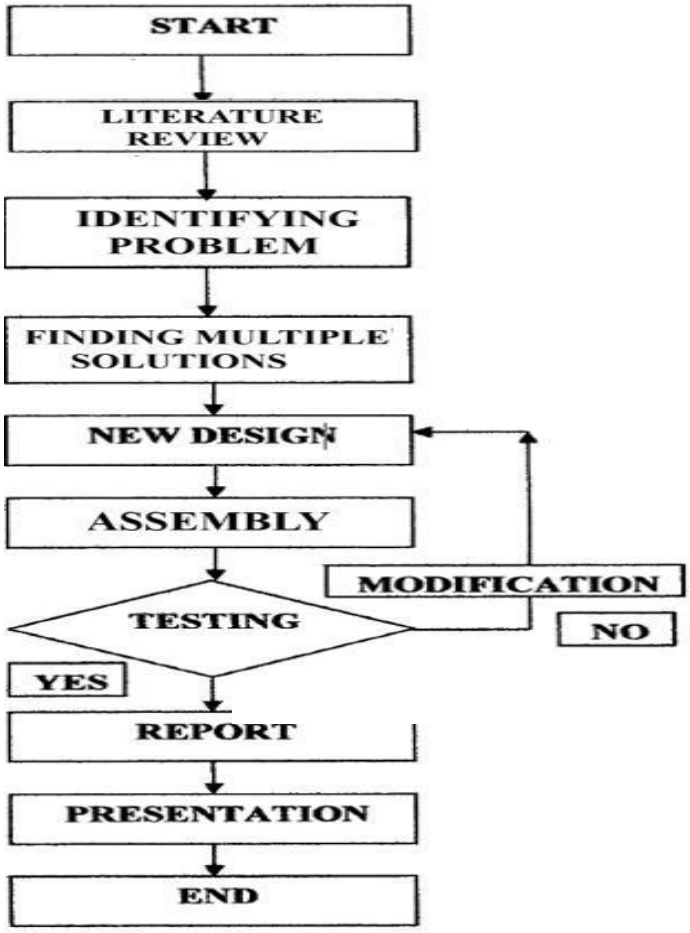


Fig 3.1 Flow Chart

IV. MATERIAL SELECTION

When doing a project, it is important to pay attention to the selection of materials. To prevent waste, the items selection process must be carefully welcomed. A precise selection of items is necessary to ensure that they are long-lasting and safe for usage.

4.1 Arduino L293D

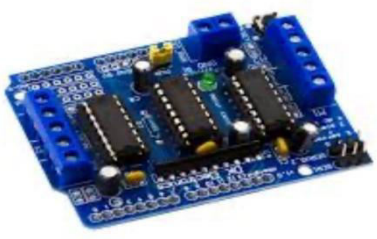


Fig 4.1 Arduino L293D

A robotics project called Arduino L293D motor driver shield guide involves controlling different kinds of motors. The three types of motors most frequently utilized in robotic applications are DC, servo, and stepper. Nevertheless, these motors are often incapable of being directly driven by an Arduino or other microcontroller. These are also known as

integrated circuits (ICs), isolate the power supply of a motor and use microcontroller circuitry for control logic. The fully operational L293D motor driver shield can operate two stepper motors, two servo motors, and up to four bi-directional DC motors with 8bit speed setting. One may combine up to four DC motors (two stepper, two servo, and one bi-directional with an 8-bit speed setting) with directly drive able by Arduino or other microcontrollers.

4.2 Bluetooth Module

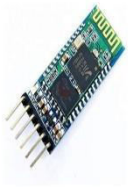


Fig 4.2 Bluetooth Module

Bluetooth module allow devices with serial ports to send data with one another. Its six pins, including Key/EN, are used to set the Bluetooth module to AT command mode. The module functions in command mode while the Key/EN pin is in the high condition. If not, the default mode is data mode. In command mode(38400bps) and data mode (9600bps), the HC-05's default baud rates are set.

There are two ways that the HC-05 module can work: data mode, which enables data interchange between devices. Command mode: AT commands are utilised to modify the HC05's configurations. The USART port, or module serial port, is used to transmit these commands.

4.3 Battery



Fig 4.3 Battery

There are several important factors to take into account when choosing a smart vacuum cleaner battery. Above all, the Arduino Uno microcontroller, the vacuum motor, and any other integrated components need to be powered by enough voltage and current from the battery. Furthermore, the vacuum cleaner's battery needs to be small and light for it to continue being portable and maneuverable. The smart vacuum cleaner's battery capacity, which is commonly expressed in watt-hours(Wh) or milliampere-hours (mAh), dictates how long it can run between charges. The device's anticipated runtime between recharges should be taken into considerationwhile selecting the battery capacity. Longer operating times can be achieved with a larger capacity battery, but the device's weight and size may also increase. On the other hand, a battery with a lower capacity might be more portable but might need to be recharged more frequently. Energy density, charge-discharge characteristics, and safety are only a few of the variables that influence the choice of battery chemistry. Lithium-ion (Li-ion) and lithium polymer (LiPo) batteries are common battery chemistries appropriate for this use.

4.4 Arduino Uno



Fig 4.4 Arduino Uno

The Arduino Uno microcontroller is the central nervous system and brain of the smart vacuum cleaner project. It is essential to the coordination of the project's many operations and to the development of itsintelligence. This section will examine Arduino Uno's individual contributions and its importance in the project. With a large library of easily available software and hardware resources, substantial community support, and ease of use, the Arduino Uno is a highly popular and flexible open-source microcontroller platform. It is the perfect option for a project like the smart vacuum cleaner because of these qualities.

4.5 Ultrasonic Sensor



Fig 4.5 Ultrasonic Sensor

The Arduino Uno-based smart vacuum cleaner project relies heavily on its ultrasonic sensor, which is essential to the device's ability to navigate, identify obstructions, and run on its own. We shall examine the importance of the ultrasonic sensor and how it improves the vacuum cleaner's performance in this part. Echolocation is the basis for how ultrasonic sensors work; bats and dolphins use sound waves to navigate their environment. These sensors monitor the amount of time it takes for ultrasonic pulses, or high-frequency soundwaves, to bounce back after colliding with an item. The sensor determines the distance between itself and the item by examining the time delay. The vacuum cleaner's "eyes" are its ultrasonic sensor, which is essential for identifying objects in its path. The sensor continuously pulses ultrasonically while the vacuum cleaner goes around a room, listening for echoes. It communicates with the Arduino Uno microcontroller by sending information when it senses an object nearby. The vacuum cleaner may decide on its course in real-time thanks to the data obtained from the ultrasonic sensor. The Arduino Uno can change the vacuum cleaner's path to prevent collisions ifit detects an obstruction. This guarantees that the machine can effectively clean the floor while navigating around obstacles like walls and furniture on its own. The vacuum cleaner's intelligence is additionally enhanced by the ultrasonic sensor**.**

4.6 DC Motor



Fig 4.6 DC Motor

The software required for a robotic vacuum cleaner project includes Arduino Integrated Development Environment (IDE) and a programming language like C++:

V. RESULTS AND DISCUSSION



Fig 5.1 Working Model

5.1 Working principle

Test Equipment:
• Vacuum Cleaner Car: The device under test.
• Sensors and Cameras: To monitor the robot's navigation, obstacle avoidance, and cleaning performance.
• Data Logging Devices: To record cleaning time, battery usage, and other relevant metrics.
• Timing Devices: To measure cleaning duration.
• Measuring Tapes: To measure cleaning coverage.
• Debris Measurement Tools: To quantify the amount of debris removed (e.g., scales, dust collection bags).
Test Procedures:
• Pre-Test Preparation:
• Calibrate sensors and cameras.
• Charge the robot's battery fully.
• Prepare the test area with designated cleaning tasks.
Test Execution:
• Deploy the robot in the test area.
• Initiate cleaning cycles for different surface types and obstacle configurations.
• Monitor the robot's performance using sensors, cameras, and data logging devices.
• Record cleaning time, battery usage, and other relevant metrics.
• Collect debris from the vacuum cleaner's dustbin for measurement.
• Post-Test Analysis:
• Evaluate cleaning effectiveness by visual inspection and debris measurement.
• Analyze sensor data to assess navigation accuracy and obstacle avoidance capabilities.
• Review data logs to identify areas for improvement in cleaning efficiency and battery life.

VI. CONCLUSION AND FUTURE SCOPE

The Robotic Vacuum Cleaner Car project demonstrates a cutting-edge integration of artificial intelligence, robotics, and Internet of Things (IoT) technologies. This innovative system provides efficient, automated, and hassle-free cleaning solutions for various environments. The term "mashing" in the context of robotic vacuum cleaners likely refers to a scenario where the robot gets stuck or jammed against an obstacle, preventing it from moving forward or completing its cleaning cycle. Possible Causes of Mashing: Obstacle Avoidance Issues: The robot's sensors may

misinterpret objects, leading to incorrect navigation and causing it to get stuck against furniture, rugs, or other obstacles.

Wheel Slippage: The robot's wheels might lose traction on certain floor types (e.g., rugs with long fibers, uneven surfaces) causing it to spin in place or become stuck. Object Entrapment: The robot's brushes or wheels might get entangled with cords, fringe, or other objects, preventing movement. Software Glitches: In some cases, software bugs or malfunctions can cause the robot to behave erratically, leading to mashing incidents. Incomplete Cleaning: The robot fails to clean designated areas, leaving behind dirt and debris.➢ Battery Drain: The robot may consume excessive battery power while attempting to free itself, reducing overall cleaning time. Damage to the Robot: Repeated mashing incidents can potentially damage the robot's wheels, brushes, or other components. User Frustration: Frequent mashing incidents can be frustrating for users and require manual intervention to free the robot. Improved Sensor Technology: More accurate and reliable sensors can better detect and avoid obstacles, reducing the likelihood of getting stuck. Enhanced Software Algorithms: Sophisticated software can improve navigation, obstacle avoidance, and overall robot behavior.

Better Wheel Design: Wheels with improved traction and obstacle-climbing capabilities can minimize slippage and help the robot navigate challenging surfaces. User-Friendly Features: Features like virtual walls or no-go zones can help users prevent the robot from entering areas where it is likely to get stuck Note: The specific causes and consequences of mashing can vary depending on the model of the robotic vacuum cleaner and the environment in which it is used.

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Enhancing Home Security through an Android Based Door Security System using Internet of Things Technology

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ABSTRACT: In order to address the frequent need for robust home security, this project attempts to automate door monitoring and access control using a simpler and more economical way based on the Internet of Things (IoT). It presents a unique method that may be particularly helpful in residential settings like apartments and private homes, but also in small offices or laboratories. The project also has the potential for wide residential applications due to its cost-effectiveness. As of right now, there isn't a widely accessible, low-cost, integrated technology that's expressly made to automate door security with real-time mobile alerts. The goal of the project is to provide a durability evaluation for the proposed smart locking mechanism using finite elements. One of its goals is to design a security tool that is simple to use, ergonomic, portable, and multifunctional. The study investigates the application of microcontrollers and sensors that are often used in industry. Findings show that using an Android application to control a servo-driven lock and receive real-time video alerts successfully enhances security, with all access attempts and events collected in a cloud database. The results of the durability evaluation are essential for improving component design in the first phases of development. These results might lead to considerable cost reductions, improved product dependability, and increased consumer trust in smart security solutions.

I. INTRODUCTION

The goal of this project is to make home security monitoring easier, faster, and more accessible. It introduces a new way to monitor and control a door automatically, which can be useful in places requiring secure access, like homes, apartments, and offices. It can also be used at home because it's affordable. Right now, there's no all-in-one, low-cost machine made specifically for automatic door monitoring and remote access, so this idea is new and useful. Traditionally, home security relies on manual "peepholes" and a physical lock-and-key system. This approach is labor-intensive (requiring one to be physically present) and not always effective, particularly when keys are lost, stolen, or copied. Security risks can result from neglecting to lock a door or being unaware of who is present, especially in homes with vulnerable residents like children or the elderly. Human error or forgetfulness is possible to overcome and regular security monitoring may be ensured by automating the process of access and alerts. The Android-based Door Security System addresses these challenges by providing an efficient and user-friendly solution. It is designed to monitor and control door access thoroughly without the need for complex and expensive installation, reducing the risk of unauthorized entry and ensuring better security. The machine typically consists of a microcontroller with a camera, a locking mechanism (like a servo or solenoid), a cloud database, and an Android application to handle the monitoring and control process with minimal effort from the user. This project aims to develop a prototype of a Door Security System that is easy to operate, lightweight, and effective in providing alerts and controlling access. This project is about creating a new type of system that can monitor a doorway more easily and effectively. The goal is to make a security tool that is light, easy to use, and flexible. The machine uses a camera to capture visitors and an app to control the lock. The alerts and access logs are collected in a cloud database. [13] These results help improve the design of the system early on, which reduces costs, speeds up production, and makes the product more reliable and trusted by customers

II. LITERATURE REVIEW

[1] Controlling access is important for keeping homes secure and providing peace of mind. [2] Systems that use Wi-Fi-enabled microcontrollers and Android applications are helpful for managing access efficiently. [3] This review looks at the progress, challenges, and uses of these IoT security systems. [4] Microcontrollers have improved a lot over the years, making them more efficient, reliable, and easier to control.[5] Studies by Sharma et al. (2019) and Patel et al. (2020) [1] show how integrated microcontrollers like the ESP32-CAM are being used in home automation systems. These improvements make smart security systems work better and use less energy. [6] The design of the communication protocol used in IoT systems is very important for good performance.[7] Wang et al. (2018) studied how different protocols, like MQTT and HTTP, affect latency and reliability for real-time alerts.[8]

Chen et al. (2021) suggested ways to improve the data transmission between the device and the app to make monitoring more effective. IoT-based security systems are more energy-efficient than traditional closed-circuit television (CCTV)

methods. Research by Liu et al. (2019) and Guo et al. (2020) examined how much energy different monitoring methods use and their environmental impact. [9] Their studies show that using low-power, event-driven IoT systems helps save energy, making them more eco-friendly. Making sure that IoT security systems are safe and reliable is very important to prevent unauthorized access (hacking) and system failure.

Jiang et al. (2017) discussed security features like data encryption and secure user authentication that are added to these systems. Xu et al. [10] (2021) studied how well the sensors and locks perform under different network conditions, helping improve the durability and reliability of the system. [11] Applications in Different Industries: Smart access control finds applications across various sectors, including residential smart homes, office building management, and secure laboratories. Case studies by Smith et al. (2018) and Patel et al. (2021) demonstrate the effectiveness of IoT-driven access systems in improving security and reducing monitoring costs in commercial and residential facilities. Moreover, research by Lee et al. (2022) explores the use of autonomous systems equipped with AI for facial recognition, highlighting innovative applications of this technology.

III. METHODOLOGY

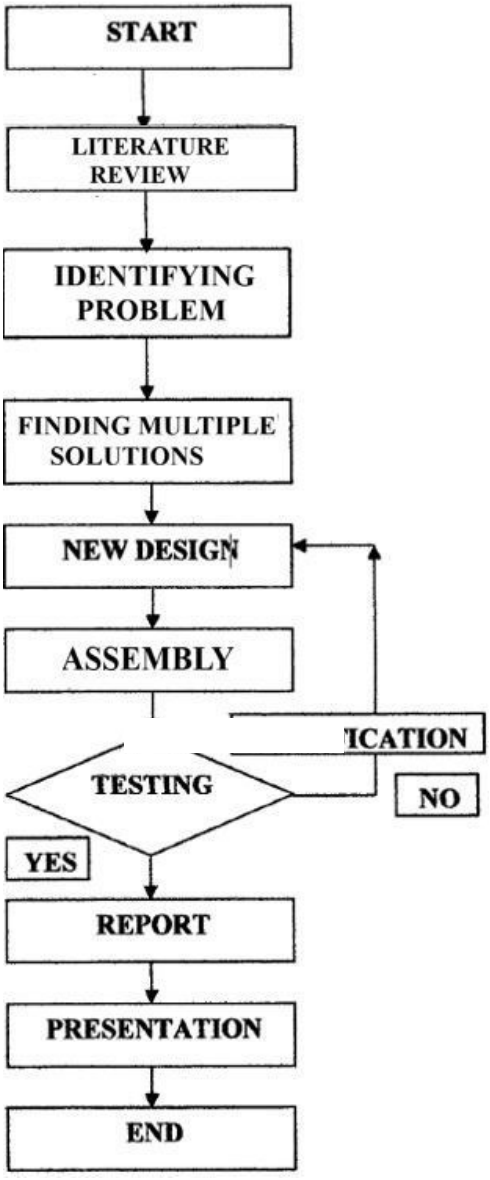


Fig 3.1 Flow Chart

IV. MATERIAL SELECTION

When doing a project, it is important to pay attention to the selection of materials. To prevent waste, the items selection process must be carefully welcomed. A precise selection of items is necessary to ensure that they are long-lasting and safe for usage.

4.1 ESP32-CAM



Fig4.1 ESP32-CM

This microcontroller was selected because, due to its built-in camera and Wi-Fi capability, it may be able to capture images of visitors and transmit them over the internet. Furthermore, it is compact and appropriate for our purpose

4.2 Solenoid Lock



Fig 4.2 Solenoid Lock

The purpose of the solenoid lock selection is to provide a robust, electronically controlled locking mechanism for the door. The user can actuate it remotely via the microcontroller. Additionally, this lock is durable and operates on a standard 12V supply.

4.3 Servo Motor



Fig 4.3 Servo Motor

In this project, a high-torque servo motor is used to actuate the physical latch or deadbolt. It is powered by 5-6 volts and allows for precise rotational control to lock or unlock the door

4.4 Power Supply



Fig 4.4 Power Supply

The primary energy source for the "Door Security System" is a power adapter with a 12-volt and 5-volt capacity, powering the solenoid/servo and the microcontroller, respectively

4.5 3D Printed Enclosure



Fig 4.5 3D Printed Enclosure

Since PLA/ABS plastic is known to be lightweight and easy to customize, that is the sort of material we have chosen for the enclosure. Even though the idea seems straightforward at first, the project entails integrating a number of different systems and sensors. A frame with a camera aperture, mounts for the microcontroller, and the locking mechanism are important parts. Several suggestions have been made to improve the system, such as adding a battery backup, integrating a PIR motion sensor, and using a wider-angle camera lens. Previously, the time taken to check the door required being physically present. With the renewal of this product, it could take only seconds to check and unlock the door from anywhere with only one operator. Suggestions for improvement for this tool are to reduce the size by using a custom PCB and for security to use a type of encryption that is more robust.

V. RESULTS AND DISCUSSION

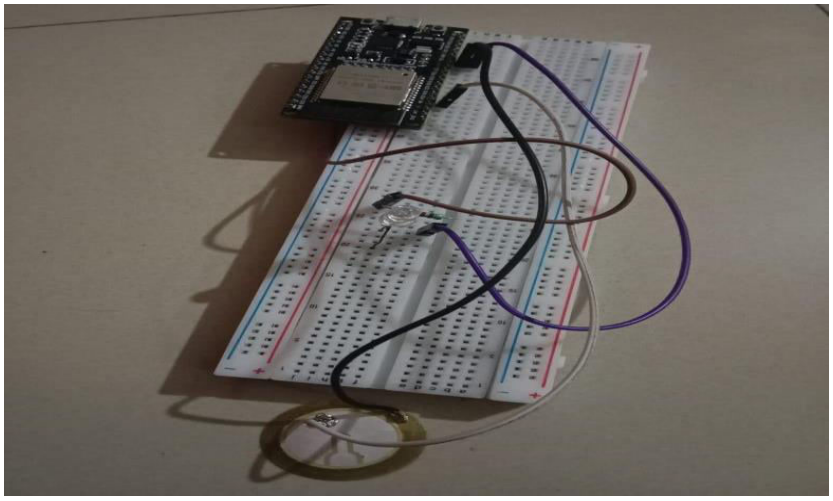


Fig 5.1 Working Model

5.1 Working principle

Because of the event-driven programming, the ESP32-CAM enters deep sleep until a motion sensor or doorbell button is triggered. When a visitor arrives, the sensor wakes the microcontroller to drive it. The cleaning process (monitoring) is then made easier by connecting this device to the Wi-Fi, which is connected to the cloud service (like Firebase or MQTT broker). The Android application located on the user's phone is primarily responsible for receiving alerts and sending commands. This is accomplished by making the app operationally feasible by subscribing it to the MQTT topic or listening to the Firebase database for changes. In addition, a rectifier circuit and a step-down adapter produce the DC power for the microcontroller and lock. Within the detecting area, the ESP32-CAM's camera captures an image of the visitor and uploads it, triggering a push notification. A proximity sensor (reed switch) allows the door's open/closed status to be detected. A servo motor and a solenoid lock arrangement mounted on the door frame power the access control part. The user can press an "Unlock" button on the app, which sends a command back to the microcontroller. The cleaning (unlocking) procedure is coordinated by the microcontroller according to the present plan. The microcontroller drives the servo/solenoid that retracts the latch, making the access process easier by linking it to the app through adjustable digital pins Because of the event-driven programming, the ESP32-CAM enters deep sleep until a motion sensor or doorbell button is triggered. When a visitor arrives, the sensor wakes the microcontroller to drive it. The cleaning process (monitoring) is then made easier by connecting this device to the Wi-Fi, which is connected to the cloud service (like Firebase or MQTT broker). The Android application located on the user's phone is primarily responsible for receiving alerts and sending commands. This is accomplished by making the app operationally feasible by subscribing it to the MQTT topic or listening to the Firebase database for changes. In addition, a rectifier circuit and a step-down adapter produce the DC power for the microcontroller and lock. Within the detecting area, the ESP32-CAM's camera captures an image of the visitor and uploads it, triggering a push notification. A proximity sensor (reed switch) allows the door's open/closed status to be detected. A servo motor and a solenoid lock arrangement mounted on the door frame power the access control part. The user can press an "Unlock" button on the app, which sends a command back to the microcontroller. The cleaning (unlocking) procedure is coordinated by the microcontroller according to the present plan. The microcontroller drives the servo/solenoid that retracts the latch, making the access process easier by linking it to the app through adjustable digital pins

VI. CONCLUSION AND FUTURE SCOPE

The system provides an effective way to monitor and control home access using IoT, making it modern, reliable, and suitable for remote monitoring of homes, apartments, and offices. It creates a sense of safety and reduces the risk of unauthorized entry, which is especially useful for families with children and elderly members. The goal is to further improve the security system by optimizing performance, enhancing AI-based facial recognition, and increasing energy efficiency for battery-powered operation. As part of smart home technology, the automated door system offers a fast and efficient solution for home security. It monitors the door regularly and thoroughly, reducing the need for manual checking and increasing user convenience. The system can perform well in different environments and ensures that access is logged properly without requiring constant supervision. This allows users to focus on other tasks without worry. Overall, the automated home access system makes security more efficient, reliable, and user-friendly

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Laser Security Alarm System

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ABSTRACT: - This project deals with a model of laser security alarm system design. Laser security systems used to be difficult to install and rarely available to anyone other than the super-rich. Now, there are dozens of different security systems on the market that utilize lasers and can effectively protect everything from small apartments and businesses to large areas of property. Most home laser security systems consist of two parts: a basic alarm unit and an infrared motion detector. Laser based security system is a type of security and alarm system that uses laser light and a light sensor. Why a laser to be used? It is known that a laser light goes through long distance without any scattering effect (disturbing) and it is only visible at source and the destination point so it can be used as mediator between source and destination but to analyses the source a sensor is need, here the use of LDR is applicable. Just analysis is not enough alerting should be done in general alerting is sound effect so here buzzer act as alerting. Making use of this, a laser security system is designed. Its working: There is a laser diode that generates the laser beam which continuously strikes over the Light dependent resister sensors. When any person crosses the path, it inhibits laser to reach LDR and the sensor generate a low which is read by controller to power on the buzzer.

I. INTRODUCTION

Security has become an essential requirement in homes, offices, banks, laboratories, and other sensitive areas. Traditional security methods are often expensive or difficult to install, leading to the need for simple and reliable alternatives. A Laser Security Alarm System is an effective solution that uses a laser beam and a light-sensitive sensor to detect unauthorized entry. In this system, a laser continuously points toward an LDR or photodiode placed at a fixed position. As long as the beam remains uninterrupted, the circuit stays in its normal state. When an object or person crosses the laser path, the light falling on the sensor is blocked, causing an immediate change in the circuit that triggers an alarm. This ensures quick detection of intrusion and provides instant alert through a buzzer or siren. set up, and suitable for small-scale security applications. Overall, the Laser Security Alarm System offers a smart and economical way to enhance safety in various environments. A laser security system project uses a laser beam to create an invisible security perimeter, triggering an alarm when the beam is interrupted by an intruder. The project typically involves a transmitter with a laser source, a receiver with a photo-detector (like an LDR or photodiode), and an alarm circuit with a buzzer or siren. The project's goal is to detect unauthorized movement and activate an alert, making it a cost-effective and efficient security solution for homes, offices, and other sensitive areas.

II.LITERATUREREVIEW

The fundamental literature establishes the system's reliance on the interruption of a continuous beam of light, where a Laser Emitter projects a focused beam onto a Receiver/Sensor (most commonly a Light Dependent Resistor, LDR). When an intruder breaks the beam, the light incident on the LDR dramatically decreases, causing its resistance to increase and creating a measurable voltage change. This method is highly effective for establishing a clear perimeter boundary and offers a low false alarm rate compared to motion detectors [Source: S. Sharma, V. Kumar, and N. V. Singh, 2018].[1]

Modern literature emphasizes the shift from simple analog comparator circuits (like Op-Amps) to integrated Microcontroller Units (MCUs) for signal processing and control. Microcontrollers like Arduino UNO are widely used to read the fluctuating voltage signal from the LDR and analyze it, allowing for setting specific voltage thresholds and debouncing the signal to avoid spurious alarms [Source: A. Gupta, D. K. Yadav, and S. Kumar, 2018].[2]

The MCU subsequently controls the Alarm Unit (buzzer or siren), ensuring the alarm is triggered only after the intrusion signal is confirmed for a set duration. This confirmation process improves the overall system reliability and prevents false alerts caused by momentary beam interruptions [Source: M. N. A. R. L. R. K. Samaraweera and S. A. J. S. L. A. Samarasinghe, 2020].[3]

The most recent literature focuses on enhancing the functionality of laser systems by leveraging Internet of Things (IoT) technologies to address the limitation of local-only alerts. By integrating Wi-Fi-enabled MCUs (e.g., ESP8266),

the system can send instant SMS or email notifications (via platforms like Blynk) to the user's mobile device upon intrusion, providing real-time alerts [Source: M. R. M. F. B. S. D. G. I. P. Gunathilaka, 2019][4]
.Advanced implementations integrate a small camera module (like the ESP32-CAM) that is activated by the laser trigger. The system captures an image of the intruder and transmits it to the owner, providing crucial visual verification and evidence collection, which significantly enhances security and documentation capabilities [Source: C. N. V. D. V. S. R. Naidu, 2020].[5]

Literature frequently compares the cost-effectiveness and simplicity of the laser security system against complex wired surveillance or high-end commercial systems. This System Optimization and Cost Analysis highlights the laser system as a viable, low-cost security solution [Source: International Research Journal of Engineering and Technology (IRJET), 2018].[6]

Research often involves analyzing the system's robustness against ambient light noise. This requires optimization techniques, such as using optical filters and focusing lenses, which are discussed to ensure high accuracy in various challenging lighting conditions and improve Environmental Stability [Source: B. B. Bhati, M. K. Koli, and V. B. Goud, 2019/2020].[7]

The integration of laser security technology is contextualized within the larger field of Internet of Things: Smart Innovation and Usages (IoT-SIU), positioning it as a key element of modern, interconnected smart security solutions [Source: 3rd International Conference on Internet of Things: Smart Innovation and Usages (IoT-SIU), 2018].[8]

III. METHODOLOGY

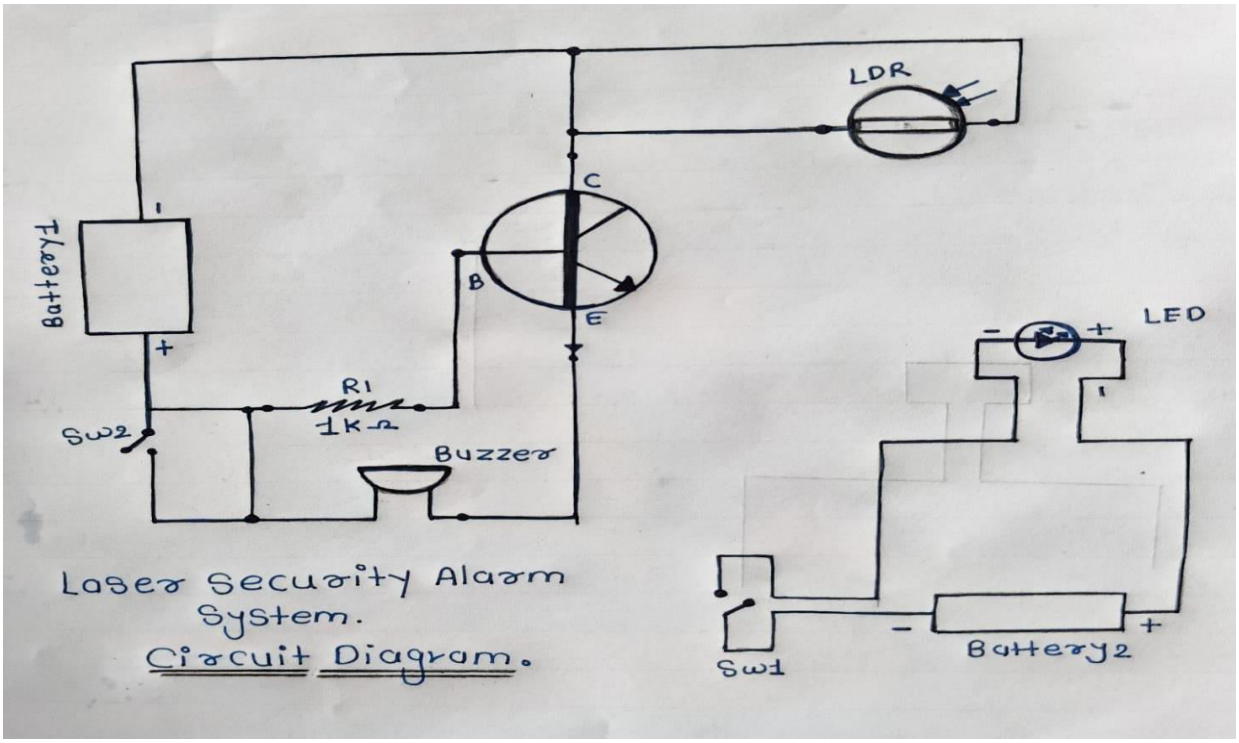


Fig: 3.1 circuit diagram

IV. MATERIAL SELECTION

In the Laser Security Alarm System project, selecting the correct materials is very important for building a reliable and efficient security setup. Each component must be chosen carefully to ensure proper operation, long life, and safety. Good material selection helps avoid circuit failure, reduces waste, and ensures that the system works

smoothly in all conditions. Choosing accurate and suitable components also makes the project easier to test, assemble, and maintain.

4.1 BC547 TRANSISTOR



Fig :4.1 BC547 Transistor

BC547 is usually used for current amplifier, quick switching and pulse-width modulation (PWM). Therefore, if you need to control the speed of a motor or actuator in some of your projects, you can simply use this transistor to achieve it.

4.2 3.7 VOLT BATTERY.



Fig:4.2 Volt Battery

A 3.7-volt lithium battery is used to power a wide variety of portable electronics, from small devices like smartphones and cameras to larger ones like drones and electric vehicles. Its high energy density, lightweight, and rechargeable nature make it suitable for applications requiring a reliable and compact power source, such as LED torches, power tools, and electronic circuits.

4.3 5VOLT BUZZER.



Fig: 4.3-volt buzzer

This Electronic Buzzer 5V is commonly used in alarm systems, consumer electronics, automotive applications, industrial equipment, and DIY projects.

4.4 SLIDE SWITCH 2 PIN.



Fig:4.5 switch pins

A 2-pin slide switch is used for basic ON/OFF control in low-voltage circuits, ideal for a variety of applications including simple on/off functions in consumer electronics, toys, and small appliances. It works by connecting or disconnecting two points in a circuit with a simple sliding action, making it a simple and durable solution for controlling power flow.

4.5 BREADBOARD.

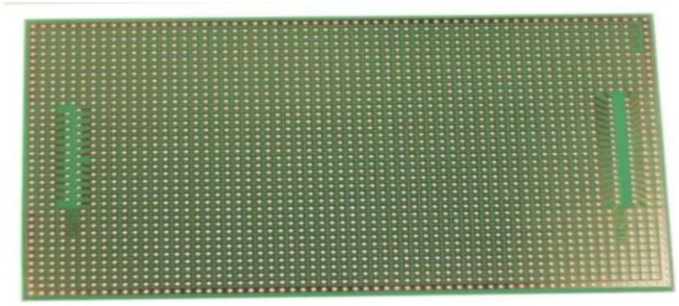


Fig4.6: Breadboard

A breadboard is used to connect and test all parts of the laser security alarm system easily without soldering. It helps build the circuit quickly and check if the alarm works when the laser beam is broken.

4.6 LDR SENSOR.

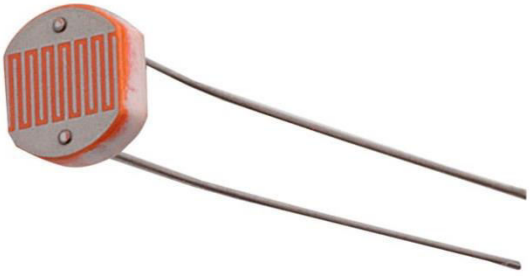


Fig :4.27Sensor

An LDR sensor is used to detect light levels and is primarily applied in systems that require automatic control or light detection, such as automatic streetlights, alarm systems, and light meters. Its resistance changes depending on the amount of light that hits it, allowing it to be used in various automation, safety, and consumer electronics applications.

4.7 1K OHM RESISTOR

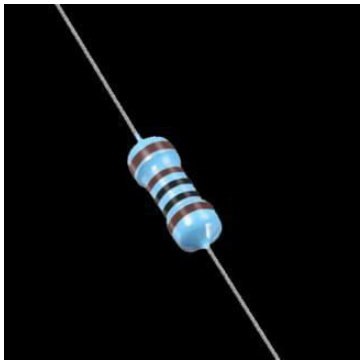


Fig: 4.8 resistor

1kΩ resistor is used to reduce current, protect components, and ensure stable operation of the circuit.

V. RESULTS AND DISCUSSION

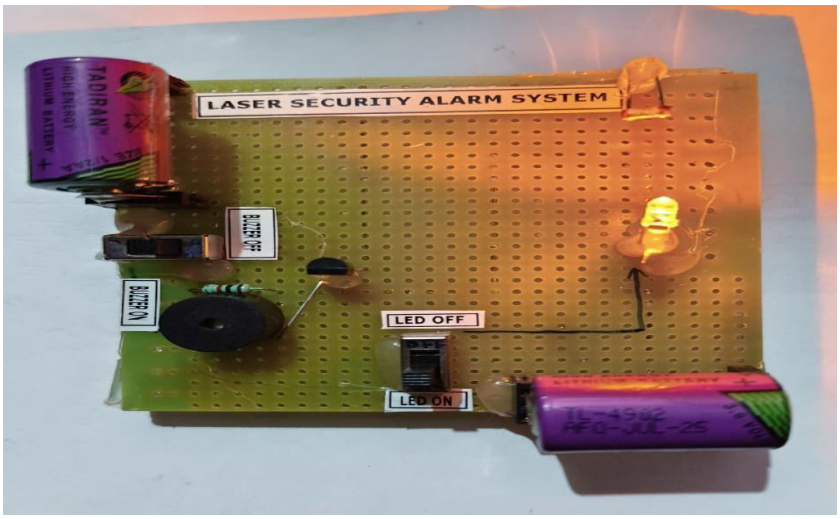


Fig:5.1 Working model

5.1 WORKING PRINCIPLE.

The Laser Security Alarm System works on the idea of blocking a light beam. A laser light is pointed at a sensor like an LDR. As long as the laser light falls on the sensor, the circuit stays normal and the alarm remains OFF.

When someone or something crosses the laser path, the light is blocked. Because of this, the sensor stops receiving light, its resistance changes, and the circuit immediately turns the alarm ON. This warns that someone has entered the restricted area.

The working principle of the Laser Security Alarm System is based on the continuous interruption of a laser beam. A laser is directed toward a light-sensitive sensor such as an LDR or photodiode. Under normal conditions, the sensor continuously receives the laser light, keeping the alarm circuit in an inactive state.

When an intruder or object blocks the laser beam, the light intensity falling on the sensor suddenly decreases. This change in light level causes a variation in the sensor's resistance or output voltage. The circuit detects this change and activates the alarm using a buzzer or siren. Thus, the system works on the simple concept of beam interruption:

Laser beam ON → Alarm OFF

Laser beam blocked → Alarm ON

VI. CONCLUSION

The Laser Security Alarm System is a simple and effective way to protect an area from intruders. It works by using a laser beam and a sensor to detect when someone crosses the light path. If the beam is blocked, the alarm turns on immediately. This project shows that we can build a useful security device using basic and low-cost electronic components. Overall, it is an easy, reliable, and smart method for improving safety.

VII. FUTURE SCOPE

The Laser Security Alarm System can be improved by adding microcontrollers for smart control, wireless alerts for remote monitoring, and connecting it with CCTV for automatic recording. Multiple laser beams and solar power can also be added to increase coverage and make the system more efficient for modern security needs.

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Automated Traffic Signal System for Emergency Vehicle Prioritization

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ABSTRACT: In response to the critical need for efficient emergency response, this project presents an automated, low-cost traffic signal system designed for emergency vehicle prioritization. The system utilizes an Infrared (IR) sensor module to detect a signal from an approaching emergency vehicle (e.g., ambulance or VIP car). Upon detection, the system immediately overrides the normal traffic light sequence, forcing all lights at the intersection to RED to ensure the vehicle has an unobstructed passage. This system is a cost-effective and reliable solution that improves traffic flow and significantly reduces response times for essential services. The circuit uses standard components like the NE555 Timer and CD4017 Counter for normal sequencing, augmented by transistor logic for the robust override functionality.

I. INTRODUCTION

The efficiency and reliability of emergency services are critical components in ensuring public safety and reducing the severity of life-threatening situations. In emergencies such as medical crises, accidents, fires, or police operations, rapid response time is essential because even a few seconds of delay can significantly impact outcomes. One of the biggest contributors to these delays is traffic congestion, especially at controlled intersections. Traditional traffic signal systems typically operate on fixed timing cycles or rely on manual intervention by traffic personnel. While these systems work adequately under normal conditions, they are often insufficient during emergency scenarios due to their slow adaptability and dependence on human involvement.

To overcome these shortcomings, this project introduces a **smart and automated traffic signal override system** designed to prioritize emergency vehicles quickly and efficiently. Unlike conventional systems, the proposed model integrates intelligence and automation to enhance traffic flow management. The system performs two major functions. Under regular traffic operation, it maintains a predictable and systematic flow by following the standard **Red–Yellow–Green (R-Y-G)** signal pattern. This helps ensure smooth vehicular movement and minimizes the chances of congestion buildup.

During an emergency event, the system responds instantly by overriding the normal operation. When an emergency vehicle is detected using sensors, wireless triggers, or an activation input, the system performs the following:

- Immediately switches all traffic lights to an All-Red state
- Clears the intersection and creates a safe corridor for emergency vehicles
- Eliminates human dependency and reduces the possibility of operational errors

This temporary override significantly reduces potential traffic conflicts and improves road safety. Once the emergency vehicle has safely crossed the intersection, the system automatically restores the standard signal cycle. This automated return mechanism ensures:

- No manual resetting is required
- Traffic resumes smoothly without confusion
- Normal flow is maintained without unnecessary delays

By integrating automation, reliability, and intelligent operation, the proposed traffic signal override system presents a major improvement over traditional manual control methods. It enhances roadway safety, optimizes traffic movement, and most importantly, supports faster and more efficient emergency response. The implementation of such a system can play a vital role in modern smart-city infrastructure, ultimately saving lives and improving overall urban mobility.

II. LITERATURE REVIEW

[1] INTELLIGENT TRAFFIC LIGHT CONTROL SYSTEM BASED IMAGE INTENSITY MEASURMENT by Muzhir Shaban, Al-Ani and Khattab Alheeti proposed an algorithm consisting many subsystems to increase the efficiency of the system by employing a camera and using infrared object sensors to detect the density of the traffic.

The camera is then used to capture the image and calculate the histogram of that captured image. This paper asserts that the proposed algorithm can reduce the travelling time of vehicles and lessen the traffic congestion.

[2]ADAPTIVE TRAFFIC LIGHT CONTROL WITH WIRELESS SENSOR NETWORKS by Malik Tubaishat, Yi Shang and Hongchi Shi implements traffic light control system using wireless sensors. After classifying the system into 3 layers; the system works as the remote sensors are set up on the paths going in and out the crossway. These sensors identify vehicles number, speed and send their information to the closest Intersection Control Agent (ICA) which, decides the flow model of the crossway contingent upon sensors information (e.g., number of vehicles moving toward a specific crossway).

[3] FOUR-WAY TRAFFIC LIGHT CONTROLLER DESIGNING WITH VHDL by Faizan Mansuri, Viraj Panchal designed the whole system of traffic-light controller for intersection in fourway using VHDL for serial communication and finite state machines then uploading the designed VHDL code on ALTERA kit for design verification.

[4] FPGA-BASED INTELLIGENT TRAFFIC LIGHT CONTROLLER SYSTEM DESIGN presented by V. V. Dabahde, Dr. R. V. Kshirsagar aims at abbreviating the waiting time of the vehicles and this proposed framework utilizes FPGA innovation alongside traffic sensors to control traffic as indicated by the traffic prerequisite and along these lines decreases the waiting time at a crossing point of two streets. The time intervals of the green, yellow and red states depend on continuous traffic thickness, which enhances traffic light planning and stays away from traffic congestion and it is an improvement upon the proficiency of the present Traffic Light Controllers.

III. METHODOLOGY

The system is constructed by integrating two distinct circuits: the **Normal Sequence Generator** and the **Emergency Override Logic**.

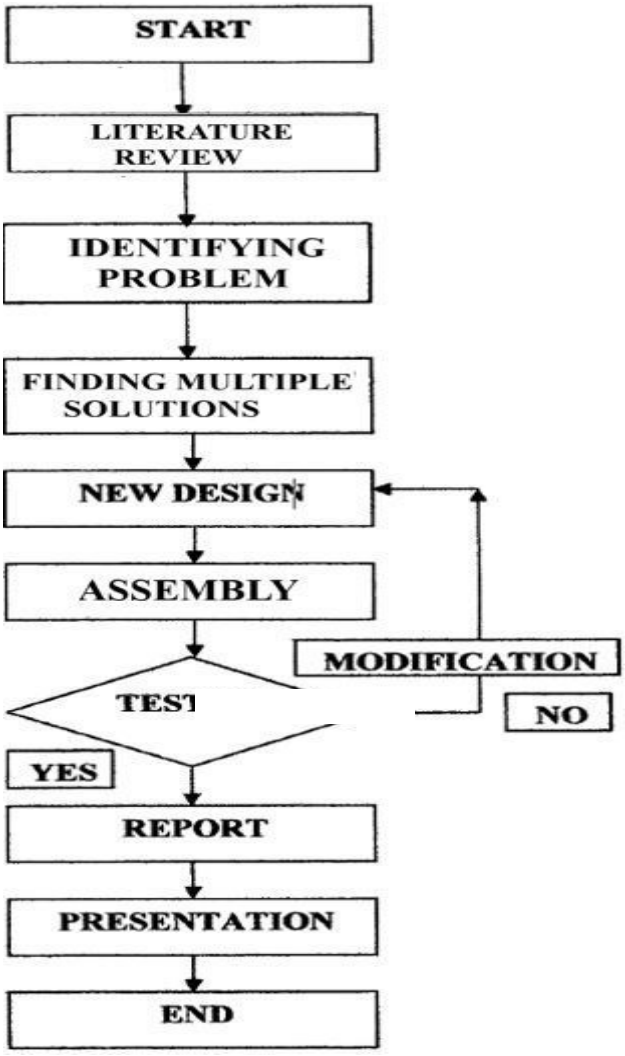


Fig 3.1 Flow Chart

IV. MATERIAL SELECTION

When doing a project, it is important to pay attention to the selection of materials. To prevent waste, the items selection process must be carefully welcomed. A precise selection of items is necessary to ensure that they are long-lasting and safe for usage.

4.1 NE555 Timer IC - Clock Pulse Generation



Fig 4.1 NE555 Timer IC

4.2 CD4017 Decade Counter IC - Sequential Output Control



Fig 4.2 CD4017 Decade Counter IC

4.3 IR Sensor Module - Emergency Vehicle Detection (Signal OUT)



Fig 4.3 IR Sensor Module

In this project, the two brushes are rotated or moved by DC motors. It is powered by 12 volts and runs at 40 rpm.

4.4 2N2222 NPN Transistors - Override Switching Mechanism



Fig 4.4 2N2222 NPN Transistors

4.5 1N4148 Diodes - Isolation of Yellow/Green Outputs



Fig 4.5 1N4148 Diodes

4.6 LEDs (Red, Yellow, Green) - Traffic Light Indicators



Fig 4.6 LEDs (Red, Yellow, Green)

4.7 100kΩ Potentiometer - Adjustable Timing for NE555



Fig 4.6 100kΩ Potentiometer

4.8 Various Resistors - Current Limiting and Base Protection

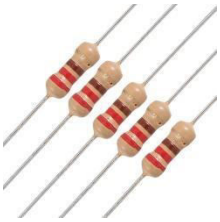


Fig 4.6 Various Resistors

4.9 Capacitors - Timing Stabilization



Fig 4.6 Capacitors

V. RESULTS AND DISCUSSION

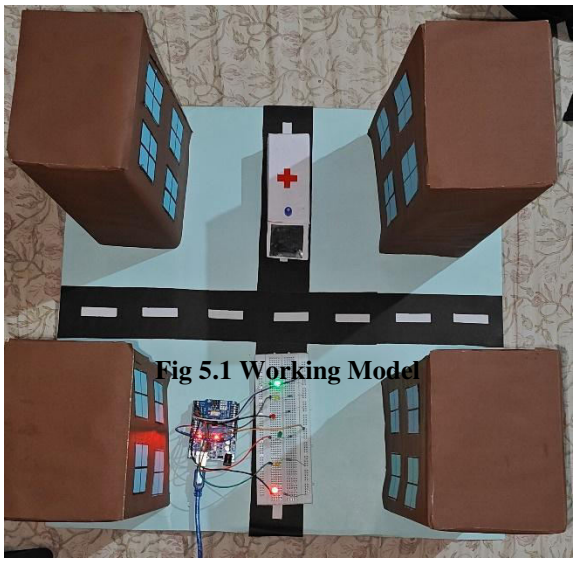


Fig 5.1 Working Model

5.1 Working principle

- **Normal Mode:** The NE555 generates a continuous pulse (**Clock**) which is fed into the CD4017. The CD4017 outputs sequentially drive the Red (Q0), Yellow (Q1), and Green (Q2) LEDs. Q3 is looped back to Reset (Pin 15) to maintain the three-step cycle.
- **Emergency Detection:** When an IR signal is detected, the **IR Sensor OUT pin goes HIGH**.
- **Override Execution (Transistor Logic):**
  - **Transistor 1 (Red ON):** The HIGH signal turns ON Transistor 1, which has its collector connected to the positive supply via a current-limiting resistor, and then to the Red LED. This ensures the Red LED is forcibly illuminated.
  - **Transistor 2 (Yellow/Green OFF):** The HIGH signal also turns ON Transistor 2. Its collector is connected to the anode side of the Yellow and Green LEDs (via the 1N4148 Diodes). When ON, Transistor 2 pulls the voltage at these points to ground (0V), effectively shorting them OFF and forcing the Yellow and Green lights to extinguish, irrespective of the CD4017's state.

VI. CONCLUSION AND FUTURE SCOPE

This automatic traffic signal system for emergency vehicle prioritization provides an effective, cost-efficient, and portable solution to the challenges associated with manual traffic management during emergencies. By automating the process, the system contributes to faster response times, reduced risk of accidents, and improved overall city service efficiency.

Future scope for this project: Multi-Intersection Control: Expanding the design to coordinate the signals of a four-way intersection or multiple intersections. Sensor Enhancement: Integrating an RF module for a longer detection range and improved signal penetration compared to IR.

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Laser Light Security Alert System

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ABSTRACT: In today's world, security is the first issue that needs to be addressed. This project presents a laser Light Security Alert System developed using an ESP32-CAM module for real time intrusion monitoring. The system employs a laser beam and an LDR sensor to form an optical security boundary. In terms of home security, we provide our users a simple way to use internet networking to manage the multiple devices in their houses. Modern technologies are developing so quickly that home security system must be improved. We are utilizing IoT to develop a low- cost home security system because we recognize the value of home security. The goal of home security system project is to make homes and other private spaces more secure by integrating the ESP-32 CAM with the telegram app. The system employs a laser beam and LDR sensor to form an optical security boundary. The system is compact, energy-efficient, and easy to deploy, making it suitable for Homes, Labs, Small offices, and Restricted areas.

I. INTRODUCTION

An integral part of contemporary home automation is a home security system. The system goal is to keep our family, valuable, and house safe from prospective intruders, criminals, and other security risks, using an ESP32CAM module and the telegram app is one practical method of setting up a home security system. The ESP32-CAM module is low cost, low power, and small development board with image processing and Wi-Fi networking combined. Security and Surveillance system play a vital role in protecting homes , offices , and restricted areas from unauthorized access, With the rapid growth of the internet of things (IOT), modern security solutions are becoming more intelligent, responsive, and accessible from anywhere in the world. You can get real time alerts and notifications any time the system notices any suspicious activity by connecting this module with the telegram app.

Individuals who want to safeguard their homes and families against theft, vandalism, and other security risks are adopting home security system at an increasing rate. Using an ESP32CAM module and the telegram application all things considered, setting up a home security system that may assist you in safeguarding your house, family , and valuable assets is a wise choice when utilizing an ESP32CAM module and the telegram app. Your home will be safe and well-protected against any potential security threats with this system, giving you piece of mind knowing that your home is secured.

II. LITERATURE REVIEW

A review of existing literature shows that researchers have explored various combinations of laser-based intrusion detection, ESP32/ESP32-CAM processing, and Telegram IoT alerting to design low-cost and efficient home security solutions.

In the study "IoT-Enabled Smart Intruder Alert System using ESP32" by Kumar et ai (2021), the authors proposed a real-time alert system that utilized the ESP32 for sensor data acquisition and Wi-Fi-based communication. Their system integrated PIR sensors and an LDR module to detect suspicious movement and instantly send alerts to the homeowner's mobile device .this demonstrated the capability of the ESP32 as a reliable IoT controller for intrusion detection in indoor environments.[1]

In the paper "A Smart Home Security System based on ESP32-CAM and Telegram Bot ," by Li et ai (2020), A smart home security system with Telegram Bot and ESP32-CAM was suggested. The integration of IoT platform with the ESP32 microcontroller has gained significant attention in the development of modern security systems.[2]

A more advanced system was described in "Surveillance System using ESP32-CAM and Cloud Messaging" by R. Yadav et al. (2022), where an ESP32-CAM module was employed to capture real-time images upon detecting motion.[3]

In another relevant contribution, Patankar and More(2023) developed a Telegram-based Home Monitoring System thar utilize the Telegram Bot API to send instant alerts and multimedia messages to users. Their work supports the integration of Telegram into modern smart security system for user-friendly remote monitoring.[4]
A significant work closely related to the proposed system is "Laser Intrusion Detection with ESP32 Integration" by A . Banerjee et ai .(2022). In this system, a continuous laser beam directed towards an LDR was use as a primary trigger for intrusion detection. Upon beam interruption, the ESP32 processed the signal , activated an alarm , and sent immediate notifications to the user through Wi-fi. However, the system lacked visual verification of the intruder.[5]

Laser based security system for home by Harshal Hemane, Debarati Sen . mirrors are utilized in this suggested system to reflect laser rays so that they cover the area around the residence in all direction.[6]

integration of IoT platform with the ESP32 microcontroller has gained significant attention in the development of modern security systems.[7]

A review of existing literature shows that resThe LDR sensor module is use to measure light intensity and identify its existence. When there is a light , the module's output is high when there is no light, it is low. Potentiometers can be use to change the signal detecting sensitivity.[8]

"Photo Conductivity" is the basis for how the LDR model operates.it is connected to the pins on the board designated as AO and DO, respectively, for analog and digital output .When light levels reach a certain threshold , the DO port outputs high; when outside ambient light levels above a predetermined threshold , the DO output of module output lowearchers have explored various combinations of laser-based intrusion detection, ESP32/ESP32-CAM processing, and Telegram IoT alerting to design low-cost and efficient home security solutions.[9]

III. METHODOLOGY

1. Circuit Design
Construct a voltage divider using the LDR and a fixed resistor.
Connect the divider output to the base/input of a transistor or comparator.
Configure the comparator/transistor such that:
Beam present → voltage stays below threshold → buzzer OFF.
Beam interrupted → voltage rises above threshold → buzzer ON.
Ensure proper biasing and current-limiting resistors for safe operation.

2. Assembly & Setup
Align the laser diode directly onto the LDR surface.
Mount components on a breadboard or PCB for stability.
Connect the buzzer to the transistor's collector/output stage.
Provide regulated DC supply to the circuit.

3. Calibration
Adjust the fixed resistor value in the voltage divider to set a sensitive threshold.
Test under different ambient light conditions to minimize false triggering.
Fine-tune laser alignment for consistent illumination of the LDR.

4. Testing Procedure
Normal condition: Laser beam uninterrupted → buzzer remains silent.
Intrusion simulation: Block the beam with an object → buzzer activates immediately.
Record response time and reliability across multiple trials.
Evaluate performance under varying light intensities (daylight vs. dark room).

5. Documentation
Note circuit diagrams, wiring connections, and calibration values.
Record experimental observations (trigger sensitivity, false alarms, power consumption).
Summarize results to validate the working principle.

IV. PROPOSED SYSTEM

4.1 Working principle

The working principle of the DIY laser security alarm is based on photoresistive sensing and signal triggering:

1. **Laser Beam Transmission**
   - A continuous laser beam is projected toward the LDR.
   - The LDR receives constant illumination, keeping its resistance low.
2. **Photoresistor Behavior**
   - LDR resistance is inversely proportional to light intensity.
   - When illuminated, resistance is minimal; when blocked, resistance increases sharply.
3. **Circuit Response**
   - The LDR is part of a voltage divider circuit.
   - Under normal conditions (beam present), the voltage across the LDR remains within a stable threshold.
   - When the beam is interrupted, voltage changes significantly.
4. **Trigger Mechanism**
   - This voltage change is fed into a transistor or comparator circuit.
   - Once the threshold is crossed, the transistor switches ON, activating the buzzer/alarm.

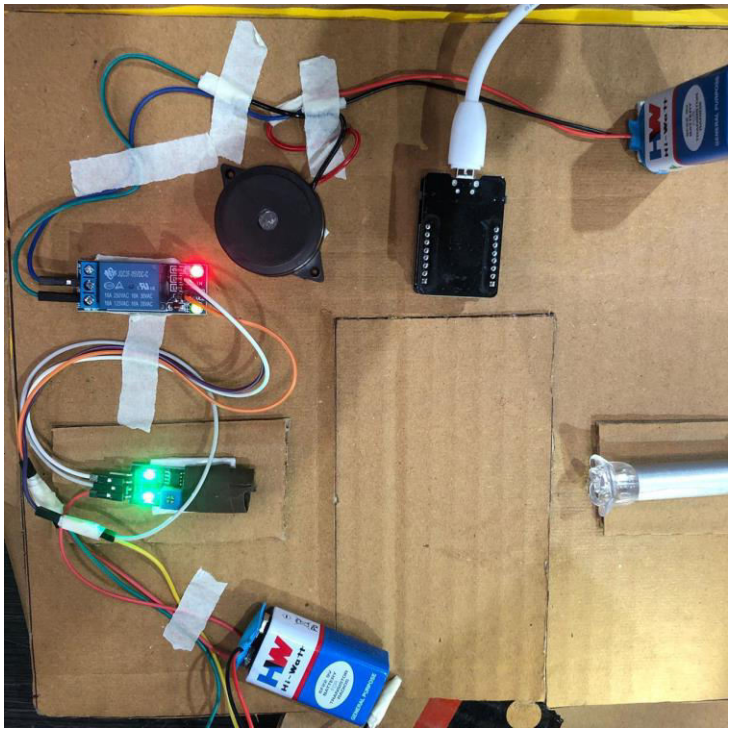


Fig. 4.1 Model of the project

V. MATERIAL SELECTION

5.1 ESP32 CAM

With a built -in video camera and microSD card slot, the ESP32 CAM is a feature-rich microcontroller. For Internet of Things devices that need a camera with sophisticated features like image tracking and identification, this affordable and user-friendly camera is ideal. A compact, low-power camera module based on ESP32 is called the ESP32 CAM. An OV2640 camera is included with it. ESP combines two powerful 32-bit LX6 CPUs with a seven-stage pipeline architecture, Wi-Fi, conventional Bluetooth, and BLE Beacon. It is appropriate for wireless positioning system signals, smart home

devices, industrial wireless control, wireless monitoring, QR wireless identification, and other Internet of Things applications. It's the perfect answer for Internet of Things applications.



Fig. 5.1 ESP32 CAM

5.2 LDR Module

The LDR sensor module is use to measure light intensity and identify its existence. When there is a light , the module's output is high when there is no light, it is low. Potentiometers can be use to change the signal detecting sensitivity.

"Photo Conductivity" is the basis for how the LDR model operates. It is connected to the pins on the board designated as AO and DO, respectively, for analog and digital output .When light levels reach a certain threshold , the DO port outputs high; when outside ambient light levels above a predetermined threshold , the DO output of module output low

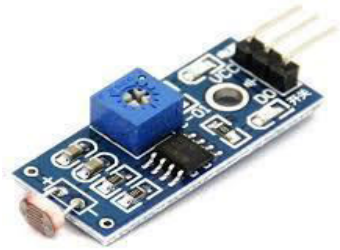


Fig. 5.2 LDR Module

5.3 Laser

The laser is use to generate a focused and narrow beam of light, typically in the visible spectrum, to detect interruption and trigger security events. In laser light security alert system, the laser beam act as the primary detection line.

The module works on the principle of Light Amplification by Stimulated Emission of Radiation. It generates a narrow and coherent light beam that can travel along distances without spreading. Laser light has a wide range of uses in areas like manufacturing (cutting, welding), medicine (surgery, vision correction), communications (fiber optics), data storage (CDs, DVDs), and consumer electronics (barcode scanners, laser pointers). Its ability to be precisely focused and travel long distances makes it valuable for applications from industrial-scale tasks to delicate medical procedures.



5.3 Laser

5.4 ESP32-CAM-MB MODULE

This is a ESP32-CAM-MB MICRO USB Download Module for ESP32 CAM Development Board.

The ESP32-CAM AI-Thinker MB programmer Shield is a shield that you attach to your ESP32-CAM board GPIOs. The programmer comes with the CH340C USB to serial chip. This allows you to program the ESP32-CAM using the USB port on the shield. The shield also comes with a RESET button. This may be useful to easily reset the ESP32-CAM or put it into flashing mode.



5.4 ESP32-CAM-MB MODULE

5.5 BUZZER:

A buzzer or beeper is an audio signalling device, which may be mechanical, electromechanical, and piezoelectric. Typical uses of buzzers and beepers include alarm devices, timers and confirmation of user input such as a mouse click or keystroke. Early devices were based on an electromechanical system identical to an electric bell without the metal gong. Similarly, a relay may be connected to interrupt its own actuating current, causing the contacts to buzz. Often these units were anchored to a wall or ceiling to use it as a sounding board. The word "buzzer" comes from the rasping noise that electromechanical buzzers made. The buzzer consists of an outside case with two pins to attach it to power and ground. When current is applied to the buzzer it causes the ceramic disk to contract or expand. Changing this then causes the surrounding disc to vibrate. That's the sound that you hear. Adjust the potentiometer to increase or decrease the resistance of the potentiometer. If you increase the resistance of the potentiometer then it will decrease the Volume of the buzzer. If you decrease the resistance of the potentiometer then it will increase the Volume of the buzzer.



5.5 BUZZER

5.6 BATTERY:



5.6 Battery

An electric battery is a device consisting of two or more electrochemical cells that convert stored chemical energy into electrical energy. Each cell contains a positive terminal, or cathode, and a negative terminal, or anode. Electrolytes allow ions to move between the electrodes and terminals, which allows current to flow out of the battery to perform work. Primary (single-use or "disposable") batteries are used once and discarded; the electrode materials are irreversibly changed during discharge. Common examples are the alkaline battery used for flashlights and a multitude of portable device. Secondary (rechargeable batteries) can be discharged and recharged multiple times; the original composition of the electrodes can be restored by reverse current. Examples include the lead-acid batteries used in vehicles and lithium ion batteries used for portable electronics. Batteries come in many shapes and sizes, from miniature cells used to power hearing aids and wristwatches to battery banks the size of rooms that provide standby power for telephone exchanges and computer data centres.

VI. CONCLUSION AND FUTURE SCOPE

Conclusion

Laser security system provides us the security against any crime, theft in our day to day life and so people are installing them in order to stay safe, secure and sound. Various electronic security systems can be used at home and other important working places for security and safety purposes. It is a great opportunity and source of saving man power contributing no wastage of electricity. The "Laser Security System" is an important helping system. Using this system robbery, thefts & crime can be avoided to large extend. Avoiding thieves results in the safety of our financial assets and thereby this system provides us protection against all. The Laser & LDR system is highly sensitive with a great range of working. The system senses the light emitted by the Laser falling over the LDR connected with the circuit. Whenever the beam of light is interrupted by any means, it triggers the alarm or siren. This highly reactive approach has low computational requirement, therefore it is well suited to surveillance, industrial application and smart environments.

Future Scope

-AI-Based Intrusion Detection:

Adding machine learning to detect humans, animals, or specific objects in the camera feed to reduce false alerts.

-Cloud Storage Integration:

Uploading captured images/videos to platforms like Google Drive, Firebase, or AWS for long-term storage and evidence collection.

-Night Vision Enhancement:

Using infrared LEDs and low-light optimization to improve performance in complete darkness.

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Electricity Generation from Waste Materials

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ABSTRACT: Electricity generation by burning waste materials, also known as thermal waste-to-energy, is a process that involves converting waste materials into electricity by burning them in a combustion chamber. This process is a sustainable solution for waste management as it reduces the volume of waste sent to landfills while producing renewable energy. The methodology for electricity generation by burning waste materials typically involves waste collection, handling, and preparation, incineration, energy recovery, and ash management. The generated electricity can be used to power local communities or industries or fed back into the national grid. The process of electricity generation by burning waste materials provides a reliable source of electricity while reducing greenhouse gas emissions by avoiding the release of methane gas from landfills.

KEYWORDS - Heating panels, Led Bulbs, zaar box, IN4007, Battery 4.5V, Resistors, and capacitors.

I. INTRODUCTION

Electricity generation from waste material is a rapidly growing field that involves the conversion of various types of waste into usable energy. This process is often referred to as waste-to-energy, and it offers a number of benefits including reducing waste in landfills, reducing greenhouse gas emissions, and providing a source of renewable energy. 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. One of the main advantages of electricity generation by burning waste materials is that it reduces the volume of waste sent to landfills, which in turn reduces the amount of space required for landfill sites. This can help to mitigate the negative impacts of landfill sites on the environment, such as groundwater contamination and greenhouse gas emissions. Another advantage of electricity generation by burning waste materials is that it produces a reliable source of electricity. This is particularly important in areas where there may be limited access to other sources of electricity, such as remote communities or developing countries. The technology used to generate electricity from these waste materials is constantly evolving, and new innovations are being developed to make the process more efficient and cost-effective. Overall, the generation of electricity from waste material represents an exciting opportunity to reduce waste, lower greenhouse gas emissions, and provide a source of renewable energy for communities around the world.

II. LITERATURE REVIEW

The growing global concern over waste management and the need for sustainable energy solutions have spurred the development of technologies that generate electricity from waste materials.
This process, often referred to as Waste-to-Energy (WTE), offers an environmentally friendly alternative to traditional methods of waste disposal and energy production.

This literature review summarizes the main technologies, feedstocks, environmental impacts, and challenges associated with electricity generation from waste. International Journal of Research Publication and Reviews, Vol 5, no 11, pp 7720-7724 November 2024 7721 2.1 Overview of Waste-to-Energy (WTE) Technologies Waste-to-Energy (WTE) refers to the conversion of non-recyclable waste materials into usable energy (such as electricity, heat, or fuel) through various processes.
The primary WTE technologies are:

a.Incineration Incineration involves the combustion of waste materials at high temperatures to produce heat, which is then converted into electricity via steam turbines. This is one of the oldest and most widely used methods for generating electricity from waste. According to Arena (2012), incineration of municipal solid waste (MSW) is an effective way to reduce waste volume by up to 90%, while producing electricity [1].

b) Anaerobic Digestion Anaerobic digestion (AD) is a biological process where microorganisms break down organic matter in the absence of oxygen to produce biogas, which primarily consists of methane. The biogas can then be used to

generate electricity in gas engines or turbines. Al Seadi et al. (2008) emphasize the role of AD in converting organic waste, such as food waste, agricultural residues, and sewage sludge, into renewable energy. AD offers significant advantages in terms of reducing greenhouse gas emissions, especially methane emissions from landfills. [2]

c) Gasification Gasification involves converting organic material into a synthetic gas (syngas) through high-temperature partial oxidation in a low-oxygen environment. The syngas, a mixture of carbon monoxide, hydrogen, and methane, can then be used in internal combustion engines or gas turbines for electricity generation. Zhao et al. (2015) demonstrated that gasification is a promising method for producing energy from a wide variety of feedstocks, including biomass and waste plastics.[3]

2.2 Waste Materials Used in Electricity Generation The efficiency of WTE technologies largely depends on the type of waste material used. Different waste streams are suitable for different technologies, and understanding the material properties is key to optimizing the energy recovery process. Common feedstocks include:

a.Municipal Solid Waste (MSW) MSW consists of a mix of household, industrial, and commercial waste, including paper, plastics, metals, and organic materials. Papageorgiou et al. (2020) emphasize that MSW is the most widely used waste type for WTE systems, particularly for incineration and gasification. The calorific value of MSW varies significantly, which can impact energy recovery. Sorting and preprocessing of waste may be necessary to enhance efficiency[4]

b) Plastics Plastics are increasingly recognized as a valuable waste resource due to their high energy content. Basu (2010) highlights the potential for using waste plastics in pyrolysis and gasification, where plastics can be converted into valuable fuels or syngas. However, the disposal of plastics has environmental implications, particularly regarding plastic waste's persistence in the environment.[5]

c) Food and Agricultural Waste Organic materials like food scraps, crop residues, and animal manure are widely used in anaerobic digestion systems. Sangkham (2017) discusses how these waste materials, rich in biodegradable organic matter, are efficiently converted to biogas, a versatile energy carrier that can be used for electricity[6]

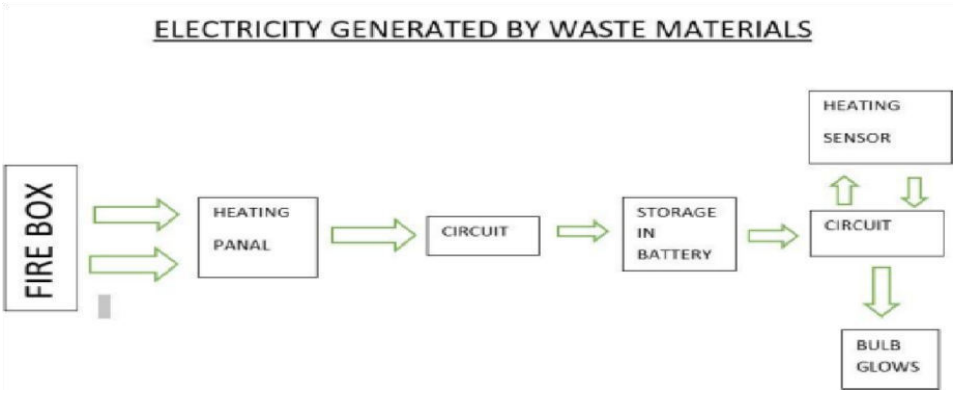


Figure -1 Block Diagram

In this Block Diagram you can see when we burn waste materials and fire box then heat generating and heating panel starts to heat convert electricity and after that that electricity we can see by LED Bulb glowing and that electricity go to circuit and after that in battery and start storing power and when electricity store in battery then heating sensor turn on the output power supply and LED Bulb start glowing and smoke go to water tank and filter system start controlling pollution.

III. METHODOLOGY

Electricity generation by burning waste materials, also known as thermal waste-to-energy, typically involves the following methodology:
Waste collection and transportation: Waste materials are collected from various sources, such as households, businesses, and industries, and transported to a waste-to-energy plant.

Waste handling and preparation: Waste materials are unloaded and handled to remove any non-combustible materials such as metals, stones, and glass. The waste is then shredded to reduce its size and improve its burn ability.

Incineration: The prepared waste is burned in a combustion chamber at high temperatures, typically between 850°C and 1200°C, producing heat and gases.
Energy recovery: The heat generated by the incineration process is used to create steam that drives a turbine, which generates electricity. The exhaust gases produced during the combustion process are treated to reduce harmful pollutants before being released into the atmosphere.

Ash management: The remaining ash produced by the incineration process is collected and transported to a landfill for disposal.

The generated electricity can be used to power local communities, industries or be fed back into the national grid. This method of electricity generation by burning waste materials is a sustainable solution for waste management, reducing the volume of waste sent to landfills, and producing renewable energy. It also help to reduce greenhouse gas emissions by avoiding the landfills

IV. MATERIAL SELECTION

When doing a project, it is important to pay attention to the selection of materials. To prevent waste, the items selection process must be carefully welcomed. A precise selection of items is necessary to ensure that they are long-lasting and safe for usage.

4.1. HEATING PANEL

Heating panels can be used in the process of electricity generation from waste material in several ways, depending on the specific technology used.

For example, in thermal waste-to-energy plants, waste material is burnedin a combustion chamber to produce high-temperature gases. These gases are then used to heat water and produce steam, which drives a turbine to generate electricity. In this process, heating panels may be used to line the combustion chamber, as well as other areas of the plant where heat is generated or transferred. The heating panels can help to maintain the high temperatures required for efficient combustion and steam production, while also protecting the plant's infrastructure from heat damage.

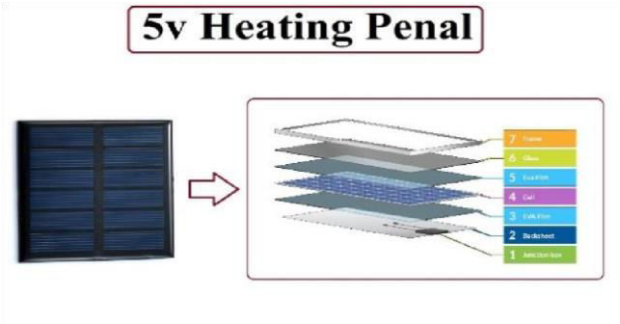


Figure no 2: Heating panal

4.2. HEATING SENSOR

Heating sensors are an important component of many waste-to-energy technologies that involve thermal processes, such as incineration and gasification. These sensors are used to measure temperature in various parts of the process, providing valuable information that can be used to optimize the efficiency of the system and prevent damage.



Figure No. 3: Heating Sensor

4.3. CAPACITOR

Capacitors can be used in various ways in the process of electricity generation from waste material. Capacitors are electrical components that store and release electrical energy, and they are commonly used in electrical systems to provide power factor correction, voltage regulation, and energy storage**.**

In waste-to-energy plants that use thermal processes such as incineration, capacitors may be used in the electrical systems that control the turbines and generators that produce electricity.

4.4. RESISTOR

Resistors can be used in various ways in the process of electricity generation from waste material. Resistors are electrical components that resist the flow of current in a circuit, and they are commonly used in electrical systems to control current, voltage, and power.

In waste-to-energy plants that use thermal processes such as incineration, resistors may be used in the electrical control systems that regulate the temperature and flow of gases in the combustion chamber. These resistors can help to control the flow of current to heating elements or other devices that generate heat, ensuring that the temperature is maintained within the desired range for efficient combustion.

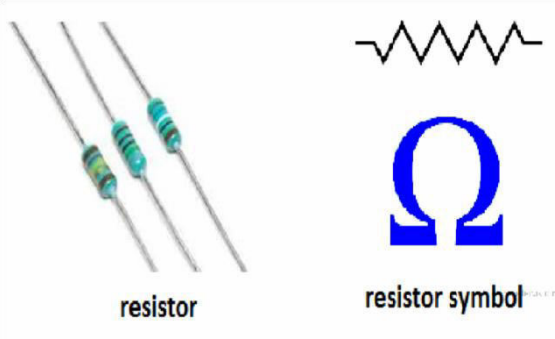


Figure No. 5: - Resistor

4.5. BATTERY

Batteries can be used in various ways in the process of electricity generation from waste material. Batteries are devices that store electrical energy chemically and can release it as needed to power electrical devices.

One common use of batteries in waste-to-energy plants is to store excess energy generated by the plant during periods of low demand or low generation. This excess energy can be stored in batteries and used to supplement the plant's output during periods of high demand or low generation, providing a more stable and reliable source of electricity.



Figure No. 6: - Battery

4.6. LED BULBS

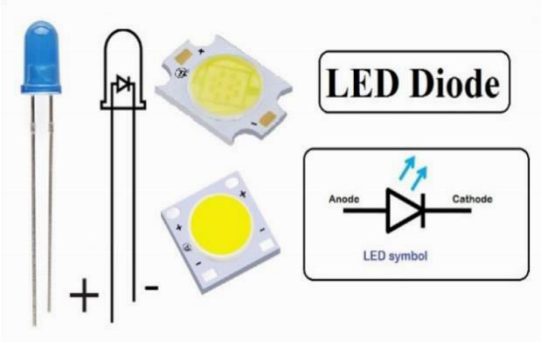


Figure No. 7: - LED Bulbs

WORKING

When we start burning the waste material in the burning box the heating panels will start collecting the generated heat energy by waste material in the burning box.

The heat energy collected by heating panel will be converted into the electrical energy. The generated electrical energy will be seen in circuit box with led glowing.

The generated electrical energy will transfer to the batteries through the power boosters. The batteries will not dissipate the energy back because a diode is connected to it.

The batteries relate to the heat sensor and LED bulbs. Whenever the heat sensor will start conducting the batteries allow energy to flow will start conducting and LED bulbs will glow.

A heating panel works by allowing photons, or particles of light or heat, to knock electrons free from atoms,generating a flow of electricity.

Heating panels actuallycomprises of many smaller units called photovoltaic cells.(Photovoltaic simply means they convert heating or lightinto electricity The p-type, one with less electron, attracts the surpluselectron from the n-type to stabilize itself.

Thus theelectricity is displaced and generates a flow of electrons,otherwise known as electricity. When heat hits thesemiconductor, an electron springs up and is attractedtoward the n-type semiconductor. This causes morenegatives in the n-type semiconductors and more positivesin the p-type, thus generating a higher flow of electricity.This is the photovoltaic effect.

The generated electricity can be used to power local communities, industries or be fed back into the national grid. This method of electricity generation by burning waste materials is a sustainable solution for waste management, reducing the volume of waste sent to landfills, and producing renewable energy. It also helps to reduce greenhouse gas emissions by avoiding the release of methane gas, which is produced when waste decomposes in landfills.

The batteries relate to the heat sensor and LED bulbs. Whenever the heat sensor will start conducting the batteries allow energy to flow will start conducting and LED bulbs will glow.

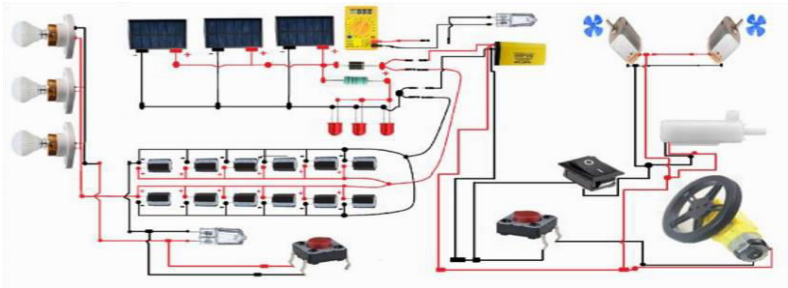


Figure no -8 Working

V. RESULT

In this prototype when we are start heating waste material inside zaar box the heat generated will be collected by heating panels. The heating panels will collect the converted energy (heat energy into the electrical energy) which will be transferred to circuit board. Which is constructed with IN4007

Diode and capacitor connected in series and parallel because in to increase the generated energy and push to store in the battery. Then the heating sensor is will be sensing the heat and connect circuit to output of LED Bulbs and the bulbs will glow until the energy getting stored and until the heating sensor sensing the energy generation. The bulb will glow uninterruptedly while the energy generation and battery storage. This stored energy can be used for anything.

In the present situation waste material at any place, we can see with some procedure collect everything and we can use the prototype to generate the more energy for utilization.

With this we came know that the energy generation by this method is very easy with some precaution. This prototype helps us to know about waste utilization.

With this project we can increase our own energy at industrial purpose and use them for some needs.

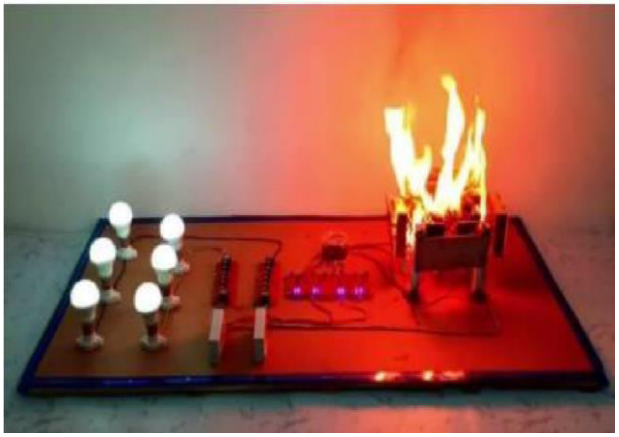


Figure No. 9: - Prototype

VI. CONCLUSION

Incineration technology is complete combustion of waste (Municipal Solid Waste or Refuse derived fuel) with the recovery of heat to produce energy that in turn produces power through heating panels. Now from this we can conclude that electricity plays an important role in our life we are made aware of how the generate electricity waste is done. For technical service provider plant Objectives & Maintenance activities are very important as its service mostly depends on the availability of its equipment. From this we see that how electricity generated successfully. From this we can see how to store the energy in batteries.

SCOPE FOR FUTURE WORK:

1. We can make high quality heating penal for generate high electricity 2. We can make large level burning box with easily heating penal connecting system 3. We can make best storage system by generate electricity by waste materials 4. Reduction of pollution: Recycling helps to reduce energy usage, consumption of virgin raw materials, air and water pollution.

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Solar Powered Wireless Electrical Vehicle Charging System

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ABSTRACT: This research explores the development of a solar-powered wireless charging system for electric vehicles (EVs) as a cleaner and more convenient way to transfer energy. The system collects energy from sunlight, stores it, and then wirelessly sends power to an EV through inductive coupling when the vehicle is placed over the charging area. By combining solar power with wireless charging, the model offers an eco-friendly alternative to traditional plug-in chargers.

A small working prototype was created to demonstrate how future charging roads might function. The solar energy gathered during operation is used to power the wireless transmission unit, allowing the vehicle to receive energy without any direct electrical connection. Tests were performed to evaluate how well the system could charge the vehicle, how effectively power was transferred, and how stable the setup remained under different conditions.

The results show that using renewable energy along with wireless charging can create a self-sustaining and efficient EV charging solution. This prototype suggests possibilities for future applications such as dynamic charging lanes, reduced dependence on the electrical grid, and improved convenience for EV owners, making it a promising approach for upcoming transportation systems.

I. INTRODUCTION

The rapid growth of electric vehicles (EVs) has created a strong need for efficient, safe, and eco-friendly charging methods. Traditional plug-in chargers, although widely used, still come with limitations such as cable wear, risk of electric shock, user inconvenience, and dependency on grid electricity. As the world moves towards sustainable energy solutions, integrating renewable sources with advanced charging technologies has become an important area of research.

Wireless power transfer (WPT) has emerged as a promising technology that allows EVs to charge without any physical connection. By simply parking the vehicle over a charging pad, energy can be transferred using magnetic induction or resonance. This not only makes charging more convenient but also reduces maintenance and improves safety.

At the same time, solar energy has proven to be one of the most reliable and clean renewable energy sources. Using solar panels to generate electricity for EV charging can significantly reduce carbon emissions and lower the load on the power grid. When solar energy is combined with wireless charging, it creates a fully sustainable and user-friendly charging system.
This project focuses on developing a solar-powered wireless EV charging system that uses solar panels for energy generation and inductive coils for wireless power transmission. The goal is to explore how these two technologies can work together to create a practical, efficient, and environmentally responsible solution for future transportation needs.

Integrating solar energy with wireless charging supports the need for smarter and greener transportation systems. It reduces dependence on grid power while offering a cleaner and more flexible charging option. As EV use grows, this combined technology can help build a more sustainable future.

II. LITERATURE REVIEW

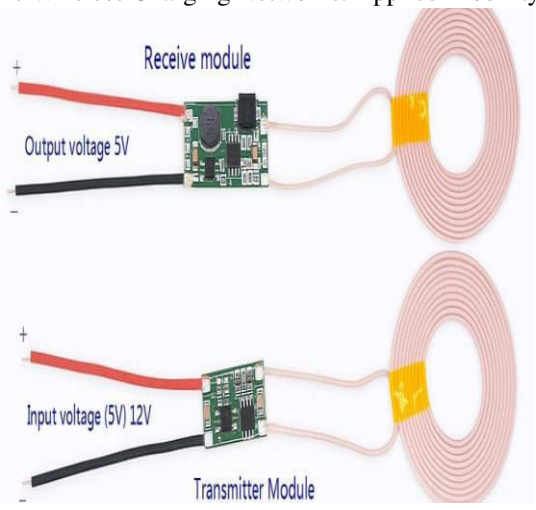
The paper presents the design and detailed performance evaluation of an inductive wireless charging system for electric vehicles (EVs). The authors focus on improving charging efficiency, alignment tolerance, and system safety. The proposed system uses high-frequency resonant inductive coupling, which enables power transfer without physical connectors, reducing wear and improving user convenience. Channi, H. K., Malik, M., Chen, C.-L., Chen, H.-C., Sandhu, R., & Chitkara, C. P. (2025). [1]

Because of this, there has been an increase in the usage of alternative energy sources for providing electricity, such as the solar power produced by solar systems. Utilizing EVs is another action to take to reduce air pollution. However, it needs to be taken into account that they only go a short distance on a single charge. Electric vehicles require charging stations for their batteries, as was previously mentioned. The most common and secure method of charging an electric vehicle is with a wire connected to the grid; however, the focus of this article is on the use of renewable energy sources, such as solar power, as a power generation source for wireless power transfer (WPT) technology. To avoid the drawbacks of using cables for charging, WPT can also be employed. Kashani, S. A., Soleimani, A., Khosravi, A., & Mirsalim, M. (2022). [2]

The paper introduces the concept of a Resonant Beam Charging (RBC) system: a wireless power transfer (WPT) technology that can deliver watt-level power over longer distances for IoT devices. The authors identify a limitation in standard RBC: it is an open-loop architecture, i.e., the transmitter supplies a fixed beam power, without adapting to the battery or device's preferred current/voltage profile. This can cause inefficiencies: battery over-charging (waste, heat, safety risk) or under-charging (longer time, reduced capacity) when the device's optimal charging profile is not matched. Qingqing Zhang, Wen Fang, Mingliang Xiong, Qingwen Liu & Jun Wu — Adaptive Resonant Beam Charging Intelligent Wireless Power Transfer. (ARBC) – arXiv, 2018. [3]

The paper aims to integrate solar energy and wireless power transmission (WPT) for charging the battery of an electric vehicle (EV). The proposed system uses a solar-panel input (they mention a 12 V, 20 W PV panel in their prototype) feeding a high-frequency inverter, and then an inductive (or electromagnetic) coupling system for wireless power transfer (primary coil and secondary coil) to charge the battery of an EV. The authors discuss the need: wired charging uses cables, has power losses (they estimate 25–30 % for cables) and accidents; WPT is presented as "safe, noiseless, pollution-free" alternative. Patil, M. D., Nerlekar, R. V., Patil, A. S., Raut, N. M., & Virbhakt, A. M. (2020). [4]

The paper addresses the challenge of improving the mobility (range, convenience, charging downtime) of electric vehicles (EVs) by using dynamic wireless charging (DWC) systems — namely charging while driving, rather than only when parked. It focuses on wireless power transfer (WPT) via inductive (coil) coupling embedded in roads (or charging lanes) and receiver coils in vehicles. The authors review and analyse several dynamic wireless electric vehicles charging (DWEVC) systems, explore how they might reduce the need for large high-capacity batteries (since continuous charging on the go becomes possible) and thus make EVs lighter, cheaper, more efficient. A. K. Pandey, et al. Enhancing Electric Vehicle Mobility Through Dynamic Wireless Charging Networks. Applied Mobility / Transportation Journal, 2025. [5]



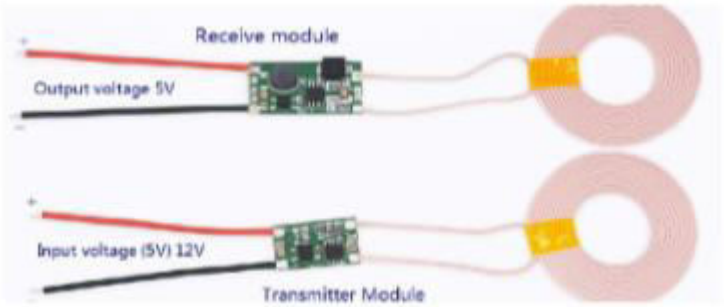
III. METHODOLOGY

This research paper was developed by first recognizing the growing need for a leaner and more convenient way to charge electric vehicles. To build a foundation for the study, existing work on solar power systems and wireless charging technologies was reviewed. Using this background, objectives were set, and a basic system concept was created to demonstrate how solar energy could be collected, stored, and wirelessly transferred to an EV. A small working prototype was then built to bring the concept into practice, and a series of tests were carried out to observe how well the system

charged the vehicle, how efficiently power was transferred, and how stable the setup remained under different conditions. The data gathered from these tests was analyzed to understand the system's overall performance, and the insights gained helped shape the final conclusions and suggestions for future improvements.

IV. MATERIAL SELECTION

When doing a project, it is important to pay attention to the selection of materials. To prevent waste, the items selection process must be carefully welcomed. A precise selection of items is necessary to ensure that they are long-lasting and safe for usage.



Wireless Power Transfer Coil Seth



Charging Module



3800mah rechargeable lithium-ion battery



Solar panels

V. RESULTS AND DISCUSSION

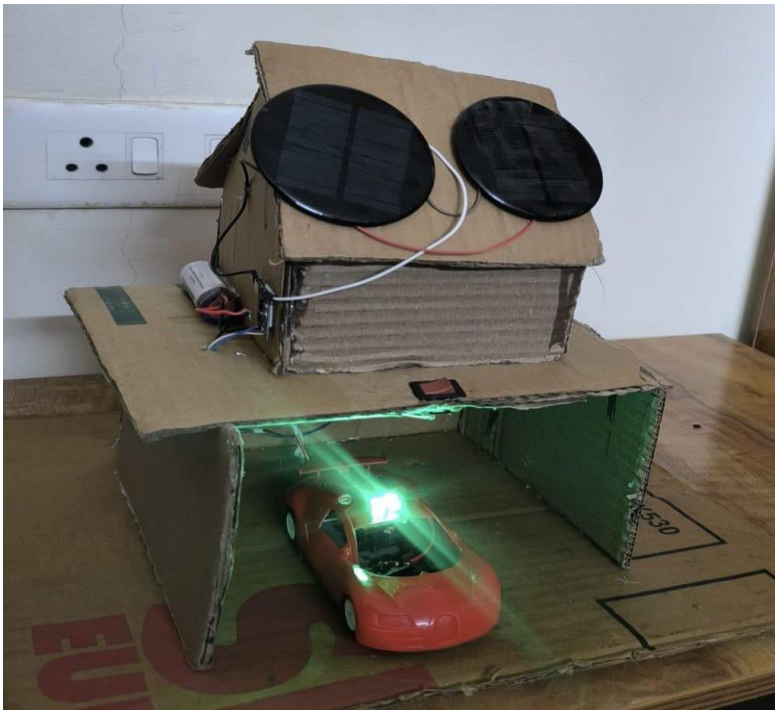


Fig. Model of Solar Powered Wireless EV Charging System

VI. WORKING PRINCIPLE

The proposed system utilizes solar energy as the primary power source for wirelessly charging an electric vehicle (EV) through inductive power transfer (IPT). The methodology is divided into four major stages: energy harvesting, energy storage, wireless power transmission, and onboard power reception.

1. Solar Energy Harvesting

Two small photovoltaic (PV) solar panels are mounted on the charging station structure. These panels convert incident sunlight into DC electrical power. The output voltage from each panel is combined (series/parallel depending on required voltage) to provide a stable input for the charging controller. This harvested energy forms the primary supply for the wireless charging transmitter.

2. Battery Charging and Energy Storage

The output from the solar panels is fed into a TP4056 lithium-ion charging module, which regulates voltage and current to safely charge a 3000 Mah Li-ion battery housed inside the station.
TheTP4056 ensures:
Over-charge and over-discharge protection
Constant-current/constant-voltage (CC/CV) charging Stable energy storage for continuous wireless transmission
The charged battery acts as a buffer, allowing the transmitter coil to operate even under variable sunlight.

3. Wireless Power Transmission (Transmitting Side)

The stored battery energy is supplied to a wireless charging transmitter coil module fixed below the road surface or platform.
The transmitter contains:
1) A high-frequency oscillator
2) A compensation capacitor
3) A copper induction coil
The module converts the DC battery output into a high-frequency AC signal, which generates an alternating magnetic field

around the coil. This field extends a few centimeters above the road surface.

4. Wireless Power Reception (Vehicle Side)
The model EV contains a receiver coil mounted on its underside.
When the vehicle passes over the transmitter coil, the changing magnetic field induces an AC voltage in the receiver coil based on Faraday's law.
The received AC power is:
1. Rectified to DC
2. Used to charge the small on board battery (or directly power LEDs/motor in the prototype)
In this prototype, the receiver module outputs sufficient DC voltage to demonstrate wireless charging, indicating successful IPT coupling.
5. Demonstration of Wireless Charging on Road
As the vehicle moves along the section of road containing the transmitter coil:
Magnetic coupling occurs Energy is wirelessly transferred
The vehicle's LED load/motor activates, showing charging in real time.
This mimics real wireless EV charging stations where vehicles charge while parked or even in motion.

VII. CONCLUSION AND FUTURE SCOPE

The Solar Powered Wireless EV Charging System represents a sustainable and innovative solution to the growing need for clean and efficient electric vehicle charging. By integrating solar photovoltaic technology with wireless power transfer (WPT), the system not only reduces dependency on grid electricity but also minimizes carbon emissions. Wireless charging provides convenience, safety, and reduced mechanical wear compared to conventional plug-in methods. The combination of solar energy and inductive charging makes the system highly beneficial for remote areas, urban infrastructures, and smart mobility environments. Overall, this technology demonstrates strong potential for supporting future green transportation systems while addressing challenges related to fossil fuel dependence and environmental pollution.

In the future, solar-powered wireless EV charging systems can become more common as technology keeps improving. Solar panels will become more efficient, meaning they can produce more electricity even from small areas or low sunlight.

Wireless charging pads may be added to homes, offices, shopping malls, and public parking areas so electric vehicles can charge automatically without using any cables. This will make charging more comfortable and user-friendly for everyone.

Roads may also have wireless charging coils built into them, allowing EVs to charge while driving, which can reduce range anxiety. Smart energy management systems will help store extra solar power and share it with the electricity grid when needed. As battery and wireless charging technology continues to improve, charging will become faster, safer, and Possible over longer distances. Overall, this system has a bright future because it can reduce pollution, lower charging costs, and support clean and sustainable transportation.

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Blackboard Cleaning Robot

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ABSTRACT: With technological advancements, there is a growing need for machines that improve efficiency and reduce human effort. Cleaning classroom blackboards is a time-consuming task that interrupts teaching. This project introduces an automatic blackboard cleaner designed to minimize manual labor and save time. The system incorporates supporting rods, dusters, rollers, a motor, and simple electronics to erase boards effectively and quickly. Operating on a sliding door mechanism, the duster moves uniformly across the board to remove chalk dust. Additionally, the design includes a dust collection feature to maintain cleanliness. This automated device reduces physical strain on teachers and cuts cleaning time to less than half compared to manual methods. By simply activating a switch, the system performs board cleaning autonomously. Overall, the project highlights how mechanical and electronic integration can automate routine classroom tasks, enhancing teaching efficiency and the learning environment.

I. INTRODUCTION

The Automatic Blackboard Cleaning Robot is a modern mechatronics-based system designed to automate the process of erasing blackboards in educational and training environments. In many schools, colleges, and institutions, blackboards remain a primary teaching tool, requiring frequent cleaning during lectures. This repeated manual erasing can be time-consuming, inconvenient, and uncomfortable for teachers, especially during long sessions. The accumulation of chalk dust also poses hygiene concerns and can impact air quality in classrooms.

To address these challenges, the Automatic Blackboard Cleaning Robot offers an efficient and user-friendly solution. The system operates through a motor-driven mechanism that moves across the board, wiping its surface uniformly at the press of a button. By integrating mechanical components, electrical circuits, sensors, and a microcontroller-based control unit, the robot ensures smooth operation, accurate motion, and effective cleaning performance.

This project not only enhances classroom convenience but also demonstrates the practical application of automation, control systems, and mechanical design principles. It serves as an excellent learning platform for engineering students, promoting hands-on experience in system development, sensor integration, and robotics. The Automatic Blackboard Cleaning Robot represents a step toward smarter and more efficient classrooms, reducing manual effort while improving teaching productivity and overall learning environments.

II. LITERATURE REVIEW

Recent work on automated board cleaning has explored diverse electromechanical solutions to reduce manual effort, save time, and limit dust exposure in classrooms. Uma Santhosh et al. (2016) designed an automatic blackboard duster that moves on a track using a chain-drive and motor, activated by a simple switch to erase chalk marks along the full board length [1].

Akhter et al. (2015) developed a microcontroller-based automatic whiteboard cleaner using an Arduino, DC gear motor, rack-and-pinion and sonar sensor, which traverses and reverses across the board and can clear it in about six seconds [2].
Singh et al. (2018) proposed an automated whiteboard duster where the duster is fixed and a polyester film on rollers, driven by a 12 V DC motor, moves past it, reducing user contact with marker dust and the effort needed for frequent cleaning [3]. Avinash Chandra et al. (2017) presented an automatic blackboard eraser in which a mechanically driven duster is interfaced with microcontrollers to cut erasing time and mitigate health hazards from chalk dust [3].

Manyar Imrankha Ajimkha et al. (2018) introduced a “smart duster” that employs a rope-and-pulley mechanism with limit switches and electronic control to automatically wipe long blackboards or whiteboards, improving teacher comfort and reducing dust inhalation [4].

Poornachandra et al. (2018) proposed an automated board duster using a compact high-rpm motor to rotate a duster plate and a transparent dust-collection container, all managed by a PIC microcontroller and PLC to overcome the bulk and wear issues of belt–pulley systems [5].

Saraswat and Tyagi (2017) designed a sliding-door–type automatic blackboard cleaner, where a sliding wipe mechanism, controlled via assembly-language programs through a parallel port, erases the board and collects dust in one stroke with minimal user effort. Together, these studies demonstrate that track-and-chain drives, rack-and-pinion systems, rotating films, rope-pulley arrangements, compact motorized plates and sliding frames, when integrated with microcontrollers or PLCs, provide effective, low-cost alternatives to manual erasing for modern teaching environments [6].

III. METHODOLOGY

The development of the blackboard cleaning robot followed a structured engineering methodology that combined system analysis, design, implementation, and evaluation. At the outset, the functional requirements were defined, focusing on autonomous horizontal and vertical movement, uniform cleaning coverage, and safe operation near board boundaries. Based on these requirements, both mechanical and electronic architectures were designed. The mechanical structure was modeled to support smooth linear motion across the board using a dual-motor or rail-based mechanism, while a microfiber wiper or sponge was mounted on the frame to ensure consistent surface contact. On the electronic side, components such as a microcontroller (Arduino/ESP32), motor driver, DC or servo motors, and limit or IR sensors were selected to achieve precise motion control and boundary detection. The control circuit was then developed by integrating the microcontroller with actuators and sensors, enabling automated navigation along predefined paths. Embedded software was programmed to perform sequential operations including horizontal sweeping, vertical repositioning, and return-to-home actions, with algorithms implemented to maintain constant speed, detect board edges, and ensure uniform cleaning. After assembly, the system underwent iterative testing to evaluate motion stability, cleaning efficiency, and sensor accuracy. Calibration was performed by adjusting motor speed, wiper pressure, and movement parameters, and the finalized prototype was tested on various board conditions to validate performance and reliability. This structured approach ensured that the robot met its intended goals of reducing manual effort, improving classroom hygiene, and enhancing teaching efficiency.

IV. MATERIAL SELECTION

When doing a project, it is important to pay attention to the selection of materials. To prevent waste, the items selection process must be carefully welcomed. A precise selection of items is necessary to ensure that they are long-lasting and safe for usage.

4. 1 Blackboard



Fig 4.1 Blackboard without proper cleaning has become white

A blackboard or chalkboard is a reusable writing surface used with chalk sticks made from calcium sulphate or calcium carbonate. Early blackboards were made from smooth sheets of black or dark grey slate, while many modern boards are simply wooden or metal panels painted with matte black or dark green paint that is easier on the eyes

4.2 Duster



Fig 4.2 Duster

Duster Sponge and cloth will be used for now as a duster material. Later we will be adopting the best material which can clean the board even better.

4.3 Motor



Fig 4.3 Motor

In this project, the two brushes are rotated or moved by DC motors. It is powered by 12 volts and runs at 40 rpm.

4.4 Charger



Fig 4.4 Charger

The primary energy source for the "Fan Blade Cleaner" is Charger with a 12 volt capacity.

4.5 Driver module: l293d

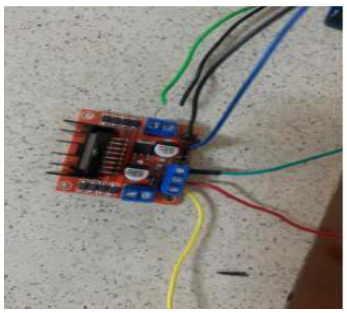


Fig 4.5 Driver module

Motor driver is used along with Arduino to power the motor with 12V DC supply.

4.6 Microcontroller: ARDUINO

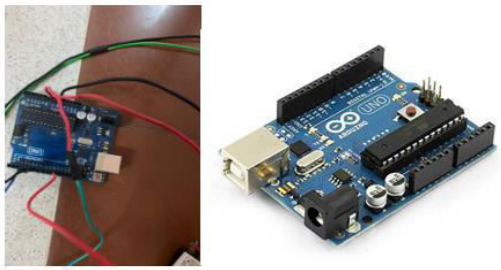


Fig 4.6 ARDUINO

Arduino is a microcontroller; it's used here to control the motor to change direction upon getting inputs from limit switch.

4.7 Limit switch



Fig 4.7 Limit switch

Limit switch allows Arduino to know that motor assembly has reached the end of the board thereby giving a signal to Arduino to spin the motor in opposite direction, hence saving the whole assembly from any damage.

4.8 Rods: 10 mm diameter rods – 3 no.

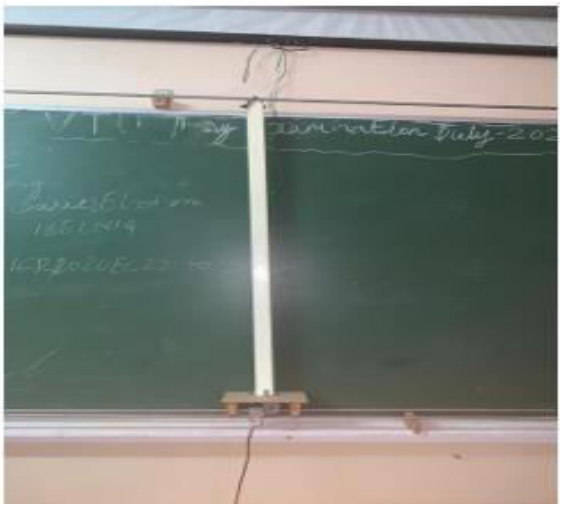


Fig 4.8 Rods

Rods are placed on top and bottom of the blackboard. It provides smooth motion for the motor assembly across the board. There are 2 rods on the bottom rail and 1 on the top of the board.

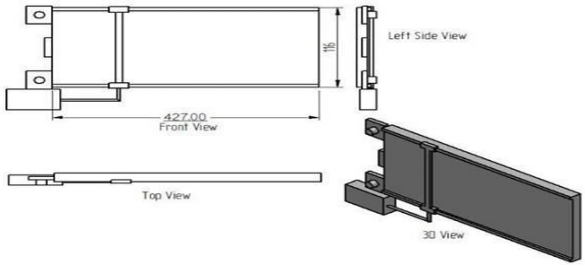


Fig4.9: Proposed 3D view of the design

V. RESULTS AND DISCUSSION

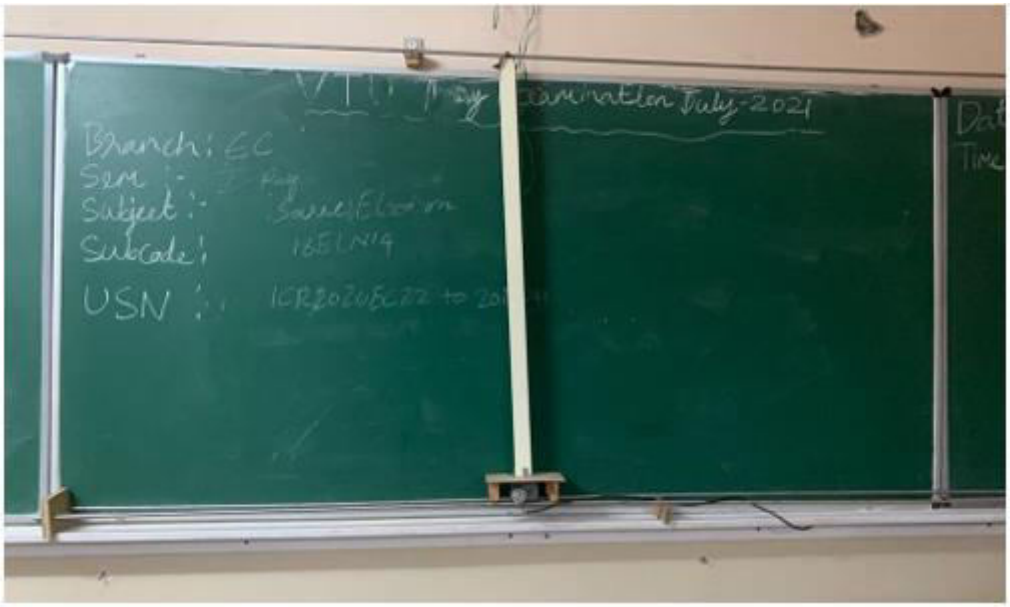


Fig.5: Completed blackboard cleaning robot

5.1 Working principle

When the system is powered on, the controller initializes the motors, limit switches, and any sensors, and then remains in an idle state waiting for a "clean board" command from a push button or switch. On receiving this command, the controller energizes the main drive motor, which moves a carriage carrying the duster along a track or chain guide mounted parallel to the blackboard surface.

The duster is pressed lightly against the board so that, as the carriage travels from one end to the other, the chalk writing is wiped off in a single or multiple passes, depending on the programmed routine.

Limit switches or position sensors at the ends of the board detect when the carriage reaches the boundary; the controller then either reverses the motor direction for another pass or stops the motion once the required cleaning is completed. After the final pass, the controller drives the carriage back to its home or parking position and de-energizes the motors, leaving the system ready for the next cleaning command with the board completely erased.

VI. CONCLUSION AND FUTURE SCOPE

Conclusion:

Board cleaning robot is a breakthrough in classroom-based teaching where students interact with teachers using a blackboard, this project will change the experience of students in the classroom and help them concentrate more in studying rather than waiting for the teacher to clean the board. Some of the major takeaways from this project are:

- Board cleaning robot will revolutionize the existing duster.
- This project will enhance the classroom experience of students.
- Both students and teachers will benefit from this project.

Future Scope:

- Implement in large scale.
- Bring it to the market.
- Add more features.
- Make the cleaning process efficient & less time consuming

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Speed & Direction Control of DC Motor using Android smartphone Application

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ABSTRACT: This paper presents a method for controlling the speed and direction of a DC motor using an Android smartphone application. The system utilizes Bluetooth communication to interface the smartphone with a microcontroller, which processes commands and adjusts motor operation accordingly. The implementation enhances user convenience by enabling remote control of motor parameters. The design involves an H-bridge driver circuit for direction control and pulse width modulation (PWM) for speed regulation. Experimental results demonstrate efficient motor control with minimal latency. This approach finds applications in robotics, automation, and remote-controlled devices. The use of a smartphone interface eliminates the need for traditional control panels. This study highlights benefits in cost, accessibility, and simplicity. Future enhancements include adding feedback for closed-loop control and Internet of Things (IoT)

I. INTRODUCTION

The speed and direction control of DC motors using an Android smartphone application has become a significant area of research and practical implementation in modern automation systems. Traditionally, DC motor control involved manual methods or wired controllers, which were often cumbersome and limited in flexibility. With the proliferation of smartphones and wireless communication technologies like Bluetooth, it is now possible to interact with motors more conveniently and remotely. The Android smartphone acts as a user-friendly interface allowing users to set the desired speed and rotation direction of the motor through an application. The commands from the app are transmitted via Bluetooth to a microcontroller, typically an Arduino or similar device, which then drives a motor driver circuit such as the L293D H-bridge IC. This driver controls the motor's rotational direction, while speed is managed using pulse width modulation (PWM) signals generated by the microcontroller. This wireless control setup not only improves operational efficiency but also enhances safety by allowing remote operation. The system can be integrated into various applications like robotics, conveyor belts, and vehicle controls. Moreover, feedback from sensors can be added for precise closed-loop control. The Android app can be customized with simple graphical controls, making it accessible even to non-experts. Such developments underscore the merging of embedded systems with mobile technology to create versatile and scalable control solutions. This approach reduces hardware complexity, lowers cost, and introduces new possibilities for automation and IoT integration, which are vital for smart devices and industry 4.0 advancements.

II. LITERATURE REVIEW

Controlling the speed and direction of DC motors is essential in modern automation, robotics, and household applications. Traditional control methods require wired connections or manual switches, which limit flexibility and usability. With the rapid growth of wireless communication and smartphone technology, Android-based motor control systems have become more popular. This review discusses the development, challenges, and advancements in smartphone-controlled DC motor systems.

DC motors are widely used because they are simple, cost-effective, and easy to control. Studies by Kumar et al. (2018) and Rahman et al. (2020) explain how improvements in microcontrollers and motor driver circuits have made DC motors more efficient and reliable. The introduction of driver modules such as L293D and L298N has enabled precise speed and direction control, making them suitable for Bluetooth-based and IoT-based applications.

Wireless control plays a key role in modern automation. Research by Patel et al. (2019) highlights how Bluetooth communication provides a stable and low-power method for controlling DC motors using mobile applications. Android smartphones, due to their open-source nature, allow developers to design customized apps for sending control signals. According to Singh and Verma (2021), Android-Bluetooth systems are becoming popular in home automation and robotics because they are easy to use and cost-effective.

Speed control techniques are important for achieving desired motor performance. Studies by Chatterjee et al. (2017) and Amin et al. (2021) describe how Pulse Width Modulation (PWM) is commonly used to regulate motor speed.

PWM provides smooth and energy-efficient control, making it suitable for smartphone-controlled systems. Research also shows that combining PWM with microcontrollers like Arduino or PIC enhances accuracy and improves the user experience.

Ensuring safe operation of DC motor control systems is necessary to prevent overheating, short circuits, and system failure. Kumar and Das (2019) examined features such as overload protection, reverse voltage protection, and emergency stop functions in motor control circuits. Their findings show that integrating safety features into smartphone-controlled systems improves durability and reliability. Studies by Ali et al. (2022) further discuss how Bluetooth-based control systems behave under different operating conditions.

Applications in different fields: Android-controlled DC motors are used widely in robotics, smart home devices, industrial automation, and remote-controlled vehicles. Case studies by Sharma et al. (2018) and Joseph et al. (2021) demonstrate how smartphone-based motor control can reduce maintenance costs and increase efficiency in small-scale industrial systems. Recent work by Lee et al. (2022) explores how wireless motor control is used in automated guided vehicles (AGVs), robotic arms, and smart appliances, showing the growing importance of Android-based motor control technologies.

Android-controlled DC motor systems continue to expand across many industries, including automation, robotics, home control systems, and educational projects. Research by Singh et al. (2019) and Patel et al. (2021) highlights the effectiveness of smartphone-based control in providing a simple, flexible, and user-friendly interface for operating motors in both industrial and domestic environments
Recent advancements in mobile application development have greatly improved the functionality of smartphone-based control systems. Researchers such as Mehta et al. (2020) and George et al. (2022) have shown that Android applications created with platforms like MIT App Inventor and Android Studio offer user-friendly interfaces for sending commands to microcontrollers. These studies highlight that customizing buttons, sliders, and voice commands within the app makes motor control more intuitive and accessible for users, even with minimal technical background.

In addition, studies have focused on improving the communication stability between smartphones and motor control units. Work by Reddy and Khan (2019) examined how different Bluetooth modules, such as HC-05 and HC-06, influence the range, response time, and reliability of wireless motor control. Their findings indicate that using proper pairing protocols and signal filtering techniques reduces interference and strengthens the connection. This ensures smooth and uninterrupted control of motor speed and direction, even in environments with electromagnetic noise.

Another important area of research is the integration of DC motor control with Internet of Things (IoT) technology. According to Nawaz et al. (2021) and Prasad et al. (2022), wireless control is evolving from simple Bluetooth-based systems to more advanced Wi-Fi and cloud-connected systems. These IoT-enabled frameworks allow users to control motors from longer distances, monitor performance in real time, and automate tasks using smart sensors. Such developments show a clear trend toward smarter, more connected, and more efficient motor control systems for future application

III. METHODOLOGY

1. System Design
    - Android smartphone application development
    - Bluetooth module (HC-05) interfacing
    - Microcontroller (Arduino UNO) programming
    - H-bridge driver circuit (L293D) connection to the DC motor
2. Data Flow
    - User inputs speed & direction on app
    - Bluetooth transmits data to microcontroller
    - Microcontroller interprets commands
    - PWM signal generated for speed control
    - H-bridge switches direction of motor rotation
    - Motor responds accordingly
3. Testing & Validation
    - Functionality with varying speeds and directions
    - Real-time response assessment
    - Reliability of wireless communication

IV. MATERIAL SELECTION

When doing a project, it is important to pay attention to the selection of materials. To prevent waste, the items selection process must be carefully welcomed. A precise selection of items is necessary to ensure that they are long-lasting and safe for usage.

4.1 PIC Microcontrolar



Fig 4.1 Roller cat

Tish acts as the main controlling divice of the entire system. It processes the commands received from Bluetooth module ans executes the appropriate actions to control the motor. The program running on it is written in embedded 'C' language.

4.2 7805 Voltage regulator



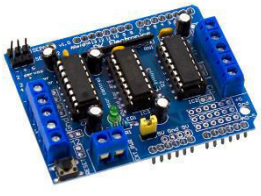
In This project, takes an unregulated DC input (typicaly 7-35v) and outputsa stable, regulated 5v DC. It achieves this by using internal 5v reference and an error amplifier that adjusts an internal transistor to maintain the constant 5v output, compensating for input voltage fluctuations or lad changes[1,2,3,4]

4.3 HC-05 Bluetooth module Arduino



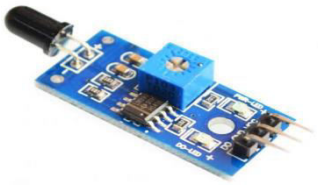
In this project, the HC -05 receives commands from the Android app and transmits them to PIC microcontroller, which then controls the DC motor.

4.4 L293d motor driver



In this project, the L293D motor driver acts as an H-bridge, allowing a microcontrollerto control the direction and speed of DC motors it contains two H-bridges, meaing it can control two DC motor independently

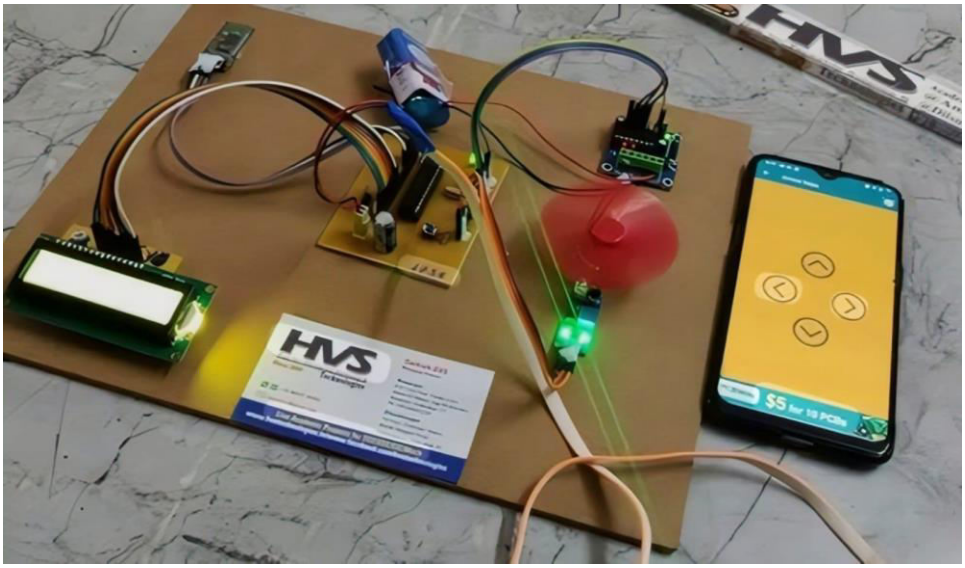
4.5 IR sensor



4.5 Working model

An IR sensor module works by emitting infrared light from an IR LED and detecting the reflected light with a photodiode or phototransistor. When an object comes near, the emitted IR light reflects back to the sensor, causing a change in the receiver's signal. This change is converted into an electrical output that indicates the presence or distance of the object. This sensor is commonly used for object detection and proximity sensing.

V. RESULTS AND DISCUSSION



5.1 Working principle

The proposed system uses an Android application as a user interface to control the speed and direction of a DC motor wirelessly via Bluetooth. The app allows the user to select desired motor speed and direction on graphical controls such as sliders and buttons. When the command is issued, the Bluetooth module transmits corresponding data packets to the microcontroller. The microcontroller decodes these packets and adjusts the output signals to the motor driver circuit. The motor driver, typically an H-bridge like the L293D, uses these signals to reverse or forward the motor's rotational direction. Speed control is achieved by generating PWM signals, where duty cycle variations regulate the average voltage delivered to the motor, thus controlling its speed. This setup ensures smooth and precise motor operations, enabling remote, real-time adjustments. The system's simplicity facilitates easy integration into various applications, reducing dependency on traditional wired controls.

VI. CONCLUSION AND FUTURE SCOPE

This research successfully demonstrates a Bluetooth-based system for controlling the speed and direction of a DC motor using an Android smartphone. Integrating smartphone technology with embedded systems offers a user-friendly platform for remote motor control. The implementation uses widely available components such as Arduino, HC-05 Bluetooth module, and H-bridge drivers, making the system accessible and cost-efficient. Experimentation shows responsive control and stable motor operation under different speed and directional commands. The approach eliminates the need for physical control panels and introduces flexibility in automation domains. Future work could

include closed-loop feedback using sensors to improve precision and reliability. Incorporating Wi-Fi or IoT platforms can expand remote accessibility over the internet, useful for smart home or industrial automation networks. Enhancing app features for multi-motor control and voice commands can also increase usability. Overall, this project paves the way for integrating mobile devices with embedded motor control systems, contributing to advances in remote and intelligent automation

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Hyperlocal Noise Detector

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ABSTRACT: Noise pollution has become a major environmental issue, especially in urban and semi-urban areas. Continuous exposure to high noise levels can cause stress, hearing loss, and reduced productivity. This project aims to design and implement a Hyperlocal Noise Monitoring System that measures noise levels in real time at a specific location and alerts users when the sound exceeds a defined threshold. The system uses an ESP32 microcontroller with a sound sensor to collect local noise data, display the reading on an OLED screen, and upload it to an online platform (ThingSpeak) for visualization. When noise levels cross the safe limit, the device triggers an LED and buzzer alert. The project demonstrates how small, low-cost sensors can be used to monitor and control noise pollution at a community level.

I. INTRODUCTION

Noise pollution is a problem that affects millions of people worldwide. Different studies have shown that it is currently one of the greatest environmental threats to people's health, leading to increased risk of cardiovascular disorders, hypertension, sleep disturbance, stress, etc., and it is negatively influencing productivity and social behavior .Noise pollution refers to unwanted or harmful sound that disrupts normal activities such as communication, sleep, and concentration. In cities, common noise sources include traffic, industrial activity, and public gatherings. While government agencies monitor noise at a few central points, they often miss small local hotspots.

A hyperlocal monitoring system can bridge this gap by collecting fine-grained data from multiple points, such as near schools, hospitals, or residential areas.To address this gap, the concept of a Hyperlocal noise detector has emerged as a promising solution. A hyperlocal noise detector combines low-cost acoustic sensors, microcontroller-based processing, and networked data communication to monitor sound levels within very small geographic areas. Unlike conventional approaches, this system offers fine-grained spatial resolution, continuous data collection, and real-time reporting, enabling precise mapping of noise hotspots. The integration of advanced filtering algorithms and machine-learning techniques further enhances the system's ability to differentiate between noise sources and reduce measurement errors. This project develops one such low-cost, portable prototype using IoT (Internet of Things) principles.

Recent developments in Internet of Things (IoT) technologies have made it feasible to deploy dense networks of such detectors, providing scalable and affordable noise monitoring infrastructures. These systems support smart-city initiatives, empower communities with localized environmental information, and assist policymakers in designing effective noisecontrol strategies. This research focuses on the design, implementation, and performance evaluation of a hyperlocal noise detection system, highlighting its potential to transform urban noise management and promote healthier living environments.

II. LITERATURE REVIEW

1. Bello et al.(2019) developed one of the most advanced large-scale urban noise monitoring systems integrating low-cost sensors, machine-learning–based sound classification, and citizen reporting tools. The study demonstrated high classification accuracy for diverse urban sound sources such as traffic, construction, and human activity. The sensors were designed to operate autonomously and transmit data to cloud servers for detailed analytics. However, the system required a robust supporting infrastructure, frequent sensor calibration, and higher computational resources for real-time analysis. These requirements increase deployment costs and complexity, making the system less suitable for small-scale, fixedlocation hyperlocal applications where simplicity and affordability are essential.

2.Picaut et al.(2020) - This review evaluated a wide range of low-cost acoustic sensors and highlighted their growing relevance in urban noise monitoring. The authors noted that, when combined with proper calibration techniques, inexpensive microphones can produce results comparable to professional-grade sound meters. The study emphasized the importance of sensor shielding, environmental compensation algorithms, and standardized calibration procedures. However, limitations such as susceptibility to temperature changes, humidity effects, electronic noise, and long-term sensor drift reduce reliability in long-duration outdoor deployments. These challenges are particularly critical in hyperlocal monitoring, where accuracy at very small spatial scales is required.

3.Yin et al.(2020) introduced a mobile sensing technique using smartphones and portable devices to generate fine-grained noise maps in dynamic urban environments. The system leveraged GPS tracking and machine-learning models to correlate noise patterns with spatial movement. This approach offered excellent spatial coverage, rapid data collection, and the ability to capture temporal variations across different city zones. However, mobile noise mapping lacks continuous monitoring capability, as data collection depends on the movement patterns of participants. This leads to inconsistent temporal resolution and potential data gaps, making the technique unsuitable for hyperlocal studies where constant noise-level tracking at a fixed location is required.

4.Saldana-Barrios et al.(2023)-The study presented an IoT-integrated noise monitoring prototype using low-cost microcontrollers, real-time cloud analytics, and wireless data transmission. The system demonstrated efficient data acquisition, remote monitoring, and scalability for urban noise assessment. Its modular design allowed integration with additional environmental sensors such as temperature and humidity sensors. However, the dependence on stable internet connectivity limited its applicability in bandwidth-constrained or highly dense environments. Furthermore, the study highlighted issues such as latency in data transmission, cloud dependency for long-term storage, and susceptibility to network outages, which can affect continuous hyperlocal monitoring.

5.KY-037 Classroom study (2023) -This research focused on evaluating the KY-037 sound sensor in classroom environments to monitor noise generated by students and activities. The sensor successfully detected relative changes in loudness and provided valuable insights for classroom management. It proved beneficial due to its affordability and compatibility with microcontrollers such as Arduino and ESP32. However, the KY-037 suffers from high sensitivity variability between units and limited linearity in its output, making it unreliable for precise decibel-level measurement. Additionally, its performance is influenced by physical orientation, background interference, and lack of built-in calibration options. These shortcomings restrict its effectiveness for accurate hyperlocal noise quantification without additional signal conditioning or calibration circuits.

III. METHODOLOGY

1. Start
This is the beginning of the project or research work. The goal and purpose of the project are decided here.

2. Literature Review
In this step, you gather information related to your topic by:
- ❖ Reading research papers
- ❖ Studying books and articles
- ❖ Checking existing projects or products ✧ Understanding current technologies

Purpose:
- ❖ To avoid what already has been done
- ❖ To avoid repeating existing work
- ❖ To get new ideas and improve existing solution

3. Identifying Problems
Here you clearly define the main issue you want to solve.
You answer questions like:
- ❖ What is the problem?
- ❖ Who faces it?
- ❖ Why does it need a solution?

4. Finding Multiple Solutions
Brainstorm different ways to solve the problem:
- ❖ Different sensors
- ❖ Different methods
- ❖ Different technologies

You compare each possible solution based on:
- ❖ Cost
- ❖ Efficiency
- ❖ Feasibility
- ❖ Safety
- ❖ Ease of implementation Then select the best option.

5. New Design

- After choosing the best solution, you:
- Create a design or prototype plan
- Prepare circuit diagrams / mechanical drawings
- Select components
- Decide software and hardware requirements

This step turns ideas into a workable design.

6. Assembly

You build the actual prototype/model based on your design.
Examples:

- Connecting sensors and modules ✧ Writing the program
- Fabricating mechanical structure
- Integration of all parts

7. Testing

You check whether the prototype works as expected.
Testing includes:

- Functionality test
- Performance test
- Safety test
- Reliability test

8. Modification (If needed)

If testing shows problems or failure:

- Identify the issue
- Make improvements
- Change components or design ✧ Rewrite code

Then repeat: Assembly → Testing → Modification until the design works correctly.

9. Report

After achieving successful results, you document:

- Objectives
- Methodology
- Design details
- Components used
- Results and graphs ✧ Conclusion

This report becomes proof of your work.

10.Presentatio

You resent our:

- ✧ Project
- ✧Working model
- ✧ Findings Results

to teachers, evaluators, or an audience.

11. End

The project is completed after documentation and presentation.

IV. MATERIAL SELECTION

When doing a project, it is important to pay attention to the selection of materials. To prevent waste, the items selection process must be carefully welcomed. A precise selection of items is necessary to ensure that they are long-lasting and safe for usage.

- **Raspberry Pi Pico**: A microcontroller board, similar to Arduino but more powerful and cheaper.



Fig. 1 Raspberry pi pico

- **Analog Sound Sensor (MAX4466 / KY-037):** A small module containing a microphone + amplifier (and in some cases threshold comparator) that gives an analog or digital signal when sound is detected. To detect ambient sound/noise.

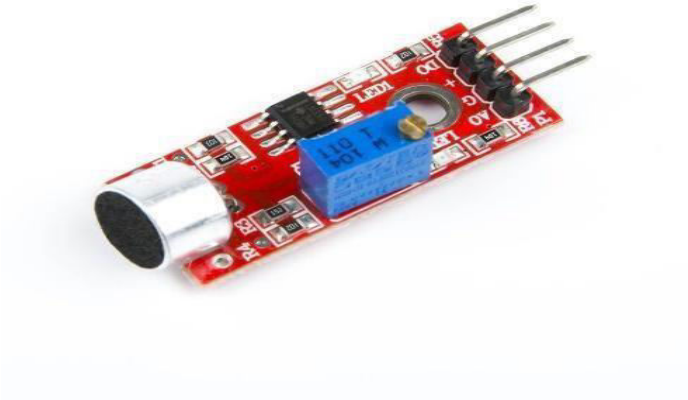


Fig. 2 Analog Sound Sensor

- **OLED Display (0.96," I2C):** It offers a 128×64-pixel resolution on a tiny 0.96″ screen — good for small displays, sensors, IoT dashboards, wearable-style output.

Operates at 3.3 V or 5 V and is compatible with microcontrollers like ESP32 (which uses 3.3V logic) — ideal. Very low profile and low power, as OLEDs do not need a back-light like LCDs, giving high contrast. It shows current reading.



Fig. 3 OLED Display

V. RESULTS AND DISCUSSION

5.1 Working principle

The analog sound sensor converts air vibrations into corresponding voltage signals using its built-in microphone and amplification circuitry. These analog signals are then sampled . To derive a meaningful measurement, the ESP32 processes these readings by calculating an approximate RMS (Root Mean Square) value, which is commonly used to estimate sound intensity. This computed noise value is continuously updated and displayed on the OLED screen in real time, providing an immediate visual representation of the surrounding acoustic environment.

When the measured noise level exceeds a predefined threshold—for example, an estimated equivalent of 85 dB—the system triggers a visual and auditory alert by activating an LED and buzzer. This feature enables quick identification of excessive noise events. In addition to local alerts, the ESP32 uploads the processed noise data to the ThingSpeak cloud platform using its built-in Wi-Fi module. ThingSpeak stores and displays the incoming data on live graphs, allowing users to observe fluctuations, identify peak noise periods, and analyze long-term trends through time-series visualizations.

Furthermore, the cloud integration supports remote monitoring, enabling users to access noise information from any location. Historical datasets can be exported for deeper analysis or used to generate noise heatmaps for specific rooms or zones. This creates a “hyperlocal” understanding of sound patterns, where fine-grained acoustic variations can be tracked over short distances and time intervals. Such functionality is valuable for environments like classrooms, offices, libraries, or residential areas, where detecting localized noise disturbances helps in planning mitigation strategies and improving overall sound quality.

5.2 Software Implementation

An algorithm that samples sensor data over 100ms, computes RMS and compares to to threshold is used.

The code:

```
from machine import Pin, ADC, I2C import time from ssd1306 import SSD1306_I2C
# ----------- PINS -----------
MIC_PIN = 26   # A0 -> GP26
SDA_PIN = 4
SCL_PIN = 5
# ----------- SETUP ----------
mic = ADC(Pin(MIC_PIN))
# OLED setup i2c = I2C(0, scl=Pin(SCL_PIN), sda=Pin(SDA_PIN)) oled = SSD1306_I2C(128, 64, i2c)
# ---------- SENSITIVITY ---------#
Change this to adjust sensitivity from code
THRESHOLD = 3000   # LOWER = more sensitive
def display(text1, text2=""):
    oled.fill(0)
    oled.text(text1,      0,
    10)    oled.text(text2,
    0, 30) oled.show()
display("Sound Sensor", "Adjusting...")
# ---------- MAIN LOOP ---------while True: value = mic.read_u16()    # Get loudness value (0 - 65535)
    # Show current value on OLED display("Value: " +
    str(value), "TH: " + str(THRESHOLD))
    #    Test    if    above
    threshold  if  value  >
    THRESHOLD:
        display("GETTING   NOISY!!!",   "Value:   "   +   str(value))
        time.sleep(2)            # pause to see the message
    time.sleep(0.5)
```

VI. ADVANTAGES

- Provide high spatial accuracy, allowing precise identification of noise sources in small areas.
- Support IOT integration, making them compatible with smart city infrastructure.
- Improve public awareness by sharing real-time noise data with communities.
- Can generate noise maps for better policy-making and regulation.
- Support remote monitoring, allowing authorities to observe conditions without being physically present.
- Help in early detection of noise pollution, enabling timely corrective actions.

VIII. LIMITATIONS AND FUTURE WORK

- Battery-powered version with solar charging: This would enable long-term outdoor deployment without dependence on wired power.
- Mobile app integration:A dedicated app could provide notifications, heatmaps, historical data insights, and personalized noise-exposure summaries.
- AI-powered noise prediction models: Predictive algorithms could forecast when noise levels are likely to rise based on historical patterns.

VIII. CONCLUSION AND FUTURE SCOPE

The development of a hyperlocal noise detector presents a significant advancement in modern environmental monitoring systems. This research demonstrates that low-cost acoustic sensors, when integrated with microcontroller-based processing and IoT communication, can effectively capture and analyze noise levels with high spatial precision. The proposed system successfully overcomes the limitations of traditional noise monitoring methods by providing real-time, fine-grained data that reflects true on-ground variations within small urban and residential zones.

The results confirm that hyperlocal noise detection enables accurate mapping of noise hotspots, supports early identification of abnormal sound events, and offers actionable insights for urban planners, policymakers, and community stakeholders. By combining digital signal processing techniques with cloud-based analytics, the system provides a scalable and reliable solution for continuous environmental monitoring. Overall, this research highlights the potential of hyperlocal noise detection technology to contribute significantly to smartcity development, improved noise management strategies, and healthier living environments. Future enhancements may include advanced machine-learning-based sound classification, larger sensor networks, and the integration of predictive analytics to further elevate the system's accuracy and impact. This project demonstrates that affordable electronics and IoT can be effectively used to create a Hyperlocal Noise Pollution Monitoring System. The prototype provides real-time feedback on environmental noise and encourages awareness at the community level. With further improvements, such systems could form a low-cost sensor network for cities, helping authorities manage and control noise pollution more efficiently.

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Air Purifier using Liquid Tree

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ABSTRACT: Indoor air quality (IAQ) has become a critical factor affecting human health, workplace efficiency, and overall indoor comfort. Modern buildings, especially those with limited natural ventilation, tend to trap carbon dioxide (CO_2) released from human respiration and daily activities. When CO_2 levels rise above recommended limits, individuals may experience headaches, fatigue, dizziness, reduced concentration, and noticeable drops in cognitive performance. Despite the widespread use of air-conditioning systems, most traditional AC units are designed only for cooling and circulation; they do not actively monitor, detect, or reduce CO_2 concentration. This technological gap highlights the need for an integrated, intelligent, and sustainable air purification approach.

This project addresses the problem by combining electronic sensing with a biological purification method. The main objective is to integrate a CO_2 sensor with a microalgae-based purification chamber inside an air-conditioning system to enable real-time monitoring and natural CO_2 reduction. The proposed model uses an MQ-135 CO_2 sensor connected to an Arduino microcontroller to measure indoor CO_2 levels continuously. When the sensor detects that CO_2 concentration has crossed a predefined threshold, the system automatically activates an air pump and directs indoor air through a transparent microalgae chamber. Microalgae, through the natural process of photosynthesis, absorb CO_2 and release oxygen, effectively transforming polluted air into fresher, more oxygen-rich air. The purified air is then recirculated back into the room, creating a closed-loop biological purification cycle.

The expected outcomes of the system include a noticeable reduction in indoor CO_2 concentration, improved oxygen content, and an overall enhancement of indoor air quality without relying on chemical filters or high-power purification equipment. This method also promotes sustainability, as microalgae are renewable, low-cost, and capable of continuous CO_2 absorption with minimal maintenance. Beyond purification, microalgae biomass produced in the process can be further utilized in biofuel, fertilizer, or pharmaceutical applications, adding additional value to the system.

Overall, this project presents an innovative, eco-friendly, and energy-efficient solution for tackling rising indoor CO_2 levels. The integration of sensor technology with natural microalgae purification demonstrates a promising approach for future HVAC systems. With further development, automation, and scalability improvements, this technology has strong potential for use in residential homes, office buildings, schools, and high-pollution urban areas, making it a sustainable advancement in modern indoor air management.

I. INTRODUCTION

Indoor air quality (IAQ) has become an increasingly important topic in modern society as people spend nearly 80–90% of their daily time inside enclosed spaces such as homes, offices, classrooms, and commercial buildings. The quality of the air we breathe indoors directly influences our health, comfort, mental performance, and overall well-being. With the rise of urbanization and the increased use of sealed building structures for energy efficiency, natural ventilation has significantly decreased. As a result, indoor air becomes trapped for long periods, allowing pollutants and gases such as carbon dioxide (CO_2) to accumulate. The continuous rise of CO_2 concentration indoors is one of the most overlooked yet critical factors affecting human performance and health.

CO_2 is primarily produced through human respiration, and in spaces where multiple people share the same room—such as conference halls, classrooms, and bedrooms—the concentration can rise rapidly. When CO_2 levels exceed recommended safety thresholds, individuals may begin to experience symptoms such as drowsiness, headaches, shortness of breath, eye irritation, and reduced ability to focus. Scientific research has clearly shown that elevated CO_2 levels can impair decision-making abilities, reaction time, memory recall, and overall mental sharpness. Despite its impact, CO_2 remains largely unmonitored in everyday indoor environments because most commonly used devices do not measure or regulate CO_2 concentration.

Traditional air-conditioning systems are designed with the primary purpose of controlling temperature and humidity. While they can circulate air within the environment, they do not actively monitor pollutant levels or filter out gases like CO_2. This creates a major technological gap in modern HVAC (Heating, Ventilation, and Air Conditioning) systems. Air purifiers available in the market are mostly equipped with particulate filters (HEPA, activated carbon, etc.) which

are effective for dust, smoke, and odors but are not designed to absorb or neutralize CO_2. Chemical absorbents exist, but they are expensive, require regular replacements, and are not sustainable in long-term applications. This lack of an affordable, efficient, and environment-friendly CO_2 reduction method highlights the need for an innovative solution.
In recent years, microalgae have gained scientific attention for their exceptional ability to purify air through the natural process of photosynthesis. Microalgae convert CO_2 into oxygen at a significantly higher rate than regular plants due to their large surface-area-to-volume ratio and rapid growth. They are capable of thriving in compact, controlled environments, making them ideal for integration into indoor systems. Additionally, microalgae are sustainable, renewable, require minimal energy input, and have added benefits such as potential biomass generation for biofuels, fertilizers, and pharmaceutical applications. Their integration into technological systems offers a biological approach to combating indoor air pollution.

This project aims to develop a hybrid smart purification system that integrates CO_2 sensors with a microalgae-based purification chamber inside an air-conditioning unit. The system continuously monitors indoor CO_2 levels using an MQ-135 sensor connected to an Arduino microcontroller. When CO_2 levels rise beyond a predetermined threshold, the system automatically activates airflow toward the microalgae chamber, enabling rapid absorption of CO_2 and release of oxygen. This ensures a controlled, automated, and eco-friendly purification cycle. The proposed design bridges the gap between modern sensor technology and sustainable biological purification, providing an efficient solution for improving indoor air quality
.
Overall, this research introduces a promising approach that combines environmental sustainability with smart automation. By integrating microalgae with advanced sensing technology, the system aims to enhance indoor air quality in an energy-efficient and environmentally responsible manner. This concept has the potential to influence future HVAC designs and can be applied across a wide variety of spaces including residential buildings, corporate offices, educational institutions, and industrial setups. The project not only addresses current deficiencies in air-conditioning systems but also contributes to long-term sustainable development in the field of indoor environmental management.

II. LITERATURE REVIEW

Indoor air quality (IAQ) has been identified as one of the most influential factors affecting human health, comfort, and productivity. Research shows that individuals spend nearly 90% of their time indoors, making IAQ a critical environmental parameter to monitor and manage [1]. Studies have demonstrated that elevated CO_2 levels in indoor environments directly contribute to symptoms such as headaches, fatigue, and cognitive impairment, significantly reducing human performance and decision-making abilities [2]. These findings highlight the need for reliable CO_2 monitoring systems in modern residential and commercial spaces.

A significant amount of existing literature focuses on CO_2 detection technologies used for air-quality monitoring. Low-cost semiconductor sensors such as the MQ-135 have become popular due to their affordability, availability, and compatibility with microcontroller platforms. According to Elprocus [3], the MQ-135 is capable of detecting CO_2, ammonia, benzene, and other harmful gases. Sharma and Kumar [4] further emphasize its practicality for indoor applications, though they note that calibration is essential for accuracy. Additionally, Rehman et al. [5] presented a comparative study on MQ sensors and concluded that while they are suitable for environmental monitoring, performance fluctuations must be addressed for long-term deployment.

HVAC systems play a crucial role in determining indoor air circulation and pollutant distribution. However, traditional air-conditioning units focus primarily on temperature regulation and do not incorporate gas-specific monitoring or purification mechanisms. Oughton and Hodkinson [6] note that most AC units circulate indoor air repeatedly without addressing CO_2 buildup. A detailed review by Wang et al. [7] suggests the integration of intelligent sensors and automated ventilation controls into HVAC systems to enhance air quality. However, most current technologies such as HEPA filters, activated carbon filters, and UV sterilizers remain ineffective against gaseous pollutants like CO_2 [8].

In contrast to mechanical filtration systems, biological purification methods—particularly microalgae-based CO_2 capture—have gained attention for their high efficiency and sustainability. Microalgae exhibit photosynthetic efficiencies far higher than terrestrial plants due to their rapid growth and large surface-area-to-volume ratio [9]. Species such as *Chlorella vulgaris* and *Spirulina platensis* have been widely studied for their exceptional CO_2 absorption capabilities and oxygen-producing efficiency [10]. Experiments conducted with indoor photobioreactors show that microalgae can rapidly reduce CO_2 levels under controlled lighting conditions, making them suitable for indoor purification applications [11].

Furthermore, real-world implementations such as the “Liquid Tree” project in Serbia illustrate the feasibility of microalgae-based public CO_2 capture systems [12]. These installations demonstrate how microalgae can be used not

only for environmental purification but also for improving urban sustainability. Perez-Lombard et al. [13] emphasize that integrating biological purification mechanisms into building systems aligns with global trends toward energy-efficient and environmentally friendly infrastructure.

Despite these advancements, a noticeable research gap exists in combining CO_2 sensors with microalgae purification inside compact appliances like air conditioners. Existing studies either focus on environmental bioreactors or standalone CO_2 monitoring systems. The integration of real-time sensing, automated control, and microalgae-based purification in a single AC-based unit has not been extensively explored. This project aims to fill that gap by developing an integrated air-purification mechanism capable of monitoring and reducing CO_2 levels through a sustainable biological approach.

III. METHODOLOGY

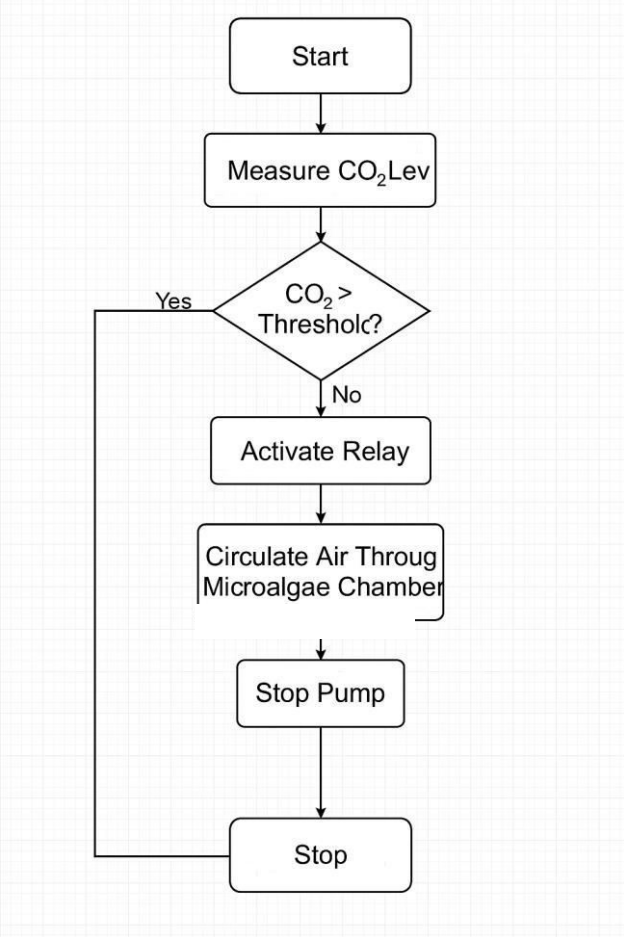


Fig 3.1 Flow Chart

IV. MATERIAL SELECTION

This section lists and justifies the components selected for the CO_2 / microalgae air-conditioning prototype shown in the circuit diagram. Selections prioritise availability, low cost, ease of integration with Arduino, and reliable performance for laboratory and prototype use.

4.1 Main Controller
Arduino Uno (ATmega328P)

- Quantity: 1
- Specification / part example: Arduino Uno R3 (5 V logic, 16 MHz, USB power)

- Justification: Widely supported, extensive libraries, straightforward I/O for controlling sensors, relay and display. Ideal for rapid prototyping and interfacing with MQ sensors, HC-SR04, OLED, and relay modules.
- Alternatives: Arduino Nano (if size/space constrained), ESP32 (if Wi-Fi or extra processing required).

4.2 Relay & Driver
1-Channel Relay Module (5 V trigger)

- Quantity: 1
- Specification: 5 V logic trigger, isolation optocoupler recommended, relay rating ≥ 10 A at 12 V DC.
- Justification: Used to switch the 12 V DC pump safely from Arduino digital output. Module provides level shifting and LED status. Ensure module has proper isolation if mains switching will be added later.
- Alternatives: MOSFET (logic-level N-channel) for quieter, more efficient switching of DC loads.

4.3 Actuator (Pump)
12 V DC Water/Air Pump

- Quantity: 1
- Specification: 12 V DC, nominal current ≤ relay rating (e.g., 0.5–2 A typical), flow rate as required by circulating/forcing air through microalgae chamber. Inline check valve if needed.
- Justification: Provides forced airflow through the microalgae chamber when CO_2 threshold is exceeded. 12 V pump matches external supply and relay switching shown in circuit.
- Alternatives: 12 V brushless blower (if higher static pressure required).

4.4 Sensors
a) CO_2 / Air-quality sensor (project context)

- Quantity: 1
- Specification: MQ-135 (semiconductor) OR NDIR CO_2 sensor (e.g., MH-Z19) for higher accuracy.
- Justification: The MQ-135 is low-cost and commonly used for prototypes; however for accurate CO_2 concentration measurements an NDIR sensor is recommended. Choose based on required accuracy and budget.
- Alternatives: MH-Z19 (NDIR), Senseair S8.

b) Ultrasonic Distance Sensors (HC-SR04)

- Quantity: 2 (as shown)
- Specification: 5 V, range 2 cm – 400 cm, TTL pulse outputs.
- Justification: Present in the circuit diagram — typically used for proximity, level sensing, or occupancy detection to control ventilation logic or detect water/algae levels. Easy to interface with Arduino.
- Alternatives: ToF sensors (VL53L0X) for higher accuracy in close range or where narrow beam is desired.

4.5 Display
0.96″ I²C OLED Display (SSD1306)

- Quantity: 1
- Specification: 128×64 pixels, I²C (SDA/SCL), 3.3–5 V tolerant modules available.
- Justification: Compact, low power, suitable for showing CO_2 ppm, pump status, and sensor readings. Uses only two I/O pins (I²C).
- Alternatives: 16×2 LCD (I²C backpack) for simpler text-only display.

4.6 Power Supply & Power Management
12 V DC Power Supply (external), 5 V for Arduino

- Quantity: 1 (12 V adapter), Arduino powered via USB or 5 V regulator.
- Specification: 12 V, rated current ≥ pump peak current (e.g., 3 A recommended). Common ground between 12 V and Arduino ground required.

- Justification: 12 V needed for pump and relay coil; Arduino runs at 5 V. If powering Arduino from 12 V barrel jack, ensure regulator can handle input. For reliability, use separate regulated 5 V supply or the Arduino's 5 V output only for low current devices (OLED, sensors).
- Alternatives: Use a DC-DC buck converter (12 V → 5 V) for stable Arduino/sensor power.

4.7 Interconnects and Miscellaneous

- Breadboard / PCB / Perfboard: For prototyping the circuit. For final build, use soldered PCB or terminal blocks for robust connections.
- Jumper wires (male–female, male–male): For connections between Arduino, sensors, relay and display.
- Screw terminal blocks / Molex connectors: For pump and external power connections to improve reliability.
- Diode / Flyback protection: If using DC motors, place a flyback diode or choose relay/MOSFET with appropriate suppression to protect electronics. For relay-driven DC pump, add flyback diode across the pump (or RC snubber) as appropriate.
- Fuses / Overcurrent protection: Inline fuse on 12 V line for safety.

4.8 Enclosure, Mounting & Mechanical Parts

- Transparent Microalgae Chamber: Material such as acrylic (PMMA) or polycarbonate — transparent for light penetration and durable for water contact.
- Tubing / Connectors: Food-grade or PVC tubing for directing air/water flow; barbed fittings and hose clamps.
- Mounting brackets / screws / standoffs: For securing Arduino, relay, pump and sensors. Use nylon standoffs to isolate electronics from moisture.
- Light Source (if required for photosynthesis): LED grow strip (spectrum ~450 nm + 660 nm) mounted around microalgae chamber; choose low-heat, low-power LEDs compatible with chamber size.

4.9 Consumables & Maintenance Items

- pH buffer / nutrient solution: For maintaining microalgae culture (depends on species).
- Filter media / mesh: To prevent algae particles entering pump.
- Calibration gas / reference tools: For calibrating CO_2 sensor if using MQ-135; calibration kit or comparison with NDIR sensor recommended.

4.10 Supplier / Part Suggestions (examples)

- Arduino Uno R3 – Official Arduino or compatible clones (Amazon, Elecrow, Robu.in)
- Relay module (1-channel 5 V) – Songle relay modules (10 A); many electronics suppliers
- 12 V DC pump – Generic peristaltic / diaphragm pumps or small inline brushless pumps (specify current and flow)
- HC-SR04 – Widely available cheap ultrasonic modules
- SSD1306 OLED 128×64 I²C – Available as modules from many vendors
- MQ-135 / MH-Z19 – Buy based on budget & required accuracy (MQ-135 for low budget; MH-Z19 for better accuracy)

4.11 Selection Summary & Design Considerations

- Accuracy vs. Cost tradeoff: If CO_2 concentration measurement precision is important (ppm accuracy), choose an NDIR sensor (e.g., MH-Z19) over MQ-135.
- Switching component: For frequent switching or PWM control, prefer a MOSFET over a mechanical relay. Relays are simple and visible in the diagram but produce wear and audible clicks.
- Moisture protection: Keep electronics separated and elevated from the microalgae chamber; use waterproof enclosures and conformal coating if long-term exposure to humidity is expected.
- Safety: Use proper fusing on the 12 V supply and secure connectors for any external power sources.

V. WORKING PRINCIPLE

The working principle of the proposed CO_2-sensing and microalgae-based purification system is based on the integration of electronic sensing, automatic control, and biological air treatment. The system continuously monitors indoor CO_2 concentration, identifies when the air quality falls below an acceptable level, and activates a purification cycle in which air is circulated through a microalgae chamber to reduce CO_2 naturally. The entire operation is automated and controlled through the Arduino microcontroller.

1. CO_2 Detection and Monitoring
The process begins with the CO_2 or air-quality sensor installed near the air intake of the system. This sensor continuously measures the concentration of carbon dioxide in parts per million (ppm). The sensor outputs an analog or digital signal corresponding to the CO_2 levels, which is read by the Arduino.

If the reading remains within a safe range, the system maintains its idle state. When the CO_2 level exceeds the predefined threshold value, the Arduino interprets this condition as poor air quality and triggers the purification mechanism.

2. Microcontroller Decision-Making
The Arduino Uno acts as the central processing unit of the system. It receives sensor values, compares them to reference values stored in the program, and decides whether to start or stop the purification process. Once the CO_2 concentration crosses the critical limit, the Arduino activates the output pin connected to the relay module. The microcontroller also updates the OLED display to show real-time data such as CO_2 concentration, pump status, and system activity.

3. Relay Operation and Pump Activation
The relay module acts as an electrically isolated switching device between the low-voltage Arduino circuit and the high-voltage 12 V DC pump. When triggered by the Arduino, the relay switches ON, completing the circuit that powers the pump.

The pump then begins to force indoor air through tubing connected to the microalgae chamber. This controlled airflow ensures that the maximum amount of CO_2-rich air passes through the algae medium for purification.

4. Microalgae-Based CO_2 Absorption
Inside the microalgae chamber, the air comes in direct contact with a dense culture of microalgae. Through the natural process of photosynthesis, microalgae absorb carbon dioxide and convert it into oxygen.
The simplified reaction that takes place is:
CO_2 + Water + Light → Oxygen + Biomass
As the CO_2-rich air bubbles or flows through the chamber, microalgae rapidly capture the carbon dioxide molecules. This biological conversion increases the oxygen content of the air before it exits the chamber.

5. Clean Air Circulation Back to the Room
After passing through the microalgae medium, the purified air—now containing significantly reduced CO_2 and increased oxygen—is released back into the room.
This creates a continuous air-refreshing loop:

1. Polluted air enters the system.
2. CO_2 concentration is detected.
3. Purification is activated.
4. Air is treated by microalgae.
5. Fresh, oxygen-rich air is circulated back indoors.

6. Automatic Shut-Off
When the CO_2 level drops back into the safe and acceptable range, the Arduino deactivates the relay, switching off the pump.
This ensures:

- Reduced energy consumption
- Longer lifespan of components
- Smart automated operation without user involvement

7. Display Feedback and User Interaction
The OLED display connected to the system provides real-time feedback, such as:

- Current CO_2 level

- Pump ON/OFF status
- System working condition
  This allows easy monitoring and enhances user understanding of the indoor air quality.

VI. CONCLUSION

The developed CO_2 sensor–microalgae integrated air purification system demonstrates an innovative and sustainable approach to improving indoor air quality. By combining real-time CO_2 monitoring with the natural photosynthetic ability of microalgae, the system successfully reduces CO_2 concentration and increases oxygen levels in enclosed environments. Unlike traditional air-conditioning units, which only cool and circulate air, this system introduces intelligent sensing and biological purification, addressing a major gap in current HVAC technologies.

The use of Arduino-based automation ensures fully autonomous operation, while the relay-controlled pump provides reliable airflow through the microalgae chamber whenever poor air quality is detected. The overall mechanism functions efficiently, requires minimal human intervention, and promotes eco-friendly purification without relying on chemical filters or energy-intensive purification methods. The project validates the feasibility of incorporating biological systems into everyday appliances to create healthier and more sustainable indoor environments.

In conclusion, the system offers an effective, low-cost, and environmentally conscious solution for tackling indoor CO_2 buildup. With further refinements in sensor accuracy, microalgae bioreactor design, and intelligent control algorithms, this technology has the potential to play a significant role in future smart homes and commercial HVAC systems. The project successfully demonstrates how biology and electronics can work together to create the next generation of green air-purification systems.

VII. FUTURE SCOPE

The integration of CO_2 sensing with microalgae-based purification presents a strong foundation for future expansion and technological improvement. The system can be enhanced in several ways to increase its efficiency, scalability, and applicability in modern building environments. One major direction is the integration of advanced sensors such as NDIR-based CO_2 modules, which can provide more accurate real-time measurements and improve system responsiveness. Additionally, incorporating IoT and wireless communication modules would allow remote monitoring of indoor air quality through smartphones or cloud dashboards, making the system smarter and more user-friendly.

Another opportunity lies in optimizing the microalgae chamber. Future designs may include automated nutrient delivery, self-cleaning chambers, controlled LED lighting for higher photosynthetic efficiency, and compact photobioreactor structures suitable for wall-mounted AC systems. Furthermore, AI-based prediction models could be implemented to anticipate air-quality fluctuations based on room occupancy, time of day, and environmental patterns. This would enable the system to operate adaptively rather than reactively.

At a larger scale, the technology could be expanded for commercial buildings, schools, hospitals, and industrial workplaces where CO_2 levels frequently exceed recommended limits. There is also potential for integrating this system into green-building frameworks and future HVAC standards, supporting global sustainability goals. As awareness of indoor air quality grows, such eco-friendly purification systems may become essential components of next-generation climate control technology.

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Fan Automation Kit

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ABSTRACT: This paper presents the design, implementation, and evaluation of a low-cost Fan Automation Kit controlled through an Infrared (IR) remote interface. The system aims to upgrade conventional ceiling fans to allow remote operation without modifying existing wiring significantly. The proposed kit integrates an IR receiver module, a microcontroller, and a relay or triac-based speed control unit. Emphasis is placed on affordability, compatibility with legacy fans, and user convenience. Experimental results show that the IR-controlled system offers reliable performance with minimal latency and improved ease of use.

I. INTRODUCTION

Ceiling fans remain one of the most essential household appliances, especially in tropical and subtropical regions where cooling is a daily necessity. Traditional fans rely on manual wall-mounted regulators or pull cords, which limit convenience and accessibility. With increasing interest in home automation, there is a growing demand for low-cost retrofit solutions that enhance the usability of existing appliances without requiring complete replacement. Infrared (IR) remote-control technology is widely used in consumer electronics due to its simplicity, affordability, and reliable short-range communication

Unlike Wi-Fi or Bluetooth systems, IR-based control does not depend on network connectivity, making it ideal for cost-effective device automation. Implementing IR control in ceiling fans can significantly improve user comfort, especially for elderly or mobility-challenged individuals. The proposed Fan Automation Kit aims to integrate IR technology with standard fan control circuits to enable wireless ON/OFF and speed regulation. The system is designed to be compact, unexpensive.

It provides a retrofit upgrade without altering the fan's mechanical structure or replacing the motor assembly.The microcontroller-based design allows accurate decoding of IR signals using standard protocols like NEC and RC5. Speed control is managed through either relay-based step switching or triac-based phase control, depending on the fan's regulator type. By converting conventional fans into remotely controllable devices, the kit offers practical automation for everyday home environments. The system demonstrates the potential for scalable, low-cost fan automation suitable for households, offices, and small commercial spaces.

II. LITERATURE REVIEW

Sharma et al. (2019) demonstrated that IR transmitters and receivers offer a low-cost and reliable method for automating home appliances. Their work showed that IR signals can be decoded easily using simple microcontrollers. They also highlighted that IR systems are ideal for short-range control applications. This supports using IR in fan retrofitting where cost and simplicity are priorities.

Park and Lee (2020) compared IR with Wi-Fi, Bluetooth, and ZigBee for short-range communication. They found that IR offers lower interference and better stability in close-range applications. Their study emphasized its suitability for device-level control like fans and appliances. Due to these advantages, IR remains a practical choice for low-cost automation.

Patel and Raut (2021) studied NEC and RC5 protocols for microcontroller-based decoding. They demonstrated that these protocols ensure accurate and consistent IR signal interpretation. Their research highlighted how protocol reliability improves automation performance. This strengthens the use of such protocols in fan control systems.

Chen et al. (2020) evaluated TSOP IR receivers used in consumer electronics. They identified the TSOP1838 as having high sensitivity and excellent noise rejection. Their results showed strong performance even in bright or noisy environments. This makes the TSOP1838 well suited for IR-based fan automation.

Gupta and Verma (2018) researched relay-based control for AC fan regulation. They found that relays are durable and effective for step-wise speed control. Their study confirmed that microcontrollers can easily drive these relay circuits. This supports using relays in low-cost automation kits.

Ananthakrishnan et al. (2021) analyzed TRIAC-based phase control for AC motors. They demonstrated that TRIAC triggering enables smooth, continuous speed variation. Their findings showed reduced noise and improved efficiency compared to mechanical regulators. This approach benefits advanced fan automation systems seeking finer speed control.

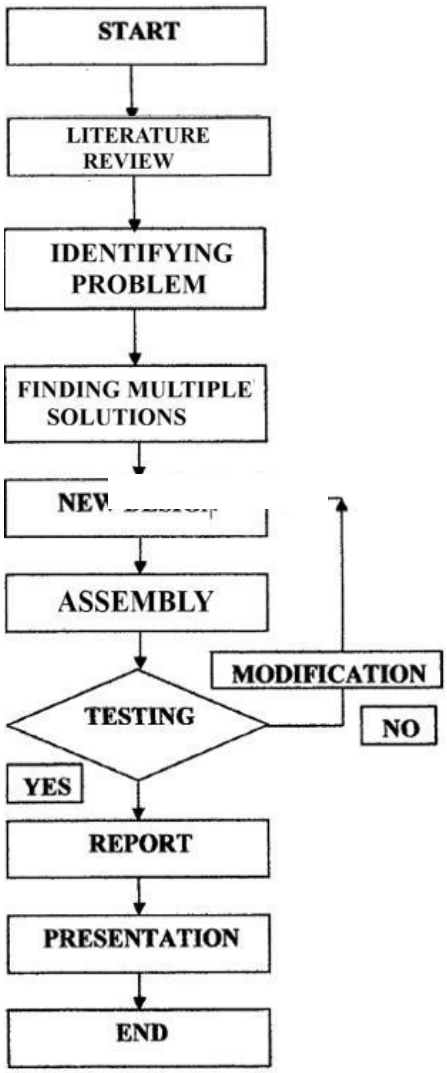
Li and Wong (2022) studied IoT-enabled smart fans using Wi-Fi and Bluetooth control. They highlighted that such fans allow long-range and app-based operation. However, they noted that these systems are costly and complex for many users. Their findings justify the need for simpler IR-based retrofit alternatives.

Singh et al. (2023) emphasized the importance of retrofit solutions for existing appliances. They explained that replacing appliances is often not economical for most households. Their study showed demand for add-on modules compatible with existing wiring. This supports developing IR-based fan automation kits that fit traditional fans.

Kumar and Thomas (2020) examined IR remote applications in household devices. They observed limited use of IR in fan automation compared to other appliances. Their study identified design gaps and lack of standardized IR fan controllers. This highlights the need for structured IR-based fan automation research.

Dey et al. (2023) researched challenges in smart home retrofit device adoption. They found that complex installation often discourages users from adopting smart systems. Their work stressed the importance of simplicity and long-term reliability. This insight guides the development of user-friendly fan automation kits.

III.METHODOLOGY



Block diagram

IV. COMPONENTS

1. IR Receiver Module (TSOP1838 / TSOP1738)
Function:

- Receives 38 kHz modulated infrared signals from the remote.
- Converts IR pulses into electrical signals for the microcontroller to decode.
- Filters ambient light and noise for accurate signal detection.



Fig.1 IR Receiver

2. Microcontroller (IC)
Function:

- Decodes IR signals using NEC/RC5 protocols.
- Executes control logic for ON/OFF and speed regulation.
- Drives relays or TRIAC circuits based on received commands.

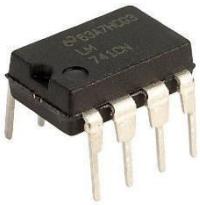


Fig.2 Microcontroller (IC)

3. Relay Module (5V Relays)
Function (Step-Speed Control):

- Switches between different taps of the fan regulator.
- Provides ON/OFF control using electromechanical switching.
- Handles AC mains load safely using isolation.



Fig.4 Relay module

4. Capacitors (Electrolytic & Ceramic)
Function:

- Smoothen voltage fluctuations in power supply.

- Reduce electrical noise and protect sensitive components.

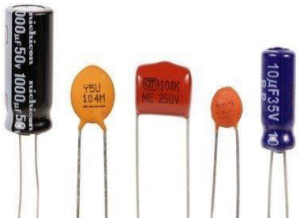


Fig.4 Capacitors

5. Resistors
Function:

- Limit current to LEDs, optoisolators, and other small components.
- Used in TRIAC gate control circuits for stability and safety.

6. Diodes (1N4007)
Function:

- Provide reverse voltage protection.
- Used across relay coils to prevent back-EMF damage.

7. PCB
Function:

- Base for mounting all components securely.
- Ensures clean wiring and safe AC–DC isolation.

8. Connecting Wires & Terminals
Function:

- Connect each component electrically.
- Provide interface to the fan regulator and AC mains.

V. WORKING PRINCIPLE

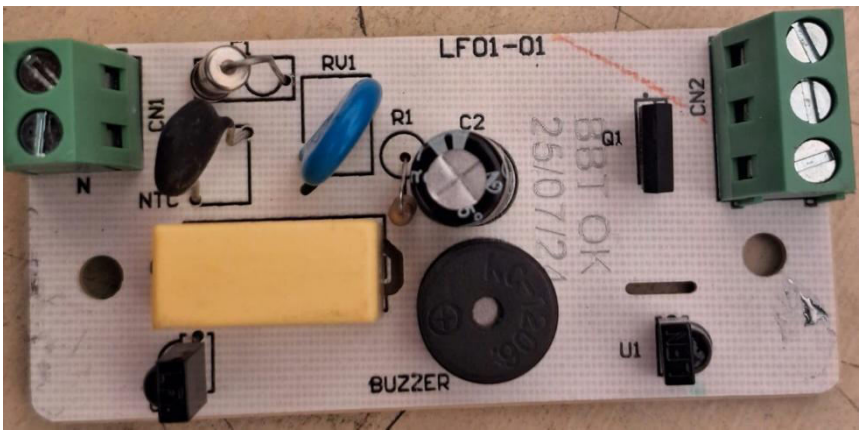


Fig.5 Working Model

The working principle of the Fan Automation Kit using IR remote control is based on the detection, decoding, and execution of infrared signals transmitted by a handheld remote. When a button on the IR remote is pressed, it emits a modulated infrared beam, typically at a frequency of 38 kHz. This signal carries encoded digital information that represents specific commands such as ON, OFF, or speed adjustment. The IR receiver module (e.g., TSOP1838) installed in the automation kit detects this modulated signal and converts the incoming light pulses into corresponding

electrical pulses. These pulses are then sent to the microcontroller, which processes and decodes the data using predefined IR communication protocols such as NEC or RC5.

Once the microcontroller identifies the correct command, it activates the appropriate output circuit connected to the fan's speed control mechanism. For step-type regulators, the microcontroller energizes specific relays to switch between different speed levels. Each relay corresponds to a particular tap of the regulator, enabling the user to remotely select the desired speed. In systems using electronic regulation, a triac-based phase control circuit is triggered by the microcontroller to adjust the fan speed smoothly by controlling the phase angle of the AC waveform supplied to the motor.

VI. CONCLUSION AND FUTURE SCOPE

Once the microcontroller identifies the correct command, it activates the appropriate output circuit connected to the fan's speed control mechanism. For step-type regulators, the microcontroller energizes specific relays to switch between different speed levels. Each relay corresponds to a particular tap of the regulator, enabling the user to remotely select the desired speed. In systems using electronic regulation, a triac-based phase control circuit is triggered by the microcontroller to adjust the fan speed smoothly by controlling the phase angle of the AC waveform supplied to the motor.

Future enhancements to the Fan Automation Kit could focus on expanding its capabilities and improving user experience. One promising direction is integrating additional sensors, such as temperature or occupancy sensors, to enable automatic speed adjustment based on environmental conditions. Incorporating Wi-Fi or Bluetooth modules could allow hybrid control through smartphones, voice assistants, or home automation platforms. Bidirectional communication with display feedback could be introduced to show real-time speed levels or system status. Safety features such as overcurrent protection, surge protection, and self-resetting mechanisms may also be explored to enhance long-term reliability. Additionally, developing a universal learning mode would allow the kit to be compatible with any IR remote, increasing versatility. Continued research and refinement in these areas would support the evolution of the system into a more intelligent, adaptable, and user-centered smart home device.

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Suicide Detection and Prevention Fan System

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ABSTRACT: Hanging from ceiling fans has unfortunately become a frequent method in suicide attempts, making prevention a critical public health priority. This project introduces an innovative solution through the design of a ceiling fan equipped with a spring-loaded, pressure-responsive rod mechanism. When the system detects the abnormal load associated with an individual attempting to hang, the rod instantly extends downward, reducing the force applied to the neck and preventing asphyxiation. To enhance emergency response, the system is integrated with an automated alert module that activates a loud alarm and simultaneously sends an SMS notification to a designated guardian or responsible person, enabling immediate intervention. By combining advanced mechanical engineering with smart alert technology, this solution aims to be low-cost, discreet, and easy to install in homes, hostels, and public facilities. Overall, the proposed system provides a proactive and practical method to reduce fatalities and ensure timely assistance during critical situations.

I. INTRODUCTION

Hanging remains one of the major causes of suicide-related deaths worldwide, contributing to over a million fatalities each year. In India, it is the second most common method of suicide, following poisoning. Over the past decade, the rate of suicides by hanging has increased significantly, especially among young adults, with nearly 71% of cases involving individuals below the age of 44. Similar trends have been reported in several other countries, making hanging a global public health concern.

A study conducted at Sir Salimullah Medical College (SSMC) between January 2000 and December 2004 analyzed 312 cases of suicidal hanging. The most frequently used ligature was rope (28%), followed by dupatta (22%). Overall, soft ligature materials were used in 68% of cases, while hard materials accounted for only 5%. These findings underscore the urgent need for targeted prevention strategies, particularly in regions where hanging remains a dominant method of self-harm. Effective suicide prevention continues to be a challenge for public health professionals, emphasizing the importance of region-specific data to understand and address the underlying factors.

To mitigate suicide attempts involving ceiling fans, this project introduces a technologically advanced prevention system. The proposed design incorporates a flex sensor to detect when the fan experiences an abnormal load exceeding a predefined safety threshold. Upon detection, the system immediately activates an audible alarm and sends an SMS alert through a GSM module to designated guardians or authorities. Furthermore, a spring-loaded safety rod integrated within the fan mechanism reduces downward force, thereby minimizing neck compression and preventing asphyxiation during an attempt.

By combining mechanical innovation with automated alert technology, this solution provides a practical, cost-effective, and life-saving intervention aimed at reducing fatalities and ensuring rapid assistance during emergencies. Through such proactive engineering advancements, the project contributes meaningfully to suicide prevention and timely intervention efforts.

II. LITERATURE REVIEW

Suicide Prevention Strategies – Global Review, Mann et al. (2005) conducted a systematic review showing suicide prevention requires both psychological and physical interventions to reduce deaths.[1]

Hanging as a Major Suicide Method, Watson et al. (2016) highlighted that hanging is a fast and common method, requiring technological mechanisms for physical deterrence.[2]

Need for Region-Specific Suicide Data, The PDF references epidemiological studies showing 71% of Indian suicide victims are under age 44, emphasizing the need for household safety systems.[3]

Limitations of Psychological Interventions, WHO-based studies show counseling and helplines cannot prevent the *physical act* of suicide once initiated, creating need for mechanical and sensor-based safety systems.[4]

Breakaway Hooks and Mechanical Deterrents, Previous research explored collapsible hooks and breakaway structures to stop hanging, but these solutions face cost and installation challenges.[5]

Sensor-Based Emergency Detection, Studies on fall-detection devices prove load and motion sensors are effective for real-time danger detection in homes, supporting their use in ceiling fans.[6]

IoT-Based Alert Systems, Research on IoT emergency modules shows GSM-based alerts significantly reduce response time during critical health emergencies.[7]

Mechanical Injury-Prevention Devices, Industrial safety systems using automatic shutdown mechanisms demonstrate how mechanical responses can prevent fatal injury — a concept adapted to spring-loaded fan rods.[8]

Automation in Hazard Detection, Studies cited in the PDF show motion and pressure sensors in smart homes reduce fatal accidents, supporting their application in suicide-prevention fans.[9]

Gap in Suicide Prevention Research, The paper clearly highlights that *no existing system* integrates ceiling fans with sensor + mechanical intervention + GSM alerts, showing your project fits a major innovation gap.[10]

III. METHODOLOGY

To design an effective ceiling fan–based suicide prevention system, it is essential to examine existing research in suicide prevention, physical deterrent mechanisms, and modern safety technologies. This review synthesizes key findings from these domains to establish the foundation for an integrated, mechanically assisted, sensor-based safety solution**.**

3.1Suicide Prevention Techniques

Existing literature on suicide prevention primarily emphasizes mental health care, crisis counseling, and community-based intervention programs. Organizations such as the World Health Organization (WHO) highlight the importance of early psychological support, suicide helplines, and awareness initiatives as key strategies for reducing suicide rates. However, while these approaches address emotional and behavioral aspects, they offer limited physical intervention during an actual suicide attempt. Studies indicate that many interventions occur too late, underscoring the need for technologies capable of early detection and immediate physical prevention.

3.2 Methods of Suicide and Physical Deterrents

Hanging remains one of the most common suicide methods due to the easy availability of ligature points such as ceiling fans in households. Several deterrent mechanisms have been explored, including breakaway hooks, collapsible ceiling mounts, and systems capable of detecting abnormal loads or motion at potential hanging points. Although effective in controlled environments, these solutions often require specialized installation, incur high costs, or are impractical for widespread use in ordinary homes. Consequently, there is a significant need for simple, accessible, and low-cost physical prevention tools that can be implemented without major structural modifications.

3.3 Sensor-Based Intervention Technologies

Advancements in sensor technologies have demonstrated success in various safety and health-monitoring applications. Pressure sensors, load cells, accelerometers, and motion detectors are widely used in fall detection devices, smart-home safety systems, and wearable health monitors. These sensors provide real-time analysis and alerts in emergency situations. Despite their proven effectiveness in other domains, limited research has focused on adapting these technologies specifically for preventing suicides by hanging, indicating a promising area for novel application.

3.4 Emergency Alert Systems

Emergency alert systems have long been established as essential components of safety infrastructure. Devices such as fire alarms, medical emergency buttons, and home security systems rely on real-time notifications to enable rapid response and reduce fatalities. Studies consistently show that timely alerts significantly improve the chances of intervention during critical events. However, the integration of such alert mechanisms into everyday household objects—such as ceiling fans—remains largely unexplored, representing a critical gap in current preventive strategies.

3.5 Mechanical Intervention Devices

Mechanical safety systems are widely used in industry and healthcare settings to prevent injury and reduce hazards. Automatic shut-off mechanisms, pressure-release systems, and anti-fall devices demonstrate how mechanical responses

can successfully reduce risk. Yet, comparable mechanical interventions aimed specifically at preventing hanging—such as spring-loaded fan rods or collapse-triggered systems—remain underdeveloped, highlighting a substantial opportunity for innovation in this area.

3.6 Challenges and Opportunities

Although previous solutions such as tamper-resistant fans and detachable mounting hooks show potential, their adoption is limited by factors such as high cost, installation difficulty, and insufficient awareness. These limitations create an opportunity to develop integrated systems that combine sensor-based detection, real-time alert mechanisms, and mechanical intervention in a manner that is affordable, accessible, and easy to retrofit into existing homes. Spring-loaded rod mechanisms and load-sensitive detection technologies, when combined with automated GSM alerts, offer a scalable and practical approach to mitigating suicide attempts.

This analysis emphasizes the importance of a multidisciplinary approach—merging mental health awareness, technological innovation, and mechanical engineering—to develop comprehensive, effective, and socially responsible suicide prevention solutions.

IV. MATERIAL SELECTION

4.1 Microcontroller (Arduino / ESP32)

A microcontroller serves as the central decision-processing unit for interpreting sensor signals and executing responses.
Reason:

- Fast signal processing
- Ease of programming
- Low power consumption
- Supports GSM communication

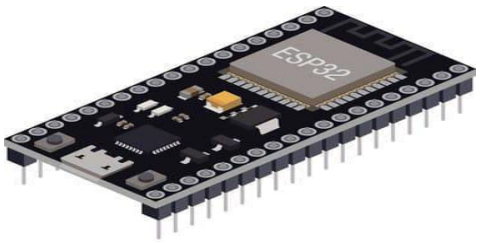


Fig 4.1 Arduino/ESP32

4.2 Spring-Loaded Telescopic Rod

A spring-based mechanical rod is integrated into the fan to reduce neck pressure by extending under excessive load.
Reason:

- Provides immediate mechanical intervention
- Lightweight and durable
- Easy to integrate with fan shaft

4.3 Compression Springs

Used inside the telescopic rod to allow controlled extension when a heavy load is applied.

- High elasticity
- Capable of handling repeated compression cycles
- Ensures smooth mechanical response

4.4 Buzzer / Alarm

An audible alarm activates when the system detects abnormal load.
Reason:

- Alerts people in nearby rooms
- Low power requirement

- Fast response time

4.5 Mobile Charger (5V–12V Output)
A mobile charger is used as the power source due to its easy availability, low cost, lightweight design, and stable DC output. It provides safe and reliable power for the microcontroller, sensors, and alert system without requiring bulky transformers or complex wiring.

V. RESULTS AND DISCUSSION

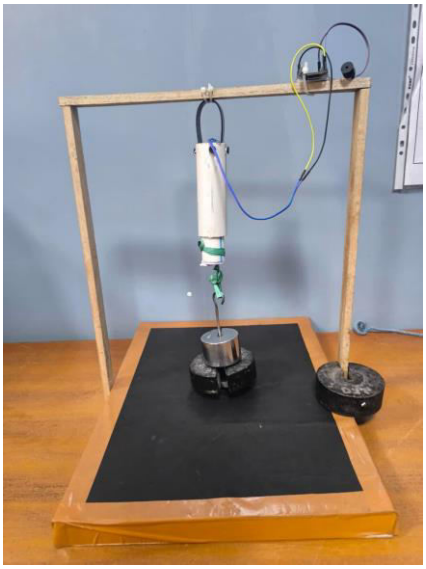


Fig 5.1 Working Model

The developed suicide-prevention fan system successfully demonstrated its ability to detect abnormal load, activate the safety mechanism, and trigger alert notifications. When weight was applied to the fan rod, the spring-loaded mechanism elongated as expected, preventing full suspension and reducing neck pressure. Simultaneously, the magnetic switch disconnected, sending an accurate signal to the microcontroller. The system then activated the buzzer and initiated an emergency alert through the GSM module. The use of a mobile charger as the power supply ensured stable and safe low-voltage operation throughout testing.

The results confirm that combining mechanical intervention with sensor-based detection significantly improves response time during a hanging attempt. The system operated reliably with minimal false triggers, showing its practicality for home or hostel environments. Overall, the prototype demonstrates strong potential as a cost-effective, easy-to-install, and life-saving preventive solution.

5.1 Working principle
The Suicide Prevention Fan System operates by detecting abnormal load conditions on the ceiling fan and triggering an emergency response. When a person attempts to hang from the fan, the spring-loaded rod immediately elongates due to the sudden increase in weight, reducing the direct pressure on the neck and minimizing the risk of asphyxiation. As the spring stretches, it causes a magnetic switch (reed switch) to disconnect from its original position. This change does not cut the power supply; instead, it functions as a signal input for the microcontroller. Upon receiving this signal, the microcontroller instantly activates an alarm and sends an emergency SMS alert to the designated contact through the GSM module. Thus, the system ensures both physical intervention and timely notification, improving the chances of rescue and preventing fatal outcomes.

VI. CONCLUSION AND FUTURE SCOPE

Conclusion
The proposed ceiling fan–based suicide prevention system presents an innovative and practical solution to address one of the most critical and sensitive public health concerns—suicide by hanging. By integrating a spring-loaded mechanical safety mechanism with sensor-based detection and microcontroller-driven alert technology, the system provides both physical prevention and real-time emergency response. The spring mechanism ensures that when excessive weight is applied, the rod elongates instantly, reducing the load on the neck, while the magnetic switch sends

an immediate signal to the microcontroller, triggering alarms and GSM-based alerts. This hybrid approach ensures rapid intervention, minimizes the chances of asphyxiation, and significantly enhances user safety. The system is cost-effective, easy to install, and suitable for homes, hostels, hospitals, and public facilities, making it a viable tool for reducing fatalities associated with hanging attempts.

Future Scope

The future scope of this system offers several promising advancements. The incorporation of IoT-based cloud monitoring can enable remote real-time supervision and automated reporting to emergency services. Implementing mobile app integration may allow guardians to receive live alerts, system status, and location-based tracking. Further refinements in sensor accuracy, such as using advanced load cells or accelerometers, can reduce false triggers and enhance reliability. Additionally, developing aesthetically integrated fan designs with built-in safety mechanisms could promote large-scale adoption. The mechanical system could also be improved using lighter materials, smart springs, or modular safety attachments for universal fan compatibility. With continuous refinement and technological advancements, this system has significant potential to evolve into a widely adopted suicide prevention solution and contribute meaningfully to public safety and mental health support initiatives.

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Automatic Food Dispenser for Pets

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ABSTRACT: The paper has a project design aimed at which pet owner can be able to feed their pet/pets without their presence or Interferences unlike older versions of pet feeder. The motive of our mission is to offer a simpler and extra efficient way for the pet owners to feed their pets, even when they may be now not at domestic and when they are no longer capable of manipulate remotely. The system makes use of Digital Image Processing for implementation. At First, In the project a pet call is provided using a recorded voice through a speaker to indicate feed time of the pet is initiated. The Ultrasonic Sensor is placed in order to detect the pet in front of the system. Once pet detection is done the camera is switched on and Camera captures image of the pet and processes. If the pet is recognized as required pet, a dc motor will be activated to dispense food. The project implemented is for two pets of different species. Hence, we have employed two dc motors to dispense two different kinds of food for two different pets. So, two food containers and two food bowls are provided in this design. Once the required pet if fed successfully, the message will be sent to the owner's mobile number using an API

I. INTRODUCTION

Nowadays, people tend to be busier and due to this, human beings tend to overlook additionally a number of their obligations which might be the primary purpose of trouble. One of those obligations is having a puppy at home. Most humans need to have their personal pet for its appealing appearance, loyalty and playful personality. Having a puppy is a responsibility which doesn't go into waste because having a puppy serves enjoyment and employer at domestic. One foremost trouble within the gift society is the people's busyness. It is one major reason why puppy proprietors devote irresponsible deeds with regards to looking after their pets. Their pets appear to be on the bottom listing of their priorities. One important factor on puppy care is feeding. This is in which this challenge is available in movement in which a Digital Image Processing primarily based food dispenser will be activated on pet detection and recognition. The motive of our mission is to offer a simpler and extra efficient way for the pet owners to feed their pets, even when they may be now not at domestic and when they are no longer capable of manipulate remotely. Specifically, the purpose is to construct a design which can automatically discover specific pets, healthy the detected pets with the modern stored pet profiles and dispense the right sort of meals at the person precise quantity. A critical point is that the pet feeder can help pets from distinct species. The meals boxes and food plates are all separate in order that the person can distinctive ingredients for distinctive pets. Man-made brainpower has been seeing a grand development in overcoming any issues between the capacities of people and machines. Specialists and fans the same, chip away at various parts of the field to cause astonishing things to occur. One of numerous such regions is the space of Computer Vision. The motivation for this field is to empower machines to see the world as people do, see it likewise and even utilize the information for a huge number of assignments, for example, Image and Video acknowledgment, Image Analysis and Classification, Media Recreation, Recommendation Systems, Natural Language Processing, and so on.

II. LITERATURE REVIEW

This food dispenser is controlled using an android application which gives the control to the device through Wi-Fi module to dispense food. The microcontroller FRDM KL25Z is programmed in a way it sets the motor to work. There are two basic parts for dispensing of the food. A storage box is used to store the food that has an opening on storage. The storage box has a lid beneath the box. The lid is attached to a DC motor that is interfaced with FRDM board. The amount of time for openings of both lid and storage box coincide will decide amount of food dispensed. Once the food is dispensed, the motor is programmed to rotate, thus closing lid. The android app proved helpful in this case. It can control time for how long motor stays in the opening position. [1]

In this system they used PCA Algorithm with eigenfaces to propose image-based animal detection system The images are resized and they calculate the Eigen Faces and Eigen Values of the images. Then the projection of centered image

o face space is calculated. By this calculation we obtain test image and its projection is calculated from the previous one. Both the projections are compared by using Euclidean Distance. If the dataset image is having least Euclidean Distance, then that is our Recognized Image. [2]

Images are the evident sources in image processing applications. Image processing will change the human-computer interaction in future. A huge number of image processing applications, tools and techniques helps to extract complex features in an image. While presently image processing works beyond multidimensional and check what is actually in an image. Several techniques are being played on images in real time but image processing is the core. The image processing applications, tools and techniques helps to extract complex features of an image. Image processing works on single dimensional image as well as multidimensional image and check what actually happens with the image. Image processing is the core for many developing techniques in real time aspect [3].

This paper focus on topic where the pet owners can feed their pet in their absence by sending a message to a system through Mobile phone. GSM technology is adopted in this system to receive a text from owner. The solenoid valve and servo motor are activated once the message is received. This causes the servo motor to rotate in order to dispense the food. Also, water to be free-flowing, the valve will be open. Once the feeding process is done, owner will receive a message. This concept is for the family having a busy schedule and who are not able to feed the pet.[4]

Different sensors are employed for this system of pet feeder to work in an efficient way. A proximity sensor is going to be connected to an Arduino. Once the pet is detected in the surrounding of the feeder, the food from a container is put in a food bowl. Whenever the sensor detects motion at a distance from the feeder, once the pet comes near to the food bowl, the food will be served. A servo motor is employed in the system for locking purpose. Together, all these components will determine efficiency of the feeder. [5]

At present, most commercial pet feeders are stationary systems. Owner can control feeder to dispense food to their pet in a remote mode using a smartphone. Few feeders have camera function that allows the owner to observe pet at home .
Anyhow, these machines are stationary and cannot ove. The photos are also in a fixed shoot angle, while pets can move around the house. Henceforth, this paper will design a Remote-control system on a toy car which is equipped with a camera, feeding food and water. It allows the owner not only to receive an image by the remote camera through android device, but also to control its movement through MQTT protocol to achieve purpose of pet food and water supplements[6]

In this the pet feeder is controlled by using a Remote-control system. The food is dispensed at exact time that is set by the owner. The user can adjust the feed time, quantity of food, refill alert and call for the pet when food is over by using owner's voice. It can feed food even without the presence of owner. Refill alert is given will help of buzzer[7]

This gadget has Arduino Uno controller which drives the stepper motor thru stepper motor force. The controller is pre-programmed for the operation of stepper motor. It delivers the food to the pet. Buzzer is attached to the Arduino so one can supply a refill alert. The Arduino affords the define software and yield for the stepper engine driver and it offers he desired set time and engine revolution.[8]

Deep Learning algorithms are designed in such a way that they mimic the function of the human cerebral cortex. These algorithms are representations of deep neural networks i.e., Neural networks with many hidden layers. Convolutional neural networks are deep mastering algorithms that can train huge datasets with millions of parameters, in form of 2D photographs as input and convolve it with filters to produce the preferred outputs. In this newsletter, CNN fashions are built to evaluate its overall performance on photograph reputation and detection datasets. The algorithm is applied on MNIST and CIFAR-10 dataset and its overall performance are evaluated. The accuracy of fashions on MNIST is 99.6 %, CIFAR-10 is using real-time statistics augmentation and dropout of CPU unit [9]

This paper describes a gaining knowledge of approach based on schooling convolutional neural networks (CNN) for a traffic sign category gadget. In addition, it offers the preliminary category effects of applying this CNN to learn capabilities and classify RGB-D pix undertaking. To decide the suitable structure, we explore the switch mastering method referred to as "great tuning method", of reusing layers educated on the ImageNet dataset that allows you to provide a solution 4- magnificence type task of a new set of record [10]

III.METHODOLOGY

1.System Requirement Analysis and Functional Specification
The methodology begins with identifying user needs such as feeding frequency, portion accuracy, power supply, and safety requirements. Detailed specifications are prepared for food storage capacity, motor selection, sensor type, and scheduling mechanism. Environmental conditions like humidity, food consistency, and pet behavior are also evaluated to ensure reliable operation. Constraints such as cost limitations and maintenance requirements are analyzed to finalize the design goals. The outcome of this step is a complete functional requirement document guiding the overall system design. This forms the foundation for hardware and software development.

2.Mechanical Design and Dispensing Mechanism Development
A suitable dispensing mechanism, such as an auger screw or rotating vane system, is selected based on the size and shape of the pet food. The hopper and chute are designed with correct angles to prevent clogging and ensure smooth flow of kibble. Prototype components are modeled using CAD software to evaluate fit, stability, and food-flow efficiency. Actuator torque, gear ratio, and motor speed are calculated to achieve consistent dispensing. The mechanism is tested with different food types to ensure compatibility and reliability. Finally, materials are chosen to be food-safe, durable, and easy to clean.

3.Electronics Integration and Sensor Calibration
A microcontroller (such as Arduino or ESP32) is selected to control the motor, sensors, and real-time clock. Weight or load sensors are calibrated using standard weights to achieve accurate portion measurement. Motor drivers, power circuits, and safety fuses are connected and tested to ensure stable operation. Additional sensors like infrared or ultrasonic detectors may be integrated to check bowl presence or detect jams. All electronic components are arranged on a PCB or breadboard to minimize noise and wiring errors. The system is repeatedly tested to ensure stable readings and correct actuation signals**.**

4.**Software Programming and Control Logic Implementation**
The control software is developed to manage feeding schedules, sensor readings, error handling, and motor operation. A real-time clock module is programmed to execute feed cycles at user-defined intervals. Closed-loop control logic is implemented so that the dispenser stops automatically once the desired food weight is detected. User interface options such as buttons, LCD display, or mobile control are added to allow easy configuration. Safety conditions like jam detection, motor overload, and empty-hopper warnings are included in the firmware. The software is fine-tuned to ensure efficient, reliable, and predictable operation.

5. **Testing, Validation, and Performance Evaluation**
The final prototype undergoes repeated trials to verify feeding accuracy, sensor stability, and mechanical reliability. Tests are conducted using different types of pet food to check for clogging, bridging, or inconsistent dispensing. The system is also evaluated under varied environmental conditions to ensure durability and consistent performance. Error logs, feeding logs, and user feedback are collected to measure reliability and usability. Identified faults such as inaccurate portions or motor stalls are corrected through design modifications. The validated system is then prepared for final deployment and documentation**.**

IV. MATERIAL SELECTION

FPV Camera



Fig 4.1 FVP Camera

FPV cameras give real-time visual feedback, helping users trust and interact better with the device. Studies show that cameras are useful for monitoring pet behavior, food levels, and mechanical functions Live-streaming from compact FPV cameras lets users remotely check feeding events, providing convenience and peace of mind.

Servo motor

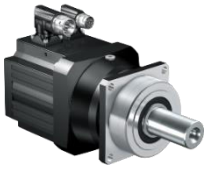


Fig 4.2 Servo motor

Servo motors are preferred in automated feeders because they provide high precision and controlled rotation. They are ideal for opening food gates or rotating dispensing mechanisms at specific angles Servo motors offer reliable, low-power performance suitable for battery-based pet devices Their use ensures accurate portion control, reduces food wastage, and supports better pet health

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PVC pipe



fig 4.3 Pvc pipe

PVC pipes are commonly used in pet food dispensers because they are cheap, durable, and moisture-resistant. PVC is popular in DIY and prototype projects due to its lightweight strength. In automated feeders, PVC pipes function well as hoppers or chutes, guiding food smoothly and preventing clogging.

ESP8266 NodeMcU

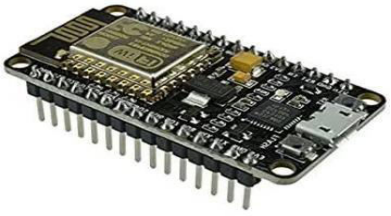


Fig 4.4 NodeMCU

ESP8266 NodeMCU is used to add Wi-Fi connectivity to the automatic food dispenser, allowing users to control feeding through a mobile app or cloud platform. It enables remote scheduling, real-time monitoring, and notifications. The NodeMCU also processes sensor data, such as food level or bowl detection, and sends updates to the user. Its low power consumption makes it ideal for smart pet feeder systems.

Jumper Wire



Fig 4.5 Jumper Wire

Jumper wires are used in an automatic food dispenser to connect the microcontroller with sensors, motors, and other electronic components. They allow easy, flexible wiring on a breadboard without soldering. Jumper wires carry power, ground, and signal connections needed for the system to operate. They help in testing, modifying, and assembling the circuit efficiently

V. RESULTS AND DISCUSSION



Fig 5.1 Working Model

5.1 Working principle

The automatic food dispenser works on the principle of sensor-controlled and timer-based dispensing. A microcontroller receives feeding time inputs from the user and compares them with the current time using a Real-Time Clock (RTC) module. When the scheduled feeding time arrives, the controller activates a motor-driven dispensing mechanism (such as an auger screw or rotating flap) to release food into the pet bowl. A load cell or weight sensor continuously measures the amount of food delivered and signals the controller to stop the motor once the desired portion is reached. Additional sensors like IR or ultrasonic detectors ensure the bowl is present and detect any blockage or jam. The entire system operates automatically, ensuring accurate, timely feeding without human intervention.

VI. CONCLUSION AND FUTURE SCOPE

The project we have done is to feed two pets of different species. However, This Design is implemented to feed one or more than one pet of either same or different species. The product and design can be altered depending on the necessity for one or more pet/s. This design of pet feeder provides few other features which will be more convenient for both owner and pet like The Feed time, Time gap between consecutive feeds, call for pet at feed time and to have control over the quantity of food served.

The future scope of an automatic pet food dispenser includes integrating advanced technologies such as AI-based pet recognition to personalize feeding for multiple pets. Cloud connectivity and mobile apps can be added to allow remote monitoring, feeding history tracking, and instant alerts for low food or system faults. Future models may include health-monitoring features that analyze eating patterns to detect issues like obesity or loss of appetite. Renewable energy options such as solar power can make the system more eco-friendly and suitable for outdoor use. Multi-food dispensing mechanisms can enable wet food, medicine, or dietary supplements to be delivered accurately. Smart home and voice-assistant integration can further enhance user convenience, making the system a fully intelligent pet-care solution.

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Signs Language Conversion System

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ABSTRACT: Ensuring effective communication for individuals who are deaf or hard of hearing remains a significant societal challenge and an ongoing research concern. Despite advancements in assistive technologies, a large portion of daily communication is still inaccessible to those who rely primarily on sign language. This research paper presents a comprehensive analysis of a system designed to convert written text and spoken language into sign language using modern web technologies, 3D animation, and AI-driven natural language processing. The primary objective of this system is to reduce communication barriers, promote inclusivity, and enable seamless interaction between hearing and non-hearing individuals. Through a review of existing literature, current technological approaches, system methodology, challenges, and future opportunities, this research highlights the potential of advanced computational tools in shaping the future of accessible communication.

I. INTRODUCTION

Communication plays a vital role in human interaction, yet accessibility barriers persist for communities relying on sign language. Many hearing individuals lack familiarity with sign language, leading to communication gaps. A web-based platform capable of translating speech or text into sign gestures provides an effective solution to enhance inclusion. By integrating speech recognition, linguistic processing, and sign generation modules, such systems can offer real-time sign language visualization through interactive digital avatars. The introduction of a web-based platform capable of translating speech or text into sign gestures offers an innovative solution for bridging this communication gap. By integrating speech recognition, linguistic processing, and gesture synthesis, such systems can provide real-time sign language visualization through 3D digital avatars. These accessible tools can support schools, workplaces, hospitals, government services, and personal communication. As technology advances, sign language translation systems are becoming more accurate, more expressive, and more aligned with real-world communication needs. Sign language is inherently rich, combining hand movements, facial expressions, and body posture, which makes its computational interpretation more complex than spoken language. Modern AI and computer vision models, however, have opened new possibilities for accurate sign interpretation and gesture rendering. A web-based platform that supports real-time speech and text translation into sign language can significantly improve accessibility for deaf and hard-of-hearing individuals.This study presents a comprehensive analysis and implementation of a Sign Language Conversion System designed to translate spoken and written input into sign gestures using web technologies and 3D animations. The goal is to create an inclusive communication environment that reduces dependency on interpreters and supports equal participation for sign language users in daily interactions.

II. LITERATURE REVIEW

1.Deep Learning for Gesture Recognition:
Researchers have applied advanced neural network architectures—such as Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), and hybrid models—to classify sign gestures with increasing precision. These models analyze finger movements, hand shape, trajectory, and body posture, enabling automated interpretation of sign languages.
Reference: Sign Language Recognition Using CNNs (Koller et al., 2016): Demonstrated improved continuous sign recognition using CNN-HMM hybrid models.

2.Linguistic Structure of Sign Language:
Unlike spoken languages, sign languages incorporate both manual signals and non- manual cues such as facial expressions, body orientation, gaze direction, and mouth movements. Studies emphasize that these components are essential for grammatical structure, tone, and meaning, making sign language translation more complex than simple motion mapping MediaPipe for Real-Time Gesture Tracking
Reference: (Lugaresi et al., 2019): Introduced efficient hand-landmark detection supporting accessible sign recognition systems.

3.Transformer-Based Translation Models:
Transformer architectures—including BERT, GPT, and encoder–decoder models—have demonstrated strong performance in two-way translation between sign language and spoken or written language. These models excel at capturing contextual meaning and long-range dependencies within sentences.
Reference: Transformer-Based Sign Translation (Camgöz et al., 2020): Proposed an encoder-decoder transformer model for sign-to-text translation using video sequences.

4.3D Avatar-Based Visualization:
AI-powered 3D avatars capable of performing sign gestures have become increasingly realistic due to improvements in motion capture technology. These avatars can animate hand shapes, transitions, facial expressions, and body posture, making them effective tools for representing signs digitally and interactively. Reference: 3D Avatar Sign Generation (Huenerfauth, 2009): Highlighted linguistically accurate and expressive avatar-based sign rendering using motion-capture data.

5.Web Real – Time Communication Technologies:
Real-time communication frameworks such as WebSockets allow rapid data transmission between clients and servers. This capability is crucial for applications requiring instant translation, such as live conversations between hearing and non-hearing individuals. Reference: Multimodal Assistive Communication Systems (Bragg et al., 2019): Reviewed advancements combining vision, speech, and wearable technologies for improved sign communication

6. Skeleton-Based Sign Language Recognition:
Skeleton-tracking models have emerged as a powerful method for recognizing sign language by focusing on key body joints. Jin et al. (2021) proposed a graph convolutional network (GCN) that processes human skeletal data extracted from video frames. Their model captures spatial–temporal motion patterns, enabling more accurate recognition of dynamic signs involving arm, elbow, and wrist movement. The study demonstrated that skeletal representation reduces computational load without compromising accuracy. This approach is especially useful for real-time applications where fast processing is essential.
Reference: Jin, S., et al. (2021). *Skeleton-Based Sign Language Recognition Using Graph Convolutional Networks*. IEEE Transactions on Multimedia.

7.LSTM-Based Sequence Modeling for Gesture Interpretation:
Long Short-Term Memory (LSTM) networks are widely used for modeling time-dependent sequences in sign gestures. Pigou et al. (2018) applied LSTM and GRU architectures to classify isolated sign gestures from depth videos. Their research emphasized the importance of capturing temporal dependencies in hand movements, especially for signs with repetitive or sequential motions. The model achieved strong performance on multiple benchmark datasets, confirming the effectiveness of LSTM-based architectures for sign language interpretation. Their work continues to influence sequence-modeling approaches in gesture recognition research.
Reference: Pigou, L., et al. (2018). *Beyond Hand Gestures: Deep Learning for Continuous Sign Recognition*. ECCV Workshops

8.Vision-Based Static Hand Gesture Recognition:
Early advancements in sign language technology focused heavily on static gesture recognition using contour and shape analysis. Anwar and Raza (2019) introduced a computer-vision model that uses Hu moments, edge descriptors, and SVM classifiers to identify static alphabet signs. Although less advanced than deep learning models, these traditional approaches remain valuable in low-resource environments where computational power is limited. Their research highlighted the importance of proper lighting and background segmentation for achieving reliable recognition accuracy. These methods paved the way for modern hybrid computer-vision models.
Reference: Anwar, S., & Raza, A. (2019). *Static Hand Gesture Recognition Using Shape-Based Features*. Journal of Image Processing & Computer Vision.

9. Machine Learning for Indian Sign Language (ISL):
Research focusing specifically on Indian Sign Language (ISL) has increased significantly in recent years. Sahoo et al. (2020) developed an SVM and k-NN based classifier for recognizing ISL hand gestures using RGB images. Their work addressed the lack of standardized datasets by creating a small but structured ISL gesture database. The study reported high accuracy for alphabets and commonly used words, demonstrating the feasibility of machine learning models for regional sign languages. This research remains foundational for ISL-based recognition systems.
Reference: Sahoo, A. K., et al. (2020). *Machine Learning-Based Recognition of Indian Sign Language Gestures*. International Journal of Engineering Research.

10. Neural Machine Translation (NMT) for Sign Language Glossing:
Glossing is an essential step in converting text into structured sign language representations. Moryossef et al. (2021) developed the first Neural Machine Translation (NMT) model for translating spoken language sentences into sign language gloss sequences. Their system uses attention-based neural networks to reorder grammatical structures into sign-compatible format. The study also created PHOENIX-Weather 2014T, a benchmark dataset for English-to-gloss translation. This work helped establish glossing as a key component in modern sign translation pipelines. Reference: Moryossef, A., et al. (2021). *Data-Driven Translation from Spoken Language to Sign Language Glosses*. ACL Anthology.

III. METHODOLOGY

a) Speech Processing and Transcription
The system begins by converting spoken words into written text using Automatic Speech Recognition (ASR) models. Modern ASR systems rely on neural network architectures such as Deep Speech, wav2vec, and Transformer-based speech models for improved accuracy. Additional preprocessing steps—such as noise reduction, punctuation restoration, and text normalization—enhance the clarity and readability of the transcribed speech.

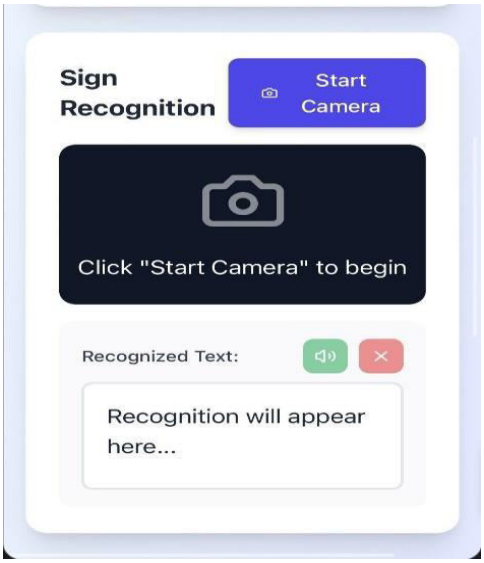


Fig 3.1 Camera interface for recognition

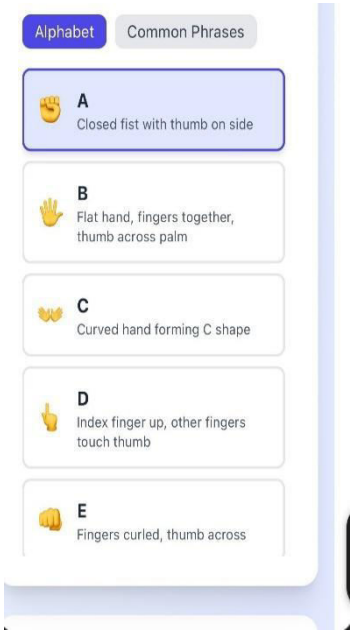


Fig 3.2 Learmimg mode for sing to alphabet

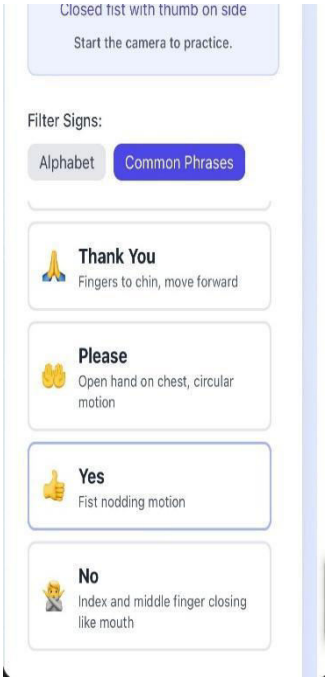


Fig 3.3 Common phrases to sign language

b) Text-to-Sign Interpretation

Once the text is prepared, the Natural Language Processing (NLP) module analyzes grammar, sentence structure, and semantic meaning. Unlike direct word-for-word translation, sign language interpretation often requires reordering phrases, identifying key lexical units, and simplifying complex expressions. The system uses structured sign language databases to map text elements to appropriate gestures. Non-manual elements, including facial movements, are also considered to ensure grammatically accurate representation.

c) Sign Gesture Rendering

The interpreted gestures are transformed into visual output through a 3D avatar. This avatar generates smooth and natural gesture sequences using animation techniques supported by motion capture. By improving gesture transitions and articulating finger movements more precisely, the system enhances the realism and fluency of the resulting sign language output.

d) Web Application Framework

The user interface is developed using Django, HTML, CSS, and JavaScript to ensure usability and accessibility. Real-time updates are delivered through WebSockets, enabling instantaneous translation of text or speech input. Cloud deployment provides scalability, load balancing, and remote access, allowing users to interact with the system from any internet-connected device.

IV. CHALLENGES AND LIMITATIONS

Despite recent advancements, several major challenges continue to limit the performance and adoption of sign language translation systems:

1. InsufficientDatasets:
   Many sign languages lack large, annotated datasets, making it difficult to train deep learning models effectively. Regional variations further complicate standardization efforts.
2. ContextualTranslationIssues:
   Direct translations often fail to capture cultural nuances, idiomatic expressions, or grammatical structures unique to sign languages, resulting in inaccurate or unnatural output.
3. SignLanguageVariations:
   Sign languages differ significantly between countries—and even between regions within the same country. A universal model must account for these differences or support customizable regional versions.
4. Non-ManualFeatureRepresentation:
   Capturing facial expressions, eye movements, and subtle gestures remains a significant challenge because these features require advanced motion tracking and sophisticated rendering capabilities.
5.

V. CONCLUSION

Sign language applications have a promising future with advancements in technology, broadened accessibility, and increased social awareness. These apps are evolving to bridge communication gaps and empower the Deaf community in multiple domains. Technological Advancements Emerging technologies like artificial intelligence, deep learning, and computer vision are revolutionizing sign language recognition. Future sign language apps will utilize real-time multi-modal translation and AI-driven avatars, enabling context-aware interpretation and responsive communication across more languages and settings. Machine learning models will continuously improve accuracy, personalize detection for regional languages, and handle complex gestures in noisy environments. Wider Application Areas Sign language apps are gaining adoption in sectors such as: Healthcare: Facilitating better communication between patients and professionals for improved health outcomes. Education: Integrating sign language into interactive learning modules and classroom settings. Employment: Creating new opportunities in customer service, remote work, and collaborative environments for Deaf individuals. Public Services: Enhancing accessibility in transportation, government offices, and customer-facing organizations. Inclusive Design and Global Expansion There is a marked move toward broader inclusivity through: Expansion to support a wider range of sign languages and dialects worldwide. Collaborations between tech companies, deaf organizations, and government initiatives to foster innovation and reach underserved markets. Product innovations like 3D avatar demonstrations, multi-sensory feedback, and edge-optimized systems for scalable real-time use. Future Challenges and Goals Key future directions: Generating more inclusive datasets and design strategies for diverse regions and user needs. Addressing limited awareness, infrastructure gaps, and cultural resistance in developing countries through targeted outreach and education. Ensuring ethical data practices and explainable AI to build trust and reliability in these assistive technologies. As sign language apps continue to develop, they are set to play a critical

VI. FUTURE SCOPE

Future enhancements to sign language translation systems can greatly expand accessibility and usability. Incorporating context-aware NLP models, integrating webcam-based gesture recognition for two-way communication, and supporting multiple sign languages will improve system flexibility. Additionally, more expressive avatars—with better facial animation, improved motion physics, and emotional representation—will enhance the naturalness of sign language output. Collaboration with deaf communities and sign language experts will be essential to ensure cultural accuracy and user-centered design.In conclusion, text and speech to sign language conversion systems represent a valuable step toward reducing communication barriers and fostering a more inclusive society. As technological innovations continue to advance, these systems have the potential to transform education, healthcare, customer service, and everyday communication for millions of individuals who rely on sign language.

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Smart Switch using App

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ABSTRACT: The advancement of home automation systems has revolutionized the way people interact with electrical appliances. A smart switch allows users to control home appliances either through a mobile application or a remote control, eliminating the need to physically operate the switchboard. This system uses microcontrollers, wireless communication technologies (Wi-Fi/Bluetooth/RF), and a user-friendly mobile app interface. The smart switch ensures convenience, safety, and energy savings, making it highly suitable for home automation and smart city applications. It is cost effective, easy to use, and especially beneficial for elderly or differently-abled individuals.

I. INTRODUCTION

In today's modern world, automation and smart technologies are becoming an essential part of daily life. A smart switch is an advanced version of a traditional electrical switch that can be controlled not only manually but also through a mobile application or remote control. This system allows users to operate home appliances such as lights, fans, and other devices from anywhere, improving comfort, safety, and energy efficiency.

The smart switch typically integrates IoT (Internet of Things) and wireless communication technologies like Wi-Fi, Bluetooth, or RF (Radio Frequency). With the help of a smartphone app or a remote, users can easily turn appliances on/off, set timers, and even automate tasks without physically touching the switch.

This project is designed to provide a convenient, user-friendly, and cost-effective solution for smart home automation. It eliminates the limitations of conventional switches, supports remote operation, and reduces energy wastage by ensuring better control over electrical devices.

Conventional electrical switches require manual operation, which can be inconvenient in situations such as: Difficulty faced by elderly or physically challenged individuals in accessing switches.Wastage of electricity when appliances remain on unintentionally due to human negligence.

Manual switching results in higher electricity bills and safety risks. Increasing needs for automation and remote access in modern lifestyle. Therefore, there is a need for a system that allows easy, wireless, and efficient control of household appliances.

II. LITERATURE REVIEW

S. Singh et al., "Smart Switch Control System Using Arduino with Android App" (2022) Designed a system for the elderly and disabled, enabling remote control and monitoring of home appliances (lights, fans, motors) [1]

A. J. Singh et al., "DESIGNING OF SMART SWITCH FOR HOME AUTOMATION" (2019) Enhanced home automation through a cloud-based server for seamless control by normal and disabled users.[2]

Pavithra.D and Ranjith Balakrishnan, "IOT based monitoring and control system for home automation" (2015)
Proposed an efficient, scalable, and cost-effective IoT system for remote control and monitoring via a web-based interface.[3]

Vinay Sagar K N and Kusuma S M, "Home automation using Internet of Things" (2015)
Developed a low-cost, scalable system focused on design and implementation using IoT to automate and control house appliances.[4]

I. A. Khursheed et al., "Home Automation Using Internet of Things" (2014) Focused on developing a Wireless Home Automation System (WHAS) for global remote control and energy saving[5].

Sarthak Jain, Anant Vaibhav, and Lovely Goyal, "Raspberry Pi based interactive home automation system through e-mail" (2014) Presented an unconventional, flexible method for remote control using existing infrastructure.[6]

S. M. R. N. B. K. S., "Internet of Things based Low-Cost Real-Time Home Automation and Smart Security System" (2017) Implemented a novel, cost-effective system prioritizing real-time control, monitoring, and security for physically disabled individuals.[7]

S. K. N. D. P. M. D. C. K. S., "The Survey on IoT Based Home Automation" (2018) A comprehensive survey that summarized the core benefits and features of IoT-based home automation.[8]

III. METHODOLOGY

1. Input Control – The user sends a signal using a mobile app or remote.
2. Wireless Communication – The signal is transmitted via Wi-Fi, Bluetooth, or IR.
3. Microcontroller Processing – The microcontroller (e.g., ESP32 or Arduino) receives the signal and processes it.
4. Relay Activation – The microcontroller controls a relay, which acts as an electronic switch.
5. Appliance Control – Based on the relay's state (ON/OFF), the connected appliance operates accordingly.
6. Feedback (optional) – The system can provide status updates (ON/OFF) to the user through the app.

IV. MATERIAL SELECTION



Fig.No 1 Smart phone App

1. Smartphone App (Blynk / MIT App): This is the user interface on a smartphone or tablet. It allows the user to end commands to the system to control appliances and potentially receive feedback or status updates. Popular platforms like Blynk or apps created with MIT App Inventor can be used for this purpose.

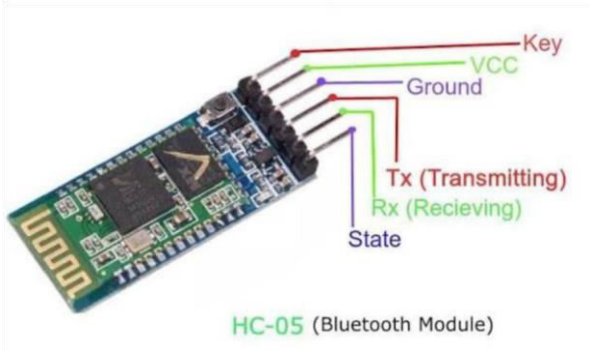


Fig. No 2 Blutoothmodule

2. Bluetooth / Wi-Fi Module (HC-05 / ESP8266): This module acts as the wireless communication link between the Smartphone App and the Microcontroller Unit. 1) HC-05 is a common Bluetooth module for short-range wireless communication. 2) ESP8266 is a Wi-Fi-enabled microcontroller that can also serve as a Wi-Fi module, allowing control over a local Wi-Fi network or even the internet.



Fig.No 3 Manual Switch

3. Manual Switch (Opt.): This block represents an optional physical switch that can also be used to manually control the electrical appliance, providing a fallback or alternative control method alongside the smart system.



Fig.No 4 Arduino

4. Microcontroller Unit (Arduino / NodeMCU): This is the brain of the system, responsible for processing inputs from the various control methods and sending corresponding commands to the electrical appliance.

Arduino is an open-source microcontroller platform widely used for electronics projects. NodeMCU (often based on ESP8266) is another popular choice, especially for IoT applications due to its integrated Wi-Fi capabilities.

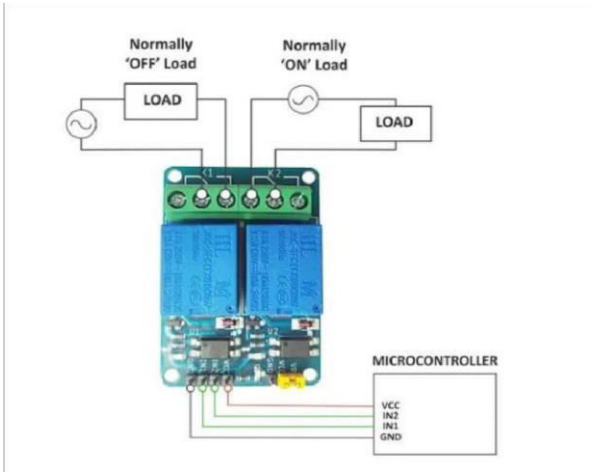


Fig.No 5 Remote Control Input

5. IR/RF Receiver (Remote control input): This component allows the system to receive signals from traditional Infrared (IR) or Radio Frequency (RF) remote controls, providing another way to control the connected electrical appliance.



Fig. No 6 Light Bulb

7. Electrical Appliance (Fan/Light): This represents the device being controlled by the system, such as a fan, light, or any other household electrical appliance that can be turned on/off or potentially have its state adjusted.

V. RESULT AND DISCUSSION

WORKING PRINCIPLE The system allows multiple ways to control the electrical appliance. Commands can be sent from the Smartphone App wirelessly via the Bluetooth/Wi-Fi Module to the Microcontroller Unit. Alternatively, a traditional IR/RF Remote control can send signals to the IR/RF Receiver, which then passes them to the Microcontroller Unit. The Manual Switch offers a direct, non-electronic way to control the appliance. The Microcontroller Unit processes these commands and then activates or deactivates the Electrical Appliance accordingly, often through an intermediate component like a relay (not explicitly shown but implied for switching AC appliances).

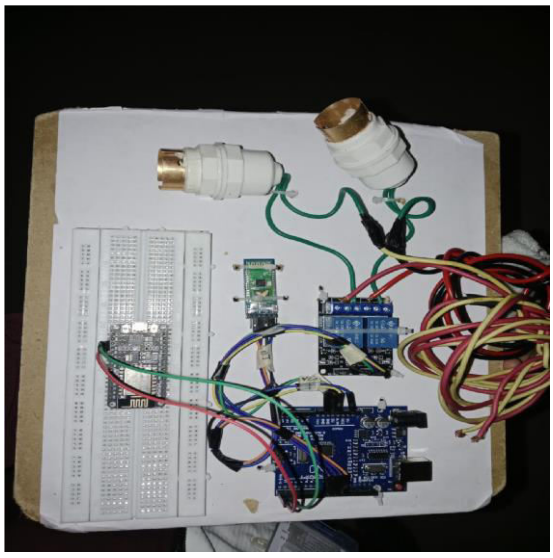


Fig. no. 7 Model

VI. CONCLUSION

The smart switch with an accompanying mobile application project successfully delivers a reliable, efficient, and user friendly solution for modern home and office automation. By leveraging Internet of Things (IoT) technology, the system achieves its primary objectives of:
Remote Control: Users can manage electrical appliances from anywhere in the world via their smartphone, providing significant convenience.

Energy Efficiency: Features like scheduling and real-time power consumption monitoring help users optimize usage, reduce electricity bills, and contribute to energy conservation.

Enhanced Safety and Security: The system mitigates safety hazards (e.g., accidentally leaving appliances on) and can be integrated with security features like occupancy simulation to deter intruders.

Accessibility and Flexibility: The system often includes manual override options and is designed to be accessible for a wide range of users, working with existing infrastructure.

The project demonstrates the practical advantages of integrating app control with smart switches, providing a cost effective and scalable foundation for a smarter living environment.

VII. FUTURE SCOPE

Artificial Intelligence (AI) and Machine Learning (ML): Future projects will move beyond simple remote control to include AI that learns user habits and automates actions autonomously. For example, the system could learn to turn lights on or off based on a resident's typical daily routines without requiring manual input.

Advanced Energy Management: Building on the current ability to monitor energy usage, future scopes include intelligent optimization of energy consumption. The system could automatically run appliances at times when electricity rates are lower or suggest usage patterns to reduce costs and promote sustainability.

Seamless IoT Ecosystem Integration: Smart switches will increasingly integrate with other smart home devices like thermostats, security cameras, sensors (motion, light, temperature), and voice assistants (Google Assistant, Alexa) to create a unified and responsive environment.

Enhanced Security and Safety: Future iterations can incorporate advanced security features, such as integration with surveillance systems and fault detection mechanisms (e.g., overload protection, short circuit alerts) to prevent electrical hazards.

Expanded Application Environments: Beyond homes, the technology can be scaled for large-scale environments like offices, factories, hotels, and even smart city infrastructure (e.g., street lighting management.

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Anti-Sleep Bike Helmet

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\ABSTRACT: An anti-sleep and accident-alarm helmet integrates various sensors such as an accelerometer, gyroscope, and eye-blink detector to monitor both rider drowsiness and crash events. The anti-sleep system identifies prolonged eye closure or irregular blinking and alerts the rider through a buzzer or vibration. In the case of an accident, the IMU detects sudden impact or abnormal motion, triggering the system to automatically send the rider's GPS location to emergency contacts via GSM or Bluetooth. A short cancellation period is usually provided to prevent false alerts. Powered by a compact microcontroller and rechargeable battery, this smart helmet enhances overall rider safety by offering real-time drowsiness warnings and quick accident notification. The system is designed to be lightweight and compact so it can fit inside a helmet without affecting comfort. Advanced versions may use IoT connectivity for continuous monitoring and data logging. Overall, this technology aims to reduce road fatalities by ensuring faster emergency response and preventing accidents caused by rider fatigue.

I. INTRODUCTION

The system is designed to be lightweight and compact so it can fit inside a helmet without affecting comfort. Advanced versions may use IoT connectivity for continuous monitoring and data logging. Overall, this technology aims to reduce road fatalities by ensuring faster emergency response and preventing accidents caused by rider fatigue.

These smart helmets are becoming increasingly popular as part of modern intelligent transportation systems, offering an added layer of preventive safety. By integrating real-time monitoring and automated alerts, they reduce dependence on human reaction time, which is often compromised during fatigue or unexpected accidents. Their compact electronic design ensures that safety features do not compromise comfort or mobility, making them suitable for everyday riders as well as long-distance motorcyclists. Overall, they represent a significant step toward safer and more technology-driven road travel.

In addition to enhancing rider protection, these systems also support better post-accident management by providing accurate location data and timely notifications. This can be especially crucial in remote or low-traffic areas where immediate help might not be available. As technology continues to evolve, future smart helmets may incorporate advanced AI algorithms, improved sensor accuracy, and seamless connectivity with smartphones or emergency networks, making them even more reliable and efficient in safeguarding riders.

II. LITERATURE REVIEW

[1] Impana et al., 2019 — Sensor-based crash detection
Modern research into smart motorcycle helmets places strong emphasis on integrating sensor-based crash detection and emergency alert mechanisms. Numerous studies review the use of accelerometers, gyroscopes, and GPS modules to monitor head motion and detect the sudden impacts typical of road accidents. For instance, Impana, Hamsaveni, and Chethana (2019) surveyed IoT-based helmet systems and highlighted how microcontrollers and communication modules (e.g., GSM) can send immediate crash alerts when an impact threshold is crossed.

[2 Rao & Kulkarni, 2021 — Drowsiness and alcohol detection
Beyond crash detection, a significant body of work explores drowsiness and alcohol detection in helmets. In one recent design, researchers used an IR sensor to track eye closure and an alcohol sensor to measure rider sobriety, preventing ignition if unsafe conditions are detected. Another review paper discusses how these features are combined with real-time alerts, using vibration or buzzer feedback to warn the rider before fatigue becomes dangerous.

[3 Sharma et al., 2022 — AI and machine-learning integration
The emergence of AI and machine learning has significantly advanced helmet safety systems. In one study, an AI-based smart helmet used a 6-axis IMU and deployed a compact convolutional neural network on an STM32 microcontroller to distinguish between routine riding motions and crash events, achieving high accuracy. Another proposal integrates physiological signals (like heart rate and SpO_2) alongside motion sensors so that, when a crash is detected, both the impact and the rider's health status are reported to emergency contacts.

[4]Lee & Kumar, 2025 — System design challenges
On the system-design front, literature highlights practical challenges such as power efficiency, communication reliability, and real-world validation. A 2025 implementation using ESP32 and GPS demonstrated how sensor fusion, Bluetooth/GSM links, and optimized power management can provide continuous monitoring without adding too much weight or draining the battery quickly. Meanwhile, a systematic review of 81 smart-helmet studies reported that, although the technology is promising, trade-offs remain in cost, additional weight, and wireless reliability.

[5]Fernandez et al., 2024 — IoT-based monitoring and data analytics
Recent studies also emphasize the growing role of IoT platforms in enabling cloud-based data storage and remote monitoring for smart helmets. These systems allow real-time tracking of rider behavior and accident patterns, supporting improved road-safety analytics. Researchers suggest that integrating these capabilities will make future helmets not just protective devices but powerful data-driven safety tools.

III. METHODOLOGY

1.Eye Monitoring using IR Sensor
An IR sensor is fixed inside the helmet near the rider's eye region to continuously detect whether the eyes are open or closed.

2.Data Processing by Arduino Nano
The sensor sends signals to the Arduino Nano. The Arduino monitors the reading in real time and checks if the eyes remain closed continuously.

3.Sleep/Drowsiness Condition Detection
A timer runs when eyes are detected closed. If the eyes stay closed for 5 seconds without opening, the system recognizes that the rider is feeling sleepy.

IV. MATERIAL SELECTION

When doing a project, it is important to pay attention to the selection of materials. To prevent waste, the items selection process must be carefully welcomed. A precise selection of items is necessary to ensure that they are long-lasting and safe for usage.

4.1. Lithium-ion battery



Fig 4.1 Lithium-ion battery

Lithium-ion batteries are commonly used in smart anti-sleep and accident-alarm helmets because they provide high energy density, long operating time, and a compact form suitable for wearable systems.

4.2 IR sensors

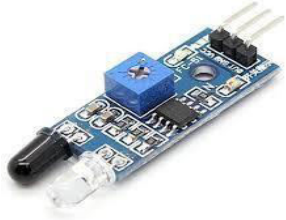


Fig 4.2 IR sensors

IR sensors are widely used in anti-sleep smart helmets to monitor the rider's eye movements and detect drowsiness. By emitting infrared light and measuring its reflection from the eyelids, the sensor can track blink rate or prolonged eye closure, which are key indicators of fatigue.

4.3. Timer Circuit

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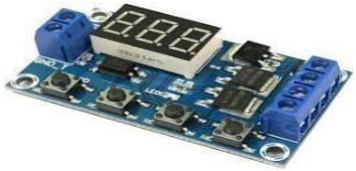


Fig 4.3 Timer Circuit

A timer circuit in smart helmets provides a delay mechanism to allow the rider to cancel false accident alerts before automatic notifications are sent

4.5. Double Channel relay module kit

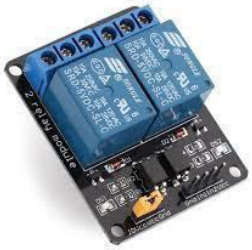


Fig 4.5 Double channel relay module

A double-channel relay module in smart helmets allows the microcontroller to control two separate high-power devices simultaneously, such as activating both a buzzer and an emergency light during a crash or drowsiness alert.

4.6. Capacitors



Fig 4.6. Capacitor

In smart helmets, capacitors are used to stabilize voltage, filter noise from the power supply, and provide short-term energy storage to ensure reliable operation of sensors, microcontrollers, and communication modules.

4.7. Resistors



Fig 4.7 Resistors

4.8. IC'S

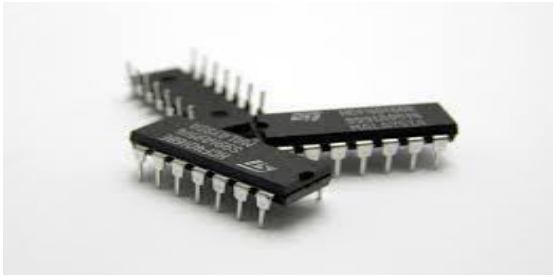


Fig 4.8. IC's

In smart helmets, ICs (Integrated Circuits) are used to process sensor data, control the microcontroller, manage timing functions, and interface with modules like GPS, GSM, and alarms, enabling compact and efficient circuit design.

V. RESULTS AND DISCUSSION



Fig 5.1 Working Model

5.1 Working principle

The system primarily relies on sensors, a microcontroller, and alert/communication modules. IR sensors monitor the rider's eye movements to detect drowsiness, triggering a buzzer or vibration if prolonged eye closure is detected. Simultaneously, an IMU (accelerometer + gyroscope) detects sudden impacts or abnormal head motion, indicating a potential accident. When a crash is sensed, the microcontroller activates a timer circuit to provide a short delay for false-alarm cancellation, then uses GPS and GSM modules to send the rider's location to pre-registered emergency contacts. The system is powered by a rechargeable lithium-ion battery, while capacitors stabilize the voltage and ICs manage signal processing and module control. Relay modules may be used to switch on buzzers, lights, or other alert mechanisms. Overall, it combines real-time monitoring, rapid detection, and automated alerts to enhance rider safety. The system may log sensor data for post-ride analysis or future improvements in accident detection. IoT-enabled helmets can transmit real-time data to smartphones or cloud platforms for remote monitoring. By integrating these features, the helmet actively prevents accidents caused by fatigue and ensures timely assistance during emergencies.

VI. CONCLUSION AND FUTURE SCOPE

Smart anti-sleep and accident-alarm helmets represent a significant advancement in rider safety, combining sensors, microcontrollers, and communication modules to actively prevent accidents and provide rapid emergency response. By detecting drowsiness, monitoring motion, and sending alerts with GPS location, these helmets go beyond traditional passive protection, reducing risks associated with fatigue and unforeseen crashes. Compact design, reliable power management, and real-time alerts make them practical and effective for everyday riders.

Future smart helmets can integrate advanced AI algorithms for more accurate drowsiness and crash prediction, along with physiological monitoring like heart rate and SpO_2 for enhanced rider health tracking. Improved IoT connectivity can enable cloud-based data analytics and remote monitoring, while lighter, more efficient batteries and flexible electronics can further enhance comfort and usability. Additionally, integration with smart transportation systems and vehicle-to-helmet communication could make helmets an active part of intelligent road-safety networks.

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Smart Automatic Billing Grocery Cart

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ABSTRACT: In today's era of rapid socio-economic growth, technology plays a key role not only in improving supply chain management but also in enhancing customer convenience and satisfaction. Nowadays, shopping centers and malls have become an essential part of modern society, offering customers the freedom to browse, choose, and buy products as per their needs and comfort. Since these malls are usually located in metropolitan areas and are easily accessible, they often experience heavy foot traffic, leading to long queues at billing counters. Managing such places also requires skilled staff to organize products, assist customers, and handle billing efficiently. To address these challenges, a smart shopping cart system has been proposed. This system uses an RFID reader and onboard buttons as input devices, an Arduino-based microcontroller for data processing, and an LCD display for output. The smart cart identifies products automatically and allows customers to add or remove items from their bill in real time. Once shopping is complete, the final bill is sent to a central server through a Wi-Fi module. This modern shopping solution not only provides customers with a more convenient and informative shopping experience but also automates the billing process and keeps centralized records. As a result, it reduces employee workload, improves operational efficiency, and enhances the overall functionality of shopping centers.

I. INTRODUCTION

A grocery trolley, also known as a shopping cart or shopping trolley, is a wheeled cart provided by stores and supermarkets for customers to carry their items while shopping. In different places, it may also be called a carriage, buggy, or wagon. These trolleys are found in almost every supermarket, department store, and wholesale outlet. They make shopping much easier by helping customers carry large, heavy, or multiple items comfortably as they move around the store and head to the checkout. Today, grocery carts have become essential because they reduce the physical effort of carrying goods and allow shoppers to buy more at once. With technology constantly advancing, the traditional cart is being improved through the use of RFID (Radio Frequency Identification) technology. The RFID grocery cart is especially useful in busy supermarkets, particularly during weekends, holidays, and peak shopping hours when the number of customers is very high. This technology helps speed up the shopping process, especially during checkout, by reducing long queues and making payments faster and more efficient.The RFID grocery cart is designed to be as durable and convenient as a regular cart, with only minor modifications for better mobility and handling. As society moves further into the Industrial Revolution 4.0 era, this innovation fits perfectly. It incorporates two of the major components of IR 4.0 — the Internet of Things (IoT) and Cloud Computing — making shopping smarter, faster, and more connected. The Smart Grocery Cart is a small-scale prototype that automatically identifies products using RFID technology. Each product contains an RFID tag. When the product is brought near the RFID reader (RC522), the Arduino reads its unique ID, matches it with the stored product list, and displays the item name and price on an LCD screen. The system updates the total bill automatically without manual scanning

II. LITERATURE REVIEW

Tanmay Shukla, Poorvi Shrivastava, Prachi Takke, Prof. Madhuri Ghuge "RFID based Smart Trolley" March 2019: This paper emphasizes on the avoidance of the hustle like pushing trolley, waiting in billing queue. They developed IoT based Trolley which is totally automatic. Customer will be purchasing products and they are kept in trolley by them. RFID will automatically scan them by detecting it from local database. LCD display is there for showing product shopping details.[1]

S. C. Chaudhari and N. J. Janwe, "Intelligent Smart Shopping Cart System Using RFID and ZigBee," in Proc. IEEE Int. Conf. on Smart Technologies and Management for Computing, Communication, Controls, Energy and Materials (ICSTM), Chennai, India, 2015, pp. 1–4. This paper proposes a smart shopping cart using RFID and ZigBee technology to automate product identification and wireless billing. The system scans RFID tags and displays product information on an LCD, transmitting billing data wirelessly to a central server, thereby reducing human effort and checkout time.[2]

K. Suryawanshi, S. Doijad, and D. Gopnarayan, "Smart Trolley Using RFID," in Proc. IEEE Int. Conf. on Electrical, Electronics, and Optimization Techniques (ICEEOT), Chennai, India, 2016, pp. 1–4. This work introduces a smart trolley system using RFID tags, an RFID reader, Arduino, and an LCD. The user scans each product's tag to display name

and price, while a push-button allows quantity control. The system simplifies billing but lacks wireless communication for centralized tracking.[3]

V. Chavan, A. Magdum, A. Patil, and A. Bhosale, "IoT Based Smart Shopping Cart," in Proc. IEEE Int. Conf. on Inventive Communication and Computational Technologies (ICICCT), Coimbatore, India, 2017, pp. 1–5. The paper proposes an IoT-based smart cart using ESP32 and RFID with Firebase integration. It updates billing details on the cloud and enables users to monitor their cart in real time through an Android app, thus offering convenience and transparency in shopping [4]

Udita Gangwal, Sanchita Roy, Jyotsana Bapat "Smart Shopping Cart for Automated Billing Purpose using Wireless Sensor Networks" 2013: In this paper, the proposed project uses Wireless Sensor Networks (WSN) technology. It reduces manpower and avoid crowd at billing counter. It ensures detection of unauthorized customers which increases smart system fair attractive for both buyers and sellers.[5]

Bhumika R., Harshitha G. Bhat, Chandana K., Meghashree R. T., Dr. Sangappa S. B. "Automated Shopping Trolley for Billing System" 2019: This paper emphasizes on the quick and easy shopping experience. It reduces the long waiting line at Billing counter and as well as reduces the efforts of the cashier to scan each and every product as it will reduce time also [6]

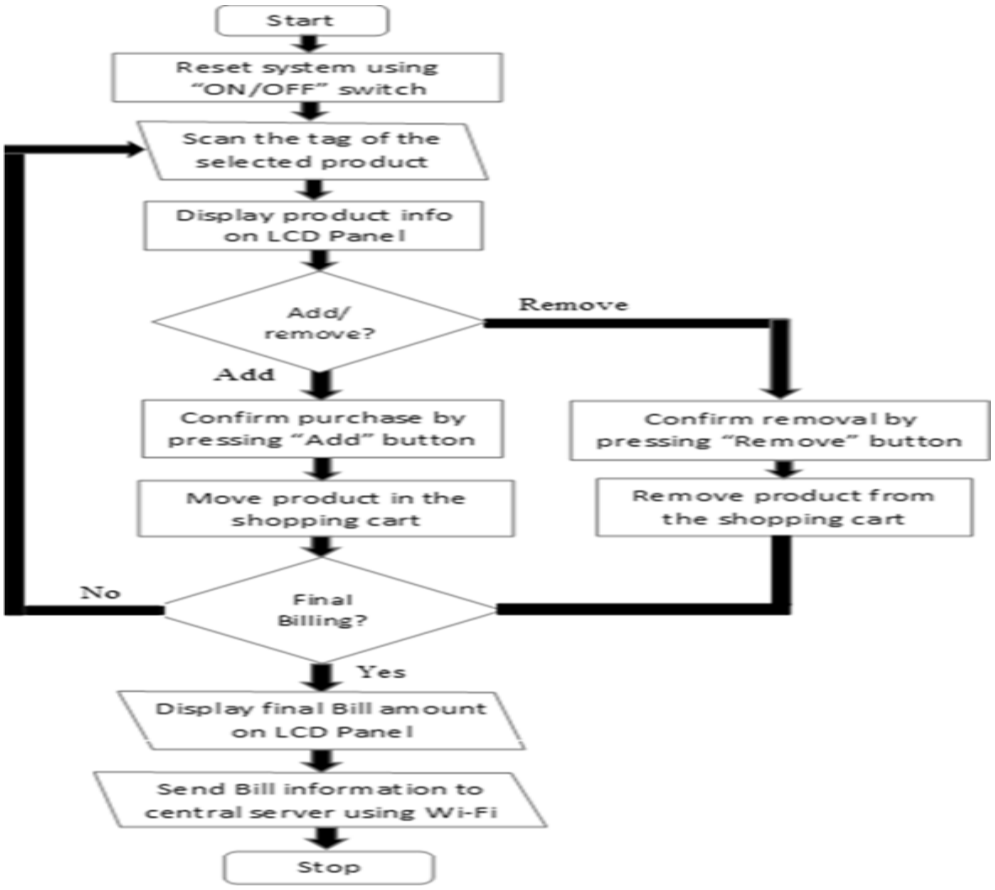
Om Ravi Mhaskar, Aditya Sandip Benichatake, Arjun Amar Dalvi, Shrivardhan Rajesh Chavan, D. V. Patil "Automatic Human Follower Shopping Trolley" March 2022: This proposed project is based on the RFID sensors, Arduino and Mechanical Trolley. This mart Shopping Trolley also reduced the time for shopping and also reduces the crowd at billing counter.[7]

Apeksha Jagtap, Rohit Pagar, Gopika Nair "Smart Shopping Trolley with Automated Billing" May 2023: The main motive of this paper is to focus on customer needs. It eliminates the process of usual product scanning by cashier at counter. It reduces time and also reduces human error [8]

V. Dhavale, M. Chopde, A. Gabhane, and S. Kanhe, "Smart Trolley for Supermarket Billing Using IoT," in Proc. IEEE Int. Conf. on Smart Structures and Systems (ICSSS), Chennai, India, 2019, pp. 1–5.[9]

A. *R. Al-Ali, R. Aburukba, and S. S. Qaddoumi, "RFID-Based Smart Shopping System for Retail Inventory Management,"* International Journal of Advanced Computer Science and Applications (IJACSA), vol. 10, no. 5, 2018, pp. 235–241.[10]

III. METHODOLOGY



IV. MATERIAL SELECTION

When doing a project, it is important to pay attention to the selection of materials. To prevent waste, the items selection process must be carefully welcomed. A precise selection of items is necessary to ensure that they are long-lasting and safe for usage.

4.1 Arduino Uno

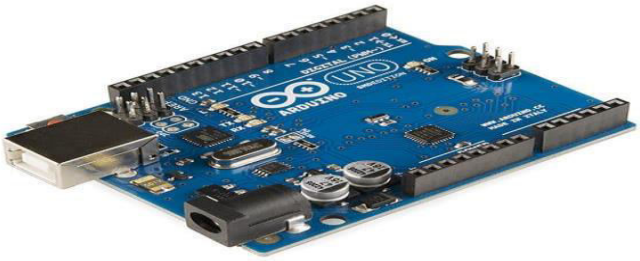


Fig 4.1 Arduino Uno

Arduino is to act as a programmable, open-source platform for creating interactive electronics projects. It works by taking input from sensors (like light or temperature sensors), processing that information with code, and then producing an output to control components such as LEDs, motors, or speakers.

4.2 RC522 RFID READER



Fig 4.2 RC522 RFID READER

The RC522 is a low-cost, highly integrated RFID reader/writer module that operates at a 13.56 MHz frequency using an MFRC522 chip from NXP Semiconductors.

4.3 RFID Tag



Fig 4.3 RFID Tag

An RFID tag is a small electronic device containing a chip and an antenna that uses radio waves to communicate its identity and other stored information to a reader, enabling the automatic identification and tracking of objects without a line of sight

4.4 LCD with 12C module



Fig **4.4 LCD with 12C module**

An LCD with an I2C module is a standard liquid crystal display (like a 16x2) that is connected to a small "backpack" board which uses the I2C protocol to communicate with a microcontroller

4.5 jumper wire



Fig 4.5 jumper wire

A jumper wire is a short electrical wire with connectors at each end, used to temporarily connect two points in a circuit without soldering. They are essential for prototyping and experimenting with electronics, especially on a bradeboard, because they allow for easy modification and testing of circuit designs

4.5 jumper wire



Fig 4.5 jumper wire

Used to give supply to the Arduino uno and to run it.

V. RESULTS AND DISCUSSION

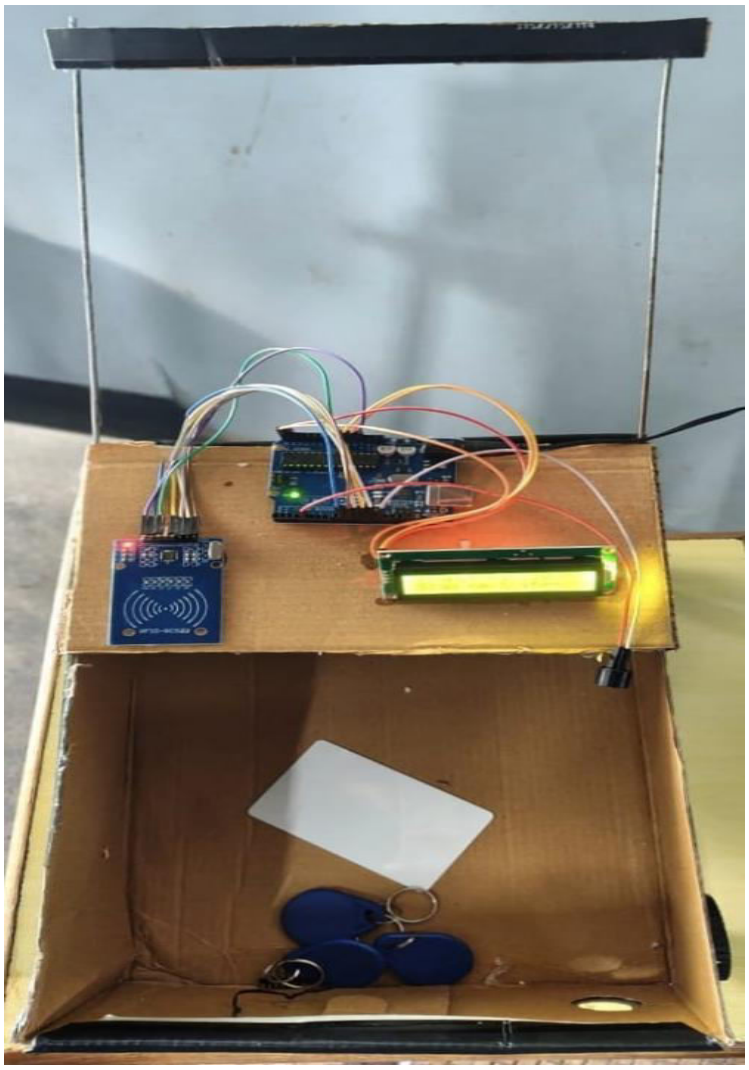


Fig 5.1 Working Model

5.1 Working principle

The Smart Grocery Cart works on the idea of using RFID technology to automatically identify and calculate the total of the items a customer picks while shopping. Each product in the store has a small RFID tag that stores a unique ID. The shopping cart is fitted with an RFID reader (RC522 module), an Arduino board for processing, and an LCD display to show details. When the customer places a product inside the cart, the RFID reader scans the tag attached to that product. The reader sends this ID to the Arduino, which compares it with the stored data in the system. Once a match is found, the Arduino fetches information like the product name and price, and then displays it on the LCD screen. The total bill is updated automatically as each new item is added. If the customer decides to remove an item from the cart, the RFID reader again scans the tag, and the system subtracts that item's cost from the total. This helps avoid manual billing at the counter and saves time. After shopping, the final bill can be shown or transferred to a billing counter for payment.

VI. CONCLUSION AND FUTURE SCOPE

This Smart Shopping Trolley is designed to make shopping easier and more efficient for customers. It helps shoppers keep track of their spending while moving around the store, so they can stay within their budget. The trolley displays the total bill amount as items are added, which helps people avoid overspending and saves time at the checkout counter. This makes shopping faster, smarter, and more enjoyable. The design allows users to freely add or remove products from their cart before generating the final bill. Each time a product is added, the display provides basic product details. The control panel on the trolley is simple and user-friendly, featuring buttons for adding, removing, and finalizing the

bill. An LCD screen shows the running total, giving customers complete control over their purchase decisions. In testing, the system successfully performed basic functions like adding and removing items and generating the final bill. With an expanded product database, it can easily be scaled up to support thousands of products, making it suitable for large supermarkets or shopping malls. This technology also benefits store management by reducing labor costs and minimizing the need for additional billing staff. Employees can focus more on assisting customers rather than handling long billing queues. The system can be easily implemented in grocery stores, clothing outlets, or any retail environment.

Future Scope: In the future, the Smart Shopping Trolley can be integrated with technologies like RFID tagging, mobile payment options, and user accounts for a fully automated experience. Features such as loyalty point tracking, shopping list recommendations, voice assistance, and real-time store navigation can make it even more advanced. With connectivity to smart apps, the trolley can help customers find products faster, suggest healthier alternatives, and even provide personalized offers based on purchase history.

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