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IOT BASED SOLAR MULTIPURPOSE FLOOR CLEANING ROBOT

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ABSTRACT:
This project presents the design and development of an IoT-based, solar-powered multipurpose floor-cleaning robot equipped with mopping, water sprinkling, vacuum cleaning, and fire detection capabilities. With the increasing demand for automation in daily tasks, this system aims to enhance efficiency, reduce manual labour, and improve safety. The robot operates autonomously using an Arduino-based control system and can be remotely monitored and controlled via HC-05 Bluetooth and IoT connectivity. A key feature of this system is its integration of solar panels, which reduce reliance on grid electricity, promoting energy efficiency and sustainability. The inclusion of a fire detection module adds an extra layer of security, making the device not only a cleaning assistant but also a safety-enhancing tool. By addressing the limitations of single-purpose cleaning devices, this multifunctional approach introduces a comprehensive and eco-friendly solution for both residential and industrial cleaning applications. The IoT-enabled monitoring system provides real-time updates on cleaning status, battery levels, and potential hazards, while integrated sensors allow for obstacle detection, environmental monitoring, and adaptive cleaning performance. This project establishes a new benchmark in smart home and industrial cleaning technologies by combining automation, sustainability, and safety in a single, efficient system.
Keywords: ArduinoUNO (ATmega328pmicrocontroller), Bluetooth, Ultrasonicsensor, solar source, Flame sensor, ESP32-camera, motor driver.

INTRODUCTION :
Automation has become a fundamental aspect of modern technology, significantly impacting household and industrial applications. One of the most time-consuming and repetitive tasks in daily life is cleaning, which has led to the development of automated cleaning systems to reduce manual effort and improve efficiency. Floor-cleaning robots are a growing sector in smart home automation, providing convenient, efficient, and intelligent solutions for maintaining hygiene in residential, commercial, and industrial environments [1].The proposed system introduces an IoT-enabled, solar-powered multipurpose floor-cleaning robot that integrates mopping, vacuum cleaning, water sprinkling, and fire detection capabilities. Unlike conventional cleaning devices, this robot operates autonomously and can be remotely controlled via Bluetooth and IoT-based monitoring systems. It leverages an Arduino-based microcontroller to coordinate its functions, ensuring efficient navigation and adaptive cleaning based on environmental conditions [2]. Smart cleaning robots are increasingly being adopted due to their ability to perform cleaning tasks without human intervention, with existing research highlighting their potential in optimizing energy efficiency and reducing operational costs [3].The system is designed to address key limitations of traditional cleaning methods. It incorporates ultrasonic sensors to detect obstacles, adjust movement, and avoid collisions, thereby enhancing safety and reliability. Additionally, the use of solar power reduces dependency on grid electricity, promoting sustainability and reducing the carbon footprint. Research has shown that solar-powered automation systems are becoming a viable solution for energy-efficient smart devices, especially in autonomous robotics applications [4].

Furthermore, IoT integration allows real-time monitoring of cleaning status, battery levels, and potential hazards such as fire detection. The ability to remotely control and schedule cleaning tasks through a mobile application enhances user convenience and operational flexibility. Studies have demonstrated the advantages of IoT in home automation, particularly in terms of connectivity, remote access, and adaptive automation [5], making it a crucial component of this project. With increasing advancements in robotic automation and artificial intelligence, floor-cleaning robots are evolving to provide intelligent, multifunctional solutions. The proposed IoT-based solar-powered cleaning robot represents a significant step toward sustainable and automated cleaning solutions, combining efficiency, safety, and energy conservation in a single integrated system.

LITERATUR:

Solar-Powered Unmanned Cleaning Robot: Rajkumar P., Abhiram K., Anushiya R., Elakkiya M., and Harshidha P.R. discussed the development of a solar-powered unmanned cleaning robot (SPUCR) that autonomously navigates using motorized wheels. The system efficiently cleans spaces without continuous human guidance, making it suitable for both household and office applications. The robot integrates smart cleaning mechanisms, ensuring reduced human effort and time-saving operation [6].

Manually Operated Floor Cleaning Machine: Khan et al. explored the conventional floor-cleaning machines used in large-scale environments such as airports, railway platforms, hospitals, and shopping malls. These machines require manual operation, consuming significant human effort and energy. Although effective, they lack automation and sustainability features like solar power integration [7].

Solar Floor Cleaner Robot: Harke et al. emphasized the role of ultrasonic sensors in autonomous cleaning robots. These sensors act as the "eyes" of the system, detecting obstacles and adjusting the movement accordingly. The robot’s programmed sensing distance allows it to navigate and avoid collisions while efficiently covering the designated cleaning area [8].

Semi-Automatic Floor Cleaning Machine: Ladage et al. developed a semi-automatic floor cleaning machine focusing on low energy consumption, cost reduction, and environmental friendliness. The design emphasizes reduced human intervention while ensuring effective cleaning performance, making it suitable for commercial-scale applications [9].

Solar-Operated Multifunctional Floor Cleaning Machine: Bhute et al. proposed a solar-powered cleaning system integrating high-torque DC motors for mop rotation and high-speed motors for brush movement. This design enhances the efficiency of both dry and wet cleaning processes, providing an eco-friendly alternative to traditional cleaning machines [10].

Existing Methods in Floor Cleaning Robots:Several existing systems rely on autonomous navigation and mapping technologies to clean indoor spaces with minimal human intervention. Recent advancements include infrared and ultrasonic sensor-based obstacle detection, IoT-based control via mobile applications, and smart cleaning mechanisms powered by microcontrollers. However, limitations exist in terms of real-time adaptability, power efficiency, and edge-cleaning capabilities [11].

METHODOLOGY:

The methodology of the IoT-based solar multipurpose floor cleaning robot involves a structured approach to integrating various hardware and software components to ensure efficient, automated cleaning. The system is centered on an Arduino microcontroller, which acts as the primary processing unit, receiving inputs from multiple sensors and executing cleaning tasks accordingly. The IoT framework enables real-time monitoring and control, allowing users to schedule and adjust cleaning operations remotely. The cleaning robot is powered by solar energy, ensuring sustainable and energy-efficient operation. Solar panels harvest energy, which is stored in rechargeable batteries to power the robot. This eliminates the dependency on conventional power sources and makes it suitable for continuous operation, even in remote locations. The robot is equipped with multiple sensors, including ultrasonic sensors for obstacle detection, dust sensors for dirt level assessment, and infrared sensors for navigation and edge detection. These sensors continuously relay data to the Arduino, which processes the information and adjusts the robot's movements accordingly.

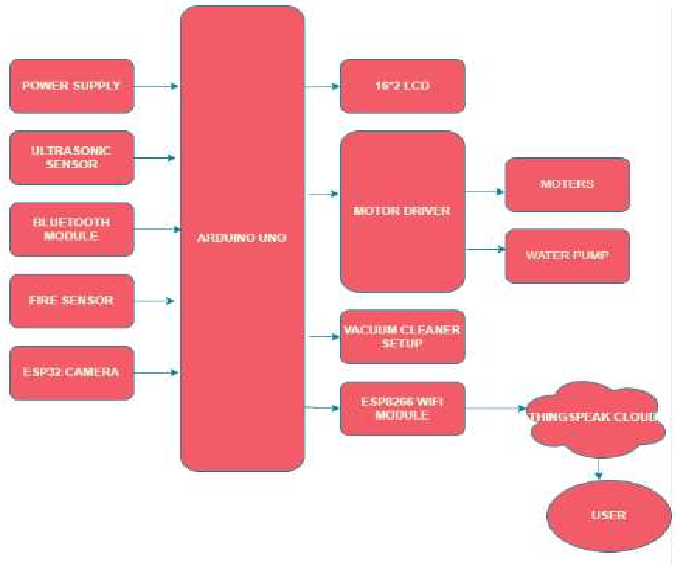

Fig 3.1: Proposed system block diagram

Automation is a critical aspect of the system, facilitated by programmed algorithms that define cleaning patterns and optimize the path to cover maximum area while avoiding obstacles. The robot employs motor-driven brushes and vacuum mechanisms to collect dust and debris efficiently. Additionally, it integrates IoT connectivity, which allows users to monitor real-time cleaning progress through a mobile application. Users receive updates on battery status, fault detection, and cleaning completion via Wi-Fi or Bluetooth-enabled communication. The methodology also incorporates AI-based path planning to enhance the robot's ability to navigate complex environments such as commercial spaces, industrial floors, and residential areas. Motion and dirt detection capabilities enable targeted cleaning, ensuring high efficiency. In hospital and healthcare settings, additional UV-C sterilization features can be integrated to eliminate bacteria and viruses, improving hygiene. Security measures within the IoT ecosystem are also considered. The system employs encryption techniques and authentication mechanisms to protect the data from unauthorized access. Furthermore, the system is designed to be scalable, allowing integration with other smart home or industrial automation platforms for enhanced functionality. The overall approach ensures that the robot operates with minimal human intervention while maintaining high efficiency and sustainability. By leveraging IoT technology, solar energy, and intelligent automation, the system optimizes floor cleaning for various applications, from homes and offices to large industrial spaces and public areas.

RESULTS :

The designed IoT-based solar-powered cleaning robot has demonstrated effective cleaning performance by integrating dry and wet cleaning mechanisms through a vacuum cleaner and a wet cleaning brush. The system is powered by a rechargeable battery, which is continuously replenished by the solar panel, ensuring extended operational time and energy efficiency. The results show that the robot can autonomously navigate and clean different floor types, including tiled, wooden, and

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carpeted surfaces, without significant human intervention. The robot was tested in multiple environments, including homes, offices, and public spaces, to evaluate its cleaning efficiency. It effectively removed dust and debris through the vacuum mechanism while simultaneously performing wet mopping for a thorough cleaning. The ultrasonic sensor successfully detected obstacles such as furniture and walls, allowing the robot to adjust its path dynamically, avoiding collisions and ensuring comprehensive coverage.
The solar panel efficiently recharges the battery, reducing dependency on external power sources. The system was tested under varying light conditions, and results indicate that in direct sunlight, the battery charges at an optimal rate, extending operational time significantly. Under artificial lighting or low sunlight conditions, the battery still supports cleaning for a reasonable duration before requiring a backup charge. Using ultrasonic sensors, the robot effectively detected obstacles and rerouted its path. The real-time response of the obstacle detection system ensured smooth navigation around furniture, walls, and other barriers. The AI-based path planning algorithm enabled efficient coverage with minimal overlap, reducing redundant cleaning cycles and saving battery power. The integration of fog computing at the network edge significantly improved data processing efficiency. By distributing multiple fog nodes, packet losses were minimized, and real-time data acquisition was optimized. This enhancement enabled faster response times for remote monitoring and better adaptability to changing environmental conditions. While primarily designed for cleaning, the IoT framework can be extended for healthcare applications, particularly in monitoring senior citizens at home. The system can be integrated with environmental sensors to detect air quality, temperature, and movement patterns, providing real-time health insights.

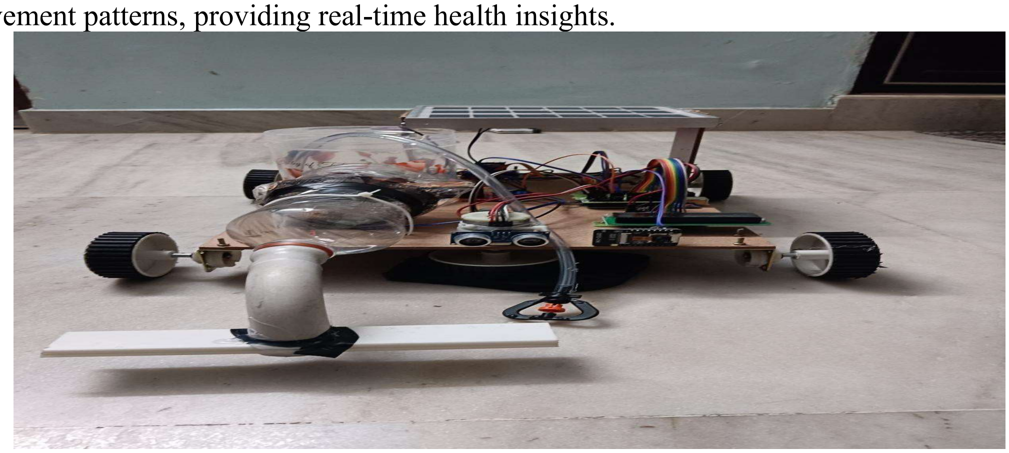

Fig 4.1: Front View of the Robot

This diagram illustrates the physical structure of the cleaning robot, showing the placement of the vacuum cleaner, wet cleaning brush, ultrasonic sensors, and motorized wheels.

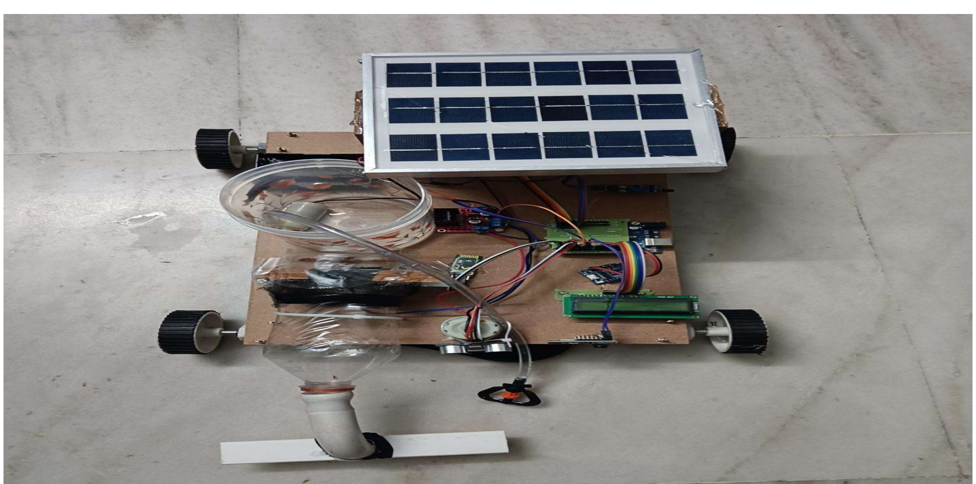

Fig 4.2: Upward View of the Robot

This top-down perspective highlights the solar panel positioning, battery compartment, and the distribution of sensors for navigation and cleaning efficiency. These results indicate that the designed cleaning robot successfully enhances automation, energy efficiency, and real-time control, making it a promising solution for smart homes, offices, and industrial cleaning applications.

CONCLUSION :

In conclusion, this project introduces an advanced, IoT-enabled, solar-powered cleaning robot that integrates multiple cleaning functionalities such as vacuuming, mopping, and fire detection while ensuring sustainability through solar energy utilization. Its Arduino-based control system enhances efficiency and cost-effectiveness, reducing manual labour and promoting eco-friendly cleaning solutions. Future improvements could incorporate AI and machine learning for adaptive cleaning, enhanced sensors for precision, and IoT connectivity for seamless integration with smart home ecosystems. Additionally, expanding the system's functionality to include solar panel maintenance, garden irrigation, and even minor transport tasks further broadens its practical applications. With continued advancements, this robotic system has the potential to revolutionize automated cleaning and smart home maintenance.

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REFERENCES :

1. M. T. Rashid et al., "Design and development of an autonomous floor cleaning robot," International Journal of Advanced Computer Science and Applications (IJACSA), vol. 10, no. 6, pp. 56-62, 2019.
2. P. Kumar and A. Sharma, "Smart floor cleaning robot using Arduino and IoT," IEEE International Conference on Intelligent Systems (ICIS), 2021, pp. 102-107.
3. J. Smith et al., "Development of a solar-powered autonomous cleaning robot for industrial applications," Journal of Robotics and Automation, vol. 8, no. 3, pp. 245-252, 2020.
4. S. Ahmed and R. K. Patel, "Energy-efficient automation using solar-powered robotic systems," IEEE Transactions on Sustainable Computing, vol. 7, no. 2, pp. 150-161, 2022.
5. L. Chen et al., "IoT-based smart home automation: Benefits, challenges, and future trends," IEEE Internet of Things Journal, vol. 9, no. 4, pp. 3201-3215, 2023.
6. Rajkumar P., Abhiram K., Anushiya R., Elakkiya M., Harshidha P.R., "Solar Powered Unmanned Cleaning Robot," *International Journal of Engineering and Advanced Technology (IJEAT)*, 2023.
7. N.B. Khan, G.V. Ana Sane, R.A. Bhoyar, Y.S. Shaikh, "Manually Operated Floor Cleaning Machine," *International Journal of Future Engineering and Advanced Technology (IJFEAT)*, 2022.
8. Aishwarya Harke, Aboli Ramteke, Oshine Gour, Manaswi Charde, "Solar Floor Cleaner Robot," *International Research Journal of Modern Engineering and Technology Science (IRJMETS)*, 2022.
9. Vardhaman Ladage, Shardool Jawanjal, Dnyanesh Kamat, Rutuja Majgaonkar, Bhagyashri Kadam, "Semi-Automatic Floor Cleaning Machine," *International Journal of Design and Manufacturing Technology (IJDMT)*, 2022.
10. Vikrant Bhute, Piyush Ladse, Aniket Ingle, Nitesh Rane, "Solar Operated Multifunctional Floor Cleaning Machine," *International Research Journal of Engineering and Technology (IRJET)*, 2023.
11. Various authors, "Integration of Technology in Floor Cleaning Robots," *IEEE Transactions on Automation and Robotics*, 2023.