Design and Development of a Smart Floor Cleaning Robot controlled by a Mobile App.

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***Abstract*—maintaining a clean floor is an essential task that often demands considerable time and effort. Many people hire individuals to handle the cleaning and compensate them accordingly. However, advancements in technology are transforming households, making them more intelligent and automated for added convenience. While there are various vacuum cleaners available on the market, most lack wet cleaning capabilities and require manual operation. Therefore, the primary objective of our project is to develop a smart floor-cleaning robot that simplifies the cleaning process by incorporating wet cleaning functions into a single design. This robot is intended for use in homes, schools, and offices, ultimately making the cleaning task easier and more efficient for everyone. The proposed robot is controlled using an Android mobile app, which serves as a transmitter, sending commands to the NodeMCU receiver. The NodeMCU features 11 digital input/output pins and one analogue pin. It receives instructions from the Android app through a BLUETOOTH or Wi-Fi connection, decodes these commands, and directs the robot's movement along the appropriate path and direction.**

***Index Terms*--- NodeMCU (ESP 32 Micro Controller), L293D Motor Driver, DC Motor, Buzzer, LCD, Sensors.**

(Keywords)

I. INTRODUCTION

In today's world, people lead increasingly sophisticated lives, particularly in urban areas where long working hours have become the norm. In this context, many seek time-saving solutions, leading to the rise of robots taking over manual tasks. For career-oriented women, balancing home and work can be particularly challenging. Traditionally, floors are cleaned using a mop or wet mop, requiring significant effort to achieve cleanliness across various surfaces, including cement, polished wood, and marble. Among these, rough cement floors, often found in semi-urban areas, accumulate substantial dust and demand more time and effort for cleaning. To address this issue, the development of House Cleaning Robots has emerged as a necessity. These automatic systems can clean autonomously without human intervention. Autonomous floor cleaning robots significantly enhance efficiency, as they can simultaneously perform sweeping and mopping tasks, detect obstacles, and feature automatic water spray functions. Recently, the popularity of service robots has grown, as they operate semi- or fully automated to provide valuable assistance in maintaining the well-being of both humans and their environments.

II. LITERATURE SURVEY

The concept of floor cleaning robots has become quite popular recently. After reviewing various documents and techniques related to several cleaning robots, we have begun working on our design for a floor cleaning robot based on NodeMCU. The papers we surveyed for our literature review are as follows:

Aishwarya Pardeshi et. al, [1] This paper presents a developed and fabricated model of an automated cleaning robot. This robot is designed to perform various automated functions and incorporates advanced features, including a choose-and-place mechanism and a dirt container equipped with an air vacuum system.

Ajith Thomas et al. [2] proposed an autonomous robotic system for floor cleaning. This robot is capable of vacuuming, cleaning, detecting obstacles, and spraying water. Additionally, it includes a manual control option. All hardware and software functions are managed by a Raspberry Pi 3 model.

Vinod J. Thomas et al. [3] developed a cleaning robot for domestic use. This robotic device features a cleaning module designed to effectively clean various surfaces. The robot was engineered to reach nearly every nook and cranny of a room while maintaining a compact design. It is operated via an Android phone through Wireless Bluetooth Technology. At its core, the robot utilizes an Arduino microcontroller, which is enhanced with communication modules, including Wireless Bluetooth connectivity, motors, and a dirt suction system, enabling it to function efficiently.

Manya Jain et al. [4] examined the Automatic Floor Cleaner, designed for both home and professional use to automatically and manually scrub surfaces. When activated, it effectively collects dust by moving across various areas. Equipped with a force control mechanism for navigation and sensors to avoid obstacles, this innovation seeks to enhance the quality of life by simplifying cleaning tasks.

Abhishek Pandey et al. [5] reviewed the need for an automatic cleaning robot in residences. They emphasized the importance of a programmed system that operates independently to save time and assist individuals with physical disabilities, ensuring the system aligns with their specific needs.

III. RESEARCH GAPS

As the demand for automation and smart home technologies continues to grow, floor cleaning robots have become increasingly notable for their capacity to streamline household chores and improve living environments. Despite significant advancements in robotics and artificial intelligence, there remain several research gaps that could enhance the functionality, efficiency, and user experience of these devices. Recognizing these gaps is essential for directing future research and fostering innovation within the field. By addressing these gaps, we can work toward developing more intelligent, adaptable, and environmentally friendly cleaning solutions that effectively meet the diverse needs of users. The key areas of focus include;

Navigation and Mapping: Many current systems rely on basic algorithms for navigation and mapping, which can struggle in complex environments. There is a need for more sophisticated algorithms that utilize AI to improve real-time mapping and obstacle avoidance**.**

Adaptability to Different Environments: Most cleaning robots are designed for standard home environments, but they often fail to perform optimally in diverse settings. Research into adaptive cleaning strategies that cater to different floor types and room layouts is essential.

Energy Efficiency and Battery Life: As battery technology evolves, understanding how to optimize energy consumption during operation can lead to longer cleaning cycles and reduced charging times. Investigating innovative power management strategies is a crucial area for improvement.

Maintenance and Repair: Current cleaning robots often lack self-diagnostic capabilities, making maintenance cumbersome for users. Developing systems that can predict maintenance needs and provide user-friendly support can enhance the longevity and reliability of these devices.

User Interaction: While user interfaces have improved, there is still a lack of personalization and intuitive controls. Exploring user-centric designs that adapt to individual preferences and habits can enhance engagement and satisfaction.

By addressing the identified research gaps, future advancements in floor cleaning robots may offer substantial enhancements in performance, user satisfaction, and environmental sustainability. Such innovations could play an important role in transforming the way we care for our living spaces.

IV. PROBLEM STATEMENT

In the traditional floor cleaning process, mops and brooms are employed to effectively eliminate dirt and dust from floors, yet this method demands significant human effort and time. In recent years, a variety of vacuum cleaners have emerged on the market, primarily designed for dry cleaning. However, these vacuum cleaners are often prohibitively expensive, making them inaccessible for many people. The added features in existing systems tend to create bulky and costly products. Additionally, the reliance on manual handling results in increased power consumption. This research confidently aims to deliver efficient solutions that address these operational challenges and enhance the effectiveness of current systems.

V. OBJECTIVES

1. To design and develop a machine that minimizes human effort and enables efficient, quick cleaning at an affordable price.
2. To create an intuitive system that can be easily operated by individuals with limited basic knowledge.
3. To prioritize safety in the operation of this machine.
4. To develop a fully self-contained system that requires minimal maintenance.
5. To ensure low power consumption in the design of the system.

VI. MOTHODOLOGY

The innovative battery-operated cleaning robot is designed to efficiently clean and mop surfaces simultaneously, all while being conveniently controlled through a smartphone connection. At its heart lies the NodeMCU (ESP32), a Lua-based firmware and a low-cost open source IOT platform for prototyping IOT products. This open-source platform not only simplifies hardware integration but also enhances the robot’s functionality. Powered by a robust 12V DC battery, the robot is equipped with a user-friendly Android application that employs Bluetooth technology for seamless control. This app connects to an HC-05 Bluetooth module embedded within the NodeMCU, enabling users to command the robot's movements from their devices. To navigate its environment, the robot features three (3) ultrasonic sensors responsible for obstacle detection. This sensor continuously emits ultrasonic waves and listens for the returning echo, allowing it to accurately gauge the distance to nearby obstacles. When an obstacle is detected, the ultrasonic sensor sends a prompt signal to the NodeMCU, triggering an immediate halt in the robot’s movement and activating a buzzer for alert. To manage the robot’s mobility, a specialized driver circuit (L293D Motor Driver) is used to control the DC motors that enable movement in multiple directions. The NodeMCU sends tailored commands to this motor driver circuit, facilitating smooth and responsive control of the robot’s wheels, ensuring a thorough cleaning experience. The water level sensor measures the water level in the robot’s tank and sends data to the NodeMCU, which processes the data and displays the water level on the LCD. The LCD receives signal from the NodeMCU and displays each and every operation carried out by the smart robot. Based on the water level, the NodeMCU controls the relay module to turn the water pump on/off. The relay module switches the power supply to the water pump.

VII. COMPONENTS AND BLOCK DIAGRAMS

In order to create an effective smart home cleaning robot, our initial step is to establish a comprehensive framework. This framework will facilitate seamless integration of multiple devices, ensuring they can communicate with one another efficiently. Attached below is the block diagram illustrating the architecture of the smart home cleaning robot.

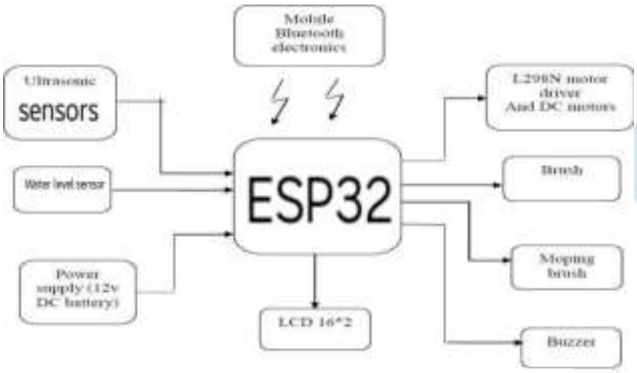

Figure 1: Block diagram of proposed methodology

A. ESP32: A powerful microcontroller with built-in Wi-Fi and Bluetooth capabilities, ideal for IoT applications. It features multiple GPIO pins, supports various communication protocols, and has a dual-core processor for efficient multitasking.

Figure 2: ESP32 Microcontroller

B. Ultrasonic Sensor: Typically, the HC-SR04, this sensor measures distance using ultrasonic waves. It emits a sound pulse and calculates the time it takes for the echo to return, allowing for accurate distance measurement, useful for detecting object proximity or water levels.

Figure 3: Ultrasonic sensor

C. Relay: An electrically operated switch that allows low-power control of high-power devices. In this setup, it controls the water pump by turning it on or off based on signals from the ESP32, providing isolation and safety.

Figure 4: Relay module

D. Motor Driver (L298N): A dual H-bridge motor driver that can control the speed and direction of DC motors and stepper motors. It allows the ESP32 to drive motors (like a water pump) efficiently, handling higher currents than the microcontroller can manage alone.

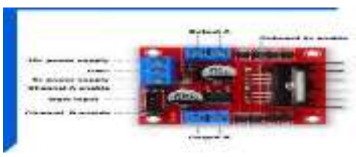

Figure 5: L298N

E. Liquid Crystal Display (LCD): A liquid crystal display that shows information such as sensor readings or system status. Commonly used LCDs like the 16x2 character display can be interfaced with the ESP32 to provide user feedback.

Figure 6: Liquid Crystal Display

F. Water Pump: A device used to move water from one place to another. In this project, it can be activated by the relay to pump water based on the readings from the ultrasonic sensor.

Figure 7: Water Pump

G. Buzzer: A simple sound-emitting device used to provide auditory feedback. It can alert users to system status changes, such as when the water level is too low or too high, or when the pump is activated.

Figure 8: Buzzer

VIII. CIRCUIT DIAGRAM

The circuit diagram of proposed system is shown in fig.2 below,

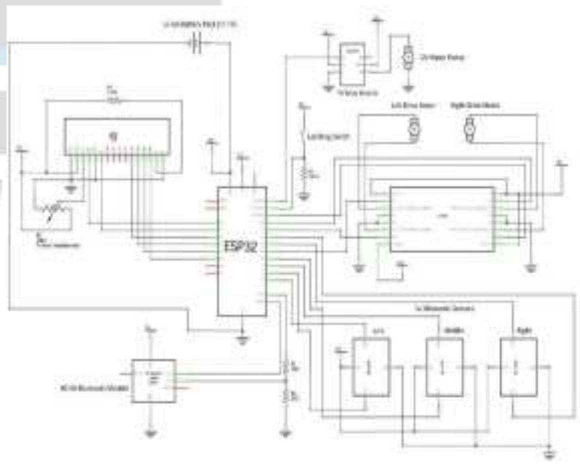

Figure 9: Circuit Diagram

IX. SOFTWARE IMPLEMENTATION

In this project, we leverage the Arduino IDE to program the NodeMCU, ensuring we select the correct plate number support and configure the CPU frequency to a robust 240 MHz for optimal performance. To facilitate communication between our mobile device and the NodeMCU, we use an Android application known as “Blynk”. The synchronization process begins by launching the Blynk app on our Android device. Upon opening the app, an authentication code is promptly sent to the email address we provided during the setup. This unique code serves as a key to link our app with the NodeMCU. Once we receive the code, our next step is to carefully paste it into the relevant section of our developed program, establishing a successful connection between the app and the hardware for seamless control and monitoring before or immediately following the equation.

Figure 10: Opening of Blynk App

X. RESULTS

A smart IoT-enabled floor cleaning robot has been developed for efficient wet floor cleaning. This cutting-edge device is designed to tackle dirt and stains with precision while operating at a lower cost compared to traditional cleaning methods. Users can easily control and monitor the robot's cleaning tasks through a user-friendly Android app, allowing for seamless management and customization of cleaning schedules right from their smartphones.

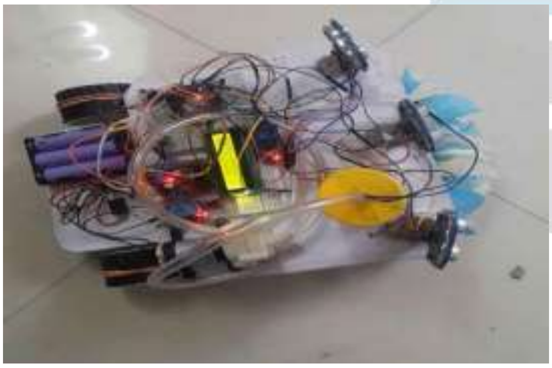

Figure 11: Hardware Output of Robot

XI. FUTURE SCOPE

As technology continues to evolve at a rapid pace, the future scope of innovative projects like floor cleaning robots presents a landscape with possibilities. By addressing current challenges and leveraging emerging technologies, we can create smarter, more adaptable, and accessible cleaning solutions that meet the evolving needs of users worldwide. Some of the potential developments that could arrive in the coming years are;

AI-Driven Navigation: Implementing artificial intelligence for more sophisticated mapping and navigation, allowing robots to learn from their environment and optimize cleaning routes.

Smart Surface Recognition: Developing sensors that can identify different floor types and adjust cleaning methods accordingly.

Predictive Maintenance: Implementing AI algorithms that predict when maintenance is needed, reducing downtime and extending the lifespan of the robots.

User Support Systems: Developing user-friendly guides and support systems for troubleshooting and maintenance.

Augmented Reality Interfaces: Utilizing AR for users to visualize cleaning progress and manage settings more intuitively.

XII. CONCLUTION

The proposed automatic floor cleaner features a model designed for efficient floor cleaning through a stabilized electronic system. This device is well-suited for both office and home environments. Built entirely on the Internet of Things (IoT), it can be operated from anywhere with an internet connection, ensuring a hygienic living space. In both industrial and domestic settings, this robot serves as a cost-effective alternative to traditional cleaning methods. Its affordability and flexibility make it an exceptional choice for floor cleaning. It not only reduces labour costs but also saves time while delivering effective cleaning results. The robot is controlled through an Android application known as “Blynk”.

XIII. CONFLICT OF INTEREST STATEMENT

We, the authors of the manuscript titled” Design and Development of a Smart Floor Cleaning Robot Controlled by Mobile App.” hereby declare that no financial support, Funding, grants, Personal relationship with any thirty party or institutional backing was received for the research, authorship, or publication of this work.

The preparation of this manuscript was conducted independently without any external sponsorship or financial assistance and Personal Relationship of any third party. All authors contributed to the study conception and Design. Material preparation, and analysis were performed by Sarpong Richard. The first draft of the manuscript was written by Samuel Twum and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript. On behave of all Authors, I Samuel Twum as the Corresponding Author state that, there is there is no conflict of interest backed by this research.

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3. Author contribution: Mr. Samuel Twum drafted the Manuscript. Mr. Sarpong Richard editing and Mr. Alpha Agusah did the design. All Authors reviewed and approved the final version.

4. Data Availability Statement: Not Applicable

5. Research Involving Human and /or Animals: This study did not involve any humans or animals.

6. Informed Consent: Informed consent was obtained from all Participant involved in the study.

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