

Automatic Floor Cleaning Robot Using ESP32

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Abstract- This paper presents the design and development of a cost-effective autonomous floor cleaning robot based on the ESP32 microcontroller. The system integrates obstacle detection, navigation, vacuum cleaning, and mopping functionalities into a single compact unit. Ultrasonic sensors enable real-time obstacle avoidance, while a grid-based navigation algorithm ensures efficient cleaning coverage. The robot can operate in both manual and autonomous modes using a mobile application interface developed on the Blynk IoT platform. Experimental results demonstrate effective performance in indoor environments with minimal human intervention. The proposed system offers an economical alternative to commercially available robotic cleaners.

Keywords— ESP32, Autonomous Cleaning Robot, Ultrasonic Sensor, Embedded System, Vacuum Cleaning, Robotic Automation.

I. INTRODUCTION

The integration of automation into everyday life has significantly reduced manual labour and improved efficiency in household and industrial applications. Among these advancements, robotic cleaning systems have emerged as a practical solution for maintaining hygiene with minimal human effort. However, many commercially available robotic cleaners are expensive and rely on sophisticated technologies, making them less accessible to a wider population.

This research focuses on developing a cost-effective floor cleaning robot using the ESP32 microcontroller. The system is designed to perform core cleaning tasks such as sweeping and mopping while ensuring basic navigation and obstacle avoidance. By emphasizing simplicity and affordability, the proposed design aims to provide an efficient alternative suitable for domestic and small-scale applications.

II. PROBLEM STATEMENT

Traditional floor cleaning methods require considerable time and human effort, particularly in large spaces. Although robotic cleaning systems are available, their high cost and limited flexibility restrict widespread adoption. Additionally, many low-cost

solutions fail to deliver effective navigation and cleaning performance.

Therefore, there is a strong need for an affordable and efficient autonomous cleaning system that can:

- Detect and avoid obstacles reliably
- Perform effective cleaning operations
- Navigate efficiently to cover maximum area
- Operate with minimal cost and complexity

III. LITERATURE REVIEW

Various research works have been carried out in the field of robotic floor cleaning systems using different sensing and navigation techniques. Advanced © 2015 Author et al. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly credited.

systems use LiDAR and vision-based technologies for accurate mapping and localization, but these solutions are expensive and complex.

Infrared-based systems are cost-effective but suffer from limitations such as sensitivity to ambient light and surface properties. Ultrasonic sensors have emerged as a better alternative for low-cost

applications due to their reliable distance measurement and robustness in different environmental conditions.

Microcontrollers such as Arduino have been widely used in earlier designs; however, ESP32 provides improved performance with features like dual-core processing, low power consumption, and built-in Wi-Fi/Bluetooth connectivity.

Simple navigation methods such as grid-based movement and obstacle avoidance are commonly used in budget robotic systems to improve cleaning coverage while maintaining system simplicity.

Overall, existing literature highlights a trade-off between cost, complexity, and performance. The proposed system aims to achieve a balanced design by combining a cost-effective sensing approach with efficient navigation and cleaning mechanisms.

IV. SYSTEM DESIGN AND METHODOLOGY

1. System Architecture

The ESP32 microcontroller acts as the central control unit, processing sensor inputs and controlling motors and cleaning components.

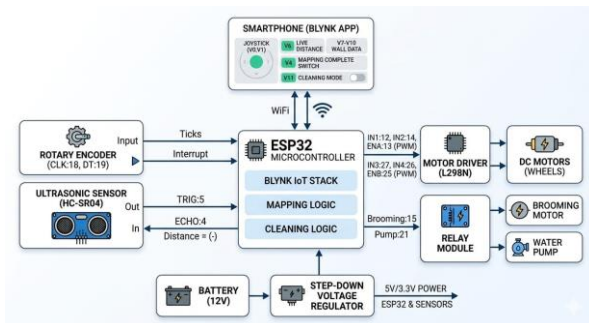


Fig 1. Block diagram of ESP32-based automatic floor cleaning robot

The ESP32 microcontroller is connected to ultrasonic sensors, rotary encoders, and motor drivers. The system communicates with a smartphone via Wi-Fi using the Blynk platform. The motor driver controls wheel motors, while a relay module operates the cleaning subsystems. A 12V battery powers the system through a voltage regulator.

2. Obstacle Detection

Ultrasonic sensors detect obstacles by measuring distance using echo time.

3. Locomotion

DC motors controlled by L298N driver enable robot movement.

4. Cleaning Mechanism

- Vacuum motor for dust removal
- Mopping system for wet cleaning
- Water pump for controlled liquid flow

V. HARDWARE COMPONENTS

The hardware design of the proposed system is centred around a compact and efficient embedded architecture. Each component plays a crucial role in ensuring smooth operation of the robot.

Component	Description
ESP32	Central controller
Ultrasonic Sensor	Obstacle detection
L298N Motor Driver	Motor control
DC Motors	Locomotion
grooming Motor	Dust removal
Mopping System	Floor cleaning
Water Pump	Water supply
MOSFET Drivers	Switching control
Battery	Power source
BLYNK android app	User interface

Software Implementation

The software for the robot is developed using Arduino IDE and programmed in Embedded C/C++. The ESP32 executes a continuous loop where sensor data is read, processed, and corresponding actions are triggered.

The control logic is based on a simple decision-making algorithm. Initially, the robot reads distance data from ultrasonic sensors. Based on predefined threshold values, it determines whether there is an obstacle in its path.

Working Principle

The robot moves forward while cleaning. When an obstacle is detected, it changes direction. The robot follows a systematic pattern to ensure maximum area coverage.

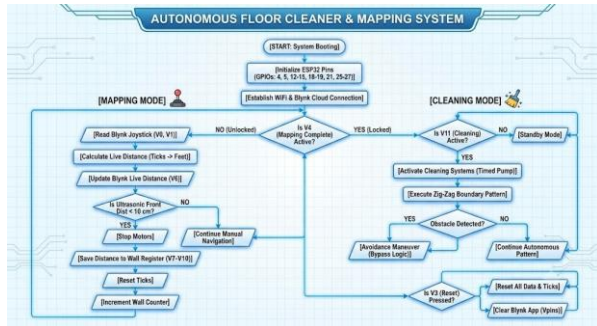


Fig 2. Flowchart of autonomous cleaning and mapping algorithm

The working principle of the proposed system follows the logical sequence defined in the flowchart (Figure 2), ensuring systematic and autonomous operation.

Initially, when the robot is powered ON, the system undergoes initialization, where all peripherals such as sensors, motors, and control pins are configured. After initialization, the ESP32 continuously reads distance data from the ultrasonic sensors to monitor the surrounding environment.

Based on the sensor input, the controller checks for the presence of obstacles in the robot’s path. If an obstacle is detected within a predefined threshold distance, the control logic immediately halts the forward motion and commands the robot to change its direction (either left or right) to avoid collision. If no obstacle is detected, the robot continues to move forward. During movement, the cleaning mechanisms (vacuum motor and mopping system) are activated simultaneously to perform dust removal and wet cleaning operations.

This process operates in a continuous loop, where sensing, decision-making, and movement actions are repeated. The loop ensures that the robot adapts dynamically to changing environmental conditions and covers the cleaning area efficiently.

Thus, the overall working principle integrates sensing, control, and actuation in a cyclic manner, as represented in the flowchart, enabling fully autonomous cleaning operation.

VI. RESULTS AND ANALYSIS

The mobile application interface shown in Figure 3 is developed using the Blynk IoT platform, which enables real-time monitoring and control of the cleaning robot through Wi-Fi communication.

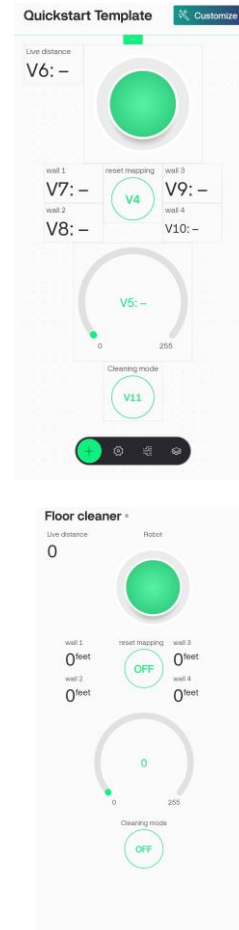


Fig 3. Blynk mobile application interface

The mobile interface provides:

- Joystick control for navigation
- Live distance monitoring
- Wall detection registers
- Reset mapping option
- Cleaning mode activation

This enables seamless control and monitoring via a smartphone.

The system was tested in indoor environments and showed satisfactory performance.

Observations

- Effective cleaning on smooth surfaces
- Reliable obstacle detection
- Continuous operation for limited battery duration

Limitations

- Reduced performance on uneven surfaces
- Limited navigation intelligence
- Battery dependency.

V. CONCLUSION

The proposed ESP32-based cleaning robot successfully demonstrates an affordable and efficient automation solution. The integration of sensors, control algorithms, and IoT interface provides a strong foundation for future intelligent robotic systems.

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