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Fire Gas Leakage Detection Housekeeping Robot using ESP32

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***Abstract*—Fire incidents and combustible gas leaks present serious dangers in homes, workplaces, laboratories, and storage areas. Traditional fire and gas detection systems are typically fixed in place, restricting their coverage to specific spots and rendering them ineffective at identifying hazards in remote or blocked areas. This paper describes the design and development of an ESP32-powered autonomous housekeeping robot that can carry out environmental monitoring and cleaning tasks at the same time. The system combines an MQ-2 gas sensor for detecting flammable gases, an infrared flame sensor for identifying fires, ultrasonic and infrared sensors for avoiding obstacles, a motor driver for self-guided movement, and a vacuum mechanism for cleaning purposes. An ACS712 current sensor keeps a constant watch on electrical current levels, while a relay-controlled ventilation unit activates automatically when dangerous gas levels are sensed. The ESP32 microcontroller handles sensor data in real time and triggers the necessary safety measures, including sound-based alerts, automatic airflow control, and unobstructed navigation. Testing and evaluation confirm that the robot effectively combines environmental safety monitoring with autonomous cleaning, offering an affordable and practical solution for smart homes, laboratories, academic institutions, and industrial settings.**

***Index Terms*—ESP32, Housekeeping Robot, Gas Leakage Detection, Fire Detection, Autonomous Navigation, Vacuum Cleaning, Embedded Systems, Industrial Safety.**

I. INTRODUCTION

The increasing demand for intelligent automation has accelerated the adoption of robotic systems in domestic, commercial, and industrial environments. Housekeeping robots are no longer limited to cleaning tasks but are increasingly expected to provide additional safety functions such as hazard detection, environmental monitoring, and emergency response. Integrating these capabilities into a single autonomous platform can significantly improve both operational efficiency and workplace safety. Fire outbreaks and combustible gas leakages remain among the leading causes of industrial and residential accidents. Hazardous gases such as Liquefied Petroleum Gas (LPG), methane, and propane may accumulate without immediate detection, increasing the risk of explosions and fire. Conventional detection systems are typically installed at fixed locations and cannot effectively monitor large areas or inaccessible spaces. As a result, hazardous conditions may remain undetected until they become critical.The increasing demand for intelligent automation has accelerated the adoption of robotic systems in domestic, commercial, and industrial environments. Housekeeping robots are no longer limited to cleaning tasks but are increasingly expected to provide additional safety functions such as hazard detection, environmental monitoring, and emergency response. Integrating these capabilities into a single autonomous platform can significantly improve both operational efficiency and workplace safety. Fire outbreaks and combustible gas leakages remain among the leading causes of industrial and residential accidents. Hazardous gases such as Liquefied Petroleum Gas (LPG), methane, and propane may accumulate without immediate detection, increasing the risk of explosions and fire. Conventional detection systems are

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II. RELATED WORK

Autonomous mobile robots have gained significant attention in recent years due to their ability to perform repetitive tasks with minimal human intervention. In domestic and industrial environments, robotic platforms have been widely employed for floor cleaning, surveillance, warehouse automation, and environmental monitoring. Recent advancements in embedded systems and Internet of Things (IoT) technologies have further enhanced the intelligence and functionality of these robots.Several studies have proposed autonomous cleaning robots equipped with ultrasonic and infrared sensors for obstacle detection and navigation. These robots efficiently perform cleaning tasks by avoiding collisions and adapting their movement to dynamic environments. However, most commercially available cleaning robots focus primarily on housekeeping functions and provide limited environmental safety monitoring. Fire and combustible gas detection systems have also been extensively investigated for residential and industrial safety. Sensors such as the MQ-2 gas sensor and infrared flame sensor are commonly used to detect hazardous gases and fire at an early stage. Although these systems improve safety, they are generally installed at fixed locations, restricting their monitoring capability to specific areas. Recent research has explored the integration of environmental sensing with autonomous robotic platforms. By combining gas sensors, flame detectors, obstacle avoidance, and embedded controllers such as the ESP32, mobile robots can continuously patrol an area while simultaneously identifying hazardous conditions. These systems provide improved coverage compared to stationary monitoring devices and reduce the need for constant human supervision. Despite these developments, many existing robotic systems concentrate on either cleaning or safety monitoring independently. The proposed Housekeeping Robot addresses this limitation by integrating autonomous cleaning, obstacle avoidance, fire detection, combustible gas monitoring, electrical current monitoring, and automatic ventilation control into a single ESP32-based platform. This integrated approach enhances operational efficiency while providing an economical solution for smart homes, laboratories, and industrial workplaces

III. PROPOSED SYSTEM

The proposed Housekeeping Robot is an autonomous embedded system designed to perform floor cleaning while continuously monitoring the surrounding environment for hazardous conditions such as combustible gas leakage and fire. The system integrates multiple sensors with an ESP32 microcontroller to achieve intelligent navigation, obstacle avoidance, environmental monitoring, and automatic safety response. The ESP32 serves as the central controller, collecting sensor data, executing decision-making algorithms, and controlling the robot's movement and safety mechanisms. By combining housekeeping and hazard detection into a single mobile platform, the proposed system provides a practical solution for smart homes, laboratories, and industrial environments.

IV. METHODOLOGY

The proposed Fire and Gas Leakage Detection Robot with Vacuum Cleaning System continually monitors its surroundings using the MQ-2 gas sensor, flame sensor, ultrasonic sensor, infrared sensor, and ACS712 current sensor. Two ESP32 microcontrollers are in charge of these sensors. The MQ-2 sensor can detect flammable gases including propane, methane, and LPG, whereas the flame sensor is designed to detect the presence of fire. The robot's infrared and ultrasonic sensors allow it to move autonomously while avoiding obstacles. The ESP32 analyzes sensor data in real time and contrasts it with predefined threshold values. If a flame is 2 found, an aberrant current condition is found, or the gas concentration over the threshold, the gadget instantly sounds a buzzer to notify the user. The robot keeps moving inside the monitoring area while the vacuum cleaning apparatus gathers dust and debris. The ACS712 sensor, which continuously checks current use to maintain electrical safety, enables the system to deliver autonomous navigation, real-time danger assessment, cleaning, and dependable performance in both home and commercial settings.

A. BLOCK DIAGRAM

The system consists of six major functional units

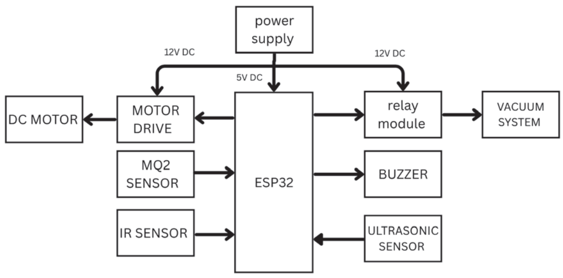

Fig. 1: System Block Diagram$_1$

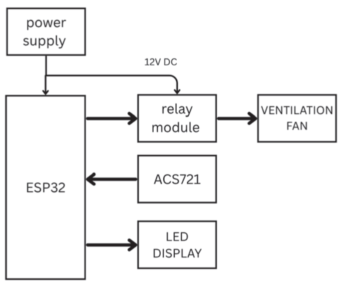

Fig. 2: System Block Diagram$_2$

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1) Processing Unit The ESP32 microcontroller functions as the central processing unit of the robot. It continuously acquires sensor data, processes environmental information, controls motor movement, and activates safety mechanisms whenever abnormal conditions are detected. Its built-in Wi-Fi capability also enables future integration with IoT monitoring platforms.
2) Environmental Monitoring Unit Environmental safety is achieved using an MQ-2 gas sensor and an infrared flame sensor. The MQ-2 sensor continuously measures the concentration of combustible gases such as LPG, methane, and propane. When the detected concentration exceeds a predefined threshold, the ESP32 identifies the condition as hazardous. The flame sensor detects infrared radiation emitted by open flames. Upon fire detection, the controller immediately initiates an emergency response by activating local warning mechanisms.
3) Navigation and Obstacle Detection Unit The robot employs an HC-SR04 ultrasonic sensor together with infrared obstacle sensors to enable autonomous navigation. The ultrasonic sensor measures the distance to nearby obstacles by transmitting ultrasonic pulses and calculating the echo return time. Infrared sensors assist in detecting nearby objects and improving navigation accuracy, particularly at short distances. Based on sensor inputs, the ESP32 determines the appropriate movement direction to avoid collisions while ensuring efficient area coverage during cleaning.
4) Cleaning Mechanism The housekeeping function is performed using a DC- powered vacuum cleaning unit mounted on the robot chassis. The vacuum motor operates continuously while the robot navigates through the environment, collecting dust and small debris from the floor surface. This allows the robot to perform cleaning simultaneously with environmental monitoring.
5) Electrical Safety Unit An ACS712 current sensor continuously monitors the current consumed by the electrical system. Abnormal current values may indicate motor overload, short circuits, or component malfunction. Monitoring current consumption enhances system reliability and enables early identification of electrical faults.
6) Ventilation and Alert System Whenever hazardous gas concentration is detected, the ESP32 activates a relay module connected to an exhaust fan or ventilation system. Simultaneously, a buzzer provides an audible warning to nearby users. This dual-response mechanism helps reduce gas accumulation while immediately informing occupants about the hazardous condition.

V. SYSTEM OPERATION

The proposed robot operates through the following sequence.
Step 1: Initialization After power-up, the ESP32 initializes all connected sensors, motor driver circuits, relay modules, and cleaning motor. Sensor calibration is performed before entering autonomous operation.
Step 2: Continuous Monitoring The controller continuously reads data from:

- MQ-2 Gas Sensor
- Flame Sensor
- Ultrasonic Sensor
- Infrared Sensors
- ACS712 Current Sensor

These measurements provide real-time information regarding environmental safety, robot movement, and electrical system health.
Step 3: Autonomous Navigation Distance information obtained from the ultrasonic and infrared sensors is analyzed by the ESP32. If an obstacle is detected, the controller automatically changes the robot's direction while maintaining continuous cleaning operation. This enables autonomous movement without human intervention.
Step 4: Hazard Detection Sensor measurements are continuously compared with predefined safety thresholds. If combustible gas is detected, the ESP32 activates the ventilation relay and buzzer.
Step 5: Continuous Cleaning While performing navigation and environmental monitoring, the vacuum cleaning motor remains active, allowing simultaneous housekeeping and safety surveillance.

A. ALGORITHAM

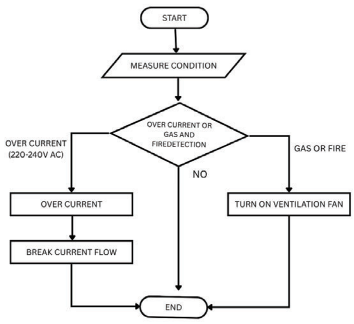

Fig. 3: Flowchart

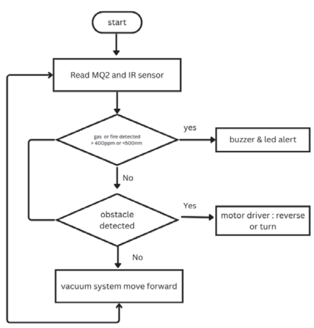

Fig. 4: Flowchart

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The complete system workflow can be summarized as follows: Initialize ESP32 and peripheral devices.Activate the vacuum cleaning mechanism.Acquire data from gas, flame, obstacle, and current sensors.Navigate autonomously while avoiding obstacles.Compare sensor readings with predefined safety thresholds. If hazardous gas is detected:Activate relay-controlled ventilation.Activate buzzer. If fire is detected:Generate an emergency alert. Continue monitoring and cleaning until system shutdown.The proposed methodology enables the robot to perform multiple tasks simultaneously, including autonomous cleaning, environmental hazard detection, obstacle avoidance, and electrical safety monitoring. The modular architecture also allows future integration of additional sensors, IoT connectivity, and artificial intelligence for enhanced autonomous decision-making.

VI. RESULTS AND DISCUSSION

The proposed housekeeping robot was developed using an ESP32 microcontroller integrated with an MQ-2 gas sensor, infrared flame sensor, HC-SR04 ultrasonic sensor, infrared obstacle sensors, ACS712 current sensor, relay module, and a DC-powered vacuum cleaning mechanism. The prototype was tested under controlled indoor conditions to evaluate its navigation, cleaning capability, and environmental safety monitoring.Experimental observations showed that the robot successfully navigated through the test environment while avoiding stationary obstacles using ultrasonic and infrared sensor feedback. The vacuum cleaning mechanism operated continuously during movement, enabling simultaneous housekeeping and environmental monitoring. The MQ-2 sensor reliably detected combustible gases when exposed to LPG and similar gases, triggering the relay- controlled ventilation system and audible buzzer. The flame sensor responded effectively to nearby fire sources by generating immediate warning signals. Current measurements obtained from the ACS712 sensor enabled continuous monitoring of the electrical system, helping identify abnormal operating conditions.The integrated operation of navigation, cleaning, hazard detection, and safety response demonstrated that the proposed robot can perform multiple functions simultaneously without significant processing delay. The ESP32 efficiently coordinated all sensing and control operations, making the system suitable for smart home and industrial monitoring applications.The comparison indicates that the proposed system extends the functionality of conventional housekeeping robots by integrating environmental safety monitoring and emergency response features while maintaining a compact and economical embedded design.

VII. ACKNOWLEDGMENT

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VIII. CONCLUSION

This paper presented the design and implementation of an ESP32-based autonomous housekeeping robot capable of performing floor cleaning while simultaneously monitoring environmental safety conditions. The integration of combustible gas detection, fire detection, obstacle avoidance, electrical current monitoring, and automatic ventilation provides a comprehensive solution for intelligent indoor safety applications. Experimental evaluation confirmed reliable operation of the sensing modules and autonomous navigation mechanism under controlled conditions. The proposed system demonstrates that multiple safety functions can be integrated into a single embedded robotic platform without significantly increasing system complexity or implementation cost. Future work may include cloud-based IoT monitoring, mobile application integration, simultaneous localization and mapping (SLAM), machine learning-based obstacle recognition, and autonomous path optimization for improved cleaning efficiency.

IX. CONCLUSION

The proposed IoT-Based Harmful UV Rays Detector continuously measures ultraviolet radiation and alerts users whenever harmful exposure occurs. Cloud connectivity enables remote monitoring and historical data analysis, making the system suitable for environmental monitoring applications.

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