An ESP32-Powered Automated Car Ensuring Fire Suppression and Gas Control for Optimal Safety and Efficiency

Sunitha P., Margaret R E
Department of Computer Science and Engineering
Malnad College Of Engineering
Hassan 573201, India

Cinchana S, Deeksha H.V, Divyashree H.R, Gagana B.S
Department of Computer Science and Engineering
Malnad College Of Engineering
Hassan 573201, India

***Abstract*—Fire and gas leakage detection systems are vital components of safety infrastructure, serving to protect lives, property, the environment, and ensuring regulatory compliance across various sectors. The proposed system uses ESP32 microcontroller to locate and extinguish gas leaks and fire dangers in various settings. The fire sensors detect fire while the motor control system allows it to move forward, backward, left, or right based on sensor readings. Inbuilt gas sensors trigger reaction systems, alerting users with a bell and fan. A GSM module-based SMS notification system sends real-time information. The servo motor allows for sweeping motions, ensuring effective response and targeted extinguishing. The flame sensor effectively identified flames within a 0.5m radius, while the gas sensor accurately detected gas leakage ranging from 300 to 1000ppm. A car robot system is crafted with dependability and safety in mind for experimental exploration.**

***Index Terms*—Microcontroller, Rasparry Pi, Flame sensor, MQ2 gas sensor, ESP32 , IoT**

I. Introduction

The field of robotics includes many branches of engineering including electronics, mechanical, digital logic, artificial intelligence, nanotechnology and bio engineering. Nowadays, many industries use robots instead of a human. This is because robots have highest accuracy in their work and also they complete their work in less time. Robots are also used in risky work. Multipurpose autonomous robots can perform a variety of functions independently. Typically, they can navigate independently in known spaces and handle their own recharging needs. Many conventional robots are designed for a particular purpose or specific field of use. To accommodate varying tasks, distinct types of robots may be necessary. Rather than developing separate robots for each task, a versatile solution can be devised, saving both time and expenses. Consequently, a multipurpose robot is created, capable of executing diverse tasks simultaneously, seamlessly, and effectively within a unified platform.

Safety is a crucial consideration in the design of residential and commercial buildings to safeguard against the loss of life and damage to property. The current fire alarm and gas leakage systems on the market are excessively intricate in their design and structure. Due to their complexity, regular maintenance is imperative to ensure proper functionality, resulting in higher costs associated with upkeep. The flame sensor reliably discerned flames within a 0.5m radius, while the gas sensor precisely detected gas leakage levels ranging from 300 to 1000ppm. This system is engineered to prioritize reliability and safety.

II. Literature survey

A literature survey is essential for situating research within the existing body of knowledge, identifying gaps, informing methodology, building credibility, and inspiring innovation in academic and scientific pursuits. A significant portion of research efforts is dedicated to developing automated systems aimed at safeguarding infrastructure integrity, thereby preserving both lives and property.

Md Rasheduzzama and et.al[1] have developed a firefighting robot that can easily identify the location of the fire via the flame sensor, and it can avoid objects on its route using the ultrasonic sensor. A PIR sensor is used to detect the human presence who is stuck in the fire place. All the equipments are connected to an ESP-32, and it controls the movement of gear motors. The Robot can be controlled manually as well as automatically, with the help of an android device.

Huan Hui Yan and et.al.[2] have designed a gas leakage monitoring system based on Arduino and Zigbee. It includes Lab VIEW GUI, Zigbee transceiver, gas detector, alarm system, and autonomous control system. The system triggers an exhaust fan to ventilate dangerous gases and shuts down main power and gas supply within 10 minutes of leakage.

Aayush Doshi and et.al.[3] have developed a system using smoke and temperature sensors, connected to an arduino controller, lcd display, buzzer, and Node-MCU module. The system ensures safety and early detection of building fire, suggesting the need for similar systems.

Gazi Zahirul Islam and et.al.[4] have developed a system that detects gas leakage, sends an alert SMS, triggers an alarm, and regulates the exhaust fan. If PPM greater than 620 and temperature reaches 50°C, the system runs, shuts off gas supply, and activates a fire extinguisher. The system's reliability, performance, and coherence are verified under various conditions.

Nandita Tripathi and et.al.[5] have developed a self-sustaining IoT-based real-time forest fire forecasting system to assist firefighting teams in suppressing fire by spraying water at controlled pressure. This outdoor fire detection prototype mainly focuses on temperature and gas measurement precision.

Mendi Manoj Kumar et.al.[6] have developed a system that detects gas and fire, inform users, and turns off nearby circuit boards using H-bridge to prevent electrical devices from causing fire. This device consume minimal power and activate a ventilator fan for dispersion of gas. This technology enhances building safety and save lives.

S Sakthi Priyanka et.al.[7] have developed a real-time firefighting robot that uses an arduino to detect and extinguish fire. The robot is connected to a mobile phone via bluetooth and uses analog and digital data to determine the fire's location. The extinguishing process is done using water through a pumping mechanism.

It is evident that numerous studies have focused on the development of IoT-based systems, addressing tasks such as gas leakage detection and fire detection with corresponding response mechanisms. The existing fire alarm system and gas lekage system on market nowadays is too complex in terms of its design and structure. Since the system is too complex, it needs regular maintenance to be carried out to make sure the system operates well. Therefore, in order to create a cohesive system, the primary objectives of the proposed work are formulated as follows:

- Detection and Alert System : The system utilizes fire and gas sensors to detect leaks, and a buzzer is integrated to provide audible alerts when detected.
- Motor Control and Navigation: Develop motor control functionality to enable the car to move in all directions based on sensor readings.
- Fire Suppression Mechanism : The task involves designing and implementing a fire suppression mechanism, such as a water pump, to extinguish fire.
- SMS Notifications : A GSM module is set up to send SMS notifications to predefined contacts when a fire or gas leak is detected, allowing users to take immediate action

III. Methodology

The central processing unit driving this proposed work is the ESP32 micro-controller. The other main supporting hardware components required are:

- Flame Sensor Module
- Gas Sensor Module : MQ-2
- GSM Module : SIM800C
- 2- Way and 4-way Relay Module
- Servo Motor : Micro Servo 9g- SG90

A. ESP32 micro-controller

The ESP32 is a popular micro-controller module that offers Wi-Fi and Bluetooth connectivity. It is shown below in the Figure 1. The ESP32 module is a versatile device with various

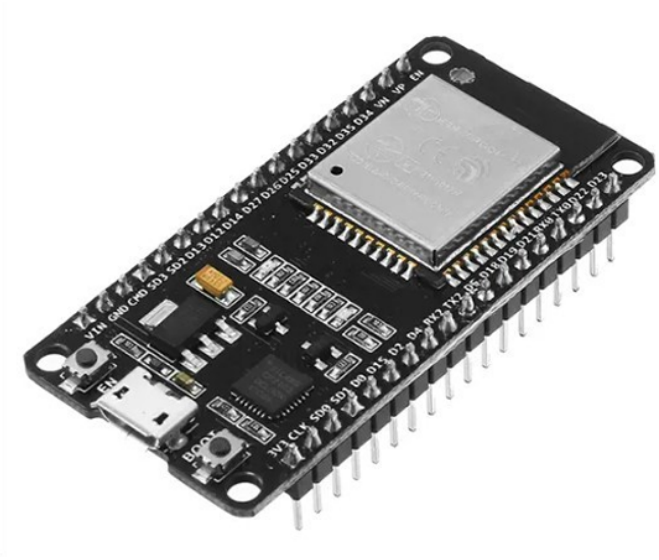

Fig. 1. ESP-32

GPIO pins, analog input pins, power pins, serial communication protocols, I2C pins, PWM pins, touch pins, external interrupt pins, SD card interface, and Eth ernet interface. It supports various functionalities such as PWM, I2C, SPI, UART communication, pulse width modulation (PWM), touch sensor functionality, external interrupt pins, SD card interface, and Eth ernet interface.

B. Flame Sensor Module

A flame-sensor is a detector designed to detect and respond to fire or flames, providing early warning and initiating safety measures like alarm and sprinkler systems. Its features include high photo-sensitivity, fast response time, user-friendly interface, and adjustable sensitivity. The Figure 2 shows the pin configuration of the Flame Sensor.

C. Gas Sensor

The MQ-2 gas sensor is a popular module for detecting and measuring various combustible gases in the air, including LPG, propane, methane, alcohol, hydrogen, and smoke. It operates on the principle of chemical resistance, with a tin dioxide sensing element that changes resistance when in contact with certain gases. The sensor has high sensitivity, a wide detection range, low cost, and stable performance. It typically has four

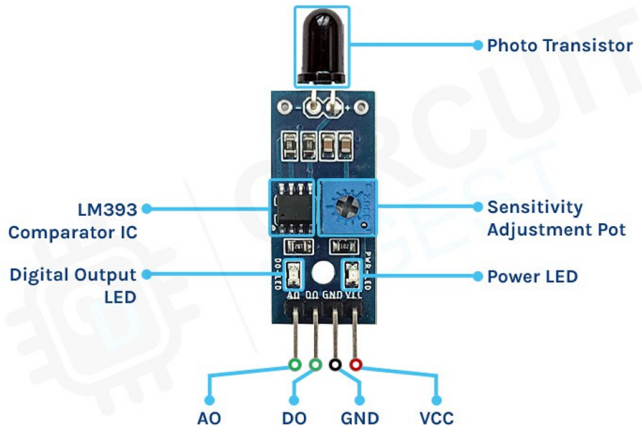

Fig. 2. Flame sensor

pins: VCC, GND, AOUT and DOUT as depcted in the figure 3.

Fig. 3. Gas Sensor

D. GSM Module : SIM800C

GSM or SIM modules are essential in IoT projects due to their limited dependencies compared to Wi-Fi and Zigbee. They offer reliable, long-range communication with only a single SIM card. The SIM800C GSMModuleis a complete Quad-band solution, supporting Quad-band 850/900/1800/ 1900MHz. Figure 4 gives the pin configuration of GSM module.

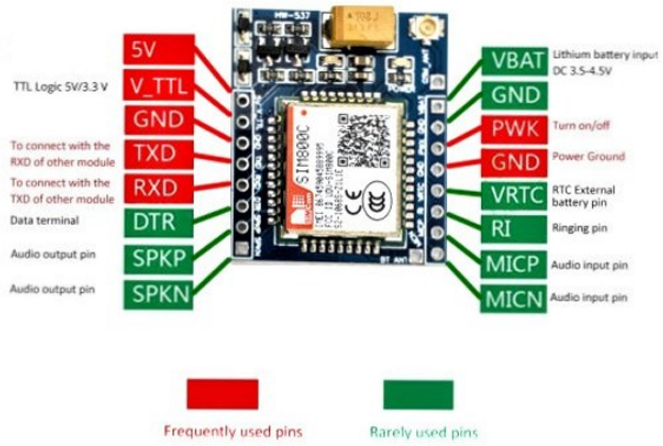

Fig. 4. GSM Module

E. 2- Way Relay Module and 4- Way Relay Module

The 2 Way Relay Module is a convenient board which can be used to control high voltage, high current load such as motor, solenoid valves, lamps and AC load.

F. Servo Motor

The analog micro servo will rotate up to 180 degrees (90 in each direc tion). It operates in the same way as standard versions, but this micro servo is much smaller and can fit into tighter spaces. Its lightweight (9g) design will still output a high amount of power.

The main phases of the proposed system are :

- The hardware design : involves assembly of motor controls, gas and fire sensor modules, and connecting them to the ESP32. A rechargeable cell is used to power the setup, synchronizing the ESP32, 4-way relay, and DC motor.A buzzer will beep if power is not delivered properly.
- Fire Detection and Prevention : The flame sensor detects fire using an IR receiver, which monitors voltage across the IR receiver. Three flame sensors are installed on a robotic car to determine the direction of the fire. Motors drive the car close to the fire, and water is used to extinguish it. A submersible pump is used to control the water spray direction. A ”FIRE EXTINGUISHED!” message is sent to the recipient’s phone. The flame sensor module’s range determines the detection distance, and potentiometers regulate the robot’s sensitivity. The flame sensors are organised as shown in Figure 5.
- Gas Detection and Prevention : The MQ-2 Gas Sensor module is used to detect gas. The ESP32 micro-controller, MQ-2 gas sensor, exhaust fan, motor controller, and other hardware components are installed. The ESP32 controls the motor controller, which is connected to the exhaust fan. When gas is detected, a buzzer beeps, and

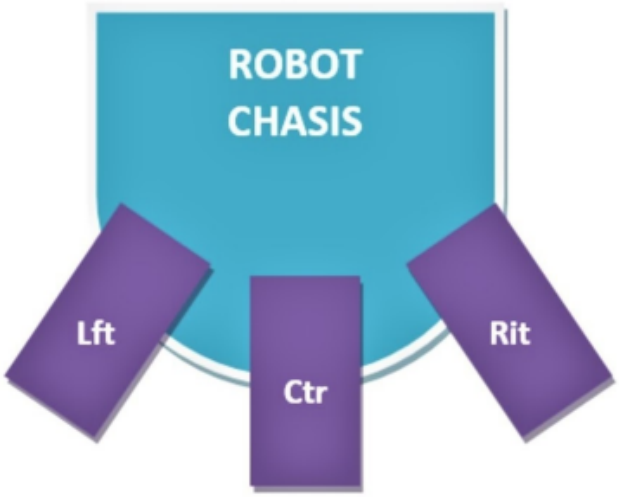

Fig. 5. Flame sensors in 3 direction

a ”GAS LEAK DETECTED” message is sent to the recipient’s phone. The exhaust fan automatically activates and distributes the gas.

IV. Implementation

The flowchart in Figure 6 illustrates the working of the system that responds to the detection of gas or fire.

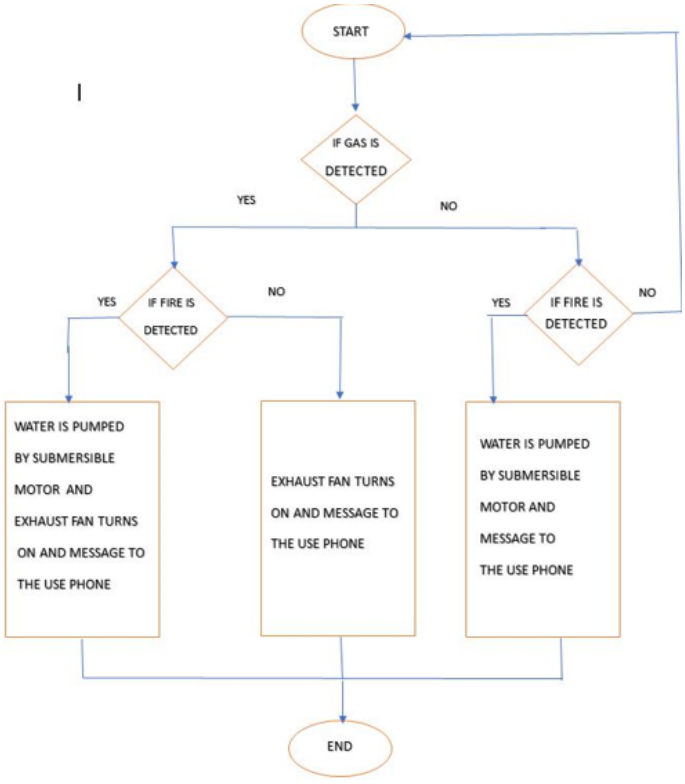

Fig. 6. FlowChart

The process commences with the initial step, where detection mechanisms are activated. If gas is detected, the system proceeds to the subsequent phase; otherwise, it skips to the condition associated with fire detection. Upon detecting fire, an orchestrated response ensues: water is pumped utilizing a submersible motor, an exhaust fan is activated, and a notification is dispatched to the user’s phone. Conversely, if fire is not detected, only the exhaust fan is activated, and a notification is still dispatched. The process iterates, continuously monitoring for gas or fire detection events. Finally, the flowchart culminates, signifying the completion of the sequence.

The complete car model is as shown in Figure 7.

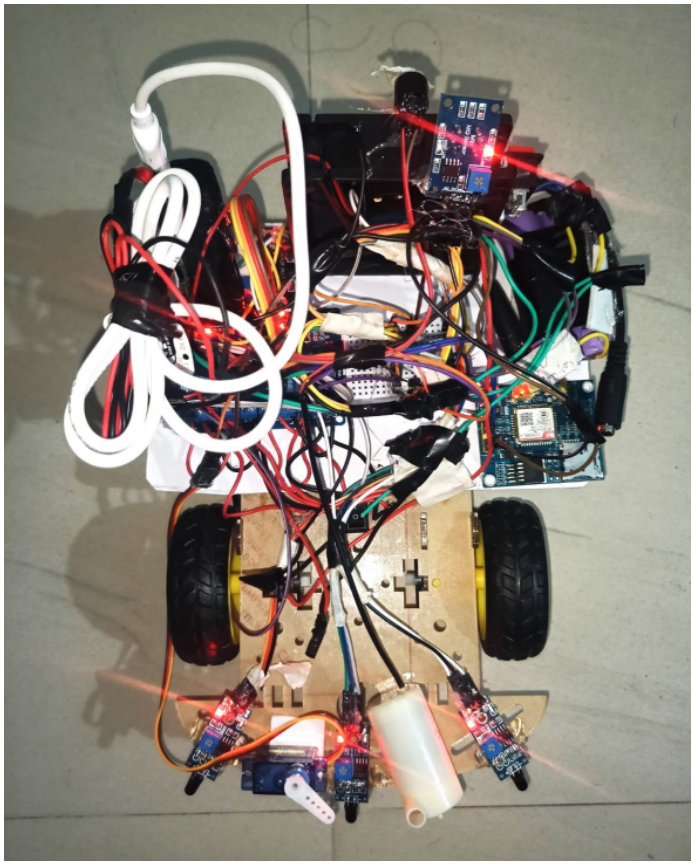

Fig. 7. Complete Model:Top View

V. Result

The project focuses on designing a fire and gas fighting robotic car using ESP32 microcontrollers. The prototype successfully collects data from multiple sensors, including fire and gas sensors, connected to the ESP32 microcontroller. It detects fire incidents in real-time, activates an alarm system, and responds by moving forward towards the fire source. The car also incorporates left and right movements for precise navigation. It detects gas leaks, triggers an alarm, activates a fan, and sends SMS notifications. Table 1 presents a comprehensive breakdown of the range and output detection capabilities of sensors.

TABLE I
RANGE PARAMETER OF SENSOR

Sl.No	Components	Test Id	Range	Expected Output	Result
1	Flame Sensor	1	¡=0.5m	Fire Detection	Detected.
2	Flame Sensor	2	Wavelength : 760nm - 1100nm¡=0.5m	Fire Detection	Detected.
3	Gas Sensor	3	¡=0.5m	Gas Detection	Detected.

The Figure 8 give the illustration of detecting Fire by the robot, while Figure 9 depicts the message got on phone during Fire Detection and Prevention

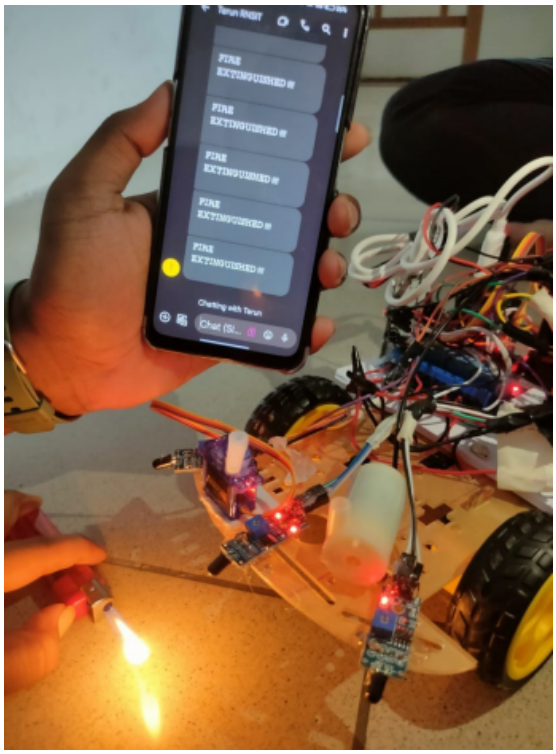

Fig. 8. Fire Detection

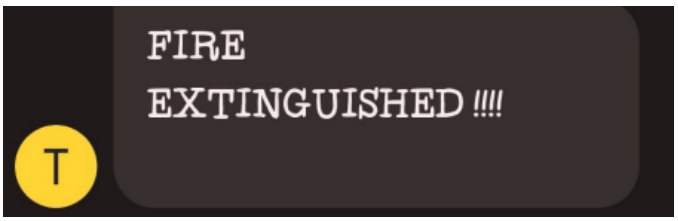

Fig. 9. ”FIRE EXTINGUISHED !!!!”:Message

Likewise, Figure 10 depicts the operational of the model concerning gas leakage, while Figure 11 visualizes the notifications received on a mobile device during gas detection and prevention.

Fig. 10. Gas Detected

Fig. 11. ”GAS LEAK DETECTED”:Message

VI. CONCLUSION

The project successfully integrated the ESP32 microcontroller with various hardware components, including fire sensors, gas sensors, water pumps, fans, and buzzers, to create a robotic car. The car’s detection capabilities, including water spraying, SMS notifications, and sweeping motions, ensure reliable fire detection and response. The GSM module also allows for immediate SMS notifications to relevant parties about fire incidents and gas leaks. The servo motors also improve fire suppression efficiency by dispersing the agent effectively.

VII. Acknowledgment

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