Fire Extinguishing Robo Car

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Abstract— The Fire Extinguishing Robo Car is an autonomous or remotely operated robotic vehicle designed to detect and suppress fires in hazardous or hard-to-reach environments. Equipped with flame or smoke sensors, a control unit, and a fire extinguishing mechanism such as a water pump, the robot can quickly respond to fire incidents while minimizing risk to human life. The system navigates through affected areas, identifies the fire source, and activates the extinguishing process efficiently. This project demonstrates the application of robotics and embedded systems in enhancing fire safety, emergency response, and industrial automation.

I. Introduction

Fire accidents represent one of the most critical and life-threatening hazards in modern society. They can occur unexpectedly in residential buildings, industrial plants, warehouses, forests, hospitals, and public infrastructure, leading to severe loss of human life, property damage, and environmental destruction. The rapid spread of fire, toxic smoke, and extreme temperatures often makes it extremely dangerous for humans to respond immediately, especially in confined spaces or hazardous environments. Despite advancements in fire safety equipment and firefighting techniques, traditional fire control methods still rely heavily on human intervention, which exposes firefighters and rescue personnel to significant risk.

In many fire-prone scenarios such as chemical industries, electrical substations, oil refineries, underground tunnels, and storage facilities containing flammable materials, human access is either restricted or highly unsafe. Delays in detecting fire or reaching the affected area can worsen the situation, allowing the fire to spread uncontrollably. Therefore, the development of intelligent automated systems capable of detecting and extinguishing fire at an early stage has become an important area of research in robotics and embedded systems. The **Fire Extinguishing Robo Car** is an autonomous robotic system designed to address these challenges by performing fire detection and suppression with minimal human involvement. The primary objective of this project is to design and implement a mobile robot that can detect the presence of fire, move toward the fire source, and extinguish it efficiently.

To enhance functionality and real-world applicability, the system can be integrated with additional modules such as GSM and GPS. The GSM module enables the robo car to send alert messages to fire stations or rescue teams, while the GPS module provides precise location details of the fire incident. This feature is particularly useful in large industrial areas, remote locations, or environments where immediate human awareness of fire is limited. Such communication capabilities ensure faster coordination and effective emergency response.

II. Objectives

1. To design a robot which can detect and extinguish fire immediately and control the movement of the robot automatically.

2. To design an autonomous or semi-autonomous robot car capable of detecting and extinguishing fire using sensors and actuators.

3. To design the system to detect the fire in front of the robot and extinguish it by sprinkling water upon it.

4. To control the robot's movement using DC motors and a motor driver module, enabling it to approach the fire source efficiently.

III Problem statement

Fire accidents are one of the major causes of loss of human life and property in residential buildings, industries, warehouses, hospitals, and public infrastructure. In many situations, fires occur in hazardous or confined environments where human access is limited or extremely dangerous. Conventional fire-fighting methods depend largely on manual intervention, which exposes firefighters to high temperatures, toxic gases, smoke inhalation, and the risk of structural collapse. In addition, delays in detecting fire and reaching the affected area can allow the fire to spread rapidly, increasing damage and making control more difficult.

Existing fire safety systems such as smoke alarms and sprinklers mainly provide alerts or fixed responses and lack mobility and intelligence. They are often ineffective in dynamically locating the fire source or responding adaptively to different fire conditions. There is a clear need for an automated and mobile fire-fighting system that can detect fire early, move toward the source, and extinguish it efficiently without endangering human lives.

IV PRPOSED FRAMEWORK

A. Hardware components used

1. IR sensor
2. Flame sensor
3. Ultrasonic sensor
4. Servo motor
5. Motor driver
6. Mosfet
7. Water pump
8. ESP 32

B. Software tools used

1. Arduino IDE

C. System Architecture

The system architecture of the fire extinguishing robo car is designed around a sensing, processing, and actuation model. The robot consists of a sensing unit that includes flame sensors to detect the presence and direction of fire, along with ultrasonic sensors to identify obstacles in its path. The data from these sensors is continuously sent to a microcontroller, which acts as the central control unit of the system. The microcontroller processes the sensor inputs and makes real-time decisions for navigation and fire extinguishing. Based on these decisions, control signals are sent to the motor driver to operate the DC motors for movement and steering of the robo car. When a fire is detected, the controller activates the extinguishing mechanism, such as a water pump or fan, often guided by a servo motor to accurately aim at the fire source. The entire system is powered by a rechargeable battery with voltage regulation to ensure stable operation of all components. This integrated architecture enables the robo car to autonomously detect fire, navigate toward it, avoid obstacles, and extinguish the fire efficiently.

D. Implementation

Objective 1 :To design a robot which can detect and extinguish fire immediately and control the movement of the robot automatically.

The fig 1 shows the overall flowchart of fire detection and extinguishing process.

The process begins with the START block, indicating the activation of the system. Once started, the Power ON System step supplies electrical power to the ESP32 microcontroller, sensors, motor driver, motors, servo motor, and water pump. This ensures that all hardware components are ready for operation. In the Initialize ESP32 & Sensors stage, the ESP32 microcontroller initializes all connected sensors, including flame sensors, IR sensors, and the ultrasonic sensor. During this step, default configurations such as pin modes, sensor thresholds, and motor control parameters are set to ensure proper functioning of the system. After initialization, the robot enters the Fire Detection phase, where flame sensors continuously monitor the surrounding environment for the presence of fire. If no fire is detected, the robot remains in a scanning mode and continues monitoring the environment, as shown by the “Continue Scanning” loop in the flowchart. When a fire is detected by the flame sensors, the system moves to the Move Toward Fire stage. In this step, the ESP32 controls the DC motors through the motor driver module to navigate the robot in the direction of the detected fire source. Once the robot reaches an appropriate position near the fire, the Reach Safe Distance step ensures that the robot is neither too close nor too far from the fire source.After reaching a safe distance, the system activates the Servo Motor to align the water nozzle toward the fire. The Turn ON Water Pump stage follows, where the water pump is activated to sprinkle water onto the fire.The Fire Extinguished? decision block checks whether the fire has been completely suppressed. If the fire is still detected, the system continues spraying water by keeping the pump ON. If the fire is extinguished, the system proceeds to Turn OFF Pump to stop water flow .Finally, the robot either stops its operation or resumes scanning for new fire sources, as indicated in the Stop / Resume Scanning block. The process ends at the END block, completing one full cycle of fire detection and extinguishing.

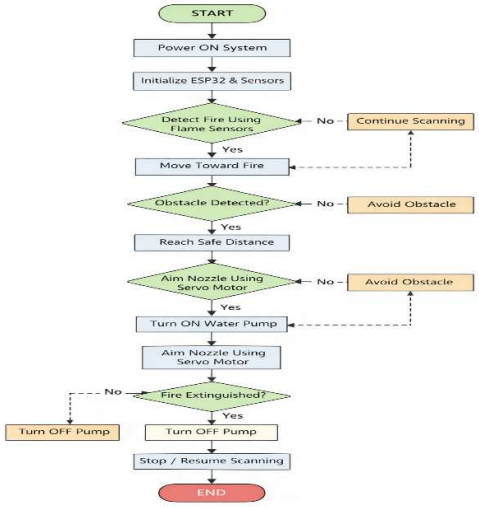

Fig 1:Flowchart to display alert information to the road user which type of vehicle can pass in

Objective 2: To design an autonomous or semi-autonomous robot car capable of detecting and extinguishing fire using sensors and actuators.

The objective of the project is to design an autonomous or semi-autonomous robot car capable of detecting and extinguishing fire using sensors and actuators. In such a system, the flame sensor plays a vital and central role, as it is responsible for detecting the presence, direction, and status of fire, thereby triggering the entire fire extinguishing process.A flame sensor operates based on the detection of infrared (IR) radiation emitted by flames. Fire produces infrared light within a specific wavelength range, and the flame sensor is designed to sense this radiation and convert it into an electrical signal. This signal is continuously monitored by the

microcontroller in the robot car. When a flame is detected, the sensor output changes, indicating the presence of fire and initiating the response sequence.In the autonomous or semi-autonomous fire extinguishing robot car, the flame sensor acts as the primary sensing element. It continuously scans the environment in front of the robot to identify fire at an early stage. Early detection is critical because it allows the robot to respond immediately, preventing the fire from spreading and reducing damage. Once fire is detected, the microcontroller processes the flame sensor data and commands the actuators to perform appropriate actions. The flame sensor also supports directional detection of fire. By using one or multiple flame sensors mounted at the front of the robot, the system can determine the approximate direction of the fire source. This directional information helps the robot car navigate toward the fire using DC motors and ensures that the robot is correctly aligned before activating the extinguishing mechanism. During the extinguishing process, the flame sensor continues to play an important role through real-time monitoring. As the water pump sprays water onto the fire, the sensor continuously checks for the presence of flame.

Objective 3 :To design the system to detect the fire in front of the robot and extinguish it by sprinkling water upon it.

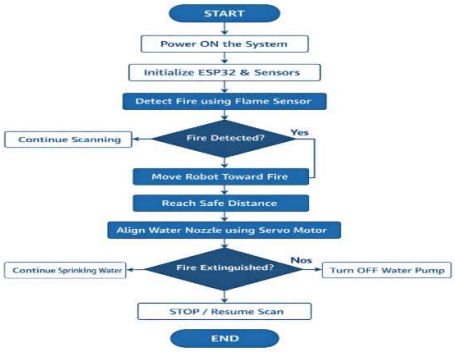

Fig 2 Flowchart for Automatic Fire Extinguishing Using Water Pump

The flowchart of a fire extinguishing robo car represents the logical sequence of operations followed by the robot from startup to fire suppression and standby mode. The process begins with system initialization, where the ESP32 microcontroller powers up and initializes all connected components such as flame sensors, IR sensors, ultrasonic sensors, motor driver, servo motor, water pump, and display unit. Once initialization is complete, the robot enters a continuous monitoring state, during which it constantly scans the surroundings for the presence of fire while also checking for obstacles in its path.When the flame sensor detects infrared radiation above the predefined threshold, the flowchart moves to the fire detection decision block. If no fire is detected, the robot continues patrolling or remains in standby mode. If fire is detected, the controller commands the robot to move toward the fire source while simultaneously using ultrasonic and IR sensors to avoid obstacles. This navigation step ensures safe and accurate movement in cluttered or confined environments. As the robot approaches the fire, sensor readings are continuously updated to determine the optimal stopping distance.Once the robot reaches the effective extinguishing range, the flowchart directs the system to stop the motors and activate the fire extinguishing mechanism. The ESP32 controls the servo motor to align the nozzle toward the flame and switches ON the water pump using a MOSFET or relay circuit. During this stage, the flame sensor continuously monitors the fire intensity to confirm whether the flame is being reduced. If the fire is still detected, the pump remains active and the servo angle may be adjusted for better coverage.When the flame sensor confirms that the fire has been completely extinguished, the flowchart transitions to the final decision stage. The water pump is turned OFF, the servo motor returns to its default position, and the robot either resumes monitoring mode or waits for the next command. This flowchart ensures a systematic, safe, and efficient operation of the fire extinguishing robo car by clearly defining each step from detection to extinguishing and reset, enabling reliable autonomous performance.

Objective 4: To control the robot's movement using DC motors and a motor driver module, enabling it to approach the fire source efficiently.

The methodology for controlling the robot's movement using **DC motors and a motor driver module** is designed to ensure accurate navigation, smooth motion, and efficient approach toward the fire source. In this system, DC motors are fixed to the robot chassis and are responsible for converting electrical energy into mechanical motion, enabling the robot to move forward, backward, and turn in different directions. A **motor driver module (such as L298N or L293D)** is used as an interface between the **ESP32 microcontroller** and the DC motors, since the microcontroller alone cannot supply the high current and voltage required by the motors. The ESP32 sends low-power digital control signals to the input pins of the motor driver, which then amplifies these signals and drives the motors accordingly. Directional control of the robot is achieved by configuring the motor driver's input pins in different logic combinations, allowing independent control of each motor. For example, both motors rotating forward move the robot straight ahead, while stopping or reversing one motor enables left or right turns. To achieve precise and smooth speed control, **Pulse Width Modulation (PWM)** signals generated by the ESP32 are applied to the enable pins of the motor driver. As the robot approaches the fire source, the control algorithm gradually reduces motor speed to maintain stability and ensure accurate positioning at a safe extinguishing distance. Once the robot reaches the optimal location, the ESP32 commands the motor driver to stop the motors completely, allowing the fire extinguishing mechanism to operate effectively. This methodology ensures **efficient navigation, reliable obstacle avoidance,** and precise

positioning, enabling the fire extinguishing robo car to approach the fire source safely and effectively under various environmental conditions.

V RESULTS

Objective 1 To design a robot which can detect and extinguish fire immediately and control the movement of the robot automatically.

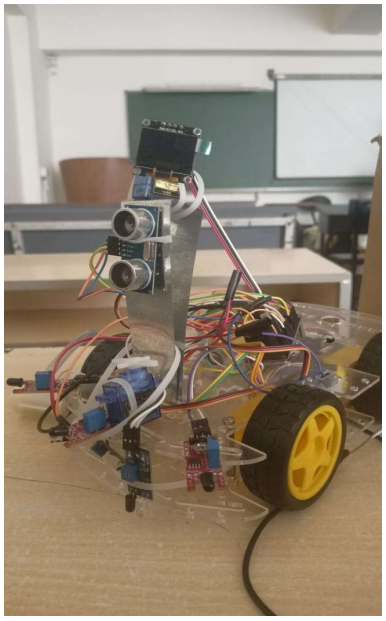

Fig.3: Fire Extinguishing Robo Car

Fig.3 represents figure shows an autonomous fire-extinguishing robot car designed to detect fire using sensors. Upon detecting a flame, the robot moves toward the source and activates a water pump to extinguish the fire, ensuring quick and safe fire suppression.

Objective 2 To design an autonomous or semi-autonomous robot car capable of detecting and extinguishing fire using sensors and actuators.

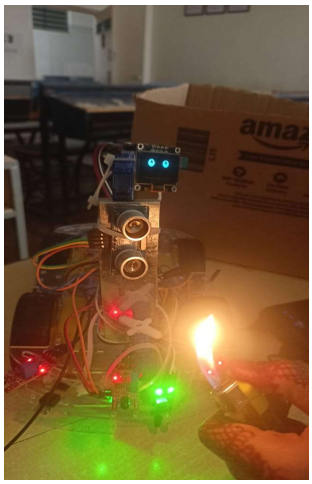

Fig.4: Fire Extinguishing Robo Car Detecting Fire

Fig 4 represents a fire extinguishing robo car designed to automatically detect fire using flame sensors. When fire is detected, the sensor transmits signals to the microcontroller, which processes the data and controls the movement of the robot toward the fire source. The motor driver enables precise navigation, allowing the robot to approach the flame safely.

Objective 3 To design the system to detect the fire in front of the robot and extinguish it by sprinkling water upon it.

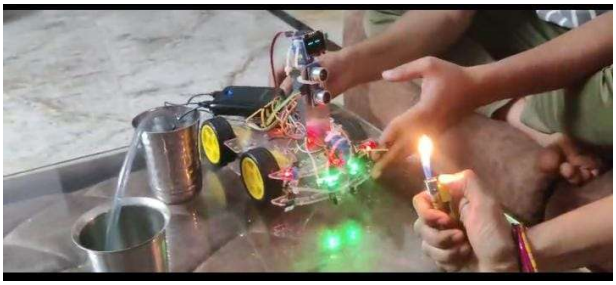

Fig.5: Fire Extinguishing Robo Car Detecting Fire and Sprinkling Water

Fig 5 demonstrates the complete working stage of the fire extinguishing robo car during fire detection and suppression. The flame sensor continuously monitors the surroundings and detects the presence of fire based on infrared radiation emitted by flames. Once fire is detected, the sensor sends a signal to the microcontroller, which acts as the control unit of the system. The microcontroller processes this input and commands the motor driver to move the robot toward the fire source in a controlled manner.

Objective 4 To control the robot's movement using DC motors and a motor driver module, enabling it to approach the fire source efficiently.

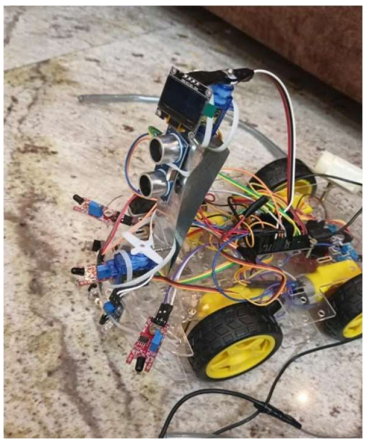

Fig.6: Fire Extinguisher Robo Car Controlling Using Motor driver

Fig 6 illustrates how the fire extinguisher robo car is controlled using a motor driver module. The motor driver acts as an interface between the microcontroller and the DC motors, enabling the robot to move forward, backward, and turn in different directions.

VI CONCLUSION

The Fire Extinguishing Robo Car project successfully demonstrates how robotics and automation can be used to detect and control fire hazards in a safe and efficient way. By integrating sensors, a control system, and a fire-extinguishing mechanism, the robot can respond quickly to fire without risking human life. This project highlights the practical application of embedded systems and robotics in real-world safety solutions and shows strong potential for further improvement and real-time deployment.

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