Fire Fighting Robot

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***Abstract*—The Fire Fighting Robot is an autonomous system designed to detect and extinguish fires in hazardous environments. This paper discusses the design, working, and implementation of a firefighting robot using sensors, microcontrollers, and actuators. The robot detects fire using infrared and flame sensors, navigates obstacles, and extinguishes fires using a water spray mechanism. This system is ideal for small-scale industrial applications and residential safety. The proposed solution minimizes human intervention in risky fire scenarios.**

***Index Terms*—Fire detection, firefighting robot, infrared sensors, obstacle avoidance, robotics.**

I. INTRODUCTION

Fire accidents in residential and industrial settings pose significant threats to human life and property. Quick detection and suppression of fire can prevent major disasters. The Fire Fighting Robot is a solution designed to autonomously detect the presence of fire and extinguish it without human intervention. It utilizes flame sensors, IR sensors, water pumps, and microcontrollers for real-time fire detection and suppression. The robot navigates through its environment using obstacle avoidance techniques to reach the fire source efficiently.

II. LITERATURE SURVEY

Several studies have explored autonomous fire detection systems using robotics and embedded sensors. Previous research highlights the importance of real-time fire response in reducing property damage and improving safety. However, many earlier models relied on manual control or lacked mobility. This project advances prior work by integrating flame sensors, temperature monitoring, and an automatic water pump system into a mobile robot capable of detecting and extinguishing fires autonomously.

III. METHODOLOGY

Hardware Used: Arduino UNO, flame sensor, LM35 temperature sensor, water pump, DC motors, L298N motor driver, buzzer.
Software:Arduino IDE, Embedded C/C++.
Process:
[1]. Sensors detect fire through temperature rise and flame presence. [2]. Arduino processes sensor data and determines fire location. [3]. Upon detection, the robot moves toward the fire source.[4]. The water pump activates to extinguish the fire.[5]. Buzzer triggers as an alert mechanism. [6]. Motors enable autonomous navigation and obstacle avoidance.

IV. SYSTEM ARCHITECTURE AND METHODOLOGY

A. Components Used

[1]. Arduino UNO: Acts as the central microcontroller, responsible for processing sensor data and controlling actuators. [2]. Flame Sensor: Detects the presence of fire based on infrared light. [3]. Temperature Sensor (LM35): Monitors ambient temperature to detect heat from fires. [4]. Motor Driver (L298N): Controls the movement of the robot's motors. [5]. DC Motors: Provide locomotion to the robot. [6]. Water Pump: Activates to extinguish fire by spraying water. [7]. Buzzer: Provides audible alerts during fire detection. [8]. Power Supply (Battery Pack): Powers the entire system, allowing for autonomous mobility.

B. Working Method

The firefighting robot is equipped with flame and temperature sensors that continuously scan the environment. Upon detecting a fire (based on infrared light intensity or a temperature threshold breach), the Arduino processes the data and activates both the buzzer and the water pump. Simultaneously, the robot moves toward the fire source using motorized wheels.

The fire is extinguished by the onboard water pump. The buzzer provides local alerts, and the robot returns to standby once the fire is eliminated.

V. SYSTEM DESIGN

The Fire Fighting Robot is built on a layered, modular architecture focusing on real-time responsiveness, mobility, and autonomy. The design includes an input module (flame and temperature sensors), a processing unit (Arduino UNO), an actuation layer (motor driver and water pump), and alert modules (buzzer). The mobile platform enables dynamic navigation, while the fire detection module allows the robot to engage fire zones effectively.

The system is designed to operate wirelessly, with a battery-operated power system, making it ideal for use in small, enclosed, or hazardous indoor environments where human intervention may be risky. The modular approach ensures ease of repair, scalability, and adaptability for future upgrades (e.g., adding wireless control or obstacle avoidance).

1. ARDUINO UNO

A microcontroller is called Arduino. The robot's mind is controlled by this little computer. It can be set up to control how switches, motors, lights, and other electrical components work together. Arduino ishands-onn, which is one of the multitudinous reasons it's fascinating to adolescents. It may be hooked into your computer. You may develop a programme on the computer and shoot it to Arduino. Arduino is impor-tant since it's employed in multitudinous daily activities. —_ multitudinous youngsters and grown-ups don't recognise that the Arduino is ahead of umultitudinousgoods that are used every day. Companies who use Square, a gadget that can be connected into cellphones to process payments with credit cards, may not understand that it's made possible by Arduino.

Fig:5.1 Arduino Uno

2. SERVO MOTOR

Akind of motor that can spin with extraordinary accuracy is a servo motor. This type of motor often features a control circuit that gives feedback on the position of the motor shaft while it is in motion; this feedback enables the servo motors to spin quite precisely. Nonetheless, additionally you use a servo motor, If you desire to spin an object at an exact angle or distance. It's simply created off of a simple motor that runs through a servo system. And also, If the motor is driven by a DC power source, then it is considered a DC servo motor, and if it is an AC-powered motor then it's called an AC servo motor

Fig: 5.2 Servo motor

3. DC MOTOR

Direct current (DC) motors are machinery that transform DC energy into mechanical power. Its functionality is predicated on the notion that when a current-carrying captain is put in a glamorous field, the captain obtains a mechanical force. The direction of the force is indicated by both the magnitude and Fleming's left-hand rule.

Fig:5.3 DC Motor

4. MOTOR DRIVER

The L293D, a common motor automobilist or motor automobilist IC, allows DC motors to go either way. The 16-leg integrated circuit L293D can drive two DC motors simultaneously in either direction. It indicates that a single L293D IC may run two DC motors. integrated double H-ground motor automobilist circuit.

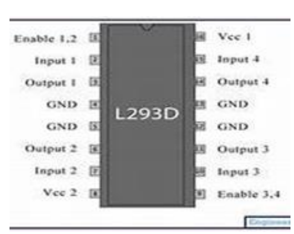

Fig:5.4 Motor Driver

5. Infrared (IR) Sensors

Infrared (IR) sensors are vital components in fire-fighting robots, helping them detect obstacles and navigate safely in complex environments. These sensors emit infrared light and measure the reflection from nearby objects to determine distance, allowing the robot to avoid collisions while moving toward the fire source. In fire-fighting applications, IR sensors can also help detect heat signatures or flames, enabling the robot to identify the fire's location accurately.

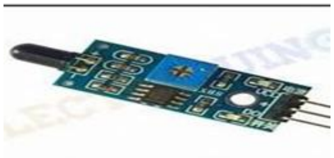

Fig:5.5 Infrared Sensors

VI. IMPLEMENTATION

The Arduino UNO was programmed using the Arduino IDE. The code initializes sensor inputs and motor outputs. The flame sensor checks for infrared signatures, while the LM35 monitors ambient temperature. If fire is detected (either flame sensor triggers or temperature exceeds 50°C), the buzzer is activated, and the motor driver directs the robot toward the source of the fire.

Upon reaching the fire zone, the water pump is activated via a relay to spray water for a defined interval (e.g., 10 seconds). After extinguishing the fire, the system returns to its scanning state. The design includes safety features to prevent over-spraying and avoid repeated alerts.

The prototype was tested in controlled indoor environments with simulated fire using candles. The robot successfully detected and extinguished the flames in under 30 seconds and performed consistent movement and response actions.

A

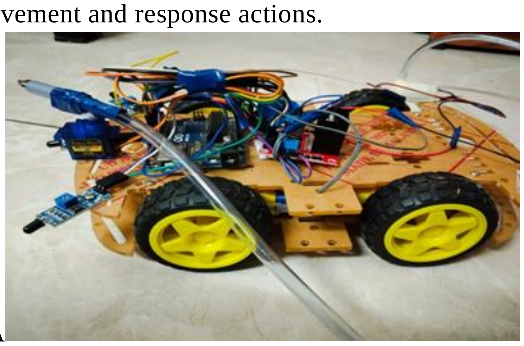

Fig:6.1 Fire Fighting Robot

VI. SCALABILITY AND MODULARITY

The design of the Fire Fighting Robot emphasizes both scalability and modularity, ensuring that it can adapt to varied firefighting scenarios and technological improvements. Additional sensors—such as gas sensors for detecting smoke or toxic emissions, or LDRs for light detection—can be integrated without altering the core architecture. This modularity allows easy maintenance, as individual components can be replaced or upgraded independently. The microcontroller's support for Over-The-Air (OTA) firmware updates through Wi-Fi makes it convenient to push software patches or enhancements without requiring physical access to the hardware. This flexibility allows the system to evolve continuously to meet the dynamic requirements of modern disaster response applications.

VII. RESULTS AND DISCUSSION

The Fire Fighting Robot was tested in a controlled indoor simulation where artificial fire sources and elevated temperatures were introduced. The robot successfully detected the fire conditions using its flame and temperature sensors. Upon detection, the system responded by activating the buzzer, logging the event to the cloud via ThingSpeak, and initiating the water pump and directional servo motors to suppress the fire. The ThingSpeak dashboard provided live updates on sensor readings, enabling remote observation of the robot's status and actions. This functionality demonstrated the robot's ability to identify and respond to fire hazards autonomously, significantly reducing response time. The combination of cloud-based monitoring and local actuation created a robust dual-alert system that enhanced reliability.

During testing, a series of test cases were evaluated to assess the system's accuracy and responsiveness. The system consistently detected fire conditions within a few seconds of ignition and responded appropriately. Data logs showed how temperature and flame readings peaked at the onset of fire and gradually reduced as the suppression mechanism was activated. The serial monitor provided real-time feedback during operation, ensuring transparency during testing. Overall, the system proved to be both effective and reliable under simulated hazardous conditions.

VIII. CONCLUSION

The Fire Fighting Robot project presents a practical and forward-thinking approach to automated fire detection and suppression. Through the integration of IoT-enabled sensors, real-time data logging, and remote monitoring, the system addresses critical gaps in traditional fire safety solutions. The use of a Wi-Fi-enabled microcontroller allows for flexible deployment and continuous updates, while the cloud dashboard facilitates transparent data visualization and trend analysis.

This robot serves not only as a reactive system to fire outbreaks but also as a proactive monitoring tool. Its modularity and scalability make it adaptable to various use cases—from warehouses and factories to smart homes and office environments. The field testing confirmed its capability to respond swiftly to fire hazards, minimizing potential damage and providing crucial alerts both locally and remotely.

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