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ARDUINO BASED FIRE FIGHTING ROBOT

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ABSTRACT :

A fire outbreak is a dangerous situation that can cause severe injuries, heavy property loss, and even fatalities. Managing such incidents requires quick, safe, and efficient action to reduce damage and avoid risking human lives. Since fire detection and suppression involve high-risk activities, firefighters are often exposed to life-threatening conditions.
To enhance early fire response, firefighting robots have become a highly effective alternative. In industrial setups, timely identification of fire is vital to avoid major damage. Robots integrated with embedded technologies can safeguard personnel working in hazardous areas.

In this project, an Arduino-based firefighting robot is developed to quickly identify and tackle fire hazards. It employs two flame sensors to detect fire and uses a sensor-driven mechanism to trigger the extinguishing action. The robot supports forward, backward, left, and right movements through Bluetooth signals transmitted from an Android mobile application. When an obstacle is detected, it automatically halts and resumes its movement once the path becomes clear.

Overall, this robotic system offers a reliable and safe method for early fire detection and suppression, making it especially useful in environments where human presence is risky or impractical.

INTRODUCTION

One of the most serious issues during fire emergencies is the loss of human lives, especially those who perish while trying to rescue others. Firefighters frequently encounter extreme difficulties when approaching fire zones due to explosive substances, dense smoke, and intense heat. Detecting a fire at an early stage can greatly lower the risk of a large-scale disaster. As shown in the referenced statistics (Fig.1), fire incidents can take place in both residential and industrial environments. Even a minor spark has the potential to escalate into a major fire.
Insufficient fire safety measures endanger not only industrial workers but also people in homes. However, such incidents can be minimized through proper fire control strategies.

To overcome these challenges, a fire-fighting robot is introduced. Today, robots are increasingly deployed to handle tasks that are dangerous, risky, or life-threatening for humans. They can efficiently manage hazardous or physically demanding work, ensuring greater human protection. The proposed fire-fighting robot makes use of Internet of Things (IoT) technology to operate autonomously and respond to fire situations in real time. It is built to sense and extinguish small flames by independently navigating toward the fire's source.
The robot incorporates three flame sensors arranged to monitor the left, front, and right directions, allowing it to automatically detect fire from multiple angles. Once the system identifies the fire's location, it advances toward the source and triggers its built-in fire-extinguishing mechanism. When the robot reaches the origin of the fire, it activates the water pump to spray water and put out the flames.

This system is designed not only to extinguish fires but also to offer continuous fire monitoring, helping to prevent serious fire hazards and greatly reducing the danger to human life.

LITERATURE SURVEY

Pushpendra Kumar, Saurabh Verma, Pradeep Kumar, Sandeep, and their team [5] presented an advanced Automatic Fire-Fighting Robot capable of providing round-the-clock fire detection and suppression. This economical system uses an electric thermostat-based mechanism to identify and control fire effectively. The robot integrates various components, including flame sensors, water sprayers, a wireless control unit, a GSM module, an Arduino

Uno, and a camera for coordinated functionality. It supports both autonomous and remote operation while also offering live video transmission for real-time supervision.

Dr. J. Subash Chandra Bose, Dr. Marzougui Mehrez, Dr. Ahmed Said Badawy, and Dr. Wade Ghribi, along with their research team, introduced a firefighting robot enhanced with cyber-security features to ensure safer and more reliable operation. This robotic system has been successfully deployed in real industrial environments, including the Southern Province Cement Company and the Saudi Electricity Company. Its performance was evaluated using a Cathode Ray Oscilloscope (CRO) and through practical experiments, confirming its effectiveness and industrial applicability.

S. Sridevi, G. Manikandan, J. Dhanasekar, and P. Sengottuvel developed a fire-fighting robot that uses four thermistor-based flame sensors to continuously monitor temperature variations. When the temperature surpasses a preset limit, the system triggers an alarm and sends alerts to responsible personnel and the nearest fire station via GSM communication. The robot then moves toward the direction showing the highest temperature among the four sensors and activates a water pump to extinguish the fire. After completing the task, it returns to its starting point. This early-stage response mechanism enables the robot to detect and suppress fires at the very beginning, providing a clear advantage over conventional smoke detectors that react only after combustion has progressed.

METHODOLOGY

This study focuses on developing a system that can automatically detect and extinguish fires without requiring human intervention. The proposed method is divided into three main sections: system design, hardware integration, and software development. These elements were combined and tested to build a fully functional prototype capable of effectively handling fire suppression.

Design Structure

This section explains the construction of the robotic model, which includes infrared flame sensors, servo motors, a submersible water pump, a motor driver module, a mini breadboard, BO motors, rubber wheels, a controller, and a communication module that enables data transfer between the robot and the Arduino platform. The system performs four core functions, starting with initialization as soon as the sensors become active after powering on.

The robot first scans its surroundings, monitoring temperature variations to determine the exact location of a fire. After identifying the source, it generates movement commands and navigates toward the flame. Finally, the servo motors and submersible pump are activated to spray water and extinguish the fire.

IMPLIMENTATION

The Arduino functions as the central processing unit of the system, managing and coordinating all activities. Fire detection is performed using a dedicated sensor module equipped with an infrared (IR) photodiode that senses the IR radiation produced by flames. When a fire occurs, it emits IR light, which the photodiode captures. An operational amplifier (Op-Amp) tracks the resulting voltage changes across the photodiode. If a flame is detected, the sensor's digital output (DO) pin switches to LOW (0V); otherwise, it stays HIGH (5V).

The robot determines the direction of the fire using multiple flame sensors positioned at key locations. Once the fire is identified, the Arduino interprets the sensor readings and controls the robot's movement through the L293D motor driver module, guiding it toward the fire source. As the robot nears the flame, a 5V submersible water pump mounted inside a small container and connected to a servo motor is activated. The servo motor adjusts the angle of the water jet, allowing the robot to accurately aim and extinguish the fire.

COMPONENTS

- IR 4 pin Flame sensors x 3
- Arduino UNO
- Chachies
- BO motors x 4 (+wheels)
- L298 Motor driver
- Solder-less Breadboard
- Mini servo
- 5-9 V Water pump + pipe
- Water tank / bottle
- 3.7 V batteries (18650) x 2
- Jumper wires
- TIP-122 Transistor + 104 pf capacitor + 1K Resister

COMPONENTS OVERVIEW

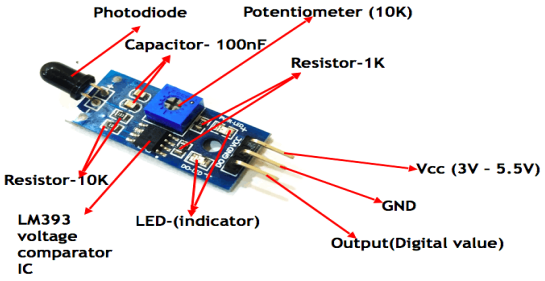


Figure 1 : IR 4 pin Flame sensors

An IR (Infrared) 4-pin flame sensor is an electronic device used to identify the presence of a flame by detecting the infrared radiation produced by it. These sensors are widely used in fire-fighting robots and various safety and monitoring systems.

Figure 2 : Arduino uno

ArduinoUNO:

The Arduino UNO is a widely used and beginner-friendly microcontroller board, commonly utilized in robotics and electronic system development.

Chassis:

The chassis forms the physical framework of the robot, supporting and holding components such as the motors, sensors, and Arduino board.

BOMotors:

BO motors are simple DC geared motors used in basic robotic systems. They enable wheel movement and allow the robot to navigate in different **directions.**

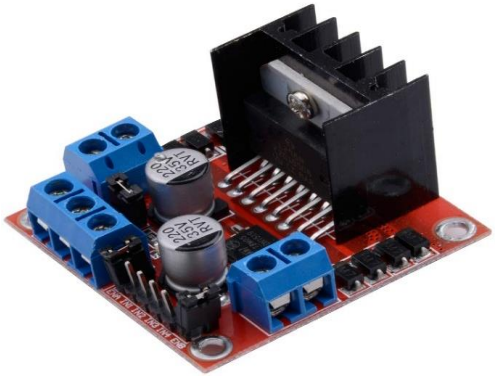


Figure 3 : L298 Motor Driver

L298 Motor Driver:

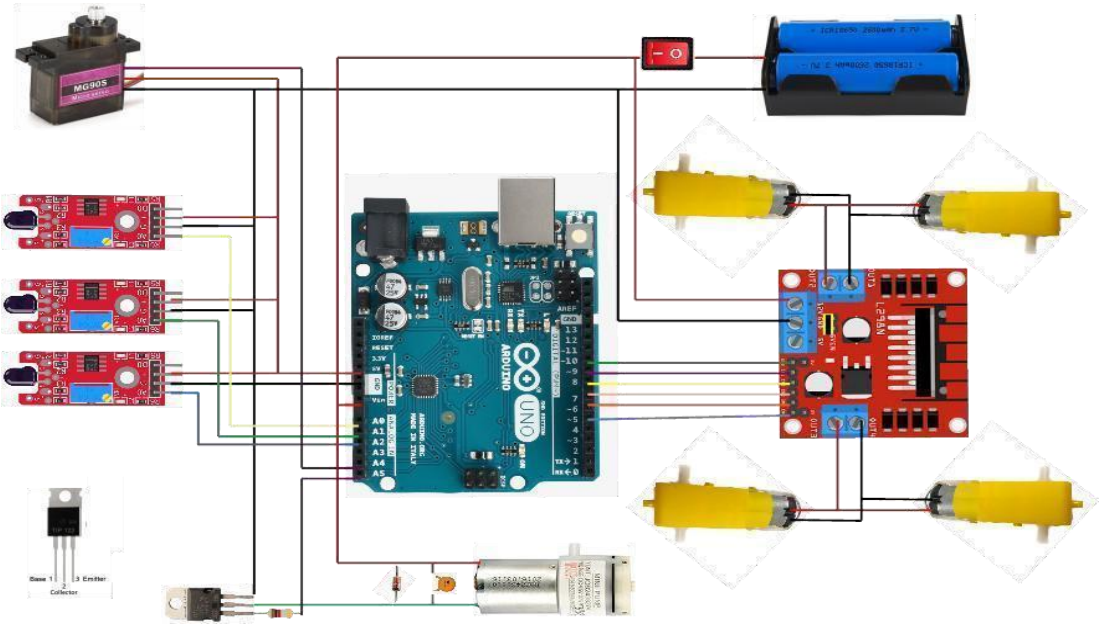
An H-bridge–based motor driver module that controls the speed and direction of BO motors using input signals from the Arduino.

Solder-less Breadboard:

A reusable platform for assembling and testing electronic circuits without soldering, allowing easy connection of components during prototyping.

Mini Servo:
A compact servo motor capable of rotating to specific angles (typically between 0° and 180°), commonly used for precise motion control, such as directing a water nozzle.
3.7V 18650 Batteries:
Rechargeable lithium-ion cells that supply power to the robot. When two are connected in series, they produce 7.4V, suitable for driving the motors and water pump.
Jumper Wires:
Flexible wires used to establish electrical connections between components, especially on a breadboard or between different modules and the Arduino.

CIRCUIT DIAGRAM



CONCLUSION

The Arduino-powered fire-fighting robot offers an affordable and dependable method for detecting and extinguishing fires at an early stage. Equipped with flame sensors, a water pump, and autonomous navigation, the robot can identify and put out minor fires without needing human assistance. This capability makes it especially valuable in dangerous or inaccessible areas and demonstrates how microcontroller-based robotic systems can significantly enhance safety during fire incidents.

RESULT

The system operated efficiently with seamless coordination between the flame sensor, Arduino controller, motor driver, and water pump. The robot successfully identified fire, navigated around minor obstacles, and extinguished the flames rapidly. All components functioned consistently without any significant issues, demonstrating the robustness and reliability of the prototype.

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