

Fire Fighter Robot

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Abstract - The project aims to build and develop a firefighting robot using Arduino. Fires offer a serious risk to people and property, necessitating creative and effective mitigation strategies. This project presents a cutting-edge technical development in firefighting: an Arduino Uno-based firefighting robot. Fire detection is crucial to preventing significant losses in the majority of industries. In hazardous industrial environments, engineers can be protected by robots equipped with these embedded devices. Ideally, a robot should be able to recognize fire and put it out as soon as possible. In order to put out a fire, the robot will be able to maneuver inside a predetermined area and be supplied with sensors to detect any fire. The robot, which is intended to move independently and perform firefighter tasks, will be controlled by an Arduino microcontroller. The robot will be equipped with a water tank, a pump, and a nozzle to apply water to the flames. It will also have infrared sensors to detect the heat of the fire and navigate towards it. The Arduino microcontroller will handle the sensor data and control the robot's movement and firefighting. This will involve designing the project's mechanical system.

Key Words: Fire Detection, Flame Sensor, Motor Driver, Fire Extinguisher, Water Pump

1. INTRODUCTION

Fire accidents are a significant threat to both human life and property. Despite advances in firefighting technology, firefighters continue to face numerous challenges while extinguishing fires, such as accessibility to the fire site, visibility, and smoke inhalation. This paper presents the design and development of a firefighting robot based on the Arduino microcontroller platform. The robot is equipped with a water pump and a range of sensors to detect fires and obstacles in its path. The robot is also capable of navigating manually through the environment and can

be remotely controlled by a human operator. The use of Arduino platform makes the robot cost-effective and easily accessible for researchers. The paper presents a step towards the development of advanced robotic systems that can assist firefighters in their tasks, making firefighting safer, more efficient, and effective.

Problem Definition:

The problem addressed in the research paper is the increasing severity of fires in various environments, which pose significant risks and challenges to human firefighters. The proposed solution is a firefighting robot based on the Arduino platform, designed to navigate manually, detect fires, and extinguish them using a water pump. The robot can be remotely controlled, reducing the risks faced by human firefighters. The proposed robot is intended to be efficient, effective, safe, and feasible, providing a valuable tool for firefighters to combat fires in various environments.

Objective:

The main objective of the Fire Fighting Robot project is to design and develop an autonomous or semi-autonomous robotic system capable of detecting and extinguishing fires efficiently, safely, and without human intervention. The robot aims to reduce human risk during fire accidents, especially in hazardous environments such as industrial plants, warehouses, residential buildings, and laboratories.

Key goals of the project include:

- **Fire Detection:**
To integrate sensors (such as flame sensors, temperature sensors, or smoke detectors) for early detection of fire and accurate identification of its source.
- **Autonomous Navigation:**
To enable the robot to move autonomously or via remote control through a given area, avoiding obstacles using ultrasonic or infrared sensors.

- **Extinguishing Mechanism:**
To design an efficient mechanical system (such as a water pump, CO₂ spray, or foam dispensing unit) to suppress or extinguish the fire effectively once detected.
- **Human Safety:**
To minimize human involvement in dangerous firefighting scenarios, thus reducing the risk of injury or fatality.
- **Rapid Response:**
To provide a quick and intelligent response system that can operate continuously, even in smoke-filled or low-visibility environments.
- **Mechanical Design Efficiency:**
To develop a compact, stable, and mobile mechanical structure capable of moving on different surfaces and carrying the firefighting equipment.

1.2. LITERATURE REVIEW

An Infrared Image Sensor for Fire Location, Alessandro Pesatori, Alessandro Magnani, Michele Norgia [1] This article presents a novel sensor and interpolation method for fire localization in enclosed settings like rooms or highway tunnels. The aim is to detect and pinpoint the origin of a fire using image data obtained from two thermopile arrays. By accurately locating the source of the fire, this system enables effective positioning of fire extinguishers to prevent fire spread. Notably, this system holds great promise for implementation in closed environments due to its cost-effectiveness and straightforward installation, thereby enhancing fire prevention measures.

A Survey on Fire Safety Measures for Industry Safety Using IOT Mon Arjay F. Malbog, Luisito Lolong Lacatan, Rhowel M. Dellos [2] In this study, various image processing algorithms were examined and multiple edge detection techniques were evaluated to identify the most effective approaches for fire detection using image processing. The RGB (Red, Green, and Blue) Colour Model and HSV conversion were utilized to extract fire-related features. Two edge detection methods were employed: Sobel, which detects vertical and horizontal edges separately, and Canny, which identifies edges while suppressing noise. By leveraging these algorithms, the detection of fire growth, particularly in the event of a disaster, becomes significantly more feasible through the application of image processing and advanced algorithms.

Improvement of Fully Automatic Fire Extinguish System for Residential Use. Ryo Takeuchi, Kouki Yamaguchi, Hayato Takahashi, Masahiko Hanada, Hiromichi Hanada [3] This system has the capability to automatically initiate fire extinguishing in a household setting. Notably, it incorporates features that enable remote control operation of the extinguisher through a web browser interface. Furthermore, the system utilizes a Python program with OpenCV to process the infrared camera images. As a result, it can automatically detect fires and promptly alert the user. In this study, enhancements were made to expand the system's fire detection capabilities, allowing for the detection of a broader range of fire incidents.

Autonomous Fire Fighter Robot Based on Image Processing. A.Q.M. Sazzad Sayyed, Md. Tasnimul Hasan, Shakib Mahmood [4] In this research paper, we introduce a design methodology and the practical realization of an affordable autonomous robot prototype. This robot can detect the presence of fire in its environment and taking appropriate actions to extinguish it. Equipped with a mounted camera, the prototype continuously captures video footage of its surroundings, which is then utilized for fire detection within its vicinity. To detect fire, an image processing algorithm was devised and tested using a database created by the authors. The robot's performance and accuracy were evaluated in various locations, and the success rate of fire detection and heading angle measurement was measured to assess its effectiveness.

A Survey on Fire Safety Measures for Industry Safety Using IOT. N. Savitha, Dr. S. Malathi [5] This survey examines the primary causes of fire accidents and analyses the safety measures implemented based on relevant technologies. Currently, IoT has been widely employed for enhancing safety protocols. However, most fire detection methods predominantly detect fires once they have already been triggered. In the proposed system, the focus is on implementing fire safety practices specifically for the firecracker industry. The aim is to analyse the root causes of fires and prevent them from occurring before any triggering events take place.

2. Methodology

The Fire Fighting Robot operates using an Arduino Uno microcontroller as the main control unit, which coordinates the actions of all sensors and actuators in the system.

1. Power Supply:

The system is powered by a 12V DC power supply, which provides the necessary voltage for the Arduino board, sensors, motors, and other components.

2. Fire/Flame Detection:

A Flame Sensor continuously monitors the environment for any fire or flame. When it detects infrared light from a fire source, it sends a digital signal to the Arduino controller.

3. Signal Processing (Arduino Control):

The Arduino Uno receives the signal from the flame sensor. It processes this signal and determines that a fire is detected. Based on the program logic, it activates the corresponding output components.

4. Alarm Activation:

When fire is detected, the Arduino triggers an alarm (buzzer) to alert nearby people about the fire incident.

5. Display Indication:

An LCD display shows the system's status—whether it is in scanning mode, fire detected, or extinguishing mode.

6. Motor Movement:

The Arduino sends control signals to a Motor Driver IC, which drives the robot gear motors. The robot then moves toward the direction of the fire, guided by the signal strength or sensor readings.

7. Fire Extinguishing Mechanism:

Once the robot reaches close to the fire, the Arduino activates a Relay Driver Circuit, which switches ON the Water Pump. The pump sprays water onto the fire until the flame sensor no longer detects fire.

8. System Reset:

After extinguishing the fire, the Arduino turns off the water pump, deactivates the alarm, and resets the system to scanning mode for further monitoring.

2.1 Block Diagram:

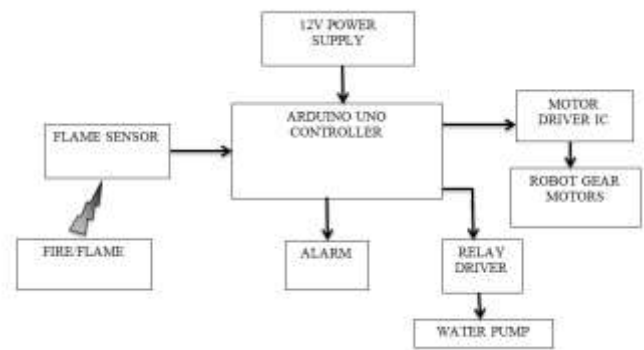


Fig -1: Block Diagram (Helmet Unit)

2.2 Arduino Uno Microcontroller

The Arduino Uno R3 CH340G with USB Programming Cable Combo is a versatile and beginner-friendly development kit widely used for learning, prototyping, and building electronics projects. Powered by the ATmega328P microcontroller and integrated CH340 USB-to-Serial interface, this board allows easy programming without the need for an external programmer. The included USB Type-A to Type-B cable ensures stable data transfer and power supply, making this combo ideal for DIY, robotics, automation, and IoT applications.

Specifications:

- Microcontroller: ATmega328P
- USB Interface Chip: CH340G
- Operating Voltage: 5 V
- Output Voltage: 5 V / 3.3 V
- External Input Voltage (Recommended): 5~9 V DC



Fig -3: Arduino Uno

2.3 Flame Sensor:



Fig -4: Flame Sensor

This flame sensor or fire sensor module works on the concept that when a flame or fire is burning it emits IR signals. This IR signal is then received by the IR receiver on the fire sensor module to detect the flame or fire.

The sensor has an operating voltage from 3V to 5.5V and has both digital and analog output. The sensitivity of the digital output can be controlled by the on-board potentiometer. Detection angle of sensor is 60 degree and range is theoretically 100cm but practically you can get upto 20-30cm

2.4 L293D Motor Driver Module:

Stepper and DC Motors are essentially used in any of the DIY Robotics projects and other applications can be found in 3D printing and steering DIY cars. Most commonly used IC for low power applications for controlling these motors in dual H bridge L293D Motor Driver which is capable of driving 2 Stepper or DC motors at the same time with direction control. It can run motors from 4.5V up to 25V rating. The shield contains two L293D motor drivers and one 74HC595 shift register. The shift register expands 3 pins of the Arduino to 8 pins to control the direction of the motor drivers. The output enables the L293D is directly connected to the PWM outputs of the Arduino.



Fig -5: L293D Motor Driver

2.5. DC Gear Motor:



Fig -6: DC Gear Motor

DC Motor – 30RPM – 12Volts geared motors are generally a simple DC motor with a gearbox attached to it. This can be used in all-terrain robots and variety of robotic applications. These motors have a 3 mm threaded drill hole in the middle of the shaft thus making it simple to connect it to the wheels or any other mechanical assembly.

30 RPM 12V DC geared motors widely use for robotics applications. Very easy to use and available in standard size. Also, you don't have to spend a lot of money to control motors with an Arduino or compatible board. The most popular L298N H-bridge module with onboard voltage regulator motor driver can be used with this motor that has a voltage of between 5 and 35V DC or you can choose the most precise motor driver module from the wide range available in our Motor driver's category as per your specific requirements.

4. Application:

- **Industrial Safety:**
Used in factories, chemical plants, and refineries to detect and extinguish fires caused by flammable materials or machinery faults.
- **Residential and Commercial Buildings:**
Deployed for automatic fire monitoring and suppression in homes, offices, malls, and hospitals.
- **Warehouses and Storage Units:**
Ideal for fire-prone areas where large quantities of goods are stored, helping to minimize property loss.
- **Military and Defense Applications:**
Used in ammunition depots, fuel storage areas, and war zones where human intervention is extremely dangerous.
- **Laboratories and Research Facilities:**
Helps prevent and control accidental fires

caused by volatile chemicals or electrical equipment.

- **Smart Cities and IoT Integration:** Can be part of IoT-based safety networks, providing real-time alerts and automated firefighting responses.
- **Remote and Hazardous Locations:** Useful in areas difficult to reach by firefighters, such as tunnels, mines, nuclear plants, or oil rigs.

CONCLUSION

We've enforced an automatic Fire Fighting Robot using detectors and wireless communication. Fire causes tremendous damage and loss of mortal life and property. It is occasionally insolvable for the fire fighter labor force to pierce the sight of fire because of explosive accoutrements, bank and high temperature. Through this we can conclude that robot can be placed where mortal lives are at threat. The robot can operate in the terrain which is out of mortal reach in veritably short time. In similar surroundings, Fire Fighting robots can be useful for extinguishing fire. The robot directly and efficiently finds the fire within minimal time after the fire is detected. This design presents the design and the perpetration of a firefighting robot that moves towards the fire and pump out water to extinguish the fire.

The Fire Fighting Robot project successfully demonstrates how robotics and automation can play a vital role in enhancing fire safety and emergency response systems. By integrating sensors, control mechanisms, and a mobile robotic platform, the system is capable of detecting, approaching, and extinguishing fires efficiently without risking human life.

This project highlights the potential of technology to assist firefighters and provide real-time solutions in hazardous environments. Though it has limitations in terms of power capacity and terrain adaptability, continuous improvements in sensor technology, artificial intelligence, and IoT integration can make such systems more intelligent, reliable, and autonomous in the future.

Overall, the Fire Fighting Robot serves as a cost-effective, life-saving innovation that contributes to modern safety automation and represents a promising step toward smart disaster management systems.

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