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A Review on Fire Fighting Robot

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Abstract: A Fire Fighting Robot is a machine that can operate on its own or with some help from a person. It is made to find and extinguish fires in places that are too risky for humans to go into. The main aim of this project is to build a robot that can detect fire sources and put them out quickly, which helps protect property and save lives. In this project, the robot has various sensors and components that allow it to act smartly. One of these sensors is an IR sensor, which detects fire by sensing the heat and light from flames. Once the robot sees a fire, it moves towards it using DC or BO motors. These motors are controlled by a module called L298N. The brain of the robot is an Arduino UNO microcontroller that receives data from the sensors and tells the motors and water pump what to do. When the robot gets close to the fire, it turns on a small water pump. This pump releases water through a nozzle that is controlled by a servo motor. The robot is powered by a rechargeable battery that can be either 3.7V or 9V. Other parts like the TIP-122 transistor, resistors, and capacitors help keep the robot electronics running smoothly. This system can be improved by adding wireless control through Bluetooth or Wi-Fi, allowing users to control the robot manually via a smartphone app if needed. The design is affordable, easy to carry, and works well for small fires that happen in homes, labs, or small factories. The Fire Fighting Robot shows how embedded systems, sensors, and automation can be used in real-world situations. It helps manage emergencies and makes environments safer by reducing the danger to people. Future improvements might include using AI for better vision, sensors like ultrasonic or LiDAR for navigation, and IoT technology for real-time updates and tracking.

Key Words: IR Flame Sensor, Arduino UNO, BO Motors, L298 Motor driver, Solder less breadboard, Mini servo, 5-9 Volt Water pump, 3.7 Volt Batteries, TIP-122 Transistor, 104PF Capacitor, 1k Resistor

1. INTRODUCTION:

Firefighting and rescuing people during a fire is a very risky and difficult job. Firefighters often find themselves in dangerous situations while trying to put out the fire. A report from the International Association of Fire Fighters (IAFF) in 2000 stated that about 1.9 firefighters per 100,000 structure fires died each year in the US. This number later increased to 3 per 100,000 fires. The main causes of these deaths include smoke inhalation, serious burns, injuries, and accidents during rescue operations. These numbers show that the number of firefighter deaths remains steady every year. Because of this, there is a strong need to develop firefighting robots or machines that can assist human firefighters in dangerous situations, making their jobs safer and reducing the risk of losing lives [1].

From above static figure 1 shows the death and injuries article :

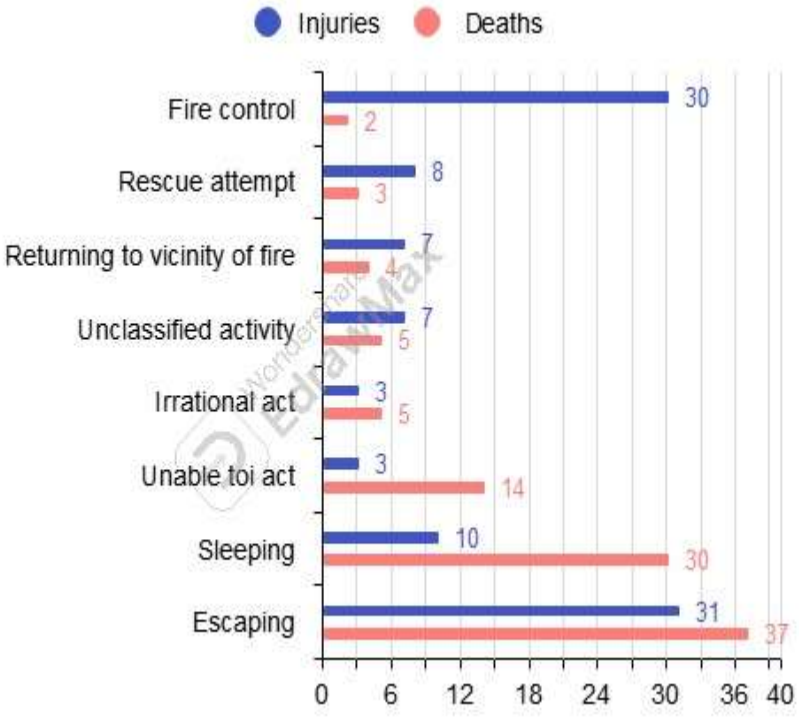

Figure 1. Death and Injuries Article from 2019-2023

Cultural property management is responsible for safeguarding an institution buildings, collections, operations, and staff from various threats such as climate change, pollution, theft, vandalism, insects, mold, and especially fire. Among all these risks, fire is the most dangerous because it spreads quickly and can cause severe and lasting damage. Although damaged or stolen items can often be repaired or replaced, items lost in a fire are permanently gone. To address this serious issue and protect both people and valuable assets, there has been a proposal to develop a robot that can combat fires [2].

The Arduino-UNO based robot moves using motorized wheels and servos. It can also send real-time information about the fire's location and status to a monitoring system from a distance. As a first responder, the robot helps control the fire until assistance arrives. Although it is still under development, it represents a significant progress in creating fully automatic fire-fighting and rescue robots capable of operating safely in hazardous environments [3]. Fire fighting robots can be used to locate, monitor, and extinguish fires without putting people at risk. The development of self-driving fire-fighting robots, particularly those that use Arduino technology, aims to reduce injuries, speed up fire response times, and assist during rescue operations in hazardous environments [4]. The IoT-based Fire Extinguishing Robot can identify fires by itself using multiple flame sensors and a water pump. It goes towards the fire to spray water and put it out, which helps prevent large accidents and ensures people's safety [5]. Arduino-UNO sends live alerts via the Blynk IoT platform, which helps increase safety in risky or difficult-to-access areas [8]. Fire safety is very important because fires can spread quickly and cause serious harm to people and their property. Usually, firefighting relies on people taking action, which can sometimes be slow. New technology, such as smart fire detection systems that use smart sensors and smart algorithms, helps respond faster and more effectively. Robots with sensors like ultrasonic, LIDAR, infrared, or LDR-based line-following systems can move through tough areas, avoid obstacles, and put out fires on their own [9].

Fire is one of the most serious dangers that can happen anywhere at any time. It can destroy buildings and put people lives in danger. Sometimes, it is difficult or too risky for humans to get near a fire to stop it. To address this issue, we can use technology to create a robot that can detect and extinguish fires on its own.

2.Proposed Work

The Fire Fighting Robot using Arduino as shown in figure 2 is a smart robot designed to identify and put out small fires. It uses flame sensors to detect fire and an Arduino UNO board as the main controller to process signals from the sensors. The robot moves using BO motors and an L298N motor driver module, which allows it to move forward, backward, left, or right depending on where the fire is. Once it detects a fire, a small servo motor and water pump system automatically activate, and water is sprayed through a pipe to put out the flames. This robot is powered by Li-ion batteries and can be used in small factories, laboratories, or homes to improve safety. It reduces the risk to people lives and helps control fires early. This project combines electronics, sensors, and robotics, showing how automation can make our surroundings safer. A fire-fighting robot is a type of autonomous or semi-autonomous robotic system designed to detect and extinguish fires in dangerous areas where human intervention is not safe or possible. In recent years, the increasing number of fire incidents in homes, factories, and offices has highlighted the importance of using new technology to protect lives and property. Designing a fire-fighting robot focuses on making it reliable, efficient, and safe, making it a major innovation in modern robotics and emergency management. With continued advancements, these robots could also use wireless communication, image recognition, and artificial intelligence to improve detection and response times.

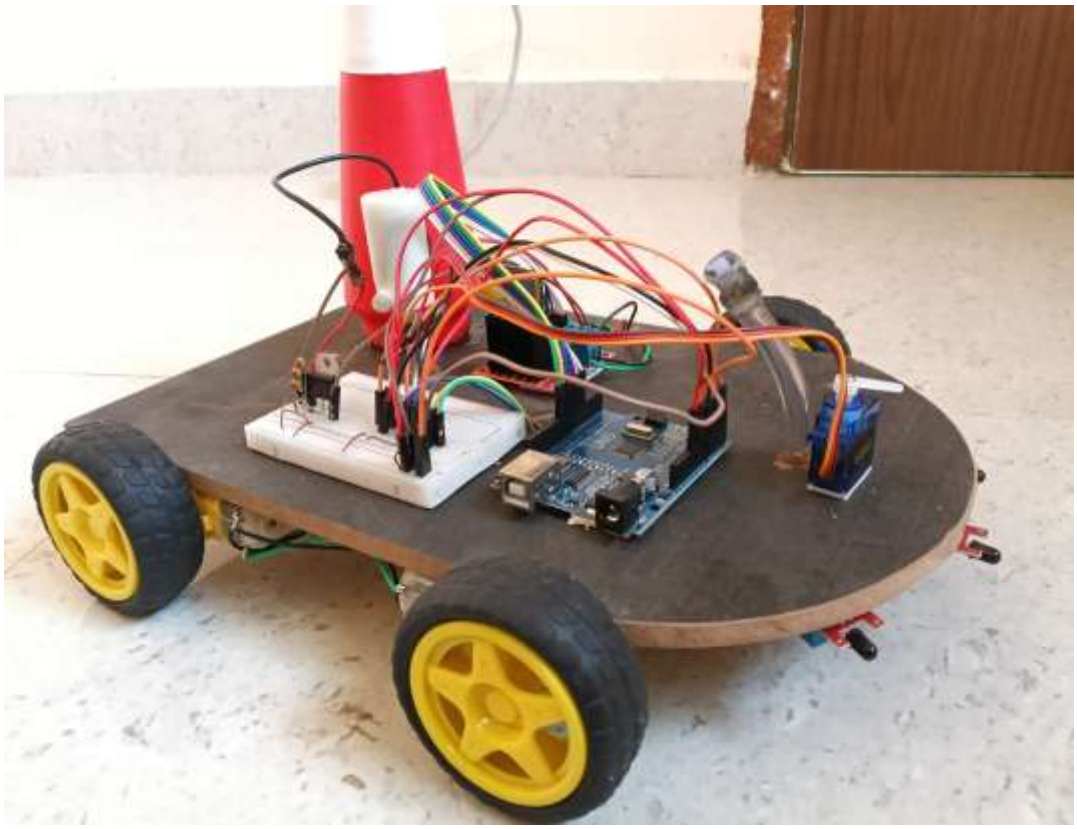

Figure 2. A Fire Fighting Robot using Arduino

2.1 Working Principle of Fire Fighting Robot :

This working principle explains how the Fire Fighting Robot using an Arduino UNO operates in figure 3. The Arduino UNO acts as the main control system, receiving signals from the flame sensor and the ultrasonic sensor. The flame sensor detects the presence of fire, while the ultrasonic sensor helps the robot identify obstacles and navigate safely. The L298N motor driver is connected to the Arduino and controls four DC motors (M1, M2, M3, and M4), allowing the robot to move forward, backward, turn left, or right. A servo motor is used to rotate the flame sensor or the water nozzle, enabling the robot to aim precisely at the fire. Once the robot detects fire, the Arduino activates the water pump, which releases water to extinguish the flames. The power supply provides electricity to all the components, ensuring everything functions properly. This setup allows the robot to detect, move towards, and put out fires on its own, without any assistance from a person.

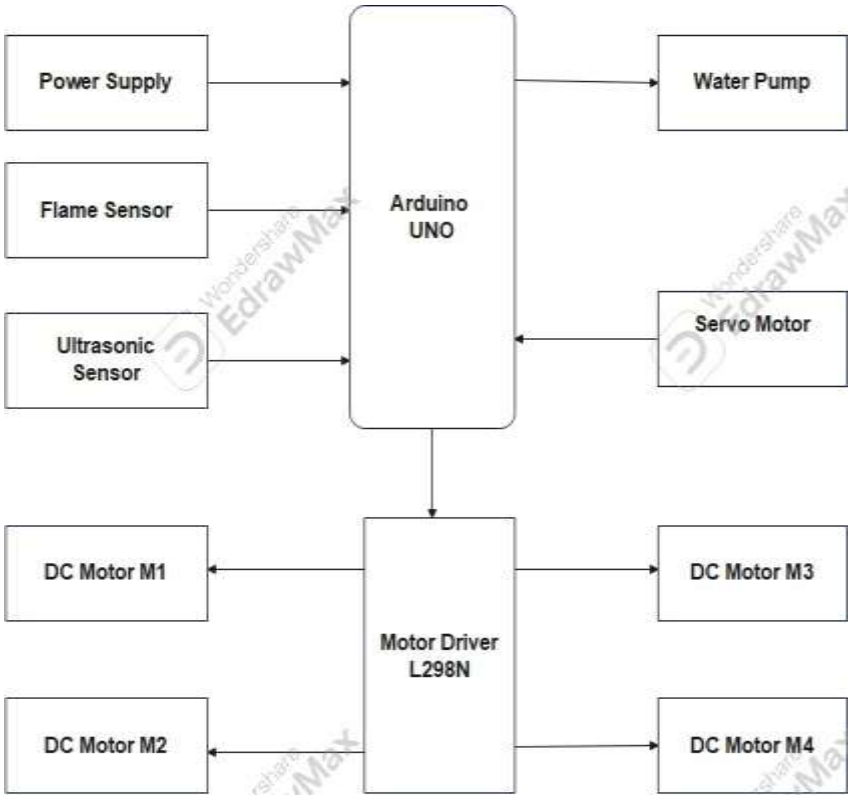

Figure 3. Working Principle of Fire Fighting Robot

- Start
- Checking the inputs from the flame sensors.
- If there is no flame detected, proceed to the next step.
- If a flame is found, collect the readings from both the CO sensor and the CO2 sensor.
- Next, examine the graph values to decide whether the CO2 level is high or low.
- If the CO2 level is high, activate the CO2 pump.
- If the CO2 level is low, turn on the water pump.
- Then stop the process.

The Fire Fighting Robot project demonstrates how embedded systems and automation can be applied in real-life safety scenarios. In this setup, the Arduino UNO serves as the main controller, receiving input from an IR 4-pin flame sensor and managing the robot's movement and water pump. The IR flame sensor detects fire by sensing infrared light emitted by flames. When it detects fire, the Arduino processes the signal and instructs the robot to move toward the flame using the BO motors, which are controlled by the L298 motor driver module. The L298 module helps regulate the direction and speed of the motors, allowing the robot to move smoothly and turn accurately. A mini servo motor is also used to rotate the flame sensor or nozzle, enabling the robot to aim precisely at the fire source.

Once the robot reaches a safe distance from the flame, the Arduino activates the water pump through the TIP122 transistor, which acts as an electronic switch. A 1k resistor connected to the base of the TIP122 manages the base current, while a 104pF capacitor helps reduce electrical noise in the circuit. Power is supplied by a 3.7V battery, which can run the Arduino and motors for a limited time. However, for improved performance, a higher voltage or a regulated 5V to 9V power source can be used. During operation, the robot successfully identifies and extinguishes small flames by spraying water directly onto the source. Some challenges were identified, such as interference from ambient light, a limited sensing range of the flame sensor, and low water pressure due to the battery's limited capacity. Despite these issues, the robot performs well in controlled indoor environments and shows reliable ability in detecting and extinguishing fires. Overall, this project serves as a practical example of a low-cost, autonomous fire-fighting system using commonly available electronic components.

It highlights the importance of managing power efficiently, establishing proper connections, and filtering noise to ensure consistent performance. Future improvements could include using multiple flame sensors for better coverage, switching

to a MOSFET driver for more efficient power control, adding wireless communication for remote control or monitoring, and integrating camera vision for better navigation. Using a more powerful battery can also increase the robot's operating time. This project combines hardware and software to create a simple yet effective fire-fighting robot prototype that has the potential for real-world applications with further enhancements. The future possibilities for the fire-fighting robot project are vast. It can be developed and enhanced for real-life fire safety and rescue operations. In the future, advanced sensors like temperature sensors, gas sensors, and thermal cameras can be integrated to improve the robot's ability to detect different types of fires. The system can also be upgraded with artificial intelligence and machine learning to allow the robot to analyze fire patterns and make more informed, independent decisions. Including wireless communication modules like Wi-Fi, Bluetooth, or GSM can enable the robot to send alerts or live video feeds to firefighters or control centers for real-time updates. Using high-capacity batteries, efficient motor drivers, and a durable metal chassis can enhance the robot's performance and durability, allowing it to operate in larger, more hazardous environments. In the long term, such robots could be used in industries, offices, and homes as a first line of defense against fire accidents, helping to prevent damage and save lives. This project has significant potential for innovation and can contribute greatly to the field of modern automation and safety technology.

3. CONCLUSION:

The Arduino-based fire-fighting robot is a low-cost, autonomous system designed to detect and extinguish small fires using IR flame sensors, BO motors, an L298 motor driver, and a water pump controlled by a servo. Simple components like the TIP122 transistor, capacitors, and resistors ensure reliable operation, while a 3.7V battery powers the robot. The project demonstrates how embedded systems and robotics can improve safety in hazardous areas by responding to fires without human intervention.

Future upgrades include a stronger body, larger water or CO_2 capacity, higher-power pumps, long-lasting batteries, and advanced sensors capable of detecting fires or survivors from greater distances. The robot will also include GSM e-SIM for remote communication, GPS modules for accurate location tracking, and advanced processors with image-processing capabilities to make faster, smarter decisions during emergency situations.

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