"Arduino-Controlled Firefighting Robot: A Technical Study"

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Abstract-- A fire outbreak is a hazardous event that can lead to severe consequences. Early detection and quick extinguishing can prevent major accidents, yet we still rely heavily on human intervention, putting firefighters' lives at risk. To address this, a fire-extinguishing robot is proposed, designed to detect fire and suppress it using a sprinkler mechanism activated by a water pump.

The robot uses three flame sensors for accurate fire detection and operates autonomously without human involvement. It employs gear motors and a motor driver for movement, navigating toward the detected fire and activating the pump automatically. A water ejector is used to spray water at the fire source, and its direction can be adjusted using a servo motor. The entire system is controlled by an Arduino UNO microcontroller, ensuring efficient and reliable operation.

Keywords:- Firefighting Robot, Arduino UNO, Flame Detection, Autonomous Navigation, IoT-Based System, Water Pump Mechanism, L298N Motor Driver, Servo Motor Control, BO Motors

Fig 1: Causes of Fire Accident

I. INTRODUCTION

A major concern in fire disasters is the loss of human life, especially when firefighters risk themselves to save others. Often, it becomes impossible for personnel to enter fire-affected areas due to smoke, high temperatures, or explosive materials. A quick response to detect and suppress fire can prevent major accidents, as even a small spark can cause a massive outbreak. Poor fire management threatens both industrial and domestic environments, leading to severe injuries and fatalities.

To handle such situations, a fire-fighting robot is proposed. Modern robotics aims to reduce human involvement in dangerous tasks, and robots are increasingly used to safely perform labor-intensive or hazardous work. The Fire Extinguishing Robot uses IoT technology to detect and suppress small flames automatically. It senses fire using three flame sensors—left, front, and right. Once fire is detected, the robot navigates toward the source and activates its extinguishing system. A water pump then ejects water to control the fire.

This system enhances fire surveillance, prevents major accidents, and significantly reduces the risk to human life.
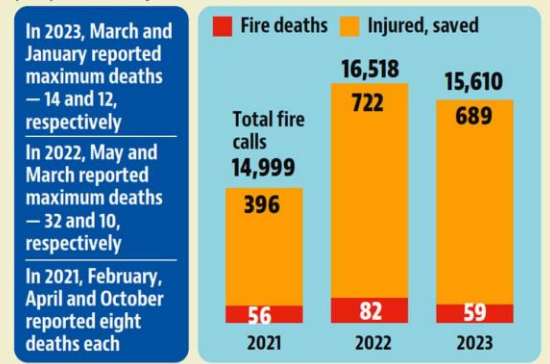
II. PROBLEM FORMULATION

Fire disaster is one of the dangerous problems that can lead to heavy loss both financially and by taking lives. Sometime it becomes difficult for fighters to access the site of a fire because of explosive materials, smoke, and high temperatures. Such situations risk the lives of fire fighters too. In such environments, fire-fighting robots can be useful. This Fire Extinguishing Robot is based on IOT Technology. In Fire Extinguishing Robot, we intend to build a system that could extinguish a small flame by sensing and moving to the location itself.Sometime delay in the arrival of fire fighters leads to numerous consequences.The Fire Extinguishing robot continuously monitors the environment and extinguishes it without delay.

III. LITERATURE SURVEY

Tawfiqur Rakib and M. A. Rashid Sarkar proposed a fire-fighting robot built on a kerosene-wood platform, using an LM35 temperature sensor, flame sensors, and a 1-litre water container made of water-resistant cardboard, with two wheels for movement. [1]

Saravanan P. and Soni Ishawarya designed a model using an Atmega2560 microcontroller, divided into three units—locomotive, fire-detecting, and extinguishing. It uses four IR and four ultrasonic sensors for obstacle avoidance, and LDR with a temperature sensor for fire detection. [2]

S. Jakthi Priyanka and R. Sangeetha proposed an Android-controlled robot using Arduino UNO R3, equipped with a gas sensor, gear motors, motor driver, Bluetooth module, water pump, and sprinkler, programmed using Arduino IDE. [3]

Nagesh MS et al. developed a robot using DTMF technology for navigation and a flame sensor capable of sensing flames in the 760–1100 nm range, with sensitivity from 10 cm to 1.5 feet. [4]

Sushrut Khajuria and team proposed an Arduino-based robot with RF remote control for operating the robot and water pump within a 7-metre range, also featuring a wireless camera for navigation. [5]

Khaled Sailan et al. developed an obstacle-avoidance robot called the Amphibious Autonomous Vehicle, which uses a fuzzy controller to avoid static obstacles in real time. [6]

J. Jalani and team proposed an automatic fire-fighting robot using three flame sensors (left, right, center) and three ultrasonic sensors for obstacle detection, along with a Bluetooth module to send warning notifications when fire is detected. [7]

IV. METHODOLOGY

The theme of this paper is to automatically sense the environmental fire and extinguish it without human intervention. The methodology is divided into three parts. The first part is on the design structure, followed by hardware description and the finally on the programming design. All these three parts were assembled together and experiments were then performed to build a system that can extinguish the fire that was carried out.

A. Design Structure

In this section, the prototype of robotic system is presented, in which it consists of IR flame sensors, servo motors, submersible water pump, motor driver, mini breadboard, BO motors, rubber wheels.

Fig 2 shows the basic prototype of our firefighting robot. The robot carries four main functions: First, it initializes itself i.e. its sensors gets initializes as the power is supplied. Second, robot sense the surrounding environment (for instance for the level of temperature) and identify the fireplace. Third, robot sends the navigating information and starts to navigate itself towards the fireplace. Fourth, finally the robot starts to extinguish the fire with the help of servo motors and submersible water pump.
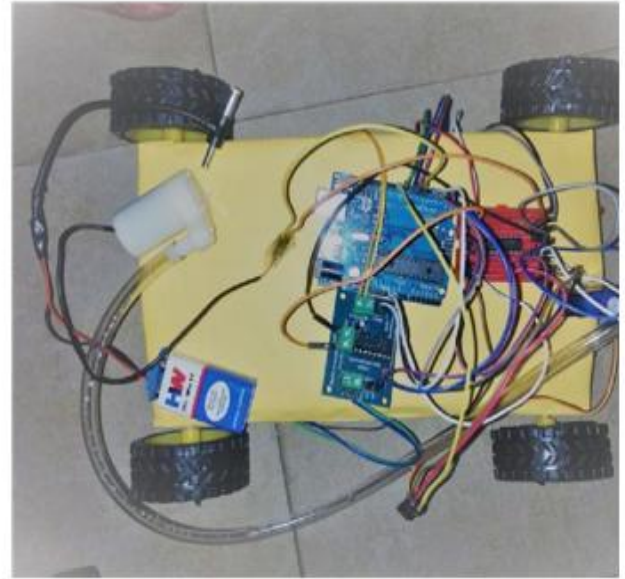

Fig 2: Prototype

B. Hardware Implementation

The hardware part is one of the crucial parts in the development of firefighting robot. It includes Arduino UNO, IR flame sensors, servo motors, submersible water pump, motor driver, mini breadboard, BO motors, and rubber wheels. Fig 3 shows the block diagram of firefighting robot which consists of three IR flame sensors as the input of the system. Arduino UNO is used as a micro-controller that connects other components. L298N Motor driver is used to drive motors and is capable of running two DC motors (Left DC motor and Right DC motor) at the same time.
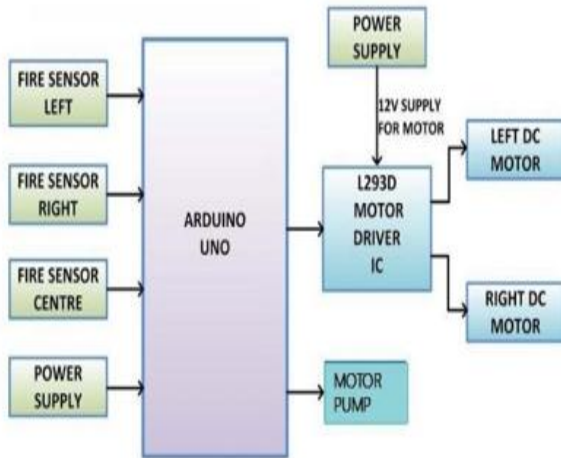
Fig 3: Block diagram

C. Hardware Used

1. *ATmega328P IC(Arduino UNO):* Figure 4. shows the Arduino UNO board. It is basically a micro-controller kit that is used to get data from peripheral devices (sensors, motors, etc.). The Arduino UNO Micro-controller board is based on the ATmega328P IC. The ATmega328P is good platform for robotics application which makes robot to extinguish fire in real time. Arduino UNO board consist the sets of digital and analog pins that may act as an interface to various expansion boards and other circuits. It contains everything needed to support the microcontroller.
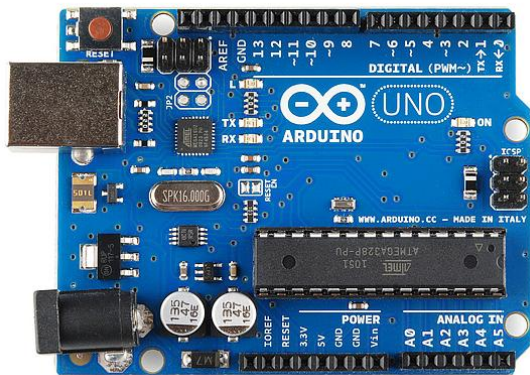

Fig 4: Arduino Uno

2. IR Flame Sensor: Fig.5 shows the IR Flame Sensor. The IR flame sensor senses the environment and detects the presence of fire or flame. The module is based on the IR receiver and basically detects the presence of flammable and harmful gases like nitrogen ,hydeogen, carbon mono oxide. The signal detection capacity is adjustable. The robot contains three flame sensors.

Fig 5: Flame Sensor

3. L298N Motor Driver: Fig.6 shows the L298N Motor Driver.L298N is a motor driver or motor driver IC which is responsible for the movement of DC motor on either direction.L298D is a 16 pin IC through which we are able to run two DC motors simultaneously in any direction.
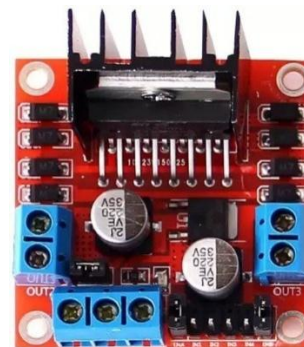

Fig 6: L298N Motor Driver

4. Servo Motors: Fig.7 shows the Servo Motors.Servo Motors are electronic devices that are mainly used for providing specific velocity and acceleration.

Fig 7: Servo Motor

5. Submersible Water Pump: Fig.8 shows the submersible water pump. Submersible Water Pump is ideal for making automatic watering system using Arduino. The water pump is an important part of the robot as it will pump water to extinguish the fire.

Fig 8: Water Pump

6. BO Motors: Fig.9 shows the BO motor.BO Motor is a dual shaft motor having 300 rpm .It converts electrical energy into mechanical energy .It is the replacement to our metal gear DC motors .Our robot uses four dual shaft motors.

Fig 9: BO Motor

V. CONCLUSION

This Fire Extinguishing Robot helps reduce the workload and risk faced by firefighters. The project aims to develop a real-time robot that moves at a constant speed, detects fire, and extinguishes it using a pumping mechanism. The system uses simple hardware components: IR flame sensors for fire detection, BO motors with rubber wheels for navigation, and a submersible water pump with a servo motor to spray water onto the fire. This allows the robot to identify the fire location and extinguish it effectively.

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