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IOT Based Smart Fire Fighting Robot

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Abstract:
A fire is a catastrophe that can result in the loss of life, property damage, and the victim's lasting disability. When a fire occurrence, we are compelled to employ human resources, which are not safe, to rescue people and put out the fire. This proposed work focused on developing a robotic system capable of moving to areas where firemen have to risk their lives to put off the fire. In this research, we created a prototype robot using Arduino UNO that identify and extinguishes fires freestanding. The water pump and servo motor are activated after detecting the fire by flame sensor. The capacity to detect fire sites automatically and extinguish fire remotely at a distance of 30 cm from the fire. The robot is designed to locate fires and spray water into them in order to decrease the amount of destruction.

Keywords*: Arduino Uno, IoT, Microcontroller, IR flame sensor, Servo motor*

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I. Introduction

The main focal point of this research revolves around a firefighting robot. Robots have a remarkable ability to carry out tasks more efficiently economically and accurately than humans beings. The Fire Protection Robot help people in any destructive burnt situation where the robot can detect and extinguish burnt area instantly using autonomous system. In real life, destructive burnt area often happens without our apprehension. Therefore, this type of robot will require a high demand in the market owing to the fact that of its usefulness to the human [1]. In our efforts to enhance fire detection we've developed a model called LTDAR. In our case, the robotic agency comes prepared with water tanks and a pump that's controlled through wireless communication. A fire-fighting robot is proposed for such background. Many robots are design and built-in today's society to replace humans in risky and harmful jobs. Robots are increasingly being used to do life-threatening or labor-intensive tasks for humans. IoT (Internet of Things) technology is used to model a fire extinguishing robot. The key features of this project is to design and build an obstacle remover and firefighting robot system that uses an Arduino mega unit with flame sensor, a motor driver (L293D) module with water pump and servo motor, is to provide surveillance of fire so that major fire accidents can be prevented and loss of human lives gets minimized.

II. Related Work

Sanusi Mohammed [1] focuses on the measured distances are suitable for use in the firefighting system under development. Sensors are utilized to detect and identify the intensity, direction and location of fires.

Patel Mohd [2], develop a real-time firefighting robot that operates at a steady pace, detects fires and utilizes a pumping mechanism to extinguish them. Basic hardware components are incorporated into the robot to identify and extinguish fires.

Anam Sheikh [3], construct a real-time firefighting robot capable of moving at a constant speed, identifying fires and extinguishing them using a pumping mechanism.

Md Abdullah Al Rakib [4] create a robot capable of clearing obstacles and combating fires autonomously. An autonomous firefighting robot with a water spray mechanism has been construed, designed and implemented.

Mr. Kondeti Chirunadh [6], detecting and extinguishing of fires are achieved through basic hardware components attached to the robot.

Overall, all of the paper mentioned above revolve around projects related to firefighting robots, aiming to provide solutions for risky and perilous tasks. Consequently, our proposed method focuses on developing a " IoT Based Smart Fire Fighting Robot" aiming to create an Arduino-based firefighting robot capable of detecting fires and automatically activating a atomizer system to dispense water onto the identified fire area. This technological solution aims to revolutionize firefighting by enabling instant and efficient responses to fire emergencies.

III. Problem Formulation

A fire disaster is one of the most serious situations that may cause significant financial and human being damage. Because of explosive materials, smoke and high temperatures, accessing a fire whereabouts can be hazardous at times. Firefighters are also at danger in such scenarios. Firefighting robots can be serviceable in such situations. This Fire Extinguishing Robot is fueled by Internet of Things (IoT) technology. In Fire Extinguishing Robot, we intend to build a method that could extinguish a small flame by sensing and moving to the location itself. Sometimes delay in the arrival of fire fighters leads to innumerable consequences. The Fire Extinguishing robot continuously monitors the surroundings and extinguishes it without delay.

IV. Fire Incidents in Bangladesh

In the previous ten years, at least 16,000 fires have occurred in Bangladesh; the number of fires has grown more than thrice across the nation since 1997, with a daily average of 53 in 2018. According to the online database Data complete, over 250,000 fires occurred in the nation between January 1, 1997 and December 31, 2018, according to Fire Service and Civil Defense figures. The nation suffered a financial loss of roughly Tk6,400 crore as a result of the flames. According to available fire department data, at least 1,970 persons were died in nearly 200,000 fires across the country between 2004 and 2018. In 2006, there were a total of 9, 542 fire events across the country, with 91 persons killed and 873 injured; in 2018, there were 130 deaths and 664 injuries in 19,642 fire incidents [3]. Bangladesh has been going through a difficult time. Prior to incident, a major fire erupted in ancient Chittagong's Sitakunda in June 2022, causing chemicals explosion [4]. At least 49 people have been killed and over 450 injured in a fire caused by an explosion at a private Inland Container Depot (ICD) in Sitakunda upazila in Chittagong. Many people in Bangladesh are comparing the explosion to the huge blast that hit Beirut in 2020, said the BBC's Akbar Hossain in Dhaka. He said people had reported hearing the blast from 30-40km (19-25 miles) away.

Figure 1: Fire incidents at Sitakunda, Chittagong, Bangladesh.

Firefighters were still struggling to put out the fire on Sunday, with continued explosions making it more difficult, according to fire officials [5].

V. Methodology

The paper's focus lies in autonomously identify environmental fires and deploying extinguishing estimate devoid of human intervention. The methodology is divided into three parts. The first part is on the design configuration, 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.

Design Configuration: In this segment, we introduce the representative of a robotic system. It includes IR flame sensors, servo motors, a submersible water pump, motor driver, mini breadboard, BO motors, rubber wheels, a processor and a communication module for exchanging data between the firefighting robot and Arduino

software. The robot performs four main functions: Firstly, it get started and initializes its sensors when powered on. Secondly, it senses the neighbouring environment, such as the temperature level and identifies any fires. Thirdly, it sends navigation instructions to itself and moves towards the fire. Finally, it extinguishes the fire using servo motors and the submersible water pump. The block diagram of this system shown in figure 2 and circuit diagram shown in figure 3.

Circuit Diagram:

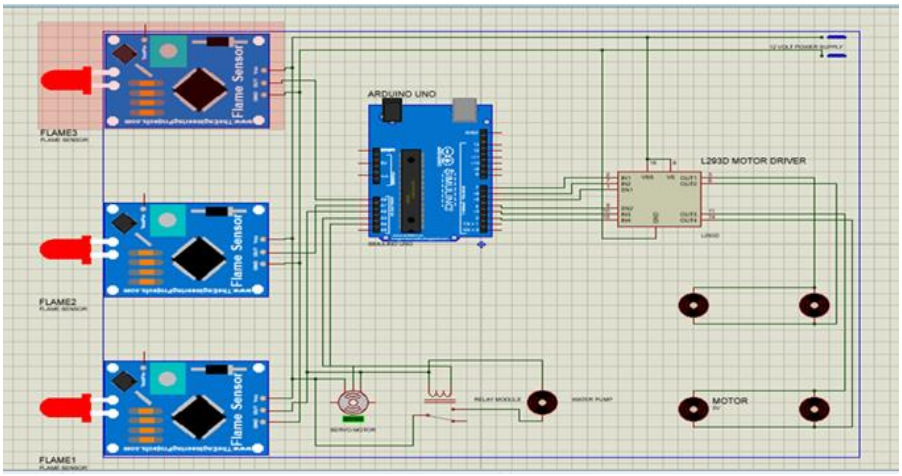


Figure 3: Circuit Diagram of fire-fighting robot.

In thi section, we present the models and materials used in our research work.

Components:

1. Arduino board (e.g., Arduino Uno)
2. flame sensors (3x)
3. Motor driver module (e.g., L293D)
4. DC water pump motor
5. Robot chassis with motors (typically DC motors)
6. Power supply
7. Jumper wires & etc.

Programming:

1) Transfer the required code onto the Arduino board for managing the flame sensors, motor driver and water pump motor.
2) Within the code, interpret the sensor outputs to identify the existence of fire.
3) Utilizing the sensor data, regulate the motor driver to enable autonomous movement of the robot.
4) Upon detection of fire, trigger the water pump motor by activating the Arduino's digital pin linked to the transistor's base.

The Automatic Fire Fighting Robot Detection and Control System using Arduino operates on the principle of integrating sensors for fire detection, processing this data through Arduino and executing appropriate actions. This harmonized approach of sensing, processing, actuating and communicating forms the foundational principle, enabling the robot to autonomously detect and control fires while adapting to dynamic environment.

VI. Working Principle

The Automatic Fire Fighting Robot uses an Arduino Uno microcontroller for its operations. It identify fires using a Flame Sensor, which monitors for flames or high temperatures. The Arduino then jurisdiction the robot's movement towards the fire using an L293D Motor Driver and wheels. Upon reaching the fire, a Relay Module activates a pump to dispense an extinguishing agent, with a Servo Motor balance the direction of discharge. Throughout this process, Arduino serves as the communication hub between ingredient, ensuring synchronized actions and real-time monitoring. Safety features, overseen by Arduino, implement fail-safe protocols and adaptability, optimizing the system's orderliness and effectiveness. Essentially, this system, under Arduino's governance, autonomously detects fires, navigates to extinguish them and ensures reliable performance with integrated welfare mechanisms. Full Setup of fire-fighting robot is shown in figure 4.

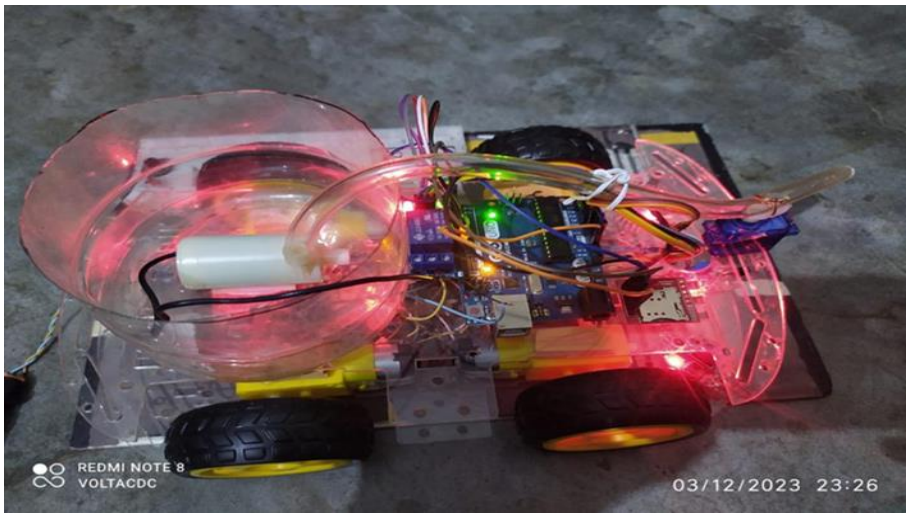


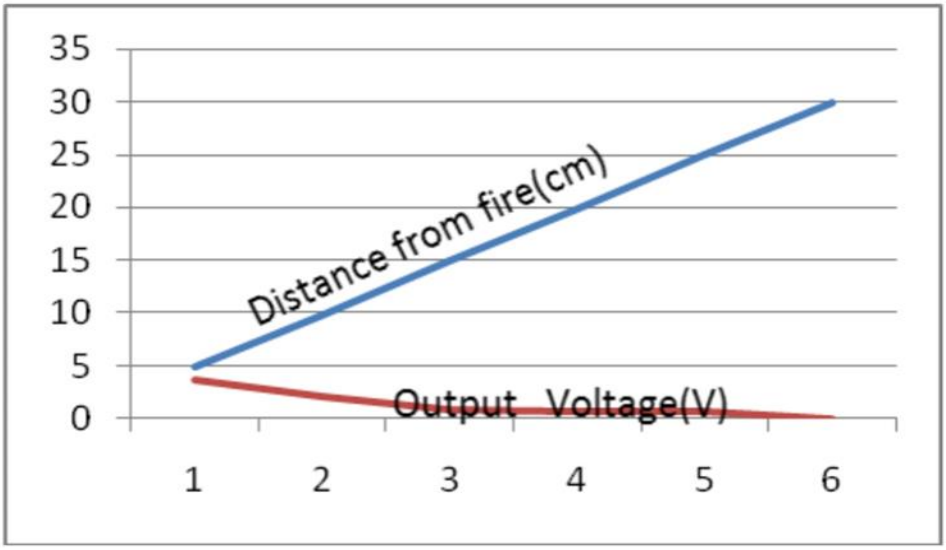
Figure 4: Full Setup of fire-fighting robot.

VII. Result and Discussion

The fire sensor sense the temperature of the environment and inform the Arduino, if this temperature is more then normal temperature then Arduino gave the commend of servo motor and water pump. In this time servo motor and water pump are activated and they start their work. Table.1 shows the different results of the fire-fighting robot. Graph.1 shows the performance of this project.

Table 1: Fire detection result value can be expressed as shown in following table.

No. of Observation	Distance From Fire (cm)	Measured Voltage (V)	Working Temperature (°C)
1	5	3.75	63 - 76
2	10	2.10	61 - 67
3	15	0.98	53 - 60
4	20	0.65	55 – 59
5	25	0.50	47 - 53
6	30	0.01	42 – 48



Graph.1: Output voltage (V) verses distance from fire(cm) place.

VIII. Conclusion

In conclusion, this model of Fire Extinguishing Robot aims to attenuate the burden on firefighters during firefighting tasks. Our project aims to construct an instantaneous firefighting robot that moves at a constant speed, identifies fires and extinguishes them. When the flame sensor detects a fire, the water pump and servo motor are

trigger off. The robot has the capability to automatically detect fire sites and extinguish fires remotely from a distance of 30 cm. It is designed to locate fires and spray water into them to diminish damage.

Arduino-based robots may face challenges due to insubstantial processing power, making it difficult to implement complex decision-making algorithms. The amount of water carried by the robot is restricted, impacting its ability to combat large fires or operate for expanded periods. Regular maintenance is necessary to ensure the bona fide functioning of the robot and its components, including sensors, motors and water delivery systems.

IX. Future Scope

In the coming times, we can enhance and enlarge the robot's frame to make room for increased water capacity and potentially a CO2 canister. Upgrading the battery pack to draw out the robot's operational duration is also essential. Furthermore, upgrading the water pump's capabilities to tackle fires at greater distances, incorporating advanced and highly sensitive sensors to detect fires and survivors over longer distances and through obstacles and introducing a GSM e-SIM module to allow complete remote control and communication with operators over extended distances are potential avenues for improvement.

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