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Fire Fight Robot using Arduino Uno

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Abstract: *Fire incident is a disaster that can potentially cause the loss of life, property damage and permanent disability to the affected victim. Major fire accidents do occur in industries like nuclear power plants, petroleum refineries, gas tanks, chemical factories and other large-scale fire industries resulting in quite serious consequences. Therefore, this project is enhanced to control fire through a robotic vehicle. With the advancement in the field of Robotics, human intervention is becoming less every day and robots are used widely for purpose of safety. In our day to day life fire accidents are very common and sometimes it becomes very difficult for fireman to save human life. In such case fire fighting robot comes in picture*

Keywords: Firefighting Robot, IR Distance Sensor, Flame Sensor, OV7670 Camera Module, Arduino Mega 2560, DC motor, Driver module

I. INTRODUCTION

One of the most important parameter in fire disaster is life, i.e. lives lost in saving someone else life. It is sometimes impossible for fire-fighters personnel to access the site of a fire because of explosive materials, smoke, and high temperatures. A fast response to detect the fire can avoid many disastrous things. From the given statics (Fig.1), it is observed that fire can take place at domestic as well as at industrial level. A normal spark can generate a massive fire breakout. Not only lives of industrial people but also the lives of domestics people is at risk because of poor fire management system. Fire can take many lives to and can injure many people for their life time. But it can be avoided using proper fire controlling methods. For such environments, fire-fighting robot is proposed. In today's generation a lot of robots are proposed and designed to remove the human factor from dangerous and deadly work. The use of robots

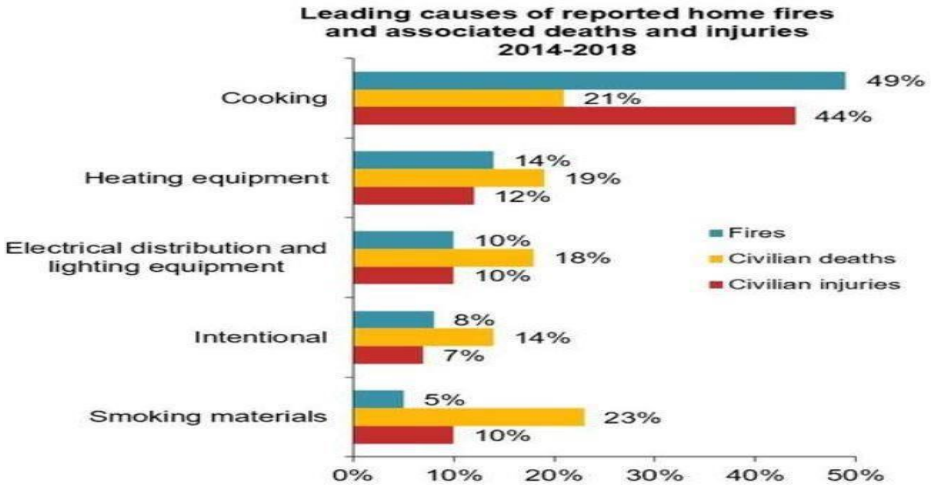

Fig1. Causes of fire accident.

are becoming very common that safely completes the labour intensive or deadly work for human beings. A Fire Extinguishing Robot is based on IOT Technology. In Fire Extinguishing robot, we intend to build a system that could

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extinguish a small flame by sensing and moving to the location itself. It will automatically detect the fire with the help of flame sensors. Once it detects the fire breakout location, it navigates itself accordingly to reach the fire source and extinguishes the fire by using built-in fire extinguishing system. For fire detection it is using three flame sensors. First one for the left direction, second one for the forward direction and third one for the right direction. Fire extinguishing system will get activated when fire detection system detects fire. It then reaches the breakout point and water pump will start ejecting the water when it detects fire. The key features of this system is to provide surveillance of fire so that major fire accidents can be prevented and loss of human lives gets minimized.

II. LITERATURE REVIEW

This literature review examines recent advancements in fire detection systems and autonomous firefighting robots, focusing on technological implementations, sensor integrations, and artificial intelligence applications in this critical safety domain. Recent advancements in firefighting robotics have leveraged AI, IoT, and modular designs to enhance autonomous fire detection and suppression. Pranamurti et al. [1] demonstrated the effectiveness of Raspberry Pi-based image processing for fire detection in CCTV systems, while Moses [2] contributed to AI-powered fire recognition through the FireNET dataset. Kirubakaran et al. [3] and Diwanji et al. [4] further developed autonomous robotic solutions using Arduino and advanced sensor integration, respectively. These innovations enable robots to operate in high-risk environments such as chemical plants, where human intervention is dangerous [4]. The integration of intelligent control systems and IoT connectivity has significantly improved firefighting capabilities. Wu et al. [7] designed an STM32-based robot with coordinated movement and fire suppression modules, whereas Kanwar and Agilandeeswari [9] implemented IoT for remote monitoring and multi-robot coordination. Prasojo et al. [5] enhanced obstacle detection using ultrasonic and UV sensors, while Aliff et al. [8] focused on mobility solutions for complex environments. These developments highlight the shift toward intelligent, collaborative, and high-efficiency firefighting systems [7,9].

Advancements in Fire Detection and Robotics: Modern fire detection systems have significantly evolved through the integration of Raspberry Pi and computer vision technologies, as demonstrated by Pranamurti et al. [1] who developed a CCTV-based fire detection system using image processing. The field has benefited from comprehensive datasets like FireNET [2], which enable more accurate machine learning models for flame recognition. Kirubakaran et al. [3] showcased the potential of Arduino-based robots in firefighting applications, particularly in confined spaces where human access is limited. Diwanji et al. [4] further advanced autonomous capabilities by creating robots that combine fire detection with immediate extinguishing functions. Sensor technology has seen notable improvements, with Prasojo et al. [5] implementing ultrasonic and UV sensors on firefighting robots for enhanced environmental awareness. Wu et al. [7] contributed to intelligent firefighting solutions through their STM32-based robot design that integrates multiple functional modules. Aliff et al. [8] focused on mobility aspects with their QROB development, addressing navigation challenges in complex environments. Kanwar and Agilandeeswari [9] demonstrated the value of IoT connectivity in firefighting robots for remote monitoring and control. These technological advancements collectively improve response times while reducing risks to human firefighters. The integration of multiple sensor types helps minimize false alarms that plagued earlier systems. Current systems now combine thermal imaging with traditional smoke detection for more reliable identification. Wireless communication capabilities allow for coordinated responses among multiple robotic units. However, challenges remain in standardization across different platforms and technologies. Energy efficiency continues to be a concern for battery-operated autonomous units. Field testing under real-world conditions remains limited for many of these systems.

System Integration and Future Directions: The development of intelligent firefighting systems has increasingly focused on comprehensive integration of various technologies, as seen in Wu et al.'s [7] STM32-based design that coordinates movement, detection, and suppression systems. IoT implementations by Kanwar and Agilandeeswari [9] enable cloud-based monitoring and data analysis, facilitating predictive maintenance and performance optimization. Sensor fusion approaches, such as those employed by Prasojo et al. [5], combine multiple detection methods to improve accuracy in diverse environmental conditions. Diwanji et al. [4] demonstrated how autonomous operation can be achieved through careful system architecture and algorithm design. Kirubakaran et al. [3] highlighted the cost-

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effectiveness of Arduino-based solutions for educational and small-scale applications. The computer vision techniques developed by Pranamurti et al. [1] provide non-contact detection methods that complement traditional sensor-based approaches. Aliff et al. [8] addressed the critical aspect of mobility in uneven terrain through their QROB platform design. Current research trends indicate growing interest in swarm robotics for large-area firefighting applications. Energy harvesting technologies are being explored to address the power limitations of mobile units. Standardization efforts are needed to ensure interoperability between different manufacturers' systems. Artificial intelligence is playing an increasingly important role in decision-making algorithms for firefighting robots. The development of comprehensive testing protocols remains a priority for the research community. Future systems may incorporate more advanced materials for heat resistance and durability. Public-private partnerships could accelerate the deployment of these technologies in municipal fire departments. The integration of firefighting robots with smart city infrastructure represents a promising direction for urban safety applications.

III. COMPONENTS

Arduino UNO: A Microcontroller is a compact device with a processor, storage and configurable input/output devices on a single integrated circuit. We'll be using the Arduino UNO board, which combines a microcontroller with all of the extras needed to quickly create and debug projects. The AT mega 3288 based UNO is a microcontroller board as shown in Figure 2. It has, 14 Digital input/output pins, 6 Analog inputs, 16MHz Quartz crystal, USB connector, Power jack, ICSP header, and Reset button. Attach it to a computer via USB cable or power it with an AC to DC adapter to get started. The AT mega 3288 has 32kb of memory, 2kb of SRAM, and 1kb of EPROM. The Arduino Software can be used to programme the UNO (IDE). The boot loader on the AT mega3288 on the UNO comes preprogramed, allowing you to upload new code. It uses the original STK500 protocol to communicate.

Fig 2. Arduino Uno

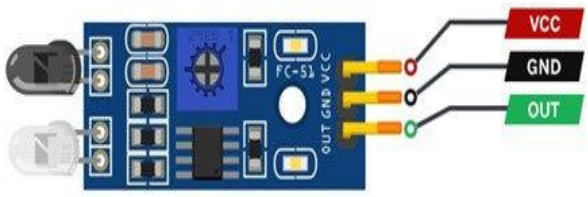

Fig 3. Flame Sensor

Flame Sensor: A flame sensor Figure 3 is a type of sensor that responds most strongly to ambient light. This sensor module is utilized in flame alarms as a result. This sensor picks up flames coming from the light source with wavelengths between 760 and 1100 nm. High temperatures have the potential to easily harm this sensor. So, a specific distance from the flame can be chosen for this sensor's placement. The flame can be detected from a distance of 100 cm. This sensor outputs either an analogue signal or a digital signal. These sensors serve as a flame alert in firefighting robots. **Flame Sensor Working Principle:** Flame sensors identify flames using UV (Ultraviolet), IR (Infra-Red), or UV-IR technology. Simply detecting UV rays is how the UV flame sensor operates. Most fires produce UV radiation near the point of ignition, therefore in the event of a fire, the sensor would become aware of it and produce a series of pulses that are altered by the detector and produce an alarm. **DC Motor:** The term 'DC motor' is used to refer to any rotary electrical machine that converts direct current electrical energy into mechanical energy. DC motors can vary in size and power from small motors in toys and appliances to large mechanisms that power vehicles, pull elevators and hoists, and drive steel rolling mills. When the motor is powered by DC current, a magnetic field is created within the stator, attracting and repelling the magnets on the rotor. This causes the rotor to start rotating. To keep the rotor rotating, the motor has a commutator. A DC Motor inserted inside the water container at the bot will extinguish the fire using water which is pumped out from the container. Flame sensor will send signal to the arduino and arduino will

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command the DC motor. **Relay:** Relay circuit is used to control the pump and when it will detect fire then it will communicate with microcontroller (Arduino UNO R3) through Bluetooth module. The proposed robot has a water jet spray which is capable of sprinkling water. The sprinkler can be move towards the required direction.

Fig 4. DC Motor

Fig 5. Relay

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 the fire that was carried out. The Block Diagram of Fire Fight Robot is shown in Figure 6 and Circuit Diagram of Fire Fight Robot in Figure 7.

Design Structure: In this section, the prototype of robotic system is presented, in which it consists of IR flame sensors, servomotors, submersible water pump, motor driver, mini breadboard, BO motors, rubber wheels, processor, and communication module for exchanging data between the fire-fighting robot and arduino software. 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.

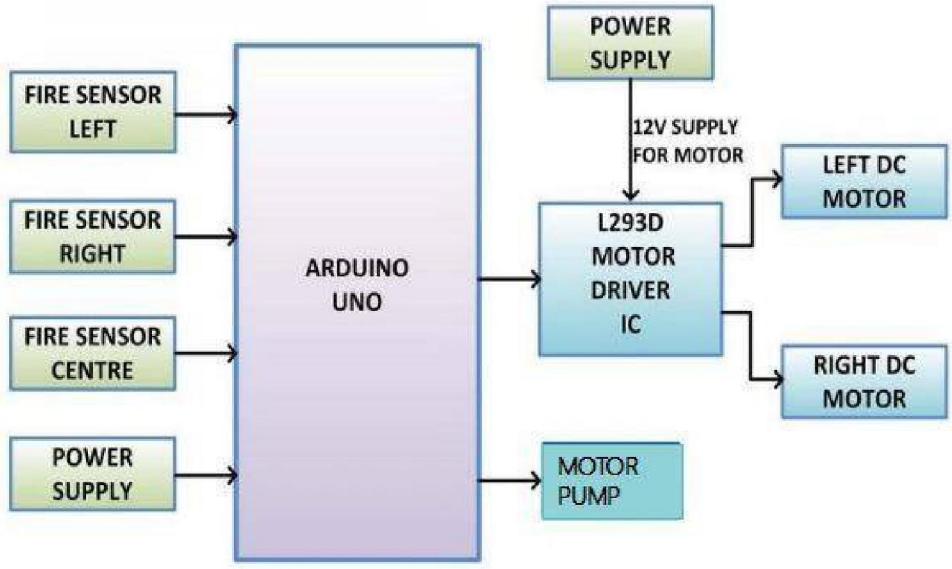

Fig 6. Block Diagram of Fire Fight Robot

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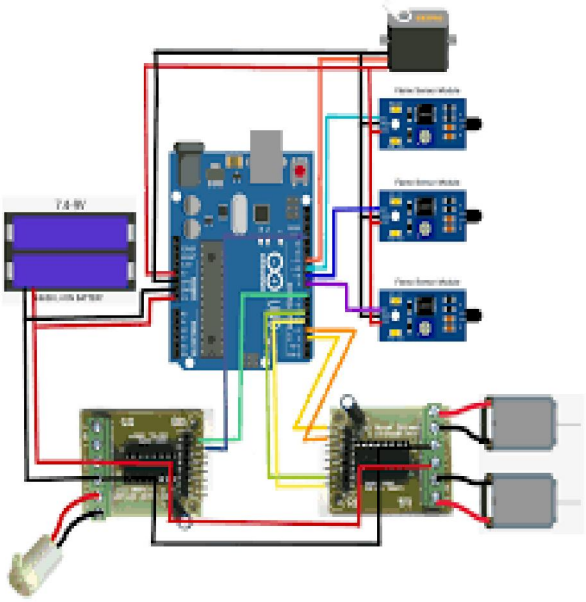

Fig 7. Circuit Diagram of Fire Fight Robot

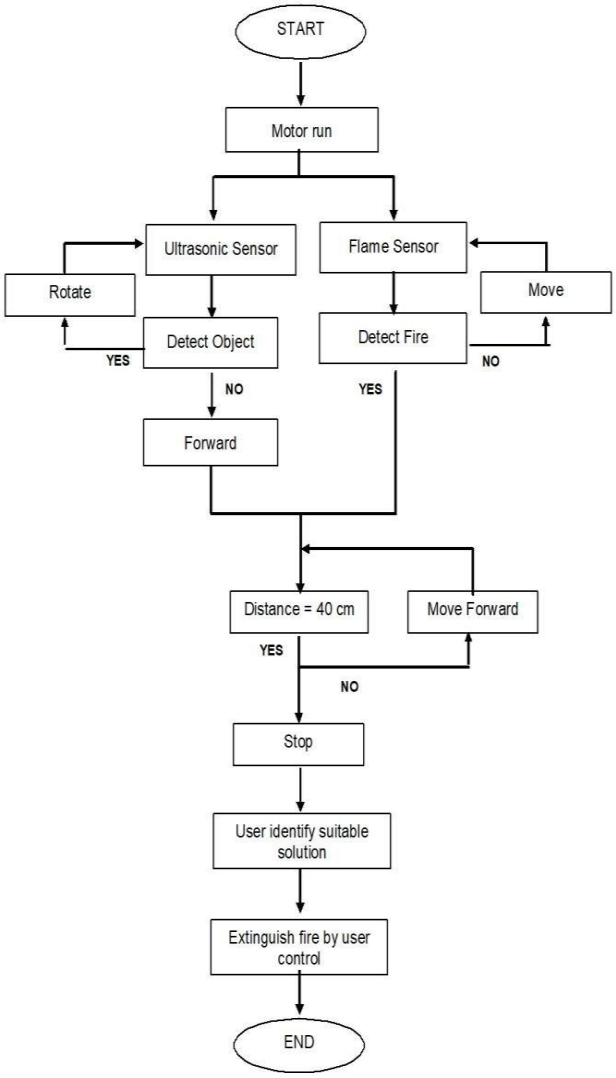

Fig 8. Flowchart

V. WORKING PRINCIPLE

The robot will move randomly in the room when the power is on. This flowchart is shown in Figure 8. When the flame sensors detected the fire, the robot will move to the fire source and send a warning message to the user. Once the robot reached the burning area, it will stop at a certain distance and extinguish the fire by using water. So, there in the working of Fire fighter robot using arduino we are providing the algorithm first so you can have the idea about the basic working of the robot. There are we are using 3 IR flame sensor which are continuously seeking for fire or flame. The IR Flame sensor sense the warm and heat from any body. we coded this sensor that it can sense the flame around it. All three sensors always searching for fire. if any of the sensor will find it. the robot will turn and start walking toward the fire.

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VI. CONCLUSION AND FUTURE SCOPE

In conclusion, This model of Fire Extinguishing Robot aids to share out the burden of fire fighters in fire fighting task. Our project aims to build a real time fire fighting robot which moves in a constant speed, identify the fire and then extinguish it with the help of pumping mechanism. The detection and extinguishing was done with the help basic hardware components attached with the robot. Firstly, IR Flame sensors are used for the detection of fire. Secondly, BO Motors and Rubber wheels are used to navigate the robot to reach the fireplace. Finally, the robot extinguishes the fire with the help of submersible water pump and servo motors. In conclusion, the development of an Arduino Uno-based Fire Fighting robot represents a transformative synergy of technology and emergency response, offering the potential to revolutionize fire management through advanced sensor integration, autonomous mobility, and real-time communication capabilities. By addressing the challenges of accurate fire detection, safe navigation in hazardous environments, and autonomous fire suppression, this innovation holds the promise of minimizing risks to human firefighters, enhancing overall response times, and safeguarding lives and property. As these robots continue to evolve and find their place in the realm of disaster management, they underscore the remarkable potential of technology to mitigate the devastating impact of fires on communities and urban landscapes.

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