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Intelligent Fire Safety Autopilot

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A B S T R A C T

An accidental fire is an unfortunate event that can occur due to either human negligence or natural causes. These types of fires happen frequently and can often be controlled, but they sometimes lead to significant loss of life and property. To mitigate these risks, an autonomous fire-fighting robot has been developed. Once the robot reaches the specified location, its fire and heat sensors detect the flames, and it automatically activates a nozzle, which rotates 180°, to spray water and extinguish the fire. With the advancement of technology, robots are increasingly being used to replace humans in hazardous, life-threatening situations. The goal is to create a robot that can detect and suppress fires independently. By designing and implementing an autonomous robot detecting and extinguishing flames, disasters can be prevented with minimal risk to human life. This research showcases a robot that can detect flames indoors and navigate toward the fire..

Keywords: autonomous Robot, Fire, Flame Sensor, nozzle, extinguishing flames.

INTRODUCTION

fire. Fires are among the most significant problems, and the robotics industry is increasingly focused on addressing this issue. Robots are now commonly used to reduce human effort in dangerous tasks, such as firefighting. The development of a Fire Extinguisher Robot, capable of autonomously detecting and extinguishing fires, is a key innovation in this field. Robotics has become one of the fastest-growing branches of engineering, with robots designed to handle labor-intensive or hazardous work, particularly in environments that are difficult for humans to access. The invention of such robots can help save lives and property while minimizing fire damage. As engineers, we aim to design a prototype that can autonomously detect and extinguish fires. The Fire Fighter Robot is specifically designed to locate fires in homes or industrial areas and put them out. Once deployed in a fire-prone area, the robot will automatically begin functioning upon detecting a fire. This prototype is particularly useful for rescue operations during fire emergencies where human access is restricted or too dangerous. Although there are existing firefighting vehicles for both residential and forest fires, our proposed robot can operate autonomously or be controlled remotely. Using such robots allows for fire detection and rescue operations with greater safety, reducing the risk to human firefighters. These robots are particularly valuable in dangerous situations, where human intervention would be too risky. The firefighting industry has long faced significant risks, and many tragic losses have occurred due to a lack of technological progress. Current firefighting methods are often inadequate, relying heavily on human efforts that, despite training, can still lead to mistakes. A growing trend is to employ robots in fire-related tasks, as they can operate in environments too dangerous for humans. In our project, we have developed a robot capable of locating and extinguishing fires within a specified area. The robot navigates the environment, avoiding obstacles, while the Node MCU board serves as the control unit for the entire system. The robot is equipped with two sensors, which help detect fire-prone areas in all directions, guiding it to the fire's location. Once it reaches the fire zone, a pump extinguisher attached to the robot is activated to put out the fire.

PROBLEM STATEMENT

The primary objective of this project is to create a robotic vehicle designed to extinguish fires during major fire emergencies, particularly in industries such as nuclear power plants, petroleum refineries, gas tanks, chemical factories, and other large-scale facilities, where fire incidents can lead to severe consequences. In many cases, fire-fighting teams are unable to access the fire site due to extreme temperatures or the presence of explosive materials, resulting in significant property damage and loss of life. In such situations, fire-fighting robots can be deployed to put out the fire. These robots are specifically used in environments where human firefighters cannot operate. Additionally, fire-fighting robots can help protect firefighters from hazardous situations in petrochemical, chemical, and explosive fire accidents, thereby reducing the risk of injury or death caused by fire.

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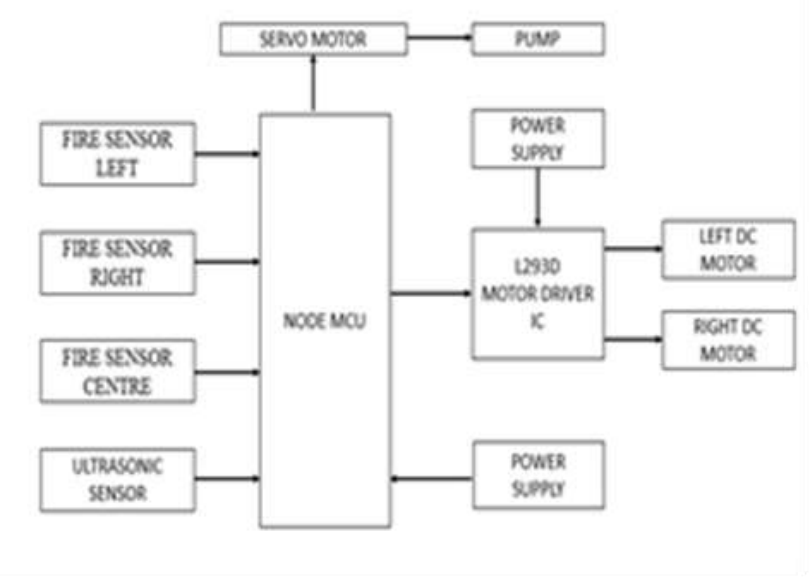
LITERATURE SURVEY

K. Shamili Devi, K. Akhileswar, C.H. Vinayaka, M. Karthik, and Y.K. Viswanadham, in their article titled "Fire Fighting Robot," published in The International Journal of Analytical and Experimental Modal Analysis (ISSN: 0886-9367, Volume XII, Issue VII, July 2020), discuss the capabilities of a fire-fighting robot designed to manage fire incidents. This robot autonomously detects fire and extinguishes it by discharging water. It is equipped with sensors that identify flames, allowing the robot to navigate towards the source of the fire. The design of the fire-fighting robot resembles that of a Bluetooth-controlled remote car. It features three sensors: one positioned at the front to detect obstacles and two located at the front corners to search for fire. Upon detecting flames, the robot will respond by moving towards the fire. The robot is constructed with four wheels, three sensors, a water tank, a nozzle, and a computer system that processes commands based on programmed instructions. As of the publication date, the robot is a compact model with basic functionalities; it initially moves forward until it detects fire. When a sensor identifies a flame, the robot directs itself towards it and activates the water nozzle, utilizing Node MCU technology to extinguish the fire in the affected area. While the fire-fighting robot shares similar sensors with line-following robots, their operational mechanisms differ significantly.L.H. Amano, "Current Status and Challenges of Fire Fighting Robots," Proceedings of the 41st SICE Annual Conference, SICE 2002, vol. 2, pp. 880-5, Feb 2022. The firefighting robot serves as a supportive tool for firefighters, significantly reducing the risks associated with their duties. Despite the advancements in the development of firefighting robots, many remain costly and challenging to maintain. Engaging in firefighting and rescue operations is inherently hazardous, making these tasks suitable candidates for robotic intervention to protect firefighters from peril. Additionally, these robots enhance the potential for rescuing a greater number of victims. Some fire departments have initiated the development and deployment of firefighting and rescue robots; however, their performance has not yet reached optimal levels. The author evaluates these robots from two critical perspectives: "size and weight" and "cost and performance." Based on this analysis, the author suggests five key elements necessary for creating effective and economically viable robots for fire departments.

BLOCK DIAGRAM

Figure 1 illustrates the various interfacing circuits used in this project, including the L293D driver module, microcontroller, flame sensors, ultrasonic sensors, servo motor, and a 5V pump. In this setup, the Node MCU serves as the central unit, or the "heart," of the project. The block diagram shows that three flame sensors and an ultrasonic sensor act as input interfaces to the microcontroller. Meanwhile, the servo motor, pump, and driver module function as output interfaces, controlled by the microcontroller. The input and output interfaces are represented by arrows, indicating the flow of signals. The microcontroller processes these inputs and executes the corresponding commands, with delays, based on the programming written in the IDE software.



. **Figure 1**: Block Diagram of Intelligent Autopilot Fire Extinguishing Robot

SIMULATION DIAGRAM

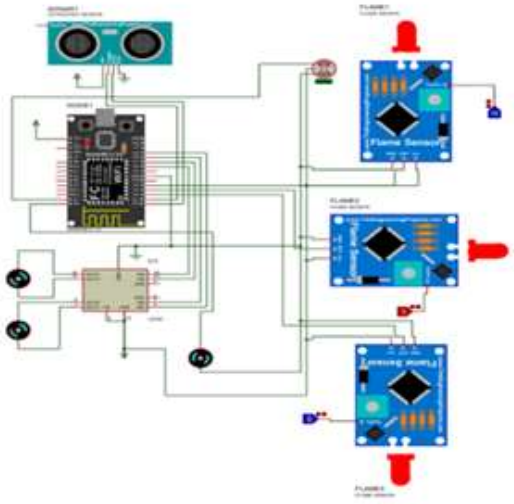


Figure 2: Simulation Diagram

The project is simulated with help of proteus software, Three(left side, right side, center) flame sensor detect the presence of the fire and send signal to Node MCU. The Arduino process the signal from any of the three-flame sensor and determine the location and intensity of fire. The Node MCU send the signal to the motor control drive(L293D) which control movement and speed of the motor which drives the wheel navigating the robot towards the fire. As soon as the robot reaches the fire the Node MCU control signal activates servo motor, servo motor rotate towards fire direction. Node MCU activates the pump releases the fire extinguishing element or water until fire completely extinguishes. The flame sensor continues to monitor the area ensuring the fire fully extinguished.

INITIALIZATION OF ROBOT

The initialization of a robot is a crucial process that prepares it for operation by ensuring all systems are functional and calibrated. It begins with powering up the robot followed by running self diagnostics to check the health of components like sensors and motors. Calibration ensures accurate measurements, while software initialization loads the necessary control algorithms. Communication systems are established to enable data exchange with other devices or networks If required, the robot maps its environment to identify obstacles and layout features. Finally operational parameters are set and initial tests are conducted to verify functionality.

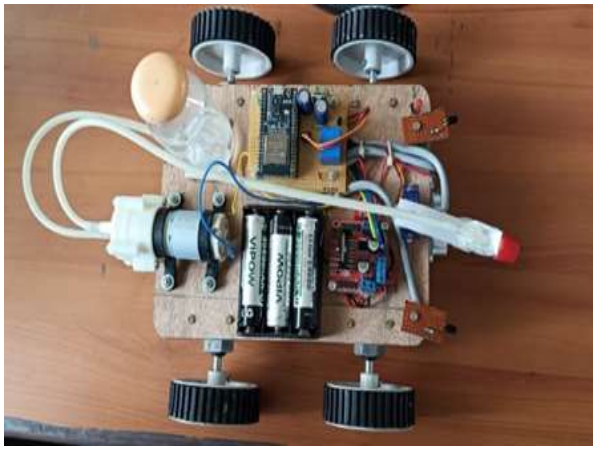


Figure 3: initialization of robot

CONCLUSION

A fire-fighting robot equipped with a flame sensor and an ultrasonic sensor offers an effective solution for early fire detection and autonomous fire suppression in small-scale applications. The flame sensor allows the robot to detect fire sources by sensing infrared radiation, while the ultrasonic sensor enables obstacle detection and navigation, ensuring the robot can move safely through environments with obstructions. Together, these sensors help the

robot locate and approach fire sources accurately and activate fire suppression mechanisms, such as a water sprayer or extinguisher, to extinguish the flames. From the experimental results, the robot can sense fire accurately in a short time.

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