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Autonomus Fire Supression Robot Based on Arduino

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Abstract - Fire hazards pose a serious threat to safety, requiring rapid detection and suppression to minimize damage. This paper presents an Autonomous Fire Suppression Robot Based on Arduino, designed to detect and extinguish fires with minimal human intervention. The system integrates flame sensors, an MQ-2 gas sensor, and a servo-controlled water nozzle for precise fire targeting. An Arduino Uno processes sensor data, while a motor driver module enables smooth movement in different environments. A solar-powered battery system ensures energy efficiency, and a SIM800L module facilitates realtime alerts for remote monitoring. The robot autonomously navigates towards fire sources, activates suppression mechanisms, and enhances safety in residential, industrial, and commercial spaces. This system provides a cost-effective, scalable, and efficient firefighting solution, reducing response time and improving fire management.

Key Words: Autonomous Robot, Fire Detection, Fire Suppression, Arduino, Flame Sensor, Embedded Systems, Water spraying mechanism, SIM800L, scalable.

1. INTRODUCTION

Fire safety is a critical concern in both residential and industrial environments, where rapid response and efficient control of fires can significantly reduce the risk of damage to property and loss of life. In recent years, the integration of robotics and automation has shown considerable promise in enhancing fire-fighting efforts, particularly in scenarios that may pose a danger to human responders. Fire-fighting robots, equipped with autonomous navigation and fire detection systems, are an emerging solution for such high-risk environments.

This paper presents the design and implementation of an Arduino-based fire-fighting robot, capable of detecting and extinguishing fires autonomously. The robot utilizes a combination of flame and temperature sensors to detect the presence of fire, while a water pump system and motordriven wheels enable it to navigate towards the fire and suppress it effectively. The Arduino platform was chosen due to its versatility, low cost, and ease of programming, making it an ideal choice for rapid prototyping and educational purposes.

The primary objective of this project is to develop a prototype that can autonomously identify fire hazards and execute a fire-extinguishing task, demonstrating the potential of robotics in emergency response scenarios. The proposed system aims to enhance safety, reduce human intervention in hazardous environments, and provide a scalable solution that can be adapted to various applications, including industrial plants, warehouses, and search-and-rescue operations.

This paper outlines the system's design, the selection of components, the algorithm used for fire detection and navigation, and the experimental results obtained from prototype testing. The outcomes of this project provide valuable insights into the feasibility of Arduino-based fire- fighting robots and the broader implications of autonomous systems in fire safety applications.

2. Body of Paper

The primary objective of designing a fire-fighting robot is to create an autonomous, efficient, and cost-effective system that can detect and suppress fires in hazardous environments without human intervention. The robot should be capable of quickly identifying fire sources, navigating through obstacles, and effectively extinguishing flames while ensuring safety and reliability. One of the fundamental design goals is accurate fire detection. This is achieved using a combination of flame sensors and temperature sensors, which enable the robot to detect heat variations and locate fire sources with precision. Unlike traditional fire-fighting methods that rely on visual confirmation, the integration of these sensors ensures real-time fire identification, even in low-visibility conditions caused by smoke.

Another critical goal is autonomous mobility and obstacle avoidance. The robot is equipped with ultrasonic sensors that help it navigate its surroundings without colliding with objects. This feature allows the system to operate in confined or cluttered environments where manual intervention may not be feasible. Enhancing this further, future upgrades could include LIDAR or camera-based

navigation for more complex path planning and obstacle detection.

Efficient fire suppression is another essential aspect of the design. The robot is built with a servo-controlled water nozzle, ensuring that water is sprayed precisely toward the fire source rather than being dispersed randomly. This targeted approach improves water efficiency and increases the chances of extinguishing the fire effectively. In future iterations, alternative suppression mechanisms such as CO_2 or foam-based systems could be integrated to make the robot suitable for different types of fires, including electrical and chemical hazards.

Additionally, reliability and ease of operation play a crucial role in the robot's design. The system is based on Arduino, which provides a user-friendly and flexible platform for control and programming. The use of readily available and affordable components ensures that the robot remains costeffective, making it accessible for educational, research, and industrial applications. Finally, future adaptability and scalability are considered in the design. While the current prototype functions independently, potential enhancements such as wireless communication, remote monitoring, and IoT integration could allow real-time alerts and remote operation in critical situations. These improvements would further enhance the robot's effectiveness in large-scale deployments, such as warehouses, factories, and residential buildings.

In summary, the design of the fire-fighting robot prioritizes accuracy, autonomy, efficiency, and adaptability, ensuring that it can operate in diverse environments with minimal human intervention. By continuously refining its capabilities, this robotic system can contribute to improved fire safety and emergency response strategies in the future. However, such implementations require high-speed connectivity and extensive computational resources, making them less feasible for low-cost or standalone fire-fighting robots. Considering the limitations of previous works, this project focuses on developing a cost-effective, autonomous firefighting robot using Arduino and ultrasonic sensors for navigation, eliminating the need for external control. Unlike prior designs that rely solely on flame sensors, this robot incorporates temperature sensors to improve detection accuracy. Additionally, it features a servocontrolled nozzle, which allows targeted water spraying rather than fixed-direction dispersion. Future enhancements, such as gas sensors for early fire detection and LIDAR-based navigation, could further improve its functionality in more complex fire scenarios.

Components	Quantity	Estimated Unit Cost (INR)	Total Cost (INR)
Arduino Uno	1	₹700	₹700
Sim800L	1	₹500	₹500
SG90 Servo Motor	1	₹150	₹150
BO Motor	4	₹100	₹400
Solar Panel	2	₹50	₹100
Flame Sensor	3	₹120	₹360
MQ2 Gas Sensor	1	₹150	₹150
Relay Module	1	₹80	₹80
Male to Male Jumper Wires	2	₹150	₹300
Male to Female Jumper Wires	2	₹150	₹300
Lithium-Ion Battery (18650)	3	₹100	₹300
Motor Driver (L298N)	1	₹250	₹250
Chassis (Car Body)	1	₹100	₹100
Battery Holder (18650)	1	₹100	₹100
LM2596 Buck Converter	1	₹120	₹120
Total			₹3910

Fig -1: Cost Estimation

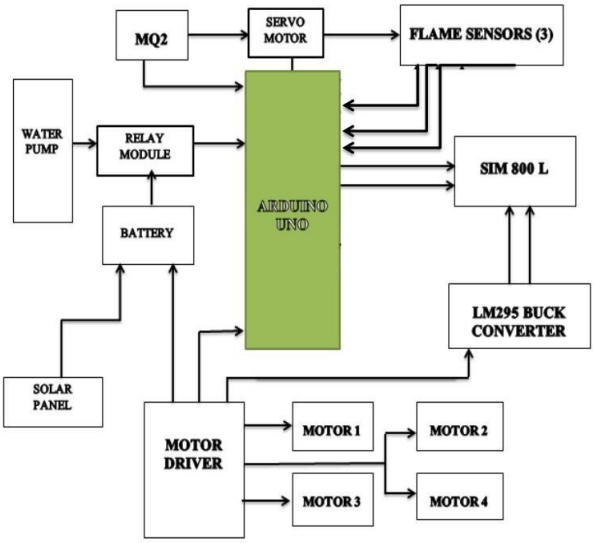

Fig -2: Block Diagram

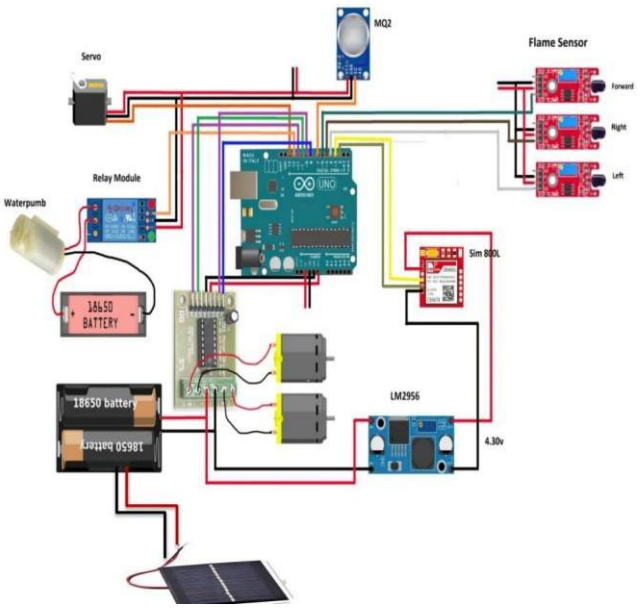

Fig -3 : Circuit Diagram

3. CONCLUSIONS

The Autonomous Fire Suppression Robot Based on Arduino is an efficient and cost-effective solution for early fire detection and suppression. The system integrates multiple sensors, including flame sensors and an MQ-2 smoke sensor, to accurately detect fire incidents. Using an Arduino Uno as the central controller, the robot autonomously navigates towards the fire source while avoiding obstacles. The water pump mechanism effectively extinguishes small-scale fires, making it suitable for deployment in homes, offices, and industrial environments.

The robot's functionality is enhanced by a SIM 800L module, which provides real-time fire alerts via GSM communication. The solar-powered battery system ensures continuous operation, improving energy efficiency and sustainability. Experimental results confirm the robot's reliability in detecting and extinguishing fire within a short response time.

Future improvements can include AI-based fire detection using thermal imaging, wireless remote control, and integration with IoT platforms for enhanced monitoring. This project demonstrates the potential for autonomous fire-fighting robots to improve safety and reduce human intervention in hazardous environments.

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