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Fire Fighting Robot Using Arduino

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Abstract: This paper presents the design and implementation of an autonomous Fire Fighting Robot using the Arduino Uno. The proposed system integrates flame sensors, an MQ-2 smoke sensor, DC motors, a servo-controlled water pump, an LCD display, and alert mechanisms to detect and extinguish fire without human intervention. The robot continuously monitors environmental conditions by sensing the presence of smoke and flame in its surroundings. When smoke is detected beyond a predefined threshold level, the system activates a warning using a yellow LED indicator and a buzzer to provide an early alert. If a flame is identified, a fire alert is triggered through a red LED and audio alarm. After confirming the presence of fire, the robot automatically navigates toward the flame source using its motor mechanism. Once it reaches the fire location, the water pump is activated, and the servo motor oscillates to spray water effectively over the affected area until the flame is extinguished. The LCD display provides real-time status updates, indicating smoke detection, fire detection, and extinguishing operations. The system then resumes its monitoring mode after successful fire suppression. The proposed model enhances safety in industrial and residential environments and demonstrates the practical application of embedded systems and robotics in real-time hazard detection and fire management. The design focuses on simplicity, reliability, and cost-effectiveness while maintaining functional efficiency. Unlike advanced firefighting robots that rely on complex image processing and high-cost navigation systems, this project emphasizes sensor-based detection and autonomous response suitable for small-scale indoor applications.

Keywords: Fire Fighting Robot, Arduino Uno, Flame Sensor, MQ-2 Smoke Sensor, Autonomous Fire Detection.

1. INTRODUCTION

Fire is one of the most destructive hazards that can cause severe damage to human life, infrastructure, and the environment. Every year, numerous fire accidents occur in residential buildings, industries, offices, laboratories, and public places due to electrical short circuits, gas leakages, overheating equipment, and human negligence. In many cases, delayed detection and slow emergency response increase the level of destruction. Therefore, early fire detection and rapid suppression play a crucial role in minimizing losses. Traditional firefighting methods mainly depend on human firefighters, fire extinguishers, and alarm systems. Although these methods are effective, they involve significant risks to human life, especially in high-temperature zones, smoke-filled environments, and areas with toxic gases. Firefighters often face dangerous conditions such as explosions, collapsing structures, and oxygen deficiency. Hence, there is a growing need for automated systems that can assist or replace human intervention during initial fire outbreaks.

With the advancement of robotics and embedded systems, autonomous robots are being developed for hazardous applications, including firefighting. A Fire Fighting Robot is a robotic system designed to detect fire and extinguish it without direct human control. These robots can enter dangerous environments, identify fire sources, and take immediate action to suppress flames. By integrating sensors, microcontrollers, and control mechanisms, such systems improve safety and efficiency during emergencies.

The proposed Fire Fighting Robot in this project is designed to detect both smoke and flame using appropriate sensors. The microcontroller continuously monitors sensor outputs and controls the robot's movement accordingly. When smoke or fire is detected, the robot navigates toward the affected area and activates a water pump system to extinguish the fire. Additionally, a 16x2 LCD display provides real-time information such as "Smoke Detected" or "Fire Detected," ensuring clear system status monitoring.

The main objective of this project is to develop a simple, cost-effective, and autonomous firefighting system suitable for small-scale indoor environments. Unlike advanced firefighting robots that use complex image processing and high-end navigation technologies, this system focuses on practical implementation using sensor-based detection and automatic response mechanisms. The project demonstrates how robotics can be effectively applied to improve fire safety and reduce human risk.

The development of an autonomous Fire Fighting Robot represents an important step toward smart safety systems. By combining detection, movement, and suppression in a single integrated unit, the system enhances emergency response capability while ensuring reliability and affordability.

2. NOVELTY OF THE PROPOSED SYSTEM

Unlike advanced firefighting robots that rely on complex image processing and high-cost navigation systems , this project emphasizes a simplified, sensor-based autonomous response. The novelty lies in the integration of both smoke and flame detection with a servo-controlled suppression mechanism into a single, cost-effective unit with LED lights and Buzzer to indicate the fire,which is suitable for small-scale indoor environments

3. LITERATURE REVIEW

Several research works have been carried out in the field of firefighting robots to improve safety and reduce human risk during fire accidents.

W. Ding et.al [1] proposed a real-time flame detection algorithm to enhance the response accuracy of firefighting robots. Their study focuses on intelligent flame recognition and situation assessment techniques to improve decision-making during fire emergencies.

A. A. Bhosle, et.al [2] developed a prototype firefighting robot capable of detecting flames using sensors and activating a fire suppression mechanism. The system emphasizes cost-effective design and practical implementation for small-scale applications.

Chairman M et al [3] presented an autonomous robot designed for fire detection and preventive action. Their model integrates sensor-based detection with automatic response mechanisms to minimize human involvement.

Y. Qiu, et al [4] focused on automatic flame recognition and tracking methods to improve fire detection accuracy. Their research highlights intelligent signal processing techniques for better flame identification.

R. R. Chaudhari, et.al [5] designed and tested a firefighting robot prototype aimed at extinguishing small-scale fires. The study evaluates system performance under controlled testing conditions.

L. Guruprasad et. al [6] developed an autonomous robot capable of detecting fire and activating a suppression system automatically. The paper emphasizes microcontroller-based control and sensor integration.

S. Li et.al [7] proposed an indoor firefighting robot using SLAM navigation and image-based flame recognition. Their approach improves navigation accuracy and real-time fire detection in indoor environments.

S. Dharmik, Pet. Al [8] designed a fire extinguisher robot that detects flame through sensors and activates a suppression mechanism. The system focuses on safety, automation, and efficient response.

J. Ren et.al [9] introduced a system capable of accurately locating fire sources and performing rapid autonomous extinguishing. Their research highlights precision and response speed improvements.

Xilong Qu, et.al [10] study presents a real-time flame detection and localization technique to enhance operational efficiency in firefighting robots. The research emphasizes accurate positioning and improved autonomous control mechanisms.

From the above studies, it is observed that many existing systems either rely on remote control, wireless

communication, or alert-based mechanisms. In contrast, the proposed system focuses on autonomous detection and suppression using integrated smoke and flame sensing mechanisms, making it simple, cost-effective, and suitable for small-scale applications.

4. PROPOSED METHODOLOGY

A. Components

1. Flame Sensor:

A detector which is most sensitive to a normal light is known as a fire detector.

2. MQ2 Gas Sensor:

An MQ2 sensor is a metal oxide semiconductor device used to detect leakage of gases like methane ,LPG etc.

3. Relay Module:

Relay is used as a switch which handle high loads with low input signal. It allows the microcontroller to safely switch these devices ON and OFF without handling high current directly.

4. Mini Water Pump:

A mini water pump is a submersible pump which is used to pump water.

5. Jumper Wires:

Jumper wires are used to make connections in a circuit.

6. Battery:

It is used to provide power supply to the circuit device.

7. Motor Driver (L293D/L298N):

A motor driver module used to control the speed and direction of DC motors.

8. DC Motors:

Motors that convert electrical energy into mechanical motion for robot movement.

9. Servo Motor:

A motor used for precise angle control, commonly used for rotating the water nozzle.

10. 16x2 LCD Display:

A display module used to show system status and sensor readings.

11. Buzzer and LED Indicators:

Alert components used to indicate fire detection through sound and light signals.

B. Working Principle

The system operates in continuous monitoring mode. The flame sensors and smoke sensor constantly send data to the microcontroller. If the smoke level exceeds a predefined threshold value, the system triggers a smoke alert using a yellow LED and buzzer.

When a flame is detected, the system activates a fire alert using a red LED and buzzer. Based on the sensor readings (left, center, or right), the robot navigates toward the fire source using its DC motors. The motor driver controls the direction of movement according to the detected flame position.

Once the robot reaches close to the flame, the water pump is activated to spray water. The servo motor oscillates to distribute water evenly over the fire area, ensuring effective suppression. After the flame is extinguished, the pump stops, and the system returns to monitoring mode.

The entire process is automatic and does not require manual control, making the system suitable for handling small-scale fire incidents in controlled environments.

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5. BLOCK DIAGRAM

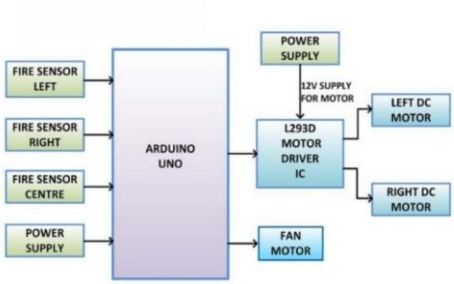

Fig. 1 Block diagram of the proposed project.

6. CIRCUIT DIAGRAM

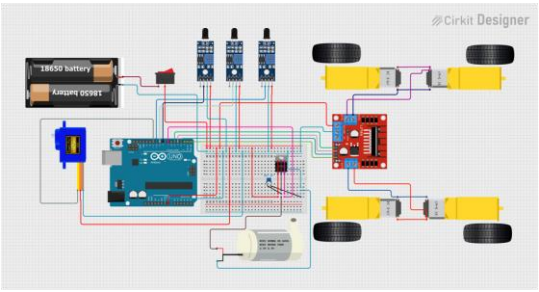

Fig. 2 Circuit diagram of the proposed project.

7. ALGORITHM

1.Start the system.

2.Initialize all components including flame sensors, MQ-2 smoke sensor, DC motors, servo motor, water pump, LCD display, buzzer, and LEDs using the Arduino Uno.

3.Set the predefined threshold value for smoke detection.

4. Display “System Ready” on the LCD.

5. Continuously read values from the left, center, and right flame sensors and the smoke sensor.

6. If the smoke level exceeds the threshold:

- Activate yellow LED.
- Turn ON buzzer.
- Display “Smoke Detected” on LCD.

7. If any flame sensor detects fire:

- Activate red LED.
- Turn ON buzzer.
- Display “Fire Detected” on LCD.

8. Determine the direction of fire:

- If left sensor detects flame → Turn robot left.
- If right sensor detects flame → Turn robot right.
- If center sensor detects flame → Move robot forward.

9. Move the robot toward the fire source using DC motors.

10. When the robot reaches near the flame:

- Stop movement.
- Activate water pump.

11. Rotate the servo motor to spray water over the flame area.

12. Continuously monitor flame sensors while spraying.

13. If flame is no longer detected:

- Stop water pump.
- Turn OFF red LED and buzzer.

8. RESULTS AND DISCUSSION

The Fire Fighting Robot was tested in a controlled environment. The MQ-2 smoke sensor successfully detected smoke and triggered the yellow LED, buzzer, and displayed “Smoke Detected” on the LCD. When a flame was introduced, the flame sensors detected it accurately,

activated the red LED and buzzer, and displayed “Fire Detected” on the LCD.

The robot moved toward the direction of the flame and activated the water pump. The servo motor sprayed water effectively, and small-scale flames were extinguished within a few seconds. After extinguishing the fire, the system returned to monitoring mode.

The results show that the system works reliably for small fire detection and suppression.

9. CONCLUSION

Fire accidents pose serious risks to human life and property, especially in environments where immediate manual response may not be possible. The main problem addressed in this project is the need for a safe and automated system that can detect and extinguish fire at an early stage without human intervention.

To solve this problem, an autonomous Fire Fighting Robot was designed and implemented using the Arduino Uno. The system integrates flame sensors and an MQ-2 smoke sensor to detect fire hazards accurately. When smoke or flame is detected, the robot provides alerts through LEDs, buzzer, and LCD display. It then navigates toward the fire source and activates a water pump mechanism to extinguish small-scale flames effectively.

The robot operates automatically and returns to monitoring mode after fire suppression. The experimental results show that the system performs reliably in controlled conditions. Overall, this project demonstrates a practical and cost-effective solution for improving fire safety using embedded systems and robotics.

10. REFERENCES

.**[1]** W. Ding, T. Yang, J. Li, C. Hua, and D. Mu, "Real-time flame detection algorithm for firefighting robots to enhance response accuracy," *IEEE Access*, vol. 13, pp. 1024-1035, 2025. Doi: 10.1109/ACCESS.2025.3660843.

[2] A. A. Bhosle, S. S. Bodhe, S. U. Bodhe, M. M. Birajdar, and S. V. Bodas, "Development of a prototype firefighting robot for automated flame detection and suppression," in *Proc. Int. Conf. on Smart Technologies and Systems for Next Generation Computing (ICSTSN)*, 2022, pp. 1-6.

[3] M. Chairman, S. Priyatharsini, M. Bhuvaneswari, C. Nandhakumar, and S. Gopinath, "Design of an autonomous robot for fire detection and preventive action," *International Journal of Intelligent Systems and Applications in Engineering*, vol. 12, no. 4, pp. 215-222, 2024.

[4] Y. Qiu, W. Wang, J. Zhan, and Y. Huang, "Automatic flame recognition and tracking methods using intelligent signal processing for firefighting," *IEEE Transactions on Industrial Informatics*, vol. 19, no. 12, pp. 11542-11551, Dec. 2023.

[5] R. R. Chaudhari, S. R. Kewate, and C. R. Chaudhari, "Design and performance evaluation of a firefighting robot prototype for small-scale fires," *Journal of Robotics and Control (JRC)*, vol. 5, no. 2, pp. 412-419, 2024.

[6] L. Guruprasad, M. U. Yashwanth, P. V. Prasad, B. V. Shreekara, and Gangappa, "Microcontroller-based autonomous firefighting robot with automatic suppression system," in *Proc. 4th Int. Conf. on I-SMAC (IoT in Social, Mobile, Analytics and Cloud)*, 2020, pp. 582-587.

[7] S. Li, J. Yun, C. Feng, Y. Gao, J. Yang, G. Sun, and D. Zhang, "An indoor autonomous inspection and firefighting robot based on SLAM and flame image recognition," *Fire*, vol. 6, no. 3, p. 93, Mar. 2023. doi: 10.3390/fire6030093.

[8] S. Dharmik, P. Rawat, S. Singh, G. Wankhede, and F. B. Sayyad, "Design of a sensor-based fire extinguisher

robot for efficient emergency response," *Materials Today: Proceedings*, vol. 62, pp. 4512-4518, 2022.

[9] J. Ren, K. Qu, J. Guo, H. Yin, and B. Huang, "Rapid autonomous extinguishing system with precision fire source localization," *IEEE Transactions on Systems, Man, and Cybernetics: Systems*, vol. 55, no. 1, pp. 88-99, Jan. 2025.

[10] Xilong Qu, Hu Dong, Xiao Tan, and Zhenjin Li, "Real-time flame detection and localization for firefighting robots," *International Journal of Modern Physics C*, vol. 36, no. 2, Art. no. 2542004, 2025. doi: 10.1142/S0129183125420045.