Flame Detecting and Extinguishing Robot Car

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Abstract: This work focuses on designing and implementing advanced fire extinguishing systems to address the limitations of traditional methods. It includes an Automatic Fire Extinguisher Rover, an autonomous, sensor-driven system capable of detecting and extinguishing fires in diverse environments, and a High-Pressure Water Mist Equipment, designed for confined spaces like passenger compartments, utilizing a two-phase flow mechanism for efficient fire suppression. Both systems enhance safety with rapid response, reduced human intervention, and effective mitigation of fire-related risks.

Keywords: Automatic Fire Extinguisher Rover, High-Pressure Water Mist Equipment and Rover.

I. INTRODUCTION

Fire-related disasters pose a significant threat to life and property. Conventional extinguishing methods are often insufficient due to slow response times and limited automation, resulting in extensive damage and loss. In many situations, it is unsafe or inefficient for humans to extinguish fires manually, especially in confined or hazardous areas. Instead of putting the lives of the humans in danger we can use these robots to detect and extinguish the fire.

The objective of this project is to design and implement advanced fire extinguishing systems, including the Automatic Fire Extinguisher Rover and High-Pressure Water Mist Equipment, to ensure rapid, efficient, and autonomous fire suppression across diverse environments.

II. LITERATURE SURVEY

Fire safety is a critical area of research, particularly in developing effective detection and suppression systems to mitigate risks associated with fire hazards. Various studies have explored smoke and temperature detection, fire extinguishing equipment, and novel suppression techniques. This review synthesizes key findings from recent research contributions. Smoke and Temperature Detection: The early detection of fire is crucial in preventing significant damage. Zhang et al. [1] investigated fire detection mechanisms using temperature sensors, highlighting their efficiency in real-time monitoring. Similarly, Khan et al. [6] proposed an automated fire-fighting system integrating smoke and temperature sensors, emphasizing the importance of timely hazard detection in emergency response. Fire Extinguishing Equipment: Fire suppression technologies have evolved significantly, especially for confined spaces such as passenger compartments. Zhang et al. [2] studied fire extinguishing equipment designed specifically for passenger compartments, presenting novel approaches to improving safety in transportation systems. Additionally, Liu et al. [4] analyzed the effectiveness of portable water mist fire extinguishers, demonstrating their potential for suppressing various fire types with minimal water usage. Sprinkler Systems and Smoke Venting: Sprinkler systems play a vital role in controlling fire spread. Mahalakshmi et al. [3] examined the interaction between sprinkler spray and natural smoke venting, revealing how the drag effect influences smoke dispersion and evacuation safety. The study contributes to optimizing sprinkler placement for enhanced fire suppression efficiency. Fire Detection Techniques Using Image Processing: Advancements in image processing have enabled the development of sophisticated fire detection systems. Van Hamme et al. [7] employed Markov random fields for fire detection in color images, improving accuracy in distinguishing fire-related patterns. Such approaches complement traditional sensor-based systems by providing visual verification of fire events. Fire Safety in Public Transport Ensuring fire safety in public transport systems is a major concern. Göransson and Lindquist [8] reviewed fire incidents in buses and trains, proposing standardized fire test methods to evaluate vehicle fire resistance. Their findings emphasize the necessity of regulatory

frameworks for fire safety in mass transportation. Fundamental Fire Safety DesignButcher and Parnell [5] discussed principles of fire safety design, offering insights into structural fire protection and risk assessment methodologies. Their work serves as a foundation for engineers and designers in developing fire-resistant infrastructures. Water-Based Fire Suppression Mechanisms. The interaction between water droplets and heated surfaces is a critical aspect of fire suppression. Manzullo and Yang [9] studied the collision dynamics of water droplets containing additives on heated surfaces, contributing to the development of more effective suppression agents. Similarly, Matala et al. [10] estimated pyrolysis model parameters for solid materials using thermo gravimetric data, enhancing the understanding of fire behaviour and suppression techniques. The reviewed studies collectively highlight advancements in fire detection and suppression technologies. The integration of sensor-based detection, image processing techniques, and optimized suppression mechanisms has significantly improved fire safety measures. Future research should focus on enhancing automation, improving detection accuracy, and refining suppression efficiency to ensure comprehensive fire protection across various domains.

III.METHODOLOGOY

1. Automatic Fire Extinguisher Rover:

Component Assembly: Integration of sensors, Arduino, servo motor, and multiple sensors.

Programming: Implemented in C to process sensor data and control operations.

Navigation System: Ultrasonic sensors enable autonomous navigation by avoiding obstacles and maintaining a safe distance from the fire source. A pre-programmed path or real-time decision-making is implemented for mobility in complex environments.

Extinguishing Mechanism: A solenoid- controlled spray system ensures a wide-angle (130°) dispersal of extinguishing agents. The system also employs a refillable cylinder to maintain operational sustainability.

Testing: The rover underwent simulations and controlled fire scenarios to evaluate its response time, accuracy in fire detection, and extinguishing efficiency. Adjustments were made to optimize performance based on test results.

2. High-Pressure Water Mist Equipment:

Two-Phase Flow System: This system utilizes a two-phase flow nozzle, which combines liquid water with compressed gas to generate a high- pressure mist. The fine droplets ensure a larger surface area for heat absorption, leading to rapid fire suppression.

Cylinder Drive Mechanism: A pressurized cylinder is used to store the extinguishing agent. Upon activation, the release mechanism ensures consistent spray pressure, enabling effective coverage of the fire-affected area.

Manual Control Mode: The system is designed for manual activation to ensure reliability and reduce the likelihood of false triggers. Operators can activate the system via a secure and straightforward interface.

Additives: The mist contains physical mechanism additives that enhance fire suppression without altering the water's physical properties. This prevents secondary damage or toxicity issues.

Performance Testing: Full-scale fire tests were conducted in a controlled passenger compartment environment. Metrics such as fire suppression time, reduction in toxic smoke, and cooling efficiency were recorded. The system demonstrated rapid activation (within 3 seconds) and effective suppression of fires within 10 seconds.
Sensors: IR flame sensors, smoke sensors, LPG sensors detect the presence of fire in three directions (front, left, and right). Mobility:L298N motor driver controls the BO motors for forward, backward, and rotational movements.

3. Algorithm:

- The robot continuously monitors sensors.
- If fire is detected, it stops, activates the water pump, and adjusts the servo to spray water toward the fire.

If no fire is detected, the robot moves randomly in its environment

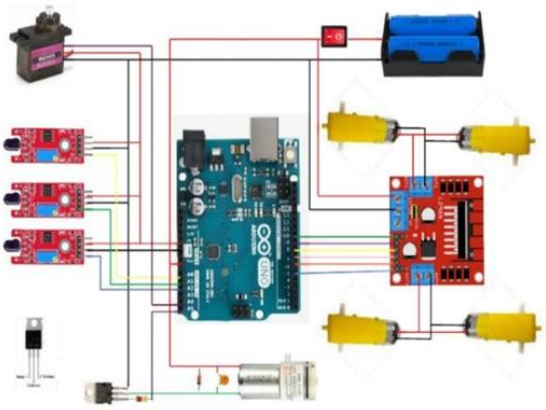

Figure: 1 A schematic of rover highlighting components like sensors, nozzle, and control unit.

4. Main Components:

Arduino Uno: This is the microcontroller at the heart of the system, responsible for controlling and coordinating the other components.

Motor Driver: This module is likely used to drive the motors, allowing for more efficient and controlled power delivery.

Motors: These are probably DC motors, used to provide movement to the robot.

Battery: This provides the power source for the entire system.

Switch: This is used to turn the system on and off.

Sensors:

IR Sensors: These are likely used for detecting obstacles or line following.

Sensors which we added later: Line tracing, gas sensor, smoke sensor.

5. Product Specifications:

Automatic Fire Extinguisher Rover:

- Sensors: MQ135, Gas Sensors, IR Flame Sensor, Smoke sensor.
- Control Unit: Arduino with embedded C programming.
- Extinguishing Mechanism: Solenoid- controlled wide-angle nozzle (130° spray).

High-Pressure Water Mist Equipment:

- Nozzles: Two-phase flow system with a flow coefficient of 4.6-11.3.
- Extinguishing Agent: Physical mechanism additive.

Hardware Components:

- IR 3-pin Flame Sensors (x3)
- Gas sensors (x2)
- Smoke sensors(x2)
- Arduino UNO
- L298N Motor Driver
- BO Motors (x4) with wheels
- Solder-less Breadboard
- Mini Servo Motor
- 5-9 V Water Pump with Pipe
- TIP-122 Transistor, 104 pf Capacitor, 1kΩ Resistor
- 3.7 V Batteries (18650) (x2)
- Jumper Wires

Power Requirement:

Powered by two 3.7 V 18650 batteries, providing 7.4 V for the motor driver and Arduino.

Control Software:

- Programmed using Arduino IDE.

IV.RESULT

Successfully detects fire in three directions (left, front, right). Activates the water pump and extinguishes fire by targeting it with a servo-controlled water nozzle. Autonomous movement when no fire is detected. Automatic Fire Extinguisher Rover: Rapid fire detection and suppression achieved within seconds. Successfully navigated complex environments while maintaining safety.

Water Mist Equipment:

Fires extinguished within 10 seconds of activation.

Toxic smoke reduced by 90%.

Compartment temperature maintained below 60°C post-activation.

V. CONCLUSION

Innovative fire extinguishing systems, such as the Automatic Fire Extinguisher Rover and High-Pressure Water Mist Equipment, demonstrate significant advancements in fire safety technology. Their ability to autonomously detect, assess, and suppress fires ensures enhanced safety in various settings. These systems pave the way for a future where fire-related risks are significantly mitigated, safeguarding lives and assets. The fire extinguishing robot demonstrated effective fire detection and extinguishing capabilities. It offers a safer alternative to manual fire extinguishing in confined or hazardous areas. The system can be further improved with more sensors and advanced navigation techniques. If we build this on a large scale it will be really helpful to extinguish fires in places where humans can't reach or it's risky for humans.

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