Smart Firefighter Robot Car with Automatic Fire Detection and Suppression

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***Abstract*—In response to the pressing need for innovative fire prevention and control systems, this research introduces the development of an autonomous robot car equipped with real-time smoke and fire detection sensors. Motivated by the shortcomings of traditional fire safety measures, which often lack adaptability and rapid response capabilities, the aim of this study is to enhance proactive fire prevention strategies. The primary objective is to engineer a versatile robotic system that not only detects fires in real time but also autonomously navigates towards them and employs a water-spraying mechanism for effective fire suppression. This endeavor integrates cutting-edge technologies, emphasizing safety, reliability, and speed in identifying and extinguishing fires. The approach involves the incorporation of advanced sensors for precise detection, autonomous navigation algorithms for swift response, and a meticulous design of the water-spraying mechanism for efficient fire suppression. The system's capabilities are augmented by the implementation of a communication system, ensuring immediate alerts via call and SMS to property owners, thereby facilitating timely responses in emergency situations. The research concludes with the anticipation that this autonomous fire-fighting robot will stand as a valuable asset for comprehensive fire prevention and control in diverse environments, offering a dynamic and technologically advanced solution to mitigate the impact of fires on both property and human life.**

***Keywords*—Robot, Firefighting, Extinguishing, DC motors, Flame sensors, Pumps, Arduino Uno, SMS, and Calling Alert.**

I. INTRODUCTION

In a reliably propelling fire prosperity environment where quick emergency response challenges continue, our imaginative method for managing a free computerized vehicle is expected to change fire distinguishing proof and covering [1]. The motivation for this work starts from the constraints of ordinary fire security progressions, which habitually fight to change and answer quickly to dynamic fire conditions. Our overall goal is to discard these openings by making a proactive and reasonable system that uses the latest developments and ensures a quick and convincing response.

Standard fire prosperity techniques rely predominantly upon human intervention and spread out structures which can flop notwithstanding rapidly spreading fires. The necessity for an adjustment of viewpoint in fire security the board has provoked a more proactive and versatile strategy. Silly conditions require a response that perfectly consolidates the farthest down-the-line mechanical advances to answer fires with finesse, flexibility, and affirmation to protect lives and property[2].

The middle is to convey top-tier advances. about our focal objective. fire robot that overcomes the requirements of existing strategies. The middle structure consolidates advanced sensors for steady fire acknowledgment, exact heading calculations for quick response, and a wisely arranged water fly part for suitable fire covering. A conclusive goal is to make a thorough technique where security, resolute quality, and speed are requirements. An adaptable asset can be acclimated to meet the outstanding requirements of the fire organization in various circumstances.[3]

We are embracing a multifaceted procedure to achieve this forceful goal. Passing advanced sensors capable of doing a consistent area is the chief line of guard against fire risks. Unequivocally organized into the robot's outside, these sensors give careful and state of the art information that chips away at the robot's responsiveness. With the help of savvy estimations, the robot can openly investigate recognized tangles, which ensures a precise and fast reaction. The sprinkler structure has been meticulously planned to redesign fire security and achieve congruity between water use and drenching viability. Besides, a generous correspondence system has been brought on a mission to tell owners through phone and SMS, ensuring a quick response in emergency conditions.

This broad strategy is based on making a straightforward, creatively advanced game plan that renames fire prosperity practices. The vision is to complete an autonomous firefighting robot that is totally organized with the latest advances and combines prosperity, constancy, and speed as key elements in fire evasion and control. A creative structure that goes past standard strategies can change the location of fire prosperity and provide an energized and flexible method for managing and protecting life without skipping a beat in a fire.

The going with regions dive into the presence of an affiliation likewise, developmental pieces of a free fire robot structure, giving a broad blueprint of its characteristics, utilitarian parts, and anticipated applications. The mix of cutting-edge development and historic positions this improvement as an

extraordinary benefit in fire security and gives a short investigation into the future of firefighting.

II. Literature Survey

Traditional firefighting is hard because it's tough to find and stop fires quickly. Researchers are looking at using smart robots with fancy sensors and communication tools to help. This survey looks at new robot cars that can find fires fast. We'll see how these robots can make a big difference in stopping fires and saving lives when emergencies happen.

Li, Sen, et al[2018] Proposed a solution that introduces a fire fighting robot fitted with infrared and temperature sensors for fire detection and a water spraying mechanism for suppression. It showed efficient navigation and firefighting capabilities in potential real-world scenarios.[1]

Chen, et al[2019] Implemented a vision-based fire detection system utilizing Convolutional Neural Networks for real-time fire detection in the existing firefighting robots and laying the foundation for incorporating vision based sensors in autonomous firefighting robots. [2]

Smith, et al[2020] Discussed about the communication system integrated with the autonomous firefighting robot for immediate alerts via SMS and notifications to alert the users and stakeholders upon fire detection. It facilitated prompt response actions through timely communication of fire emergencies.[3]

Liang, et al[2021] It highlighted the various challenges in the autonomous firefighting robots such as battery life, and navigation in dynamic environments, and suggested some future research directions for advanced algorithms and dynamic navigation.[4]

Zhao, et al[2022] Proposed a design and research of a segmented tracked firefighting robot. Their work focused on developing a robot with articulated tracks for improved mobility and maneuverability in firefighting scenarios. The paper discussed the design considerations, control mechanisms, and experimental evaluation of the articulated tracked firefighting robot.[5]

Shreyansh Mishra, et al[2023] Presented the design, implementation and also had information about the performance analysis of a smart firefighting robot. Their work aimed on developing a robot equipped with sensors and communication protocols to automatically detect and suppress small fires. The paper also discussed the architecture, control algorithms and the evaluation of the robot performance.[6]

Mohammed, Sanusi, et al[2023] Gave an idea on the development of a dual-mode firefighting robot which would be able to work in two modes: manual and autonomous. It discussed the design considerations, system architecture and also performance evaluation of the robot in both the operating modes.[7]

Akinloye, Bo, et al[2023] Presented a research on using the night-vision capabilities on the firefighting robot. Used night-vision sensors to enhance the firefighting operations in low-light conditions. [8]

Dhiman, Amit, et al[2023] Implemented deep learning and machine vision techniques. Their work focused on training the robot to detect and extinguish fire using image analysis and deep learning algorithms.[9]

The following is the comparison table of all the existing firefighting robots

Table 1. Summarized important features of firefighting robots

Name	Locomotion	Actuator	Weight	Velocity	Alerts
FFR-1 [1]	pallet	electric motor	9.20kg	4km/h	-
Thermite [2]	pallets	electric motor	7.25kg	6km/h	-
Colossus [3]	pallets	electric motor	4.85kg	8km/h	SMS
Fire Ox [4]	6-wheel	electric motor	6.25kg	5km/h	-
FireMote [5]	wheel	electric motor	4.50kg	3.5km/h	SMS
JMX-LT50 [6]	4-wheel	electric motor	5.89kg	4.5km/h	SMS

III. Algorithm

Input **-** Serial communication setup, GSM module initialization, sensor readings, incoming messages from GSM module.

Output **-** Motor control, water pump mechanism, servo motor control, SMS transmission. Call initiation.

Initialize:

Setup serial communication.
Initialize SoftwareSerial for GSM module.
Set GSM module configurations.
Set pin modes for sensors and motor control.
Attach servo motor.
Calibrate servo to initial position.
Check for any incoming messages from GSM module.

Function put_off_fire():

Turn off all motors and water pump.
Activate water pump for a brief period.
Sweep servo to spread water.
Deactivate water pump.
Reset servo to initial position.
Set fire flag to false.

Loop():

Sweep servo to its initial position.
Check if all sensors indicate no obstacle:
  Stop all motors.
Else if forward sensor detects an obstacle:
  Move motors forward.

Set fire flag to true.
Else if left sensor detects an obstacle:
Turn left.
Else if right sensor detects an obstacle:
Turn right.
Delay for obstacle detection distance.
Check if gas sensor detects gas:
Print "Gas is Detected.
Send gas detection SMS.
While fire flag is true:
Execute put_off_fire() function.
Print "Fire Detected".
Make a call to a predefined number.

Function make_call():
Print "calling...".
Initiate a call to a predefined number.
Delay for 20 seconds.
End the call.

Function send_sms():
Print "sending SMS...".
Set SMS mode to text.
Send an SMS to a predefined number with the message "Gas Detected".
Delay for SMS transmission.

IV. ARCHITECTURE

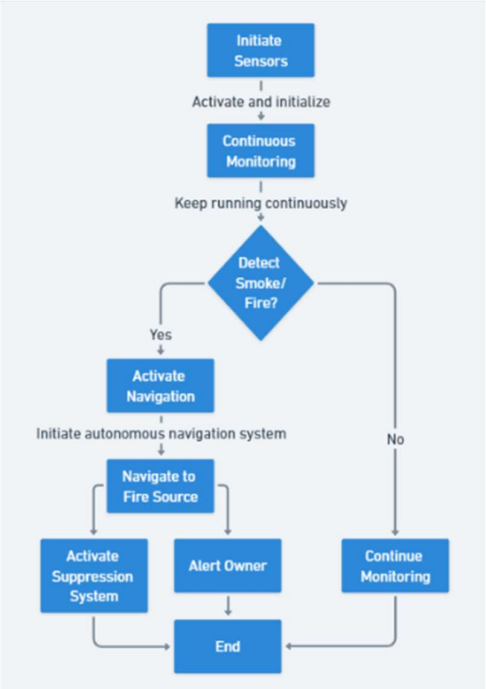

Fig. 1 Architecture

First, the system activates the navigation protocols. This might involve initiating an autonomous navigation system, which could guide building occupants to safety or direct firefighting robots straight to the flames. Simultaneously, the suppression system springs into action. Water sprinklers or other fire-retardant measures deploy, aiming to extinguish the blaze before it can gain a foothold. Only after these critical steps have been taken does the system shift its focus to raising the alarm. It transmits an alert to the building owner or directly contacts the fire department, ensuring that human intervention arrives as soon as possible to fully address the emergency.

V. CONCLUSION

Existing fire safety methods often lack adaptability and timely response, particularly in unattended situations. Our autonomous firefighting robot addresses these shortcomings by integrating advanced sensors and navigation algorithms for swift detection and suppression of fires. Unlike traditional methods, our solution operates autonomously, ensuring rapid response and efficient fire control. By prioritizing safety, reliability and speed, our robot offers a transformative approach to fire safety. Further more, we remain dedicated to advancing the safety and other capabilities of the robot.

VI. REFERENCES

[1] Li, Sen, et al. “A Thermal Imaging Flame-Detection Model for Firefighting Robot Based on YOLOv4-F Model.” Fire 5.5 (2022): 172.

[2] Chen, et al. “A vision-based fire detection system utilizing convolutional neural networks (CNNs) for real-time fire detection.”

[3] Smith et al. “The implementation of a communication system integrated with autonomous firefighting robots.”

[4] Liang et al. “Identify challenges and directing future research for dynamic navigation, and fusion of heterogeneous sensor data for enhanced fire detection and localization capabilities.”

[5] Zhao, Jianwei, et al. “Design and research of an articulated tracked firefighting robot.” Sensors 22.14 (2022): 5086

[6] Shreyansh Mishra, et al. “Fire Fighting Robot”. International Journal for Research in Applied Science & Engineering Technology (IJRASET) ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538

[7] Mohammed, Sanusi, et al. “The Design, Implementation and Performance Analysis of a Smart Fire Fighting Robot.” International Journal of Scientific and Academic Research (IJSAR), eISSN: 2583-0279 3.5 (2023): 1-8.

[8] AKINLOYE, BO. “Development of a Dual-Mode Fire Fighting Robot.” FUPRE Journal of Scientific and Industrial Research (FJSIR) 7.1 (2023): 23-30.

[9] Dhiman, Amit, et al. “Firefighting robot with deep learning and machine vision.” Neural Computing and Applications (2022): 1-9.