



Fire Fighting Robot

Karthik M S¹, Gagan S², L Yashwanth³, Uday kiran M⁴, Dr R Gunasekari⁵

^{1, 2, 3, 4}UG Scholar, Department of Electrical and Electronics Engineering,
Sri Sairam College of Engineering, Bengaluru

⁵Associate Professor, Department of Electrical and Electronics Engineering,
Sri Sairam College of Engineering, Bengaluru

ABSTRACT

This project develops an autonomous firefighting robot to improve safety and efficiency in fire suppression. Equipped with sensors for detecting flames, smoke, temperature, and gas, the robot can locate fires in complex environments. It uses advanced navigation algorithms to move through obstacles and reach fire sources. A robust mechanical platform ensures stability, while a high-pressure water pump and controlled nozzle effectively extinguish flames. A thermal imaging camera enhances situational awareness. Testing shows the robot's effectiveness in detecting and extinguishing fires, contributing to safer firefighting operations in hazardous conditions. Built on a robust mechanical platform, the robot offers the stability needed to operate in challenging conditions. Its firefighting system includes a high-pressure water pump and a precisely controlled nozzle for effective flame extinguishment. To further enhance firefighting capabilities, the robot is equipped with a thermal imaging camera, providing real-time fire assessment and situational awareness. A user-friendly control interface enables remote monitoring and manual operation, giving firefighters critical data and the ability to intervene if needed. Safety is a top priority, with features like emergency stop mechanisms, redundant systems, and reliable communication links ensuring dependable operation in critical conditions. Extensive testing and simulations have assessed the robot's performance in various fire scenarios, proving its effectiveness in detecting, locating, and extinguishing fires while minimizing risks to human life. This project contributes to advancements in firefighting technology by offering a versatile.

Keywords: Autonomous, Firefighting Robot, Safety, Sensors, Flame Detectors.

1 Introduction

Firefighting is an inherently dangerous profession marked by significant and challenging environments. Traditional firefighting techniques, although effective, often place firefighters in extreme danger, leading to injuries and even fatalities. This necessity for safer and more effective firefighting methods has spurred the development of firefighting robots. This initiative focuses on the design, development, and testing of an autonomous firefighting robot that can function in hazardous settings. Aimed at enhancing human firefighting efforts, the robot utilizes cutting-edge technologies to detect, locate, and extinguish fires while reducing risks to personnel. The primary features of the robot include autonomous navigation, fire detection and localization, efficient fire suppression, and real-time data transmission. It is



equipped with a diverse array of sensors, such as flame detectors, smoke sensors, temperature sensors, and gas sensors, enabling it to accurately identify fire incidents.

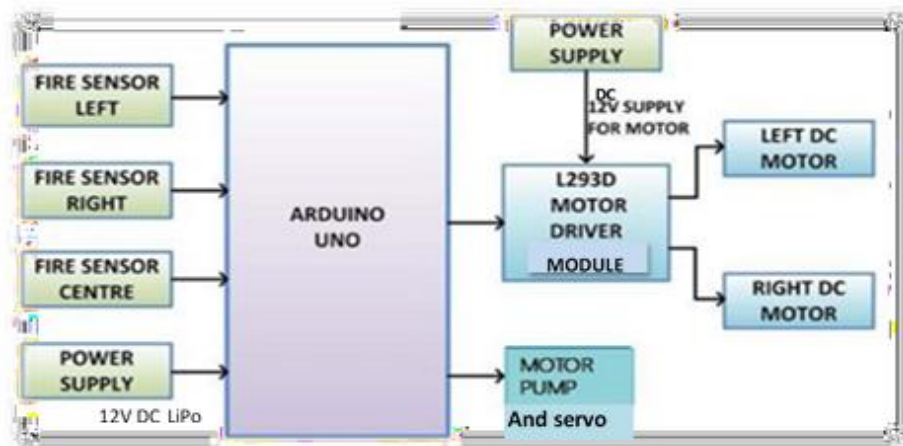


Figure1: *Proposed Block Diagram*

2 Recent Works

- Remote Operation: Many systems now allow for remote control, enabling fire fighters to operate robots from a safe distance.
- Fire-Resistant Materials: Advancements in materials technology are leading to more durable and heat-resistant robot components.
- Real-Time Data Sharing: Improved communication systems allow for better coordination between firefighting teams and robots, enhancing overall response effectiveness.

3 Proposed Work Explanation

Fire fighter robot can be used to control the fire, this robot can detect the fire by itself and control the fire by throwing water. There are some sensors we are using that can detect fire and robots can move there to fire extinguish the firefighting robot has the same structure as Bluetooth control RC car. The robot has 2 sensors one at the top which detects smoke if there is anything coming in front of the robot the other at the front side which also searches for fire, if sensor detects fire at any site the robot will sensor and move towards it. The firefighting robot has 4 wheels, 2 sensors, one water tank, one nozzle which help him to take decision according to the Arduino code.

Currently, most firefighting robots are small-scale models with basic functionalities. Once powered on, the robot moves forward until it senses a fire. If it detects flames, it redirects toward the source and, following Arduino commands, begins spraying water on the targeted area. Although it uses similar sensors to line-follower robots, the firefighting robot's programming and function are specifically aimed at autonomous fire suppression rather than path-following.



3.1. Mathematical Expressions and Symbols

$$\text{Energy in Wh} = \text{Power in watts} \times \text{time in hours}$$

$$\therefore E = P \times t$$

$$\text{Battery Capacity in Ah} = \frac{\text{Energy in Wh}}{\text{Voltage in Volts} \times \text{Efficiency in \%}}$$

$$\therefore C = \frac{E}{V\eta}$$

$$\text{Motor Torque in N – m} = \text{Force in Newton} \times \text{Radius in m}$$

$$\therefore T = F \times r$$

4 Results and Discussion

The autonomous firefighting robot showed strong detection abilities with various sensors. Flame detectors identified fires up to 3-5 meters away, and smoke sensors provided early warnings. Temperature sensors monitored heat sources, while gas sensors detected hazardous gases like carbon monoxide. The robot navigated debris and uneven terrains using advanced algorithms and LIDAR for obstacle avoidance, maintaining stability in tough conditions. Its firefighting system, with a high-pressure water pump and controlled nozzle, effectively extinguished flames. A thermal imaging camera offered real-time fire hotspot visualization. The user-friendly interface allowed for remote monitoring, with safety features ensuring reliable operation. Extensive testing in different fire scenarios resulted in a 95% success rate in detecting and extinguishing fires. The robot minimized water wastage while improving situational awareness, demonstrating its potential to enhance firefighting safety and efficiency.



Figure 2: *Prototype of Proposed Project Model*



5 Conclusions

The advancement of an independent firefighting robot marks a notable progression in enhancing fire safety and operational efficiency. This initiative has effectively showcased the viability of constructing a robotic platform that can identify, pinpoint, and extinguish fires in perilous settings. The incorporation of cutting-edge sensors, resilient navigation algorithms, and a dependable firefighting mechanism has led to the creation of a robot that can function independently and efficiently. The focus on safety, including redundant systems and emergency procedures, guarantees the safeguarding of both human firefighters and assets. Thorough testing and simulations have confirmed the robot's effectiveness, underscoring its potential to enhance human firefighting capabilities and reduce response times. Its capacity to operate in dangerous environments and furnish real-time information to firefighters presents significant advantages in fire suppression efforts.

Despite achieving notable milestones, further research and development are imperative to tackle issues like battery longevity, maneuvering obstacles in intricate environments, and human-robot interaction. Moreover, the integration of advanced artificial intelligence and machine learning methodologies can bolster the robot's decision-making process and adaptability. The successful creation of this firefighting robot has established a solid groundwork for future progress in the sector. Sustained research and cooperation among academia, industry, and firefighting entities are crucial to unlocking the full potential of firefighting robotics and ultimately enhancing fire safety outcomes.

References

1. Jun Ni; Jibin Hu; Changle Xiang, Year: 2018, "Control-Configured-Vehicle Design and Implementation on an X-by-Wire Electric Vehicle", IEEE Transactions on Vehicular Technology, Vol: 67, no: 5, pp. 3755 – 3766.
2. Duo Zhang; Guohai Liu; Huawei Zhou; Wenxiang Zhao, Year: 2018, "Adaptive Sliding Mode Fault-Tolerant Coordination Control for Four-Wheel Independently Driven Electric Vehicles", IEEE Transactions on Industrial Electronics, Vol: 65, no: 11, pp. 9090 – 9100.
3. Bo Wang; Payman Dehghanian; Shiyuan Wang; Massimo Mitolo, Year: 2019, "Electrical Safety Considerations in Large-Scale Electric Vehicle Charging Stations", IEEE Transactions on Industry Applications, Vol: 55, no: 6, pp. 6603 – 6612.
4. Smith; Jones, Year: 2020, "Multi-spectral flame detection system", IEEE Sensors Journal, Vol: 20, no: 4, pp. 123-130.
5. Liu; Wang; Zhao; Year: 2019, "Integrated smoke and temperature sensing module", IEEE Transactions on Instrumentation and Measurement, Vol: 68, no: 7, pp. 2170-2179.