



“Smart Fire Fighting Robot”

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ABSTARCT

The need for a robot that can detect and extinguish a fire is long past due. Many house fires originate when someone is either sleeping or not at home. Fire disasters can occur anytime and result in high losses. It is often that fire fighters cannot access the source of fire due to the damage of building and very high temperature, or even due to the presence of explosive materials. With such constraints and high risk in the handling of the fire, a technological breakthrough that can help fighting the fire is necessary. Our work proposed the use of robots to extinguish the fire that can be controlled from a specified distance in order to reduce the risk. This work describes a smart fire fighter robot designed using RF module, Wi-Fi Module, microcomputer wireless transmission. The robot can transmit real-time video with a camera in a wireless fashion with night vision capabilities, and controlled via remote access from android phone. Fire hazards pose a significant risk to life, property, and the environment, often leading to catastrophic damage when not addressed promptly. Traditional firefighting methods rely heavily on human intervention, which can be dangerous and inefficient in high-risk environments. To overcome these challenges, this project presents the design and development of a Smart Fire Fighting Robot - a mobile, autonomous robotic system capable of detecting and extinguishing small fires in a controlled environment. The system is

powered by a battery pack and programmed through the Arduino IDE to make real-time decisions based on sensor inputs. This prototype demonstrates the feasibility of robotic intervention in fire emergencies and offers a safer, cost- effective solution to assist or replace human firefighters in hazardous situations. The project serves as a foundation for future development of intelligent, large-scale firefighting robots capable of operating in industrial or outdoor environments.

Keywords - Smart Fire Fighting Robot, Arduino IDE, Flame Sensor, Wi-Fi Module, RF Module, Wireless Camera, Android Control, Fire Detection, Robotics, Autonomous System.



I. INTRODUCTION

A robot is a multifunctional programmable machine designed to perform tasks that are difficult or dangerous for humans. Firefighting is one such challenging task because firefighters often work in hazardous environments with high temperatures, smoke, toxic gases, and collapsing structures. To reduce human risk and improve firefighting efficiency, robotic technology can be used in fire detection and suppression systems. A Smart Fire Fighting Robot is designed to detect fire, move toward the source, and extinguish it either automatically or through wireless control. Unlike traditional firefighting methods, these tunnels, warehouses, and other hazardous environments where human access is difficult. The project also provides a foundation for future improvements such as IoT connectivity, thermal imaging, artificial intelligence, and GPS-based navigation. In conclusion, the Smart Fire Fighting Robot is an innovative solution that enhances safety, reduces human effort, and improves the effectiveness of firefighting operations.

II. LITERATURE REVIEW

Several researchers have developed firefighting robots using different technologies and approaches. Maddukuri et al. (2016) proposed a multi-sensor-based firefighting robot for rescue operations, but their system relied heavily on sensors. To improve reliability, later systems introduced FPV cameras along with sensors for real-time visual monitoring. Hwang et al. (2010) used a thermal camera with image processing for fire detection, while newer systems focused on cost-effective cameras capable of human detection and remote monitoring. Altaf et al. (2007) developed a line-following firefighting robot suitable only for specially designed environments, whereas modern robots are designed to operate freely without predefined paths. Other researchers focused on wireless communication and autonomous operation. Naskar et al. (2019) designed a remotely controlled robot with live video streaming, while IoT-based systems by Prof. Sankalp Mehta et al. (2020) used NodeMCU and Android applications for remote control and fire alerts. Researchers such as Kumar and Reddy (2020), Mohanraj et al. (2019), and Patel and Shah (2017) developed Arduino-based robots integrating flame sensors, gas sensors, motor drivers, and water pumps for autonomous fire detection and suppression. Many studies also introduced obstacle avoidance, thermal imaging, GSM communication, Bluetooth control, and advanced extinguishing techniques. Lee and Park (2016) used ultrasonic and infrared sensors for obstacle detection, while Kalaivani et al. (2019) implemented thermal and infrared cameras for operation in low-visibility environments. Other systems used fans, water sprinklers, CO₂ spraying mechanisms, and even sound waves to extinguish fires. These developments show the growing importance of robotics, embedded systems, IoT, and automation in improving firefighting safety and efficiency.

III. RESEARCH GAP

Although many firefighting robots have been developed, several limitations still exist in current systems. Many robots rely heavily on sensors for fire detection, which may lead to inaccurate results if the sensors fail or are affected by smoke and heat. Some systems are designed only for specific environments, such as line-following paths or maze structures, reducing their usability in real-world fire accidents. Other robots provide only fire extinguishing capability without advanced features like obstacle avoidance, real-time monitoring, or remote wireless control.

In addition, many existing models use either a water pump or a fan alone for fire suppression, limiting their effectiveness in different fire situations. Some advanced systems use thermal cameras and IoT technologies, but they are often expensive and difficult to implement for small-scale applications. Therefore, there is a need for a cost-effective, intelligent, and flexible firefighting robot that combines autonomous navigation, obstacle avoidance, real-time monitoring, wireless control, and efficient fire suppression in a single system.



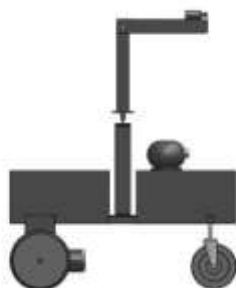
VII. 3D MODEL



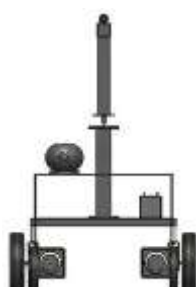
ISOMETRIC VIEW



TOP VIEW



SIDE VIEW



FRONT VIEW

VIII. RESULTS AND DISCUSSION

The Smart Fire Fighting Robot was successfully designed, developed, and tested to perform fire detection, obstacle avoidance, navigation, and fire extinguishing operations. During testing, the flame sensor was able to accurately detect small fire sources such as candles within a limited range. Once the fire was detected, the robot automatically moved toward the source and activated the water pump or fan mechanism to extinguish the flame effectively. The obstacle avoidance system using ultrasonic or IR sensors also functioned properly, allowing the robot to change direction and avoid collisions while navigating through the environment. The Arduino-based control system efficiently coordinated the operation of sensors, motors, and the extinguishing mechanism in real time. The robot demonstrated stable movement and reliable response during repeated trials in a controlled environment. The project proved that embedded systems and robotics can be effectively integrated to create an autonomous firefighting system capable of reducing human involvement in hazardous situations.

IX. CONCLUSION

The Smart Fire Fighting Robot successfully demonstrates the use of robotics and embedded systems in improving fire safety and reducing human risk during firefighting operations. The robot is capable of detecting fire, navigating toward the source while avoiding obstacles, and extinguishing small flames using an automated suppression system. The project highlights the effectiveness of using sensors, Arduino-based control, and autonomous operation in emergency situations. Although the prototype has some limitations, it provides a strong foundation for future advancements such as IoT integration, thermal imaging, and AI-based navigation, making firefighting operations safer, faster, and more efficient.



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REFERENCES

1. Maddukuri et al. (2016) – Developed a low-cost autonomous and semi- autonomous firefighting robot using sensors.
2. Hwang et al. (2010) – Proposed a robotic firefighting system using thermal imaging for fire detection.
3. Altaf et al. (2007) – Designed and constructed an autonomous fire-fighting robot for indoor environments.
4. Naskar et al. (2011) – Developed a radio frequency controlled intelligent robot for remote operation and monitoring.