Global Journal of Research in Engineering & Computer Sciences
ISSN: 2583-2727 (Online)
Volume 03 | Issue 06 | Nov.-Dec. | 2023
Journal homepage: https://gjrpublication.com/gjrecs/
Review Article

Robots for Fighting Fires: A Comparative Analysis

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DOI: 10.5281/zenodo.10384140 Submission Date: 15 Nov. 2023 | Published Date: 15 Dec. 2023

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Abstract

Fire safety is a very important issue. Big and small fires can do terrible damage to people and property. Unpredictably, fires can spread quickly, consuming entire buildings and posing a threat to human life in a matter of seconds. When paired with real-time communication, automation can greatly improve the capacity to react to fires quickly and efficiently. Fire safety has advanced significantly as a result of technological development. Advanced sensors and algorithms are used by smart fire detection systems to quickly and accurately identify fires. Earlier studies have concentrated on using sensors such as infrared, LIDAR, and ultrasonic to help robots navigate in challenging and changing environments.

Keywords: Fire out-break, Robots, Saving, Dangerous environments, Impacts.

INTRODUCTION

Fire safety is a very important issue. Big and small fires can do terrible damage to people and property. Unpredictably, fires can spread quickly, consuming entire buildings and posing a threat to human life in a matter of seconds. Efficient communication and prompt action are essential in these kinds of emergency scenarios. Conventional firefighting techniques frequently depend on human intervention, which can occasionally cause delays. When paired with real-time communication, automation can greatly improve the capacity to react to fires quickly and efficiently. Fire safety has significantly improved as a result of technological advancements [21]. Advanced sensors and algorithms are used by smart fire detection systems to quickly and accurately detect fires [22]. Earlier studies have concentrated on using ultrasonic [23–25], LIDAR, and infrared sensors to help robots navigate through intricate and dynamic environments. With the help of light-dependent resistors (LDRs), a line-following robot [26, 27] can track and navigate through a maze of lines, avoid obstacles, and put out any fires [4].

Figure 1: Fire-Fighting Robot

RELATED WORKS

A thorough investigation of small crawler fire-fighting robots was carried out using the virtual prototype technology, taking into account the unique working conditions and personal safety of firefighters in homes, public spaces, and other fire scenes. The firefighting robot's general design scheme is suggested, and a stand-alone suspension system with effective shock absorption is created. The development of an explosion-proof waterproof shell for a specialized firefighting robot allows for precise temperature [28, 29] and dangerous object detection at the fire scene through the robot's vision and temperature identification. Research shows that the small crawler fire-fighting robot has high detection intelligence and structural reliability, which is of great significance to the fire-fighting operations [1]. A fire incident at the industry poses a serious risk to human life and would result in significant losses. Early fire detection and modest firefighting efforts could prevent significant losses and save lives. If firefighting action is done promptly, the majority of fire accidents won't result in significant losses. In order to carry out early firefighting action, this paper suggests integrating the autonomous firefighting mobile robot into the conventional fire safety Internet of Things (IoT) system. In the event that a fire is discovered, the IoT system notifies the fire safety division and launches a mobile robot into action. Using a path-planning algorithm, a firefighting robot arrives at a fire location, engages in firefighting operations, and transmits the video feed of the fire location to the control room. In addition to alerting the fire safety officers, this early firefighting action prevents the fire from spreading. By watching the video that the firefighting robot sent, fire safety officers can better prepare for handling the fire incident in the interim. Businesses with a high risk of fire incidents could combine their current fire alerting system with a mobile robot that fights fires [2]. A robotic system called the Arduino-based Fire Fighting Robot with SMS Alert System is made specifically to detect and put out indoor fires. The robot looks for signs of fire using flame sensors. The robot moves in the direction of the fire source and sprays water to put out the flames when it detects a fire. When a fire is detected, the user can receive alerts via SMS messages from the robot thanks to its GSM module. This makes it possible to respond quickly in order to reduce damage and save lives. The robot is made up of an Arduino board, sensors, motor drivers, and a GSM module. The Arduino IDE is used to write the software code that reads sensor data, controls the motors, and interfaces with the GSM module. In order to make sure the robot operates correctly and safely in various situations, it is tested and debugged. With the extra advantage of remote communication and control, the Arduino-based Fire Fighting Robot with SMS Alert offers a dependable and effective solution for fire detection and suppression overall [3]. Two firefighting robots that are currently in use and have seen extensive use in industry are Thermite and Fire Robots [5]. In a noteworthy study, a fire extinguishing robot with an SMS alert feature was created. Its purpose was to use a flame sensor to detect fires and alert building occupants. The robot moves toward the fire source using Arduino technology, then uses a modem to send messages to any phone connected to the GSM network [6]. Additionally, another project used Arduino technology to create an autonomous firefighting robot that could locate and put out fires [7]. Humanoid robot applications are the subject of active research in an attempt to increase productivity, security, efficacy, and quality of work while lowering the number of firefighter fatalities and injuries [8]. The robot can improve the fire's quality, productivity, safety, and efficiency. It is smaller and more pliable than other robots. Furthermore, the robot's small size and automatic control make it suitable for use in hazardous environments like tunnels or nuclear power plants where fires occur in tight spaces [9] [10]. The creation of a fire extinguishing robot with an SMS alert feature is presented in this study. The robot is capable of alerting building occupants, sending a warning SMS message to the registered phone number, and putting out fires without human assistance. Its compact design makes it simple to maneuver in confined areas. The robot has an ultrasonic sensor to prevent collisions with obstacles and surrounding objects, and it also has a flame and smoke sensor to detect fires. This developed autonomous system shows off its ability to automatically locate fires and put them out with water that has been stored in a container on it [11]. The development of an autonomous, human-free firefighting robot that can identify and put out fires is the main topic of this report. It is crucial that we have a system in place to handle a dangerous incident like this because fires can break out in our homes, workplaces, factories, or labs at any time. The systems that are currently on the market are smoke detectors, which are effective but have certain drawbacks. For example, they cannot detect small fires and the water showers do not provide enough coverage to completely put out a fire. Additionally, the smoke detectors fail to alert people to the location or status of the fire, which can cause long-term harm because it delays help. This report's suggested model can assist in containing fires before they cause significant damage. The "Automatic firefighting robot with SMS notification" is a wireless device that is simple to set up, detects small fires, and notifies the user of the location of the fire. Our objective in creating this firefighting robot was to create a machine that could identify small fires in a closed space, which we achieved by simulating fires with candles. After detecting the fire with the help of thermal and infrared sensors, it approaches the fire and safely sprays it with water. The Arduino Nano processor on the motherboard is responsible for both the robot's movement in the direction of the fire and its detection. Additionally, the robot has GPS and GSM modules that alert the user to the location of a fire via SMS [12]. This paper's primary goal is to create an automated system that uses image processing to identify and put out fires. To avoid more harm, a firefighter needs to be able to put out a fire swiftly and safely. The gap between machines and firefighting has finally been closed by technology, enabling more effective and efficient firefighting techniques. In order to facilitate the work of firefighters and minimize the number of casualties, we develop an automated system for the early detection and extinguishment of fires. The goal of the paper is to use the Arduino UNO to create a firefighting robot. The water pump on board the robotic

vehicle is servo-controlled. For this purpose, an AT Mega 328 microcontroller is employed. The robot is controlled by commands transmitted from the transmitting end to the receiving end. These commands can be to move the robot forward, left, right, etc. Two motors are interfaced to the microcontroller at the receiving end; two are used to move the vehicle, and the other is used to position the robot. The receiver driver module uses a motor driver integrated circuit (MCU) to drive DC motors for necessary tasks, while the ultrasonic sensor's detection range is sufficient for detecting obstacles. The robot body is equipped with a water tank and water pump, which are controlled by the microcontroller output by means of the corresponding commands sent from the transmitting end. An AT Mega 328 microcontroller is in charge of the entire system. The microcontroller is interfaced with a motor driver integrated circuit (IC), which allows the controller to drive the motors. On the robot chassis, three infrared flame sensors are fixed to detect fire and travel to the site to extinguish the fire. The automated firefighting robot can successfully identify the source of the fire and put it out. Since the system offers constant monitoring, it operates in real time. Creating and operating a valuable, independent firefighting service will be fascinating [13]. We have created a firefighting robot with the help of modern technology. Various sensors are used by this firefighting robot, including PIR, temperature, smoke, and fire sensors. The robot notifies the controller when it notices a fire. Water is then sprayed in the direction of the fire when the controller signals the motor driver. The camera module is what allows the module to function in real time. The PIR sensor identifies the human, activates the buzzer, and provides victim details. It helps put out the fire for firefighters. Additionally, it will operate in areas that firefighters are unable to access. This will prevent additional damage and save the lives of the firefighters [14]. An outbreak of fire is a dangerous event with many repercussions. Early detection and extinguishment of a fire can help prevent a variety of accidents. We have up until now relied on human resources. This frequently results in endangering that person's life. As a result, fire safety becomes crucial to preserving human life. This involves the proposal and design of a fire extinguishing robot that locates the fire and uses sprinklers to activate a pump to put it out. Flame sensors are used by this robot to detect fires accurately. The purpose of this suggested Arduino-powered fire extinguishing robot model is to identify the existence of fire and put it out on its own, without the need for human intervention. When the robot senses the presence of fire, it uses gear motors and a motor driver to control its movement. It then initiates the water pump to put out the fire on its own. The water ejector on this particular robot model can shoot water where the fire breakout occurs. A servo motor can be used to move the water ejector pipe in the desired direction. An Arduino UNO controls the entire system. Being a firefighter is a dangerous but vital job. In order to limit casualties and stop additional damage, a firefighter needs to be able to get to the scene swiftly and safely. This problem has been solved by technology, which gives machines and firefighters access to more effective and efficient firefighting techniques. This provides you with an idea of how an autonomous firefighting robot might be designed. The robotic vehicle is equipped with a water pump that shoots water when a solenoid valve is opened, as well as a fire extinguisher. The intended function is accomplished with an Arduino UNO. The robot body has a water pump, fire extinguisher setup, and water tank installed. The water pump operates by receiving a signal from the sensor and sending it to the output. An Arduino UNO controls the entire system [15]. These days, there are a lot of fire incidents, which seriously harm people's lives and property. Due to the inability of firefighting robots to conduct targeted firefighting and the difficulties posed by high-altitude combustion sources, firefighting and assistance are currently facing unprecedented challenges. In light of this, the study investigated and created an automated control system for raising firefighting robots in order to address the main challenges and issues pertaining to fire control and robot combat. In order to address the issue of unsteadiness in the elevating process and expedite the application and popularization of firefighting and disaster rescue of the fire-fighting robot, the research target is comprised of three parts: first, the system has realized the elevating fire control and fighting function; second, we have designed an automatic control system for elevating the fire-fighting robot based on ROS structure; and third, the paper has established the automatic control strategy play for raising the arm of the elevating fire-fighting robot, featuring stable and controllable operation [16]. In order to create a tool that will perfectly put out fires and protect people and property from harm, an unmanned firefighting robot is being designed, developed, and put into use. To help firefighters battle inaccessible fires such as flaming gasoline tank cars, shopping centers, gas filling stations, and homes, automation systems and mobile, fire-resistant, unmanned robots are being developed. With the help of controls for both its movement and the up and down of the water nozzle, the robot will put out fires using water surf solution. It has attachments (the MZ80 flame sensor) that allow the controller to control and view the state of the robot, as well as cameras run by an Arduino microcontroller and two geared DC motors to facilitate movement and maneuverability. FEA and CAE knowledge-based software (SolidWorks for mechanical systems and Proteus for electronic systems) are used in the design and development of the mechanical system, the electronic system, and the preparation of the required software [17]. A type of motion control system for a firefighting robot is presented in this paper. Wireless remote control, which includes head motion to regulate the motion direction of the firefighting robot water gun, forms the fundamental basis of a firefighting robot's actions. The MPU6050 gyroscope is the device that gathers the head motion data. To achieve vision synchronization, the water gun's camera feeds back the image to the operator's VR goggles. The stepping motor is used as the driving method, and the water cannon can rotate both yaw and pitch angles. The water cannon is operated by the four-way navigation key module. The driving motor of the robot is controlled by the two-axis rocker sensor module, and it drives using the track driving technique. The majority of remote-controlled firefighting robots are compatible with the control system [18]. Because of the economy's explosive growth, fires happen a lot in a lot of hazardous locations. The investigation found that there were very few intelligent mobile

firefighting units in the tragic ancient fire cases, and that fires could not be promptly extinguished with standard fire extinguishers or fire-fighting trains. An intelligent firefighting robot is a type of robot that is becoming more and more significant in rescue and firefighting operations. This paper examines the design of a fire robot. A fire-fighting control system, a fire-fighting water spray system, a fire-fighting movement system, and other parts make up an intelligent fire-fighting robot. To finish the firefighting task, all components collaborate and work together [19]. Human interaction has decreased as a result of mechanical technology advancements, and robots are now used for a variety of tasks as well as for the welfare of living things. These days, there are a lot of fire incidents that put property and human lives in danger and make it harder for firefighters to save lives. In these situations, a firefighting robot is used to prevent fire accidents from endangering people's lives, property, and surroundings. Using vision technology, this model of IOT-based firefighting robot locates the fire. Authorities can begin visualizing the scene of the fire and communicating with those who are trapped once they have been notified. Humans can instruct the robot to move over long distances by installing an automatic receiver and giving it commands, such as activating the water pump or flame sensor pump, based on the type of fire. The installed sensors are used to determine the type of fire. In order for safety authorities to take the necessary steps to repair the harm, the analysis is also helpful in providing them with additional information about the quantity of toxic gases that residents of the impacted area have inhaled over time [20].

Conclusion

Numerous papers have been reviewed for this research. We have witnessed their technological advancements and the diverse effects of utilizing them.

References

1. Y. -Z. Jia, J. -S. Li, N. Guo, Q. -S. Jia, B. -F. Du and C. -Y. Chen, "Design and Research of Small Crawler Fire Fighting Robot," 2018 Chinese Automation Congress (CAC), Xi'an, China, 2018, pp. 4120-4123, doi: 10.1109/CAC.2018.8623538.
2. P. Anantha Raj and M. Srivani, "Internet of Robotic Things Based Autonomous Fire Fighting Mobile Robot," 2018 IEEE International Conference on Computational Intelligence and Computing Research (ICCIC), Madurai, India, 2018, pp. 1-4, doi: 10.1109/ICCIC.2018.8782369.
3. S. Raghunath, et al., “Fire Fighting Robot with SMS Alert System”, International Journal for Research in Applied Science & Engineering Technology (IJRASET), Vol. 11 Issue XI, Nov 2023, Available at www.ijraset.com.
4. K. Altaf, " Design and Construction of an Automated Fire Fighting Robot," in Proceedings of International Conference on Information and Emerging Technologies, 2007.
5. Nuţă, I., O. Orban, and L. Grigore, "Development and Improvement of Technology in Emergency Response.," Procedia Economics and Finance, 2015.
6. F. D. O. O. B. A. A. A. J. O. Samuel Oluyemi Owoeye, "Development of a Fire Extinguishing Robot with SMS Alert System," in Proceedings of the 3rd International Conference on Engineering Innovations as a Catalyst for Rapid Economic Growth tagged COLENG, 2021.
7. Aryan Verma, Naman Yadav, Harshita Chaubey, Aditya Srivastava, Dr. Ajay Sharma, "Arduino Based Fire-Fighting Robot with SMS Alert," Journal of Emerging Technologies and Innovative Research (JETIR), 2023.
8. Jong-Hwan Kim, Seongsik Jo, Brian Y. Lattimer, "Feature Selection for Intelligent Firefighting Robot Classification of Fire, Smoke, and Thermal Reflections Using Thermal Infrared Images," Journal of Sensors, 2016.
9. Raju, S. S. Mohammed, J. V. Paul, G. A. John and D. S. Nair, "Development and implementation of Arduino microcontroller based dual mode fire extinguishing robot," in IEEE International Conference on Intelligent Techniques in Control, Optimization and Signal, 2017.
10. Tushar Nandkishor Satbhai, R.M.K., Anant Vijay Patil, Manish Patil, "Fire Fighting Robot," International Journal on Recent and Innovation Trends in Computing and Communication (IJRITCC), 2016.
11. S. O. OWOEYE, et al., “Development of A Fire Extinguishing Robot with SMS Alert Feature”, Proceedings of the 3rd International Conference on Engineering Innovations as a Catalyst for Rapid Economic Growth tagged COLENG 2021, Federal University of Agriculture, Abeokuta, Nigeria, May 24 -26, 2021.
12. A Verma, et al., “Design and Construction of Automatic Fire Fighting Robot with SMS Notification”, Advanced Production and Industrial Engineering, pp. 1-8, 2022, doi:10.3233/ATDE220785.
13. B. R. V. Prasad, et al., “Artificial Intelligence in an Autonomous Fire Fighting Robot”, International Research Journal of Modernization in Engineering Technology and Science, Vol. 05, Issue 04, April-2023.
14. V. J. Agrawa, et al., “Industrial Application Multitask Fire Fighting Robot Design and Analysis”, Industrial Engineering Journal, Vol. 52, Issue 6, No. 3, June 2023.
15. P. Keni, et al., “Autonomous Fire Fighting Robot Using Arduino”, International Journal of Advanced Research in Science, Communication and Technology (IJARSCT) Vol. 2, Issue 2, July 2022.

16. Z. Gan, et al., "The Control System and Application Based on ROS Elevating Fire-Fighting Robot", Journal of Physics: Conference Series, 2029, 2021, 012004 IOP Publishing doi:10.1088/1742-6596/2029/1/012004.
17. A. Saturday, Ikebudu K. O, "Design and Development of an Unmanned Fire Fighting Robot", Sch J Eng Tech, vol. 11, no. 3, pp. 84-90, 2023.
18. N. Fuxiang, et al., "Design of Motion Control System for Fire Fighting Robot", Journal of Physics: Conference Series, 1635, 2020, 012059, IOP Publishing doi:10.1088/1742-6596/1635/1/012059.
19. Wu et al., "Design and Development of Intelligent Fire-fighting Robot Based on STM32", Journal of Physics: Conference Series, 1748, 2021, 062019 IOP Publishing doi:10.1088/1742-6596/1748/6/062019.
20. P. D. V. Prasad, et al., "Vision Based Fire Fighting Robot using IoT", International Journal of Engineering Technology and Management Sciences, Issue 4, Vol. 6 July –2022.
21. Abdulrahman Y.A., M. I. Bello, S.A. Sani, A. Ibrahim, & M. A. Baballe, "Fire Extinguisher types and Applications", Global Journal of Research in Engineering & Computer Sciences, vol. 3, no. 4, pp. 45–50, 2023, https://doi.org/10.5281/zenodo.8286527.
22. A. S. Bari, et al., "Forest Fires: Challenges and Impacts", Global Journal of Research in Engineering & Computer Sciences, Volume 02, Issue 04, pp. 19-23, July-Aug 2022, Journal homepage: https://gjrpublication.com/gjrecs/.
23. Mukhtar I. B., M. A. Baballe, "Simulation of Obstacle Avoidance Robots", Global Journal of Research in Engineering & Computer Sciences, vol. 3, no. 5, pp. 1–9, 2023, https://doi.org/10.5281/zenodo.8408537.
24. A. I. Adamu, et al., "The Several uses for Obstacle Avoidance Robots", Iris Jour of Astro & Sat Communicat Volume 1, Issue 1, pp. 1-6, 2023.
25. M. A. Baballe, Mukhtar I. B., S.H. Ayagi, & Umar F. M, "Obstacle Avoidance Robot using an ultrasonic Sensor with Arduino Uno", In Global Journal of Research in Engineering & Computer Sciences, Vol. 3, Number 5, pp. 14–25, 2023, https://doi.org/10.5281/zenodo.10015177.
26. M. A. Baballe, et al., "Pipeline Inspection Robot Monitoring System", Journal of Advancements in Robotics, vol. 9, no. 2, pp. 27–36, 2022.
27. M.A. Baballe, A. I. Adamu, Abdulkadir S. B., & Amina I, "Principle Operation of a Line Follower Robot", Global Journal of Research in Engineering & Computer Sciences, vol. 3, no. 3, pp. 6–10, 2023, https://doi.org/10.5281/zenodo.8011548.
28. M. A. Baballe, M. I. Bello, "A Study on the Impact and Challenges of Temperature Detection System", Global Journal of Research in Engineering & Computer Sciences, vol. 1, no. 2, pp. 22-26, 2021.
29. M. A. Baballe, A. L. Musa, M. A. Sadiq, I. Idris Giwa, U. S. Farouk, Aminu Ya'u. "Temperature Detection System implementation", Global Journal of Research in Medical Sciences, vol. 2, no. 5, pp. 92–97, 2022, https://doi.org/10.5281/zenodo.7126185.

CITATION
M. A. Baballe, M.A. Shehu, A.Surajo, Dele Z.Y., & Abdulmuhaimin M. (2023). Robots for Fighting Fires: A Comparative Analysis. In Global Journal of Research in Engineering & Computer Sciences (Vol. 3, Number 6, pp. 57–61). https://doi.org/10.5281/zenodo.10384140