

PROFESSIONAL TRAINING REPORT - II

entitled

Arduino-Enabled Firefighting Automations: Advancing Fire Safety with IR Sensors

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering degree in Computer Science and Engineering with
specialization in Artificial Intelligence and Robotics

by

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**DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
SCHOOL OF COMPUTING**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

CATEGORY -I UNIVERSITY BY UGC

**Accredited with Grade "A++" by NAAC I 12B Status by UGC I Approved by AICTE
JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119**

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Professional Training Report is the bonafide work of **Ms. ARTHIKA.A (41612006)** who carried out the project entitled **"Arduino-Enabled Firefighting Automations: Advancing Fire Safety with IR Sensors"** under my supervision from January 2024 to April 2024.

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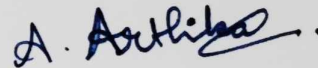
External Examiner

DECLARATION

I, **ARTHIKA.A (41612006)**, hereby declare that the Professional Training Report-II entitled **“Arduino-Enabled Firefighting Automations: Advancing Fire safety with IR Sensors”** done by me under the guidance of **Dr.SONIA JENIFER RAYEN**, is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Computer Science and Engineering with specialization in Artificial Intelligence.

DATE: 07/05/2024

PLACE: **CHENNAI**



SIGNATURE OF THE CANDIDATE

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ABSTRACT

Firefighter robots represent a cutting-edge solution to combating fires in hazardous and inaccessible environments. This presentation explores the development, challenges, and outcomes of employing firefighter robots in fire suppression operations. Traditional firefighting methods often face limitations in addressing fires in complex and dangerous settings, such as industrial facilities, chemical plants, and urban high-rises. Introducing firefighter robots revolutionizes fire response strategies by offering enhanced safety and efficiency in extinguishing fires. The inherent risks associated with firefighting, including extreme heat, smoke inhalation, and structural instability, pose significant threats to firefighters' safety. Moreover, navigating through confined spaces and hazardous environments complicates rescue and firefighting efforts, putting human lives at risk. Firefighter robots leverage advanced robotics, artificial intelligence, and sensor technologies to autonomously navigate through fire scenes, assess the situation, and execute firefighting tasks. Equipped with thermal imaging cameras, gas sensors, and water hoses, these robots can detect fire sources, suppress flames, and provide critical data to firefighters in real-time.

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CHAPTER 1

INTRODUCTION

1.1 OVERVIEW

Firefighter robots represent a cutting-edge solution to combating fires in hazardous and inaccessible environments. This presentation explores the development, challenges, and outcomes of employing firefighter robots in fire suppression operations. Traditional firefighting methods often face limitations in addressing fires in complex and dangerous settings, such as industrial facilities, chemical plants, and urban high-rises. Introducing firefighter robots revolutionizes fire response strategies by offering enhanced safety and efficiency in extinguishing fires. The inherent risks associated with firefighting, including extreme heat, smoke inhalation, and structural instability, pose significant threats to firefighters' safety. Moreover, navigating through confined spaces and hazardous environments complicates rescue and firefighting efforts, putting human lives at risk. Firefighter robots leverage advanced robotics, artificial intelligence, and sensor technologies to autonomously navigate through fire scenes, assess the situation, and execute firefighting tasks. Equipped with thermal imaging cameras, gas sensors, and water hoses, these robots can detect fire sources, suppress flames, and provide critical data to firefighters in real-time.

CHAPTER 2

LITERATURE REVIEW

2.1 SURVEY

A good amount of Literature Survey with relevant articles related to the project work.

Design And Development of Fire Fighting Robot

<https://www.irjet.net/archives/V10/i5/IRJET-V10I5267.pdf>

Fire incident is a disaster that can potentially cause the loss of life, property damage and permanent disability to the affected victim. Fire fighters are primarily tasked to handle fire incidents, but they are often exposed to higher risks when extinguishing fire, especially in hazardous environments such as in nuclear power plants, petroleum refineries and gas tanks. They are also faced with other difficulties, particularly if fire occurs in narrow and restricted places, as it is necessary to explore the ruins of buildings and obstacles to extinguish the fire and save the victim. Therefore, this paper presents the development of a firefighting robot dubbed QRob that can extinguish fire without the need for firefighters to be exposed to unnecessary danger.

Android Controlled Fire Fighter Robot Using IoT

<https://ieeexplore.ieee.org/document/9987297>

Detecting fire and extinguishing it is a dangerous job that puts the life of a firefighter at risk. There are many fire accidents in which firefighters had to lose their lives in the line of duty each year throughout the world. The research and development in the field of Artificial Intelligence has given rise to Robotics. Robots are implemented in various areas like Industries, Manufacturing and Medicines etc

The Future of Firefighting: Firefighting Robots

<https://online.eou.edu/resources/article/future-of-firefighting-firefighting-robots/>

The common conventional firefighting methods involve fire brigades, portable fire - extinguisher (hand held) and sprinklers. These conventional methods consume lot of time to reach the place of the mishap like the fire brigade must be deployed from the fire station and should get through the traffic and reach the fire struck area, the portable extinguisher is also no gift because it is generally place at one off the corners of the building which may be difficult to reach and it needs constant maintenance.

A Smart Fire Detection System with Automatic Water Sprinkler

https://www.academia.edu/109857811/A_Smart_Fire_Detection_System_Using_GSM_Technology_with_Automatic_Water_Sprinkler

The sprinkler and smoke detector set up is a very unreliable method because the sprinkler pipes have any defect that may not provide enough pressure and it is suited to cover large areas. Hence, Robotics can be used to assist firefighters to perform this task of firefighting and thus reduce the risk of their lives. FireFighter is a robot designed to use in such extreme conditions. It can be operated and controlled by remote users and has the ability to extinguish fire after locating the source of fire. It is equipped with a monitoring system and operates through a wireless communication system.

Recent Advances in Sensors for Fire Detection

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9100504/>

The robot is controlled autonomously using an Android application. Android mobile phone platform developed by Google has gained popularity among software developers due to its powerful capabilities and open platform. Therefore, Android is a great platform to control a Robotic system. Android provides many resources and already integrates a lot of sensors. This concept helps to generate interest as well as innovation in the field of robotics while working towards a practical and obtainable solution to save lives and mitigate the risk of property damage.

Fire Safety Challenges in the 21st Century

<https://journals.sagepub.com/doi/abs/10.1106/N72L-L31V-7X4P-2T4P>

The fire scene is an information-poor environment due to lack of information on location of fire, firefighters and victims, and the search and rescue opportunities are previously unimaginable due to lack of situational conditions and real-time information for targeted decision making. to this the accidents occur. Additionally, the current methods applied in firefighting are inadequate and inefficient relying heavily on humans who are prone to error, no matter how extensively they have been trained.

An Indoor Autonomous Inspection and Firefighting Robot Based on SLAM and Flame Image Recognition

<https://www.mdpi.com/2571-6255/6/3/93>

The hardware for the autonomous inspection system primarily consists of a motion unit and sensor unit. In contrast, the hardware of the automatic fire-extinguishing system primarily consists of a video monitoring system and a fire extinguishing system. The fire-fighting robot developed is a remotely controlled robot with two independent built-in fire extinguishing cylinders, built-in flame detection sensors and 3 mounted IR camera units. The exterior of the robot is Ag-coated, and it is operable under high temperatures (approximately 700° C).

CeaseFire: The Fire Fighting Robot

<https://ieeexplore.ieee.org/abstract/document/8748547>

This project is about a real-time firefighting robot that moves at a steady pace, detects a fire, and then uses a pumping mechanism to put it out. The smoke sensor, gear motor and its driver, relay driver, and other components were all interfaced to the Arduino for detection and extinguishment. The robot communicates with a smartphone through Bluetooth and uses the analogue and digital data from the sensors to detect whether or not there is a fire in the vicinity. A fire-fighting robot that can be controlled from some distance has been successfully developed. It has advantageous features such as the ability to detect location of fire automatically besides having a compact body and lightweight structure.

Development of Fire Fighting Robot (QRob)

<https://shorturl.at/fgimE>

QRob also has the ability to avoid hitting any obstacle or surrounding objects due to its provision of an ultrasonic sensor. The QRob robot can be used at a place that has a small entrance or in small spaces because it has a compact structure. The operator is able to extinguish fire using remote control from a longer distance. Operators can also monitor the environmental conditions during the process of firefighting by using the camera that is connected to the smartphone.

Design of intelligent fire-fighting robot

<https://www.sciencedirect.com/science/article/abs/pii/S0921889022000677>

This model of Fire Extinguishing Robot aids to share out the burden of firefighters in firefighting tasks. Our project aims to build a real time firefighting robot which moves at a constant speed, identifies the fire and then extinguishes it with the help of a pumping mechanism. The detection and extinguishing was done with the help of basic hardware components attached with the robot. Firstly, IR Flame sensors are used for the detection of fire. Secondly, BO Motors and Rubber wheels are used to navigate the robot to reach the fireplace.

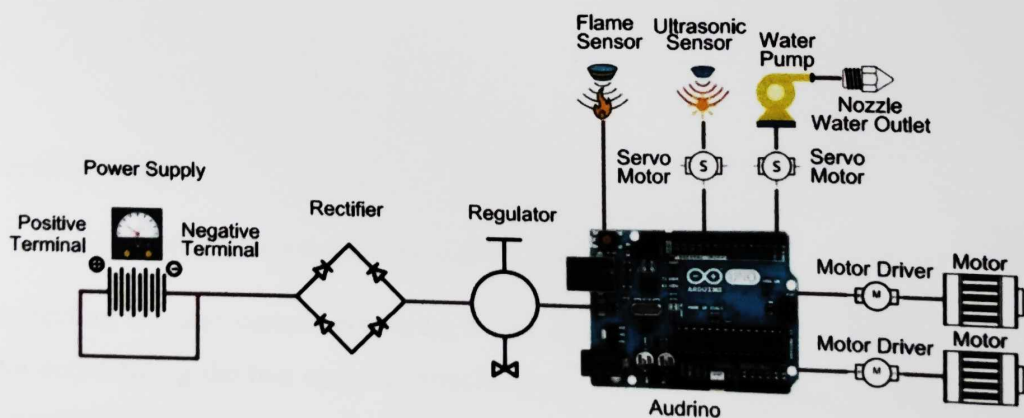
CHAPTER 4

DESIGN DESCRIPTION OF PROPOSED PROJECT

4.1 PROPOSED METHODOLOGY

PROPOSED SYSTEM

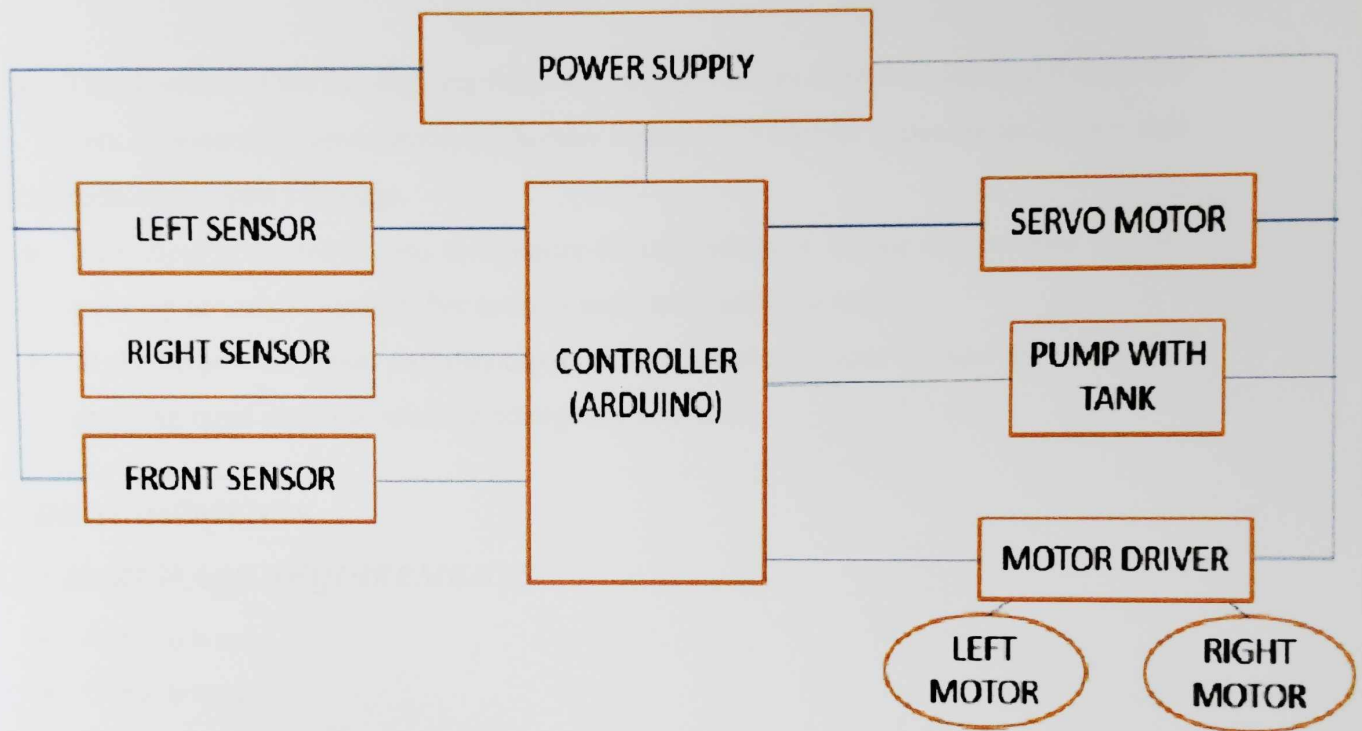
The proposed model is able to detect the presence of fire using a flame sensor and calculates object distance using an ultrasonic sensor and moves the robot to the fire accident location. It contains gear motors and a motor driver to control the movement of robots. When it detects fire it communicates with a microcontroller (Arduino MEGA) and the robo will move towards the fire affected area. The fire extinguisher is mounted on the robotic vehicle which is then controlled over the wireless communication so that it extinguishes the fire automatically. The robot will be used at places where it is dangerous for humans to enter. Capability of sensing accurately with increased flexibility. Reduce human effort. Reliable and economical. It reduces the time delay in reaching fire affected areas. It reduces the errors and the limitations that are faced by human firefighters. Sensors have a long life time and cost less.



(4.1) PROPOSED SYSTEM

4.1.1 Ideation Map/System Architecture

The system architecture of this advanced robot includes power supplies, sensory devices placed in different positions, and an arduino controller. a servo motor along with a motor driver comprising left and right motors. The main component pump with the tank can accomplish the prime task of pumping water accordingly.



(4.1.1)System Architecture

4.1.2 Various Stages

1. Assembling the base components:

Constructing the base cartons according to the convenience. Ensembling the screws and DC motor coordinating the two cartons. Attaching the lithium iron battery to the constructed base respectively. Generating an electric connection between the battery and the sensory domain based on the requirement.

CHAPTER 3

REQUIREMENTS ANALYSIS

3.1 OBJECTIVE OF THE PROJECT

- The objective of the fire-fighting robot is to autonomously detect, localize, and suppress fires in hazardous environments, thereby minimizing human exposure to danger and reducing property damage.
- Specifically, the robot aims to navigate through complex indoor and outdoor spaces, utilizing sensors to identify fire sources accurately and efficiently.
- It should possess robust mobility capabilities to traverse various terrains and obstacles, ensuring rapid response times in emergency situations.

3.2 REQUIREMENTS

3.2.1 *HARDWARE REQUIREMENTS*

- Arduino Uno
- Flame ir sensor
- Single channel relay
- Robot car kit
- Motor driver
- Pump motor
- Connecting wire
- Servo motor
- Nozzle for water spray
- Power source

3.2.2 *SOFTWARE REQUIREMENTS*

The components used are majorly hardware based tools and elements

2. Sensors integration:

Establishing an electrical junction between the previous electrical ensemble and ADIY flame sensor module. This Sensor Module can detect flames in the 760 – 1100 nanometer wavelength range. Small flames like a lighter flame can be detected at roughly 0.8m. The detection angle is roughly 60 degrees and the sensor is particularly sensitive to the flame spectrum. An on-board LM393 op-amp is used as a comparator to adjust the sensitivity level. The sensor has a digital and analog output and sensitivity can be adjusted via the blue potentiometer. Positioning three infrared obstacle avoidance sensor LM393 modules meticulously placed in their respective locations. This IR Proximity Sensor is perfect for a wide range of applications, with an effective distance range of 2 cm to 30cm. This is easy to assemble and use, making it suitable for users of all skill levels. The onboard detection indication ensures you can monitor the sensor's status. It comes with a preset knob to fine-tune the distance range, allowing for precise adjustments. When an obstacle is detected, the indicator lights up on the circuit board. This sensor is suitable for various applications, including smart homes and security systems.

3. Pump motor connection protocol

Connection of service motor to the battery, inject the pump motor into the water tank and receive the connection of signals passing through the wire, it pumps the required water level. Because it cannot pump more than sufficient water. The level of water must be convenient to pump the motor easily for the process.

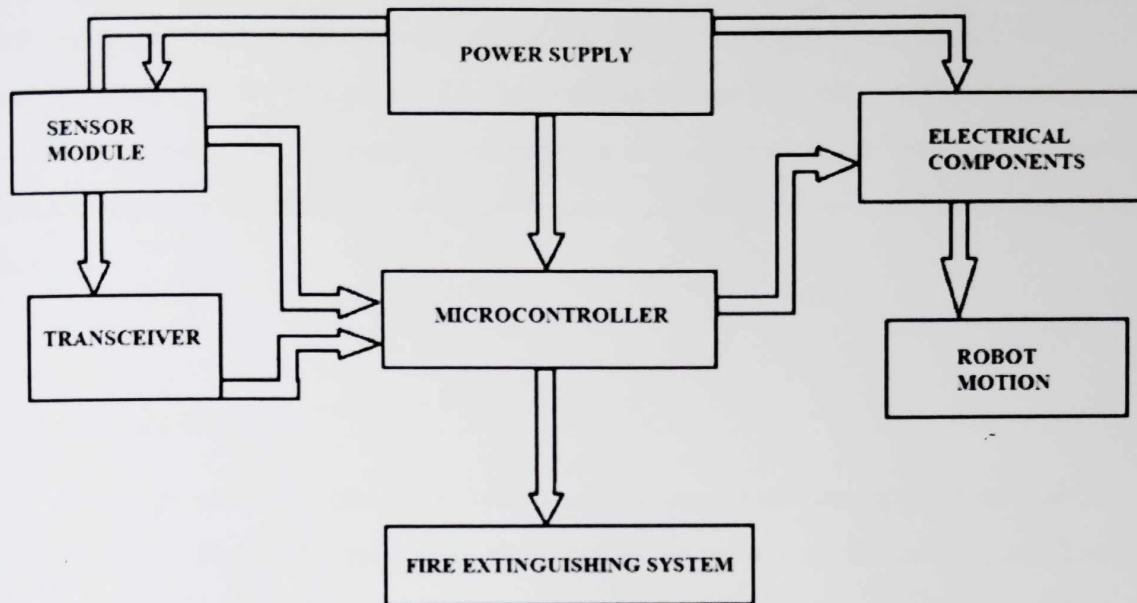
4. Assimilation of tubes and switches

If the water process connection is moved to the nozzle of the tube with the injection to inject the water then the water will be able to levelly move to the tune to outcome the process, so that the fire location will be Identified by the sensors to spread the water accordingly.

5. Testing

The final procedure is testing the Robot. The fire fighting advancing robot must be fulfilled by the infrared sensors so that it will analyze according to the flame moment, and this was observed by the sensors to spread the water over the located flame areas. If the testing of the robot is passed successfully then it can be brought upon for application purposes.

4.1.3 Internal or Component design structure



(4.1.3)Component design structure

4.1.4 Working principles

This robot performs the operation mainly through ADIY Flame sensor and Infrared obstacle avoidance LM393 modules. The main working principle lies in the implementation of IR sensor and flame sensor.

IR Sensor:

Infrared (IR) sensors operate by emitting infrared radiation from an emitter and detecting the reflected or emitted radiation using a receiver. When an object enters the sensor's field of view, it reflects or emits its own infrared radiation, which is then detected by the receiver. The receiver converts this radiation into an electrical signal, which is analyzed by the sensor's circuitry to determine the presence, absence, or characteristics of the object. IR sensors find applications in proximity sensing, motion detection, object detection, and temperature sensing due to their ability to operate in various environments and provide reliable detection even in darkness or low visibility conditions.

Flame sensor:

The flame sensors are devices used in industrial settings to prevent the presence of the flames. Flaming the output connects to the battery and receives the signals by the wire. When the flame is discerned, they trigger the output signals for safety measures. The flame is observed by the given signals to produce the connection of the signals into produced output. It detects the signals by producing the IR sensors, To obtain the harsh free environment. Enclosures to protect from the high temperature. Regular maintenance and calibration are essential to ensure the continued accuracy and reliability of flame sensors in detecting flames and preventing potential hazards.

4.2 FEATURES

1. **Fire Suppression Tools:** These robots are equipped with fire suppression tools.
2. **Mobility:** Firefighter robots are designed to navigate through complex and hazardous environments, including rough terrain, debris, and smoke-filled areas. They often feature tracks or wheels for mobility, enabling them to traverse various surfaces.
3. **Sensors and Cameras:** Firefighter robots are equipped with an array of sensors and cameras to detect and assess the extent of fires, as well as to identify potential hazards and obstacles in their surroundings.
4. **Communication Systems:** Firefighter robots are equipped with communication systems to facilitate real-time communication between the robot and human operators, as well as with other firefighting personnel on the scene.
5. **Autonomous Operation:** Some firefighter robots are capable of autonomous operation, allowing them to perform predefined tasks and navigate through environments without continuous human intervention. This feature can be particularly useful in situations where communication with human operators is limited or unreliable.
6. **Heat Resistance:** Firefighter robots are built to withstand high temperatures and exposure to flames, ensuring their functionality and safety in firefighting environments.
7. **Payload Capacity:** Depending on the specific design and intended use, firefighter robots may have varying payload capacities to carry additional equipment or tools needed for firefighting tasks.
8. **Durability and Reliability:** Firefighter robots are designed to be rugged and durable, capable of withstanding harsh conditions encountered during firefighting operations.

They undergo rigorous testing to ensure reliability and performance in emergency situations.

9. Integration with Firefighting Operations: Firefighter robots are integrated into firefighting operations as complementary tools to enhance the efficiency and safety of firefighting efforts.

4.2.1 Novelty of the proposal

- Advancement of Infrared sensors:

In this model, the new updation of infrared sensors is to locate the flame areas according to the infrared rays emitted.

- Standardized safety measures:

The Advance level of the model is to enhance the industrial automation safety of the hazardous environment.

- Reduced usage of flame sensor module:

This advanced robot can work with or without a flame sensor module. As the IR sensor is more adequate for the process.

- Relay utilization

ADY Flame sensor is placed for detection of the output. This is done through the correction of the relay.

- Adaptability:

In the future , the fire fighting robot automatic processes can be accomplished with infrared sensors alone. It can be implemented without the usage of a flaming module.

CHAPTER 5

CONCLUSION

The utilization of IR sensors allows for the detection of heat signatures associated with fires, enabling early intervention and mitigation efforts to prevent or minimize damage and loss. Furthermore, the flexibility and versatility of Arduino platforms empower developers and firefighters to customize and adapt these automations to suit various environments and scenarios, enhancing their effectiveness in diverse firefighting applications. Moreover, the integration of IoT capabilities enables remote monitoring and control, providing firefighters and building managers with invaluable insights and control over fire safety systems from anywhere, anytime. Overall, Arduino-enabled firefighting automations represent a promising avenue for enhancing fire safety measures, offering innovative solutions to address the ever-present threat of fires in residential, commercial, and industrial settings. Through continued research, development, and implementation, these technologies hold the potential to save lives, protect property, and contribute to more resilient and safer communities. The implementation of Arduino-enabled firefighting automations utilizing IR sensors yields promising results in enhancing fire safety measures. The system's performance in detecting fires promptly and initiating timely responses significantly contributes to mitigating potential damage and risks to human life. system's effectiveness in detecting fires promptly, initiating timely responses, and augmenting existing fire suppression systems. With ongoing innovation and refinement, Arduino-enabled solutions have the potential to revolutionize fire safety practices and contribute to safer living and working environments globally.

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significantly contributes to mitigating potential damage and risks to human life. system's effectiveness in detecting fires promptly, initiating timely responses, and augmenting existing fire suppression systems. With ongoing innovation and refinement, Arduino-enabled solutions have the potential to revolutionize fire safety practices and contribute to safer living and working environments globally. Moreover, the integration of IoT capabilities enables remote monitoring and control, providing firefighters and building managers with invaluable insights and control over fire safety systems from anywhere, anytime. Overall, Arduino-enabled firefighting automations represent a promising avenue for enhancing fire safety measures, offering innovative solutions to address the ever-present threat of fires in residential, commercial, and industrial settings.

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