DESIGN AND IMPLEMENTATION OF A SMART FIRE FIGHTING ROBOT WITH REMOTE MONITORING AND CONTROL

A PROJECT REPORT

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BONAFIDE CERTIFICATE

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ABSTRACT

This project focuses on the development of a smart Fire fighting robot equipped with multiple sensors and wireless communication capabilities for efficient fire detection, monitoring, and suppression. The robot is designed to have fire sensors placed on three sides (left, right, and center) to detect fires in different directions. Upon detecting a fire, the robot's servo motor will automatically turn towards the fire and activate a DC pump to spray water, aiming to suppress the fire effectively.Additionally, the robot is equipped with a temperature sensor and a gas sensor to monitor the temperature and gas levels in the environment, providing crucial information for fire monitoring and safety.

The sensor data is transmitted wirelessly via Bluetooth to a mobile application, allowing users to remotely monitor the environment and control the robot's movements and actions.The project also includes the integration of an LCD display for real-time status updates and an L298 driver circuit for controlling the motors. Overall, this project aims to enhance fire fighting capabilities through the use of advanced robotics and wireless technology, ensuring faster response times and improved safety measures in fire emergencies.

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LIST OF ABBREVATIONS

ABBREVATION	EXPANSION
BEP	BEST EFFICIENCY POINTS
CRT	CATHODE RAY TUBE
DC	DIRECT CURRENT
EEPROM	ELECTRICALLY ERASABLE PROGRAMMALE READ ONLY MEMORY
IDE	INTEGRATED DEVELOPMENT ENVIRONMENT
LCD	LIQUID CRYSTAL DISPLAY
MERS	MARINE EXPEDITIONARY RIFLE SQUAD
RTD	RESISTANCE TEMPERATURE DETECTORS
SFR	SPECIAL FUNCTION REGISTERS

CHAPTER 1

INTRODUCTION

Fires are a significant hazard in both residential and industrial settings, often leading to catastrophic damage and loss of life. Traditional fire fighting methods are effective but can be dangerous and time-consuming, especially in hazardous environments. To address these challenges, the development of autonomous fire fighting robots has gained traction as a promising solution.

This project focuses on the design and implementation of a smart fire fighting robot equipped with advanced sensors and wireless communication capabilities. The robot is designed to detect and suppress fires autonomously, reducing the risk to human firefighters and improving response times.

The robot features three fire sensors placed strategically on its left, right, and center sides, allowing it to detect fires from multiple directions. Upon detecting a fire, the robot's servo motor automatically turns towards the fire, and a DC pump is activated to spray water, effectively suppressing the flames. In addition to fire detection and suppression, the robot is equipped with a temperature sensor and a gas sensor to monitor environmental conditions. This data is transmitted wirelessly via Bluetooth to a mobile application, providing real-time monitoring and control capabilities to the user.

Fires pose a significant threat to lives and property in both residential and industrial environments. Traditional fire-fighting methods, while effective, can be hazardous and time-consuming, especially in dangerous or hard-to-reach areas. To address these challenges, the development of autonomous fire-fighting robots with advanced sensors and communication capabilities has emerged as a promising solution. This project focuses on the design and implementation of a smart fire-fighting robot equipped with cutting-edge technologies to detect and suppress fires autonomously. The robot is also integrated with remote monitoring and control features, allowing firefighters and emergency responders to manage firefighting operations from a safe distance.

By leveraging a combination of sensors, actuators, and wireless communication, the robot is designed to enhance the efficiency and safety of firefighting operations. Real-time data collection and analysis enable timely decision-making, while remote control capabilities provide flexibility and adaptability in dynamic firefighting scenarios.

The benefits of the Fire Fighting robot The autonomous nature of the robot reduces the need for human firefighters to enter hazardous environments, significantly decreasing the risk of injuries and fatalities associated with traditional firefighting methods. This enhancement in safety is particularly crucial in scenarios involving toxic fumes, high temperatures, or structural instability.

Furthermore, the Fire Fighting robot facilitates better Enchanced response times and Safety, The robot's autonomous fire detection and suppression abilities enable it to respond to fire incidents promptly. This quick response can prevent fires from spreading rapidly, mitigating potential damage to property and infrastructure. By intervening early, the robot contributes to more effective firefighting outcomes and reduces the overall impact of fire

In conclusion, our project has made significant strides in advancing the field of autonomous firefighting robotics. By reducing human risks, improving response times, and enhancing overall safety in fire emergency situations, our smart fire-fighting robot has the potential to make a lasting impact in residential, industrial, and hazardous environments. This project underscores the importance of interdisciplinary collaborations and innovative technologies in addressing critical challenges and saving lives during emergencies.

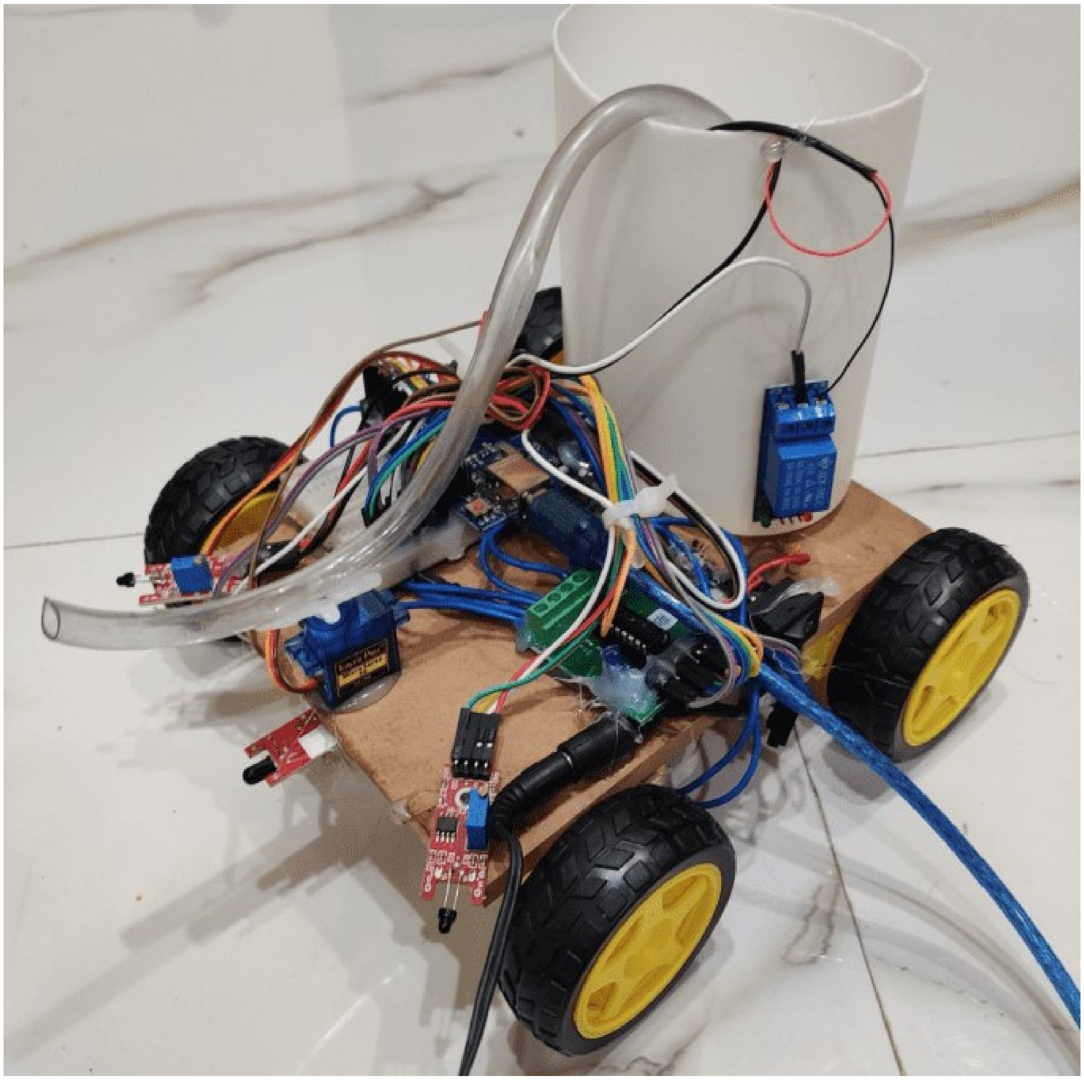

Figure 1.1 Components And Communication System In Firefighting Robot

1.1 IMPORTANCE OF FIRE FIGHTING ROBOT

The importance of designing and implementing a smart fire-fighting robot with remote monitoring and control capabilities lies in several keys

1. **Enhanced Safety:** These robots can operate in hazardous environments where human intervention is risky, such as during fires in buildings or industrial facilities. By deploying such robots, the risk to human firefighters is reduced.

2. **Efficient Fire Response**: Smart fire-fighting robots can detect and respond to fires more quickly than traditional methods. This can help contain fires before they escalate, minimizing damage to property and reducing the spread of fire-related hazards.

3. **Remote Monitoring:** With remote monitoring capabilities, emergency responders can assess the situation in real time from a safe location. This allows for better decision-making and coordination of firefighting efforts.

4. **Data-Driven Insights:** These robots can gather and transmit data about the fire's intensity, temperature, and other environmental factors. Analyzing this data can provide insights for improving firefighting strategies and equipment.

5. **Reduced Response Time:** By automating certain firefighting tasks and providing remote control capabilities, these robots can significantly reduce the time it takes to initiate firefighting measures, leading to faster response times and potentially saving lives.

1.2 CHALLENGES FACING THE FIRE FIGHTING ROBOT

Despite the advancements in technology, designing and implementing a smart fire-fighting robot with remote monitoring and control capabilities still presents several challenges

1. **Robustness and Reliability:** Ensuring the robot's robustness to operate in harsh and unpredictable environments, such as intense heat, smoke, and debris, while maintaining reliable communication with the control system, is a significant challenge.

2. **Sensor Fusion and Accuracy:** Integrating multiple sensors for fire detection, temperature sensing, gas detection, and obstacle avoidance

requires sophisticated sensor fusion techniques to ensure accurate data interpretation and decision-making by the robot.

3. **Autonomous Navigation:** Developing robust algorithms for autonomous navigation in dynamic and unstructured environments, including obstacle avoidance, path planning, and efficient localization, is essential for the robot's effective operation during firefighting tasks.

4. **Energy Efficiency:** Optimizing the robot's energy consumption to prolong operational duration during firefighting missions, especially in remote or large-scale fire scenarios, requires efficient power management and rechargeable battery systems.

5. **Real-time Monitoring and Control:** Establishing reliable real-time communication between the robot and the remote control system, ensuring low latency and high bandwidth for data transmission, is critical for timely decision-making and intervention.

1.3 OVERVIEW OF SMART FIRE FIGHTING ROBOT

This overview provides a comprehensive look into the design and implementation of a smart fire-fighting robot with remote monitoring and control capabilities. The project aims to develop a highly efficient and autonomous system capable of detecting and extinguishing fires while allowing operators to monitor and control the robot remotely. Key components such as advanced sensors, motor control mechanisms, wireless communication modules, and sophisticated software algorithms are integrated to enable seamless operation and effective firefighting in various environments.,

1. **Key Features:** The smart fire-fighting robot boasts several key features essential for firefighting operations. These include autonomous navigation, which utilizes sensor data and control algorithms to navigate environments

and reach fire-affected areas safely. The robust fire detection and localization capabilities ensure accurate identification of fires, while remote monitoring and control functionalities empower operators to oversee operations from a secure location. The robot's firefighting capabilities, facilitated by the DC pump, enable it to deploy firefighting agents efficiently to suppress and extinguish fires promptly.

2. **Hardware Components:** The hardware components of the smart fire-fighting robot include specialized sensors such as fire sensors, temperature sensors, and gas sensors. These sensors work together to detect fires accurately and assess the severity of the situation. Servo motors are used for controlling the movement and orientation of the robot, while a DC pump is employed for dispensing water or firefighting agents to extinguish fires effectively. The inclusion of wireless communication modules like Bluetooth enables seamless remote communication, while an LCD display provides real-time updates on the robot's status and environmental conditions. The L298 driver circuit ensures efficient motor control and power management

3. **Software Components**: The software architecture of the robot encompasses embedded system software responsible for data acquisition from sensors, motor control algorithms, and communication protocols. A dedicated mobile application interfaces with the robot's system, allowing users to remotely monitor its activities, control movements, and access sensor data for analysis. Control algorithms play a crucial role in enabling autonomous navigation, obstacle avoidance, and implementing effective firefighting strategies based on sensor inputs. Additionally, data analytics capabilities process sensor data to extract actionable insights for decision-making.

4. **System Integration and Testing:** System integration plays a critical role in ensuring the seamless operation of hardware and software components. Rigorous testing procedures are employed to validate the functionality, reliability, and safety standards of the smart fire-fighting robot. This includes testing the autonomous navigation system, fire detection algorithms, remote monitoring features, and overall system performance across various firefighting scenarios. Validation of remote monitoring and control capabilities ensures responsiveness and effectiveness in real-world firefighting situations.

5. **Scalability and Adaptability:** The design of the smart fire-fighting robot prioritizes scalability and adaptability to accommodate diverse firefighting environments and evolving technological requirements. Scalability ensures that the robot can operate effectively in different settings, from indoor spaces to outdoor environments with varying challenges. Adaptability encompasses the ability to integrate new technologies, upgrade software functionalities, and incorporate feedback from operational experiences to enhance performance and address emerging firefighting needs effectively.

1.4 IMPORTANCE OF REMOTE MONITORING AND CONTROL SYSTEM

Remote monitoring and control systems play a crucial role in the design and implementation of a smart fire-fighting robot. Here are some key points highlighting their importance.

1. **Remote Diagnostics and Maintenance:** Remote monitoring systems facilitate remote diagnostics and maintenance tasks, reducing downtime and ensuring the robot remains operational. Operators can remotely troubleshoot problems, update software, and perform routine maintenance checks without physically accessing the robot.

2. **Scalability and Flexibility:** Remote monitoring and control systems offer scalability and flexibility, allowing for the integration of additional sensors, communication protocols, and functionalities as technology advances. This scalability ensures that the robot remains relevant and effective in evolving firefighting challenges.Remote monitoring systems help ensure compliance with regulatory standards and safety protocols governing firefighting operations. Operators can track and document operational data, performance metrics, and adherence to protocols, supporting post-mission analysis and reporting.

3. **Integration with AI and Machine Learning:** Remote monitoring systems can be integrated with artificial intelligence (AI) and machine learning algorithms to analyze data patterns, identify anomalies, and optimize robot behavior. This intelligent automation enhances the robot's capabilities and responsiveness during firefighting missions.

4. **Adaptability to Diverse Environments:** Remote monitoring enables the robot to adapt to diverse firefighting environments, including urban areas, industrial facilities, and natural landscapes. Operators can customize control parameters based on the specific challenges posed by each environment.

1.5 SCOPE OF THE PROJECT

The scope of the paper on "Fire Fighting Robot": Automated Monitoring and Control System" are outlined as follows:

1. **Hardware Design:** This involves designing the physical structure of the robot, including its chassis, wheels or tracks, sensor placement (fire sensors, temperature sensor, gas sensor), actuators (servo motor, DC

pump), and electronic components (wireless communication module, microcontroller, motor driver circuit).

2. **Sensor Integration**: Integrate and calibrate sensors such as fire sensors for detecting fires, temperature sensors for assessing heat levels, and gas sensors for detecting hazardous gases. Ensure these sensors are reliable and provide accurate data.

3. **Communication System:** Implement a robust communication system that allows the robot to transmit data and receive commands wirelessly. This can be achieved through technologies like Bluetooth, Wi-Fi, or cellular networks, enabling remote monitoring and control.

4. **Control System:** Develop the control algorithms and software for the robot to navigate its environment, avoid obstacles, locate fires, and execute firefighting actions autonomously or under remote control. Implement safety protocols to prevent accidents or damage.

5. **User Interface:** Create a user-friendly interface, such as a mobile application or web-based dashboard, for operators to monitor the robot's status, receive alerts, and control its movements and firefighting operations remotely.

6. **Integration with Emergency Systems:** Ensure seamless integration with existing emergency response systems, such as fire alarm systems or emergency communication networks, to enhance coordination and response efficiency during fire incidents.

1.6 OBJECTIVES OF THE PROJECT

1. **Fire Detection and Response:** Develop a system that can autonomously detect fires using sensors and respond effectively by deploying firefighting mechanisms.

2. **Remote Monitoring and Control:** Enable real-time monitoring of the robot's status, such as battery levels, sensor readings, and operational status, from a remote location. Implement a robust remote control system to maneuver the robot in different terrains and environments, allowing operators to navigate obstacles and reach fire locations.

3. **Scalability and Adaptability:** Design the system to be scalable, allowing for future upgrades and adaptations to accommodate new functionalities or improve performance based on evolving requirements.

4. **User Interface:** Develop a user-friendly interface, such as a mobile application or web-based dashboard, for operators to interact with the robot, monitor its activities, and send commands intuitively.

5. **Safety Features:** Incorporate safety features such as fail-safe mechanisms, emergency stop functionalities, and obstacle avoidance algorithms to ensure the robot operates safely in dynamic environments

6. **Future Work:** Conclude by mentioning potential areas for future research or development, such as exploring advanced AI algorithms for autonomous firefighting, integrating additional sensors for environmental monitoring, or optimizing power efficiency for prolonged operation.

1.7 CHAPTER ORGNIZATION

This work consists of 6 chapters and these chapters are organized as follows

Chapter 1-Explain the smart fire fighting robot with remote monitoring and control and its importance

Chapter 2-Describe and analyzes the previous works,mainly advanced features and integration.

Chapter 3-Presents the existing system and could analyze the problem and find a solution through proposed system

Chapter 4-Deals with the components used in the proposed system that overcomes the drawbacks in existing system

Chapter 5-Describe the result and discussion of the proposed system.

Chapter 6-Conclude the report by describing various observation and scope of future work

CHAPTER 2

LITERATURE SURVEY

2.1 INTRODUCTION

The literature survey for the project on "Design and Implementation of a Smart Fire fighting robot with: Automated Monitoring and Control System" In your literature survey, you could start by exploring existing research on smart fire-fighting robots, focusing on their design, sensor integration, communication systems, and remote monitoring capabilities. Look for papers that discuss the challenges faced in developing such robots and the innovative solutions proposed. You might also highlight the importance of these robots in improving firefighting efficiency and reducing risks to human firefighters.

2.2 DESIGN AND RESEARCH OF SMALL CRAWLER FIRE FIGHTING ROBOT

Ya-Zhou Jia; Ji-Shun Li; Nan Guo; Qi-Su Jia; Bo-Feng Du; Chang-Ye Chen [2022], In view of the special working conditions and personal safety of firefighters in public places, houses and other fire scenes, the virtual prototype technology was used to conduct in-depth research on small crawler fire-fighting robots. The overall design scheme of the fire-fighting robot is proposed, and the independent suspension system with good shock absorption performance is designed. The explosion-proof waterproof shell of the special fire-fighting robot is developed, which realizes the accurate detection of the temperature and dangerous objects of the fire scene by the vision and temperature identification of the fire-fighting robot. 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.

Design and functionality of small crawler fire-fighting robots, specifically tailored to address the unique challenges faced by firefighters in public places, houses, and other fire scenes. Utilizing virtual prototype technology, the study emphasizes the precision and thoroughness achieved in understanding and refining the robot's design. A key aspect highlighted is the development of an independent suspension system with superior shock absorption capabilities, crucial for ensuring the robot's stability and agility across varied terrains encountered during firefighting operations.

Furthermore, the implementation of an explosion-proof waterproof shell enhances the robot's durability and resilience in hazardous environments, safeguarding its internal components from potential damage. The robot's advanced sensing capabilities, including temperature and dangerous object detection through vision and identification technologies, showcase its intelligence and adaptability in navigating and assessing fire scenes. Overall, the research underscores the significant impact of these small crawler fire-fighting robots, not only in enhancing operational efficiency but also in ensuring the safety and effectiveness of firefighting operations.

2.3 AUTONOMOUS FIRE FIGHTING ROBOT

Krishan Arora; Harshit Kumar; Rohit Raj Singh [2023], Firefighters risk their lives to save vulnerable people in the event of a fire. Firefighting robot designs have been proposed to reduce the loss of life for firefighters and citizens. Furthermore, currently used firefighting methods are inadequate and inefficient. In real life, fire hazards are unpredictable. It is better to extinguish the fire while it is small. This firefighting robot uses an effective fire spray extinguishing mechanism to extinguish both electrical and normal fires. This autonomous system is equipped with infrared flame sensors, microcontrollers, and ultrasonic sensors. The proposed system detects fire in all three directions, left, right, front. It has a special ability to detect and avoid obstacles. This robot reacts instantly, increasing the efficiency and success rate of firefighting.

This advanced robotic fire extinguishing system detects and extinguishes fires automatically. Currently, the world has been gradually moving towards automation and self-driving cars, putting firefighters in constant mortal danger. Although many precautions are taken to prevent fires, the natural and man-madedisasters do occur on occasion. At the time of fire accident, we are forced to use hazardous human resources to save lives and extinguish flames.

With the advancement of technology, particularly in robotics, it is very likely to replace humans with robots in firefighting. This would increase the efficiency of firefighters while also preventing them from endangering human lives if the firespreads quickly if not controlled. If there is a gas leak, there may even be an explosion. So, to overcome the problem and protect our hero's life, our system comes into play. Arduino Uno handles this firefighting, robotic system.

It is equipped with an ultrasonic sensor mountedon a servo motor for the detection of obstacle and free pathnavigation, as well as a fire sensor or flame sensor for detectionand approach fire. It also employs a water tank and a spraymechanism to extinguish the fire. To cover the greatest possiblearea, the water spray nozzle is mounted on a servo motor. Apump transports water from the main water tank to the waternozzle. This water pump necessitates the use of a driver circuitbecause it consumes far more current than the controller can provide

2.4 WEAKLY ALIGNED MULTIMODAL FLAME DETECTION FOR FIRE-FIGHTING ROBOTS

Chenyu Chaoxia; Weiwei Shang; Fei Zhang; Shuang Cong [2023] Flame detection is a key module of fire-fighting robots, especially for autonomous fire suppression. To effectively tackle the fire-fighting tasks, fire-fighting robots are usually equipped with multimodal vision systems. On the one hand, cameras of different modalities can provide complementary visual information. On the other hand, the differences in installation position and resolution between different cameras also result in weakly aligned image pairs, that is, the positions of the same object in different modal images are inconsistent. Directly fusing the image features of different modalities is difficult to meet the accuracy and false alarm requirements of fire-fighting robots. Therefore, we propose a multimodal flame detection model based on projection and attention guidance.

First, we use projection to obtain the approximate position of the flame in the thermal image and employ a neighbor sampling module to detect flames around it. Second, we design an attention guidance module based on index matching, which applies the attention map generated by the thermal modality to optimize the regional feature of the color modality. Experiments on multimodal datasets collected by an actual fire-fighting robot validate that the proposed method is effective in both fire and nonfire environments.

2.5 MULTI-ROBOT SUPPORT SYSTEM FOR FIGHTING WILDFIRES IN CHALLENGING ENVIRONMENTS: SYSTEM DESIGN

Laurent Frering; Armin Koefler; Michael Huber; Sandra Pfister; Richard Feischl; Alexander Almer; Gerald Steinbauer-Wagne [2023] Bringing autonomous systems to the field is a challenging task, especially in the context of disaster response where requirements in terms of reliability, usability, and performance are very high.

However, multiple scenarios would benefit from robotic assistance and partial automation, especially in the context of firefighting in challenging environments such as mountainous areas. We aim at advancing towards such practical deployments, by presenting a system architecture for a support system designed to help in those situations based on results from workshops performed with firefighters to specify a relevant use-case and requirements. Furthermore, we present an implementation and its testing during a realistic field experiment in mountainous terrain, where UAVs and UGVs work in cooperation to support first responders in addressing wildfires in challenging environments.

Finally, we present the results of a usability survey conducted with the firefighters present during the experiment, showing the potential of such a system for supporting firefighting and gaining insights on factors such as reliability, controllability, and safety that are important for user acceptance.

2.6 A RESEARCH PAPER ON FROZONE: AN AUTONOMOUS FIRE FIGHTER

Kailash Sharma; Nagendra Kumar; Priyanka Datta; Jay Singh; Aditya Verma [2023], Fire Fighting is considered one of the most dangerous Rescue operations that has caused many fire-fighters to lose their life. There were more than a thousand cases where the freighters lost their lives because they were made extra efforts to reach the places Inaccessible to the Human reach.

Taking all these problems and the hindrance faced in the past few years we decided to bring technology to its best use and make the most of it. We will introduce you to the paper FROZONE- AUTONOMOUS FIRE FIGHTING ROBOT" which will make use of fire sensors and a controlled water splash.

There were more than a thousand cases where the freighters lost their lives because they were made extra efforts to reach the places Inaccessible to the Human reach.

2.7 AN INTELLIGENT PATH PLANNING MECHANISM FOR FIREFIGHTING IN WIRELESS SENSOR AND ACTOR

Farzad H. Panahi; Fereidoun H. Panahi; Tomoaki Ohtsuki [2023], Forests have an important role in environmental preservation and maintenance. The primary threat is forest fires, which have disastrous repercussions. As a result, it is critical to identify and extinguish a fire before it spreads and destroys resources. To that end, we propose a forest fire detection and fighting mechanism using wireless sensor and actor networks (WSANs). Temperature sensors are utilized to detect fires, and actors (robots) are employed to extinguish them. Sensors and robots are distributed at random throughout the forest, forming clusters. Clustering, sleep/active scheduling for the sensors, and energy harvesting (EH)/moving modes for the robots, are used to extend and maximize the sensors/robots lifetime in the WSAN.

In such a network, robots should move to the fire site as quickly as possible. To do this, we further propose a robot routing mechanism that focuses on determining the shortest path for each firefighting robot. In particular, each firefighting robot equipped with on-board processing uses a fuzzy Q -learning (FQL)-based trajectory mechanism to learn the shortest path to the fire zone in the least amount of time.

2.8 DESIGN OF AUTONOMOUS FIRE HOSE DOCKING SYSTEM FOR INTELLIGENT FIRE-FIGHTING ROBOTS

Zhiwei Yang; Fei Zhang; Weiwei Shang; Chenyu Chaoxia [2023], Although existing fire-fighting robots have been able to extinguish fires, the docking task of fire hoses has always been the key obstacle to achieving autonomous fire extinguishing functions for fire-fiting robots. Therefore, it is crucial to enable robots to autonomously dock fire hoses to fire hydrants. To solve this problem, we design a new multi-DOF docking mechanism and develop a vision-guided autonomous fire hose docking system based on a robot operating system. When the robot detects the fire, the camera mounted on it can guide the docking system to complete the docking of the fire hose, laying the foundation for the robot to achieve autonomous fire extinguish.

2.9 SIMULATION OF INTELLIGENT PATH PLANNING ALGORITHM FOR A TRACKED FIRE FIGHTING ROBOT

Shichao Kuai; Wei Zheng; Ningning Li; Lei Xu; Zibo Qi[2023], The lack of robot intelligence is an important factor limiting the application of robots in the field of fire rescue. In order to solve the practical problem of insufficient intelligence of robots, based on the characteristics of kinematics analysis of tracked robots, an intelligent path planning algorithm of robots is proposed in this paper. The simulation results show that the algorithm can realize autonomous and reasonable path planning of robots under different obstacles, which has certain enlightenment for further research of robot path planning.

Simulating an intelligent path planning algorithm for a tracked fire-fighting robot serves the objective of enhancing its navigation capabilities in complex and dynamic environments. The algorithm's primary goal is to ensure efficient and safe movement by identifying optimal paths while considering real-time sensor data and adapting to changing conditions.

2.10 FIRE FIGHTING ROBOT WITH MORE ACCURACY AND IMPLEMENTATION USING ARDUINO UNO

Ayush Dubey; Bhartendu Singh; Narendra Kumar; Mohammed Ayad Alkhafaji; Mustafa Isam [2023], Nowadays technology is growing with rapid speed and we are becoming familiar with the technology more and more. We are surrounded by various equipment and the risk of failure of these types of equipment is always a concern. As these equipment contain various circuits and due to which if any kind of failure occurs it can cause a fire.

CHAPTER 3

EXISTING SYSTEM

3.1 INTRODUCTION

The existing system refers to the current state or setup in a particular context, such as technology, processes, or infrastructure. In the context of a smart firefighting robot project, the introduction of the existing system section would typically outline the current landscape of firefighting methods and technologies. This would include traditional firefighting approaches, such as manual intervention by firefighters using protective gear and standard firefighting equipment like hoses and extinguishers. It may also mention any existing automated firefighting systems or technologies that are in use, though these might not be as advanced or integrated as the proposed smart firefighting robot system. The introduction of the existing system sets the stage for discussing the limitations or challenges of the current methods, highlighting the need.

Figure 3.1 Manual Intervention

3.2 MANUAL INTERVENTION AND MANAGEMENT

In the existing system, manual intervention can lead to delays, errors, and potential risks in fire-fighting operations. To address this, incorporating automation and remote monitoring/control features in your smart fire-fighting robot is crucial. Here are some key aspects to consider:

1. **Automated Response:** Design the robot to detect fire and other hazards autonomously using sensors like fire sensors, temperature sensors, and gas sensors. This reduces the need for manual detection and intervention.

2. **Remote Monitoring:** Implement a robust remote monitoring system that allows operators to monitor the robot's status, sensor data, and surroundings in real-time from a safe location. This includes live video feeds, sensor readings, and diagnostic information.

3. **Remote Control:** Enable remote control capabilities to maneuver the robot effectively in complex environments. This includes controlling movement, activating fire suppression mechanisms, and adjusting sensor configurations remotely.

4. **Emergency Protocols:** Develop emergency protocols and fail-safe mechanisms to handle critical situations autonomously, such as detecting malfunctions, recharging battery levels, or navigating obstacles without human intervention.

5. **Communication Protocols:** Utilize reliable communication protocols (e.g., Bluetooth, Wi-Fi, or cellular networks) for seamless data exchange between the robot and the control center, ensuring uninterrupted remote monitoring and control

3.3 LIMITED DETECTION RANGE

To address the limited detection range in the existing smart fire-fighting robot system, you can consider several strategies:

Figure 3.2 Limited Detection Range

1. **Sensor Enhancement:** Upgrade the sensors used in the robot to ones with longer detection ranges. For example, using advanced infrared or thermal sensors can improve the robot's ability to detect fires from a greater distance.
2. **Sensor Fusion:** Implement a sensor fusion approach where data from multiple sensors (such as fire sensors, temperature sensors, and gas sensors) are combined to improve accuracy and extend the detection range.
3. **Deploying Additional Sensors:** Add supplementary sensors strategically placed in the environment to cover blind spots or areas beyond the robot's

primary detection range. This could involve placing sensors on walls, ceilings, or elevated positions.

4. **Integration with External Systems:** Utilize external systems such as drones or fixed surveillance cameras with long-range capabilities to provide early detection and relay information to the robot for further action.

3.4 DELAYED RESPONSE

In the context of the design and implementation of a smart fire-fighting robot with remote monitoring and control capabilities, addressing delayed response in the existing system is crucial for improving its effectiveness. Here are some strategies you can consider

1. **Real-time Monitoring:** Implement real-time monitoring of critical parameters such as fire intensity, temperature, and gas levels. This data can be continuously transmitted to the control center for immediate assessment and action.
2. **Predictive Analytics:** Utilize data analytics and machine learning algorithms to predict fire behavior and potential hazards. This proactive approach can help in early detection and faster response.
3. **Optimized Communication:** Ensure robust and low-latency communication channels between the robot and the control center. Technologies like 5G or dedicated communication protocols can minimize delays in transmitting commands and receiving feedback.

3.5 LACK OF ENVIRONMENTAL MONITORING

To address the lack of environmental monitoring in your smart fire-fighting robot system, you can consider integrating additional sensors that can detect and monitor various environmental parameters.

1. **Air Quality Sensors:** Include sensors for detecting gases like carbon monoxide (CO), carbon dioxide (CO_2), and other pollutants that can be hazardous in fire environments.
2. **Temperature and Humidity Sensors:** Monitor ambient temperature and humidity levels to assess the fire conditions and potential risks.

3.6 DEPENDENCY ON OPERATOR SKILL

In the existing system for smart fire-fighting robots with remote monitoring and control, one of the significant challenges is the dependency on operator skill. This dependency can manifest in several ways:

1. **Manual Control Complexity:** Operating the robot effectively requires a certain level of expertise in handling the remote control interface. This complexity can lead to errors or delays in responding to emergency situations.
2. **Decision-making:** Operators need to make real-time decisions based on the data received from sensors and the robot's status.

3.7 SAFETY ISSUE

In the existing system of smart fire-fighting robots with remote monitoring and control capabilities, one significant safety issue is the limited detection range of sensors. This limitation can lead to potential blind spots where fires or hazardous conditions might not be detected promptly. As a result, there's a risk of delayed response or incomplete situational awareness, compromising the effectiveness of firefighting operations and overall safety.

3.8 DISADVANTAGES

1. **Limited Detection Range:** The current system may have a limited range for detecting fires or environmental hazards, reducing its effectiveness in large or complex environments.

2. **Manual Intervention:** There might be a need for frequent manual intervention in the system, reducing its autonomy and efficiency during firefighting operations.
3. **Lack of Environmental Monitoring:** The system may lack comprehensive environmental monitoring capabilities, such as air quality sensing or obstacle detection, which are crucial for effective firefighting strategies.
4. **Data Transmission Reliability:** Issues with data transmission reliability could lead to delays or inaccuracies in remote monitoring and control, impacting decision-making during firefighting missions.
5. **Scalability and Adaptability:** The current system may face challenges in scalability and adaptability to different firefighting scenarios or environments, limiting its overall utility and effectiveness.

CHAPTER 4
PROPOSED SYSTEM

4.1 INTRODUCTION

The proposed "Smart Fire Fighting Robot" system aims to address the the limitations of existing fire fighting systems by introducing a smart fire fighting robot. Equipped with three fire sensors on its left, right, and center sides, the robot can detect fires from multiple directions simultaneously. Upon detection, a servo motor automatically turns the robot towards the fire, activating a DC pump to suppress the flames. Additionally, the robot features a temperature sensor and gas sensor to monitor environmental conditions. Data from these sensors is transmitted wirelessly via Bluetooth to a mobile application, providing real-time monitoring and control capabilities, thus enhancing safety and efficiency in fire emergency response operations.

4.2 ADVANTAGES

1. **Autonomous Operation:** The proposed system reduces the need for manual intervention, enhancing firefighter safety in hazardous environments.
2. **Enhanced Detection:** With sensors on three sides, the robot can detect fires from multiple directions simultaneously, improving response times.
3. **Quick Response:** The robot's ability to automatically turn towards the fire and activate the DC pump results in faster suppression of flames, limiting the fire's spread.
4. **Environmental Monitoring:** The inclusion of temperature and gas sensors allows for real-time monitoring of environmental conditions, aiding in fire management and safety.
5. **Remote Control:** The system allows for remote monitoring and control via a mobile application, providing flexibility and ease of use for operators.

4.3 BLOCK DIAGRAM

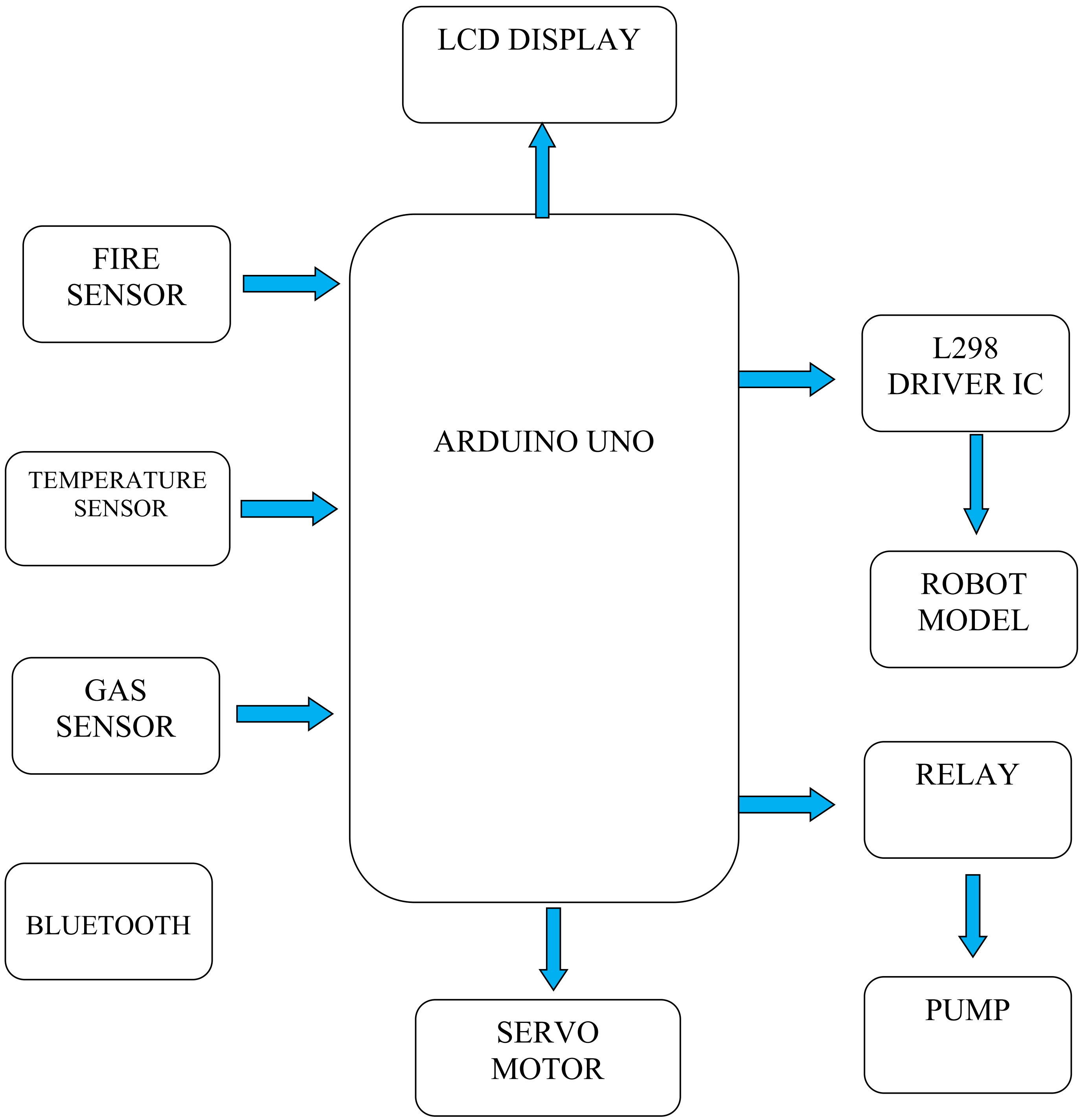

Figure 4.1 Block Diagram

4.4 HARDWARE REQUIREMENTS

- ARDUINO UNO
- LCD DISPLAY
- FIRE SENSOR
- RELAY
- ROBOT MODEL
- PUMP
- GAS SENSOR
- TEMPERATURE SENSOR
- SERVO MOTOR
- BLUETOOTH

4.4.1 ARDUINO UNO

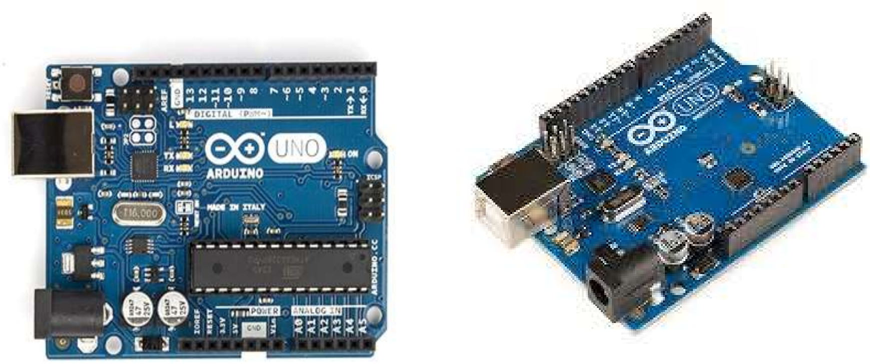

Figure 4.2 Arduino Uno

SPECIFICATION

- **Microcontroller:** This is the brain of the Arduino Uno, responsible for executing instructions and controlling the inputs and outputs.
- **Operating Voltage:** The voltage at which the Arduino Uno operates. It needs a stable 5V power supply to function properly.
- **Input Voltage:** The range of voltage that you can safely apply to power the Arduino Uno. It's typically between 7 to 12 volts.

- ❖ **Digital I/O Pins:** These are the pins on the Arduino Uno that can be set to either HIGH (5 volts) or LOW (0 volts). You can use them to connect and control various electronic components like LEDs, motors, and sensors.
- ❖ **Analog Input Pins:** These pins allow the Arduino Uno to read analog signals, such as those from sensors that provide variable voltage outputs.

Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328P) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock Speed	16 MHz
Length	68.6 mm
Width	53.4 mm
Weight	25 g

Table 4.1 Parameters For Arduino UNO Description

SMART FIRE FIGHTING ROBOT IN USE OFARDUINO UNO

1. **Control System Integration:** Arduino Uno serves as the central processing unit (CPU) for the robot, integrating various control systems. It connects and coordinates the inputs from sensors, such as fire sensors, temperature sensors, and gas sensors.
2. **Sensor Data Processing:** The Arduino Uno processes data from these sensors to detect fires, monitor temperature changes, and identify hazardous gases in the environment. This real-time data processing is crucial for timely and accurate response to fire incidents.
3. **Wireless Communication:** Arduino Uno is equipped with Bluetooth or similar wireless communication modules. This enables the robot to establish a connection with external devices, such as a mobile application or a remote monitoring station.
4. **Remote Monitoring and Control:** Through the Arduino Uno, the robot can send data and receive commands remotely. For example, it can transmit live video feeds, sensor readings, and operational status to a monitoring station. Additionally, it can receive control commands, such as movement instructions and task assignments, from a remote operator.
5. **Motor Control:** Arduino Uno interfaces with motor control circuits, such as the L298 driver circuit, to control the movement of the robot. This includes controlling the servo motors for precise manipulations and the DC pump for water or foam spraying during firefighting operations.
6. **User Interface**: Arduino Uno can also manage the user interface components of the robot, such as an LCD display. This display provides real-time status updates, system diagnostics, and alerts for the operator or monitoring personnel.
7. **Integration with Mobile App:** Arduino Uno facilitates communication between the robot and a dedicated mobile application. This app allows users to remotely monitor the robot's activities, receive alerts, and control.

4.4.2 LCD DISPLAY

A liquid crystal display (LCD) is a thin, flat electronic visual display that uses the light modulating properties of liquid crystals (LCs). LCs do not emit light directly.

They are used in a wide range of applications including: computer monitors, television, instrument panels, aircraft cockpit displays, signage, etc. They are common in consumer devices such as video players, gaming devices, clocks, watches, calculators, and telephones. LCDs have displaced cathode ray tube(CRT) displays in most applications.

They are usually more compact, lightweight, portable, less expensive, more reliable, and easier on the eyes. They are available in a wider range of screen sizes than CRT and plasma displays, and since they do not use phosphors, they cannot suffer image burn-in.LCDs are more energy efficient and offer safer disposal than CRTs. Its low electrical power consumption enables it to be used in battery-powered electronic equipment.

It is an electronically-modulated optical device made up of any number of pixels filled with liquid crystals and arrayed in front of a light source (backlight) or reflector to produce images in colour or monochrome. The earliest discovery leading to the development of LCD technology, the discovery of liquid crystals, dates from 1888. By 2008, worldwide sales of televisions with LCD screens had surpassed the sale of CRT units

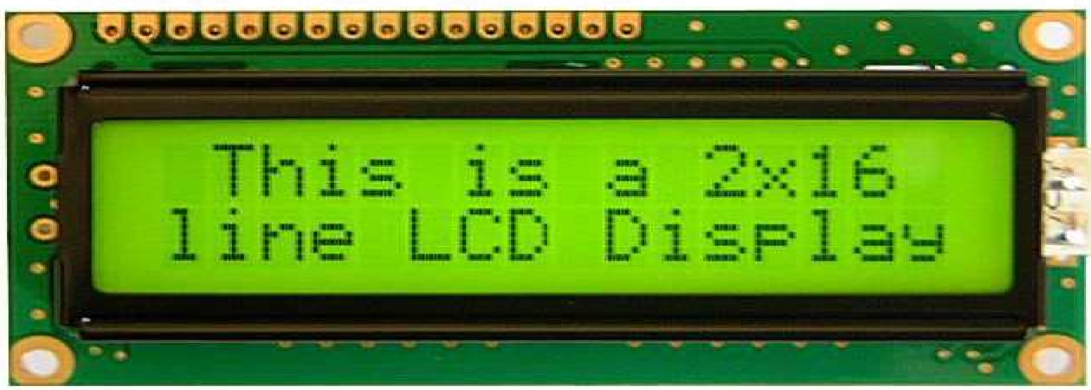

Figure 4.3 LCD Display

SPECIFICATIONS

- ❖ Display Size: 16 characters per row, 2 rows
- ❖ Character Size: 5x8 pixels per character
- ❖ Interface: Parallel (usually 8-bit or 4-bit)
- ❖ Operating Voltage: Typically, 5V DC
- ❖ Operating Temperature: 0°C to +50°C
- ❖ Storage Temperature: -10°C to +60°C
- ❖ Backlight: LED backlight (optional, can be controlled separately)

4.4.3 FIRE SENSOR

Disclosed herein is a fire alarm system for connecting a plurality of fire sensors to sensor lines, and giving an alarm in response to fire information output from the fire sensor in a line unit. The fire alarm system includes a current modulation section and an address specification section. The current modulation section is used for maintaining a current flowing in the sensor line at a predetermined value for a predetermined time at the time of a fire, and modulating the current in accordance with the inherent address information of the fire sensor. The address specification section is used for sensing fire information by judging whether or not the current has been maintained at the predetermined value for the predetermined time, and also for specifying the inherent address of the fire sensor that issued the fire information, from the modulated state of the current.

1. **Detection Principle:** The fire sensor used in the robot operates based on the principle of detecting changes in temperature or the presence of flames. It can detect both sudden increases in temperature, indicating a fire outbreak, and the characteristic infrared signatures of flames.
2. **Sensor Type:** The fire sensor employed in this project is typically a heat-sensitive sensor or a flame detector. Heat-sensitive sensors respond to changes in temperature, while flame detectors detect specific wavelengths of infrared light emitted by flames.
3. **Placement:** The fire sensor is strategically placed on the robot to ensure maximum coverage of the environment. Multiple sensors may be used to cover different angles and distances, providing comprehensive fire detection capabilities.
4. **Sensor Integration:** The fire sensor is integrated into the robot's sensor fusion system, which combines data from various sensors such as temperature sensors, gas sensors, and environmental sensors. This integration enhances the robot's ability to accurately identify fire incidents while minimizing false alarms.

5. **Alarm Triggering:** When the fire sensor detects a potential fire hazard, it triggers an alarm or alert system onboard the robot. This alert may include visual indicators such as LED lights, audible alarms, or notifications sent to the remote monitoring application.
6. **Remote Monitoring and Control:** The data from the fire sensor, along with other sensor data, is transmitted in real-time to the remote monitoring application. This allows operators or firefighters to receive immediate alerts about fire incidents, monitor the robot's status, and take control of its actions if necessary.
7. **Safety Measures:** The fire sensor's data is also used to implement safety protocols within the robot's operation. For example, it may trigger automatic maneuvers to avoid entering dangerous areas with active fires or adjust the robot's speed and behavior for optimal firefighting effectiveness.

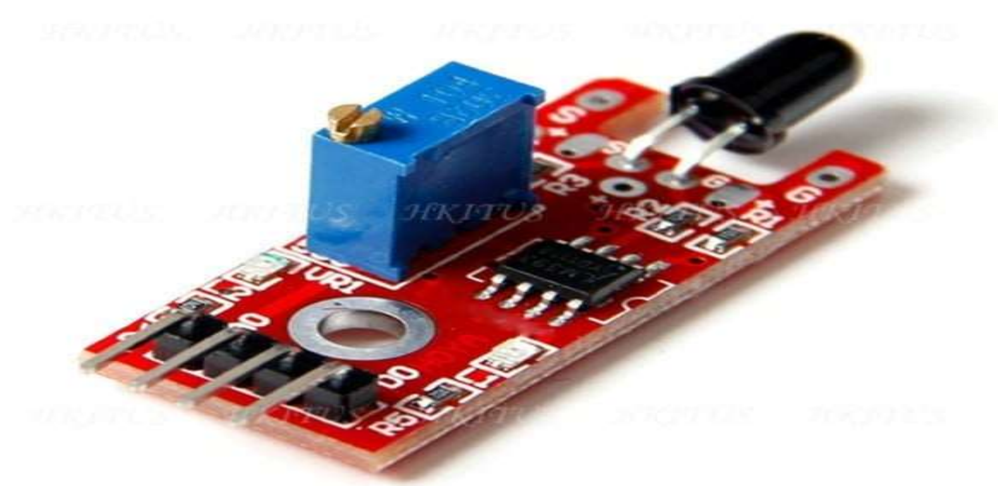

Figure 4.4 Fire Sensor

SPECIFICATIONS

- ❖ **Detection Range:** The sensor should have a sufficient detection range to detect fires at a reasonable distance, ensuring early detection and timely response.

- ❖ **Sensitivity:** It should be highly sensitive to detect even small fires or changes in temperature that indicate a potential fire hazard.
- ❖ **Response Time:** The sensor should have a fast response time to quickly detect and signal the presence of a fire.
- ❖ **Accuracy:** High accuracy is crucial to avoid false alarms and ensure reliable fire detection.
- ❖ **Environmental Adaptability:** The sensor should be designed to operate in various environmental conditions, including high temperatures, humidity, and smoke-filled environments typical of fire incidents.
- ❖ **Integration:** It should be compatible with the overall system architecture of the robot, allowing seamless integration with other sensors, control systems, and communication modules.
- ❖ **Power Efficiency:** The sensor should consume minimal power to preserve the robot's battery life during extended operations.
- ❖ **Output Signal:** The sensor should provide a clear and easily interpretable output signal to the robot's control system for initiating appropriate actions.

4.4.4 RELAY

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and they are double throw (changeover) switches. Relays allow one circuit to switch a second circuit which can be completely separate from the first. For example a low voltage battery circuit can use a relay to switch a 230V AC mains circuit. There is no electrical connection inside the relay between the two circuits; the link is magnetic and mechanical.

The coil of a relay passes a relatively large current, typically 30mA for a 12V relay, but it can be as much as 100mA for relays designed to operate from lower voltages. Most ICs (chips) cannot provide this current and a transistor is usually used to amplify the small IC current to the larger value required for the relay coil. The maximum output current for the popular 555 timer IC is 200mA so these devices can supply relay coils directly without amplification.

Figure 4.5 Relay

Relays are usually SPDT or DPDT but they can have many more sets of switch contacts, for example relays with 4 sets of changeover contacts are readily available. Most relays are designed for PCB mounting but you can solder wires directly to the pins providing you take care to avoid melting the plastic case of the relay. The animated picture shows a working relay with its coil and switch contacts. You can see a lever on the left being attracted by magnetism when the coil is switched on. This lever moves the switch contacts. There is one set of contacts (SPDT) in the foreground and another behind them, making the relay DPDT. The relay's switch connections are usually labeled COM, NC and NO.

4.4.5 ROBOT MODEL

A robot is an automatically guided machine which is able to do tasks on its own, almost always due to electronically-programmed instructions. Another common characteristic is that by its appearance or movements, a robot often conveys a sense that it has intent or agency of its own

This task comprises efforts to research and develop robot team and sensor-detection technologies in support of the Marine Expeditionary Rifle Squad (MERS). As a force multiplier for the MERS, robot teams can be equipped with other promising technologies proposed under this focus group. These technologies include reliable and high-performance UV optical sensors to provide the ability to rapidly detect fire, flame, and explosions. Also, robot teams can be equipped with lightweight, reliable, and hand-held-sized sensors able to detect small concentrations of chemical warfare agents and explosives – a vital asset to detect industrial and chemical toxins during the conduct of urban military operations.

4.4.6. PUMP

- A pump is a device used to move fluids, such as liquids or slurries.
- A pump displaces a volume by physical or mechanical action. Pumps fall into five major groups: direct lift, displacement, velocity, buoyancy and gravity pumps. Their names describe the method for moving a fluid.
- A positive displacement pump causes a fluid to move by trapping a fixed amount of it then forcing (displacing) that trapped volume into the discharge pipe. A positive displacement pump can be further classified according to the mechanism used to move the fluid:

Figure 4.6 Pump

Rotary-type, internal gear, screw, shuttle block, flexible vane or sliding vane, helical twisted roots (e.g. the Wendelkolben pump) or liquid ring vacuum pumps.

Positive displacement rotary pumps are pumps that move fluid using the principles of rotation.

The vacuum created by the rotation of the pump captures and draws in the liquid. Rotary pumps are very efficient because they naturally remove air from the lines, eliminating the need to bleed the air from the lines manually.

The positive displacement pumps can be divided into two main classes

- reciprocating
- rotary

The positive displacement principle applies whether the pump is a

- rotary lobe pump
- progressing cavity pump
- rotary gear pump
- piston pump
- diaphragm pump
- screw pump
- gear pump
- Hydraulic pump
- vane pump
- regenerative (peripheral) pump
- peristaltic

Pump efficiency

Pump efficiency is defined as the ratio of the power imparted on the fluid by the pump in relation to the power supplied to drive the pump. Its value is not fixed for a given pump, efficiency is a function of the discharge and therefore also operating head. For centrifugal pumps, the efficiency tends to increase with flow rate up to a point midway through the operating range (peak efficiency) and then declines as flow rates rise further. Pump performance data such as this is usually supplied by the manufacturer before pump selection. Pump efficiencies tend to decline over time due to wear (e.g. increasing clearances as impellers reduce in size).

One important part of system design involves matching the pipeline headloss-flow characteristic with the appropriate pump or pumps which will operate at or close to the point of maximum efficiency. There are free tools that help calculate head needed and show pump curves including their Best Efficiency Points (BEP).

Pump efficiency is an important aspect and pumps should be regularly tested. Thermodynamic pump testing is one method.

4.4.7 GAS SENSOR

Electrochemical gas sensors are gas detectors that measure the concentration of a target gas by oxidizing or reducing the target gas at an electrode and measuring the resulting current.

Figure 4.7 Gas Sensor

Construction

The sensors contain two or three electrodes, occasionally four, in contact with an electrolyte. The electrodes are typically fabricated by fixing a high surface area precious metal on to the porous hydrophobic membrane. The working electrode contacts both the electrolyte and the ambient air to be monitored usually via a porous membrane. The electrolyte most commonly used is a mineral acid, but organic electrolytes are also used for some sensors. The electrodes and housing are usually in a plastic housing which contains a gas entry hole for the gas and electrical contacts.

Theory of operation

The gas diffuses into the sensor, through the back of the porous membrane to the working electrode where it is oxidized or reduced. This electrochemical reaction results in an electric current that passes through the external circuit. In addition to measuring, amplifying and performing other signal processing functions, the external circuit maintains the voltage across the sensor between the working and counter electrodes for a two electrode sensor or between the working and reference electrodes for a three electrode cell. At the counter electrode an equal and opposite reaction occurs, such that if the working electrode is an oxidation, then the counter electrode is a reduction.

Diffusion controlled response

The magnitude of the current is controlled by how much of the target gas is oxidized at the working electrode. Sensors are usually designed so that the gas supply is limited by diffusion and thus the output from the sensor is linearly proportional to the gas concentration. This linear output is one of the advantages of electrochemical sensors over other sensor technologies, (e.g. infrared), whose output must be linearized before they can be used. A linear output allows for more precise measurement of low concentrations and much simpler calibration.

Cross sensitivity

For some gases such as ethylene oxide, cross sensitivity can be a problem because ethylene oxide requires a very active working electrode catalyst and high operating potential for its oxidation. Therefore gases which are more easily oxidized such as alcohols and carbon monoxide will also give a response. Cross sensitivity problems can be eliminated though through the use of a chemical filter, for example filters that allows the target gas to pass through unimpeded, but which reacts with and removes common interferences.

4.4.8 TEMPERATURE SENSOR

A thermistor is a type of resistor whose resistance varies with temperature. The word is a portmanteau of thermal and resistor. Thermistor are widely used as inrush current limiters, temperature sensors, self-resetting over current protectors, and self-regulating heating elements.

Thermistor differ from resistance temperature detectors (RTD) in that the material used in a thermistor is generally a ceramic or polymer, while RTDs use pure metals. The temperature response is also different; RTDs are useful over larger temperature ranges, while thermistors typically achieve a higher precision within a limited temperature range [usually −90 °C to 130 °C].

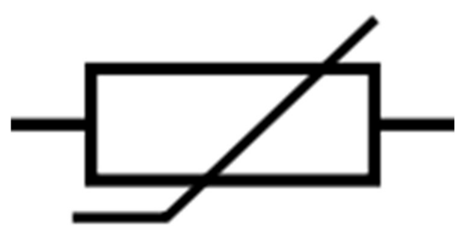

Figure 4.8 Thermistor symbol

Assuming, as a first-order approximation, that the relationship between resistance and temperature is linear, then:

$$\Delta R = k\Delta T$$

Where,

ΔR = change in resistance

ΔT = change in temperature

k = first-order temperature coefficient of resistance

Thermistors can be classified into two types, depending on the sign of k. If k is positive, the resistance increases with increasing temperature, and the device is called a positive temperature coefficient (PTC) thermistor, or posistor. If k is negative, the resistance decreases with increasing temperature, and the device is called a negative temperature coefficient (NTC) thermistor.Instead of the temperature coefficient *k*, sometimes the *temperature coefficient of resistance* α (alpha) or α_T is used. It is defined as[1]

$$\alpha_T = \frac{1}{R(T)}\frac{dR}{dT}.$$

4.4.9 SERVO MOTOR

What is Servo Motor?

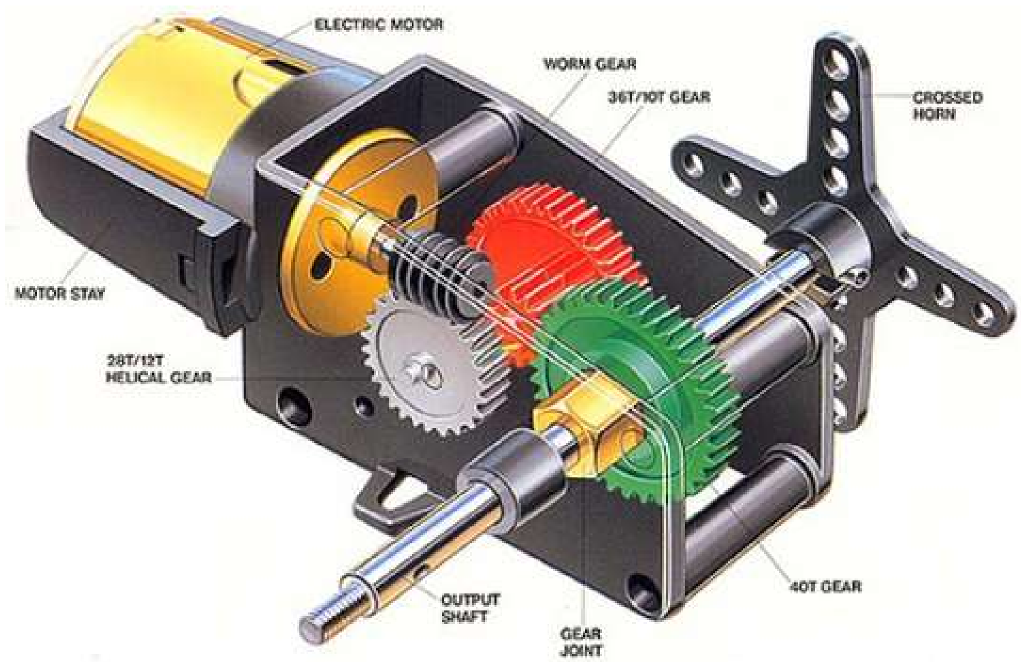

Figure 4.9 Servo Motor

This is nothing but a simple electrical motor, controlled with the help of servomechanism. If the motor as controlled device, associated with servomechanism is DC motor, then it is commonly known **DC Servo Motor**. If the controlled motor is operated by AC, it is called AC Servo Motor.

Servo mechanism

A servo system mainly consists of three basic components – a controlled device, a output sensor, a feedback system.This is an automatic closed loop control system. Here instead of controlling a device by applying variable input signal, the device is controlled by a feedback signal generated by comparing output signal and reference input signal.When reference input signal or command signal is applied to the system, it is compared with output reference signal of the system produced by output sensor, and a third signal produced by feedback system. This third signal acts as input signal of controlled device. This input signal to the device presents as long as there is a logical difference between reference input signal and output signal of the system. After the device achieves its desired output, there will be no longer logical difference between reference input signal and reference output signal of the system.

Then, third signal produced by comparing theses above said signals will not remain enough to operate the device further and to produce further output of the system until the next reference input signal or command signal is applied to the system. Hence the primary task of a servomechanism is to maintain the output of a system at the desired value in the presence of disturbances.

Working Principle of Servo Motor

A servo motor is basically a DC motor(in some special cases it is AC motor) along with some other special purpose components that make a DC motor a servo. In a servo unit, you will find a small DC motor, a potentiometer, gear arrangement and an intelligent circuitry. The intelligent circuitry along with the potentiometer makes the servo to rotate according to our wishes.

As we know, a small DC motor will rotate with high speed but the torque generated by its rotation will not be enough to move even a light load. This is where the gear system inside a servomechanism comes into picture. The gear mechanism will take high input speed of the motor (fast) and at the output, we will get a output speed which is slower than original input speed but more practical and widely applicable.

Say at initial position of servo motor shaft, the position of the potentiometer knob is such that there is no electrical signal generated at the output port of the potentiometer . This output port of the potentiometer is connected with one of the input terminals of the error detector amplifier. Now an electrical signal is given to another input terminal of the error detector amplifier. Now difference between these two signals, one comes from potentiometer and another comes from external source, will be amplified in the error detector amplifier and feeds the DC motor.

This amplified error signal acts as the input power of the dc motor and the motor starts rotating in desired direction. As the motor shaft progresses the potentiometer knob also rotates as it is coupled with motor shaft with help of gear arrangement.

As the position of the potentiometer knob changes there will be an electrical signal produced at the potentiometer port. As the angular position of the potentiometer knob progresses the output or feedback signal increases. After desired angular position of motor shaft the potentiometer knob is reaches at such position the electrical signal generated in the potentiometer becomes same as of external electrical signal given to amplifier. At this condition, there will be no output signal from the amplifier to the motor input as there is no difference between external applied signal and the signal generated at potentiometer . As the input signal to the motor is nil at that position, the motor stops rotating. This is how a simple conceptual servo motor works.

As the angle of rotation of the shaft increases from 0° to 45° the voltage frompotentiometer increases. At 45° this voltage reaches to a value which is equal to the given input command voltage to the system. As at this position of the shaft, there is no difference between the signal voltage coming from the potentiometer and reference inputvoltage (command signal) to the system, the output voltage of the amplifier becomes zero.

Continuous Rotation Servo Motors

Continuous rotation servo motors are actually a modified version of what the servos are actually meant to do, that is, control the shaft position. The 360°

rotation servos are actually made by changing certain mechanical connections inside the servo. However, certain manufacturer like parallax sells these servos as well. With the continuous rotation servo you can only control the direction and speed of the servo, but not the position.

4.4.10. BLUETOOTH

Bluetooth is a technology for wireless communication. It is designed to replace cable connections.It uses serial communication to communicate with devices. It communicates with microcontroller using serial port (USART). Usually, it connects small devices like mobile phones, PDAs and TVs using a short-range wireless connection to exchange documents. It uses the 2.45GHz frequency band. The connection can be point-to-point or multi-point where the maximum range is 10 meters. The transfer rate of the data is 1Mbps.

HC-05 Bluetooth module provides switching mode between master and slave mode which means it able to use neither receiving nor transmitting data.

Comparing it to the HC-06 module, which can only be set as a Slave, the HC-05 can be set as Master as well which enables making a communication between two separate Arduino Boards.

You can use Bluetooth module simply for a serial port replacement to establish connection between MCU, PC to your embedded project and etc.

HC-05 Specifications;

- Bluetooth protocol: Bluetooth Specification v2.0+EDR
- Frequency: 2.4GHz ISM band
- Modulation: GFSK(Gaussian Frequency Shift Keying)
- Emission power: ≤4dBm, Class 2
- Sensitivity: ≤-84dBm at 0.1% BER

- ❖ Speed: Asynchronous: 2.1Mbps(Max) / 160 kbps, Synchronous: 1Mbps/1Mbps
- ❖ Security: Authentication and encryption
- ❖ Profiles: Bluetooth serial port
- ❖ Power supply: +3.3VDC 50mA
- ❖ Working temperature: -20 ~ +75Centigrade
- ❖ Dimension: 26.9mm x 13mm x 2.2 mm

Pin Description

1.Key/EN:It is used to bring Bluetooth module in AT commands mode. By default this pin operates in data mode. Key/EN pin should be high to operate Bluetooth in command mode. The default baud rate of HC-05 in command mode is 38400bps and 9600 in data mode.HC-05 module has two modes

Command mode: It uses AT commands which are used to change setting of HC-05. Baud rate is 38400bps in command mode.

Figure 4.10 HC-05 Bluetooth

2. VCC: Connect 5 V or 3.3 V to this Pin.

3. GND: Ground Pin of module.

4. TXD: Connect with Microcontroller RXD pin of Microcontroller. Transmit Serial data (wirelessly received data by Bluetooth module transmitted out serially on TXD pin)

5. RXD: Connect with Microcontroller TXD pin of Microcontroller. Received data will be transmitted wirelessly by Bluetooth module.

6. State: It tells whether module is connected or not. It acts as a status indicator.

4.5 SOFTWARE REQUIREMENTS

- ARDUINO IDE
- ANDROID STUDIOS

4.5.1 ARDUINO IDE

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a textconsole, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuino hardware to upload programs and communicate with them.

Sketchbook

The Arduino Software (IDE) uses the concept of a sketchbook: a standard place to store your programs (or sketches). The sketches in your sketchbook can be opened from the File > Sketchbook menu or from the Open button on the toolbar. The first time you run the Arduino software, it will automatically create a directory for your sketchbook. You can view or change the location of the sketchbook location from with the Preferences dialog.

Tabs, multiple files and compilation

Allows you to manage sketches with more than one file (each of which appears in its own tab). These can be normal Arduino code files (no visible extension), C files (.c extension), C++ files (.cpp), or header files (.h).

Uploading

Before uploading your sketch, you need to select the correct items from the Tools > Board and Tools > Port menus. The boards are described below. On the Mac, the serial port is probably something like /dev/tty.usbmodem241 (for an Uno or Mega2560 or Leonardo) or /dev/tty.usbserial-1B1 (for a Duemilanove or earlier USB board), or /dev/tty.USA19QW1b1P1.1 (for a serial board connected with a Key span USB-to-Serial adapter). On Windows, it's probably COM1 or COM2 (for a serial board) or COM4, 26COM5, COM7, or higher (for a USB board) - to find out, you look for USB serial device in the ports section of the Windows Device Manager.

On Linux, it should be /dev/ttyACMx , /dev/ttyUSBx or similar. Once you've selected the correct serial port and board, press the upload button in the toolbar or select the Upload item from the Sketch menu. Current Arduino boards will reset automatically and begin the upload. With older boards (pre-Diecimila) that lack auto-reset, you'll need to press the reset button on the board just before starting the upload. On most boards, you'll see the RX and TX LEDs blink as the sketch is uploaded. The Arduino Software (IDE) will display a message when the upload is complete, or show an error.

When you upload a sketch, you're using the Arduino bootloader, a small program that has been loaded on to the microcontroller on your board. It allows you to upload code without using any additional hardware. The bootloader is active for a few seconds when the board resets; then it starts whichever sketch was most recently uploaded to the microcontroller. The boot loader will blink the on-board (pin 13) LED when it starts (i.e. when the board resets).

Libraries

Libraries provide extra functionality for use in sketches, e.g. working with hardware or manipulating data. To use a library in a sketch, select it from the Sketch > Import Library menu. This will insert one or more #include statements at the top of the sketch and compile the library with your sketch. Because libraries are uploaded to the board with your sketch, they increase the amount of space it takes up. If a sketch no longer needs a library, simply delete its #include statements from the top of your code. There is a list of libraries in the reference.

Some libraries are included with the Arduino software. Others can be downloaded from a variety of sources or through the Library Manager. Starting with version 1.0.5 of the IDE, you do can import a library from a zip file and use it in an open sketch. See these instructions for installing a third-party library.

Third – party hardware

Support for third-party hardware can be added to the hardware directory of your sketchbook directory. Platforms installed there may include board definitions (which appear in the board menu), core libraries, boot loaders, and programmer definitions. To 27install, create the hardware directory, then unzip the third-party platform into its own sub-directory. (Don't use "arduino" as the sub-directory name or you'll override the builtin Arduino platform.) To uninstall, simply delete its directory.

Serial monitor

This displays serial sent from the Arduino or Genuino board over USB or serial connector. To send data to the board, enter text and click on the "send" button or press enter. Choose the baud rate from the drop-down menu that matches the rate passed to Serial.begin in your sketch. Note that on Windows, Mac or Linux the board will reset (it will rerun your sketch) when you connect with the serial monitor. Please note that the Serial Monitor does not process control characters; if your sketch needs a complete management of the serial communication with control characters, you can use an external terminal program and connect it to the COM port assigned to your Arduino board.

4.5.2 ANDROID STUDIO

Android Studio is the official integrated development environment (IDE) for Android app development. It provides developers with a comprehensive set of tools and features to streamline the process of building, testing, and deploying Android applications.

User Interface Design

Android Studio offers powerful tools for designing user interfaces (UIs) through its Layout Editor. Developers can create UI layouts using drag-and-drop components or by editing XML code directly. The Preview window allows real-time visualization of UI designs across various screen sizes and orientations.

Coding and Development

Android Studio supports coding in Java, Kotlin, and other programming languages. It provides syntax highlighting, code completion, and debugging features to facilitate efficient coding. The IDE also integrates with version control systems like Git for collaborative development.

Emulator and Device Testing

Android Studio includes an emulator that simulates Android devices, allowing developers to test their apps on different virtual devices with various configurations. Additionally, developers can run and debug apps directly on physical Android devices connected to their development machine.

Performance Profiling and Optimization

Android Studio offers tools for performance profiling to identify bottlenecks and optimize app performance. Developers can analyze CPU, memory, and network.

Integration with Google Services

Android Studio seamlessly integrates with various Google services and

APIs, such as Google Maps, Firebase, and Google Play services. This integration simplifies the process of incorporating powerful features into Android apps, such as location-based services, authentication, and cloud storage.Android Studio is the official integrated development It provides developers with a comprehensive set of tools and features to streamline the process of building, testing, and deploying Android applications.

Deployment and Distribution

Android Studio provides tools for packaging and deploying apps to the Google Play Store or other distribution channels. Developers can generate signed APKs (Android Package files) for release, manage app signing certificates, and analyze app performance and user engagement metrics through the Play Console.

4.6 CIRCUIT DIAGRAM DESCRIPTION- POWER SUPPLY

Block diagram

The ac voltage, typically 220V rms, is connected to a transformer, which steps that ac voltage down to the level of the desired dc output. A diode rectifier then provides a full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation.

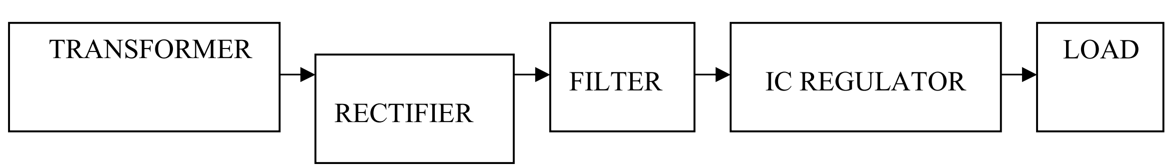

Figure 4.11 Block diagram - Power supply

4.7. WORKING PRINCIPLE

Transformer

- ❖ The potential transformer will step down the power supply voltage (0-230V) to (0-6V) level. Then the secondary of the potential transformer will be connected to the precision rectifier, which is constructed with the help of op–amp. The advantages of using precision rectifier are it will give peak voltage output as DC, rest of the circuits will give only RMS output.
- ❖ The transformer steps up or steps down the input voltage depending on the turns ratio between the primary and secondary windings. For example, a transformer with more turns in the secondary winding than the primary winding steps up the voltage, while fewer turns step down the voltage.

Rectifier

- ❖ The rectifier is used to convert alternating current (AC) into direct current (DC). It typically consists of diodes arranged in a configuration such as a bridge rectifier.
- ❖ During the positive half-cycle of the AC input voltage, one set of diodes conducts and allows current to flow in one direction, while during the negative half-cycle, another set of diodes conducts to maintain the current flow in the same direction.
- ❖ As a result, the output of the rectifier is a pulsating DC waveform, which alternates between positive and negative voltage but flows predominantly in one direction.

Filter

- ❖ The filter is used to smooth out the pulsating DC output from the rectifier and produce a more stable DC voltage.

- ❖ Capacitors are commonly used as filters in power supplies. They store electrical energy when the voltage across them is high (during the peaks of the pulsating waveform) and release energy when the voltage drops, thereby reducing the ripple in the output voltage.
- ❖ Inductors can also be used as filters to smooth out the ripple by storing energy in their magnetic fields.

IC Regulators

- ❖ Integrated circuit (IC) regulators are used to regulate the output voltage of the power supply to a precise level, regardless of variations in input voltage or load.Linear regulators, such as the popular 7805 series, use feedback to adjust the output voltage to a fixed value by dissipating excess energy as heat.
- ❖ Switching regulators are more efficient and can step up or step down the voltage using a combination of switches, inductors, capacitors, and control circuits.

Load

- ❖ The load is the device or circuit that consumes the power provided by the power supply. It could be electronic devices, motors, lights, or any other
- ❖ electrical equipment.
- ❖ The load draws current from the power supply and converts electrical energy into various forms of useful work, such as mechanical motion, light, heat, or signal processing.

4.8 ADVANTAGES

- ❖ Enhanced Safety: Reduced risk to human firefighters in hazardous environments.
- ❖ Improved Response Time: Multiple-direction fire detection for quicker

action.

- ❖ Efficient Fire Suppression: Automatic turning and water spraying for faster flame control.
- ❖ Real-time Environmental Monitoring: Temperature and gas sensors for better fire management.
- ❖ Remote Monitoring and Control: Wireless control via mobile app for flexibility and ease of use.

4.9 APPLICATION

- ❖ Industrial Settings: Effective fire detection and suppression in industrial facilities.
- ❖ Residential Buildings: Improved fire safety measures for homes and apartments.
- ❖ Commercial Spaces: Enhanced protection for shops, offices, and restaurants.
- ❖ Hazardous Environments: Safeguarding against fires in environments with flammable materials.
- ❖ Emergency Response: Quick deployment in emergency situations for rapid fire control.

CHAPTER 5
RESULT AND DISUSSION

The results of the smart fire-fighting robot project demonstrate successful hardware implementation and software development. The robot's hardware includes a range of sensors (fire, temperature, gas), actuators (servo motor, DC pump), and communication modules (Bluetooth) integrated into a robust design tailored for firefighting tasks. Software architecture encompasses control algorithms for sensor data fusion, user-friendly remote control interface, and efficient communication protocols.

Testing procedures evaluated the robot's performance in various firefighting scenarios, achieving high accuracy in fire detection, quick response times, and reliable remote control functionality.

The discussion highlights the robot's performance strengths, such as effective sensor fusion for decision-making and reliable remote monitoring and control capabilities. Areas for improvement include enhancing user experience through interface refinements and exploring scalability for broader firefighting applications.

Overall, the project lays a solid foundation for future advancements in smart fire-fighting technology, emphasizing the importance of integrated hardware-software systems for effective emergency response.

5.1 STRUCTURE OF THE PROJECT

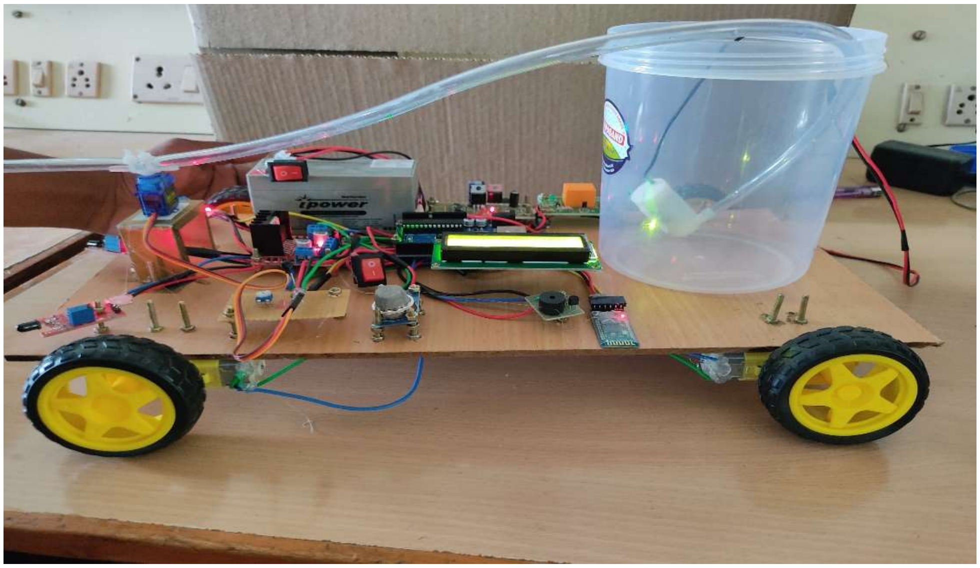

Figure 5.1 Project Outlook

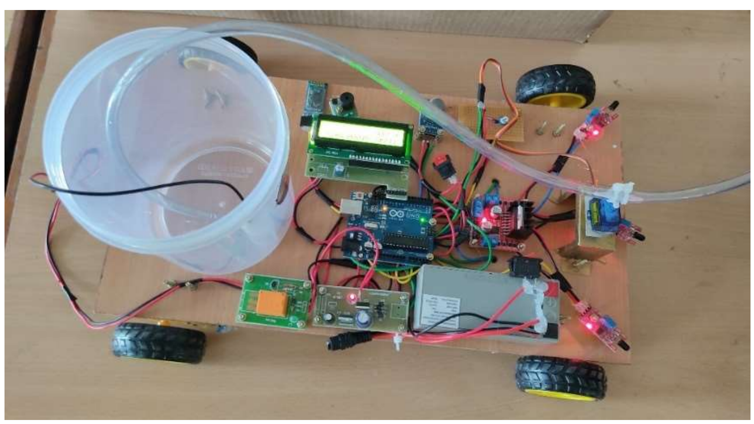

Figure 5.2 Structure Of The Project

5.2 FUNCTION OF THE PROJECT

A) FLAME SENSOR SENSE THE FIRE

The robot is designed to have fire sensors placed on three sides (left, right, and center) to detect fires in different directions.This sensor sense the fire.

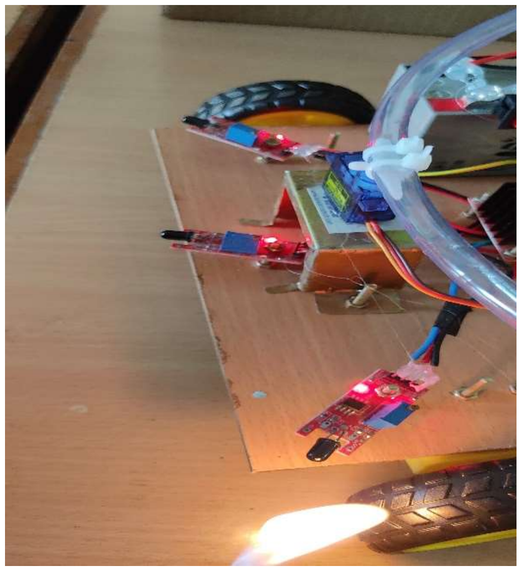

Figure 5.3 Flame Sensor ON

B) SERVO MOTOR ON AND DC MOTOR IS ACTIVATE

Upon detecting a fire, the robot's servo motor will automatically turn towards the fire and activate a DC pump to spray water, aiming to suppress the fire effectively.

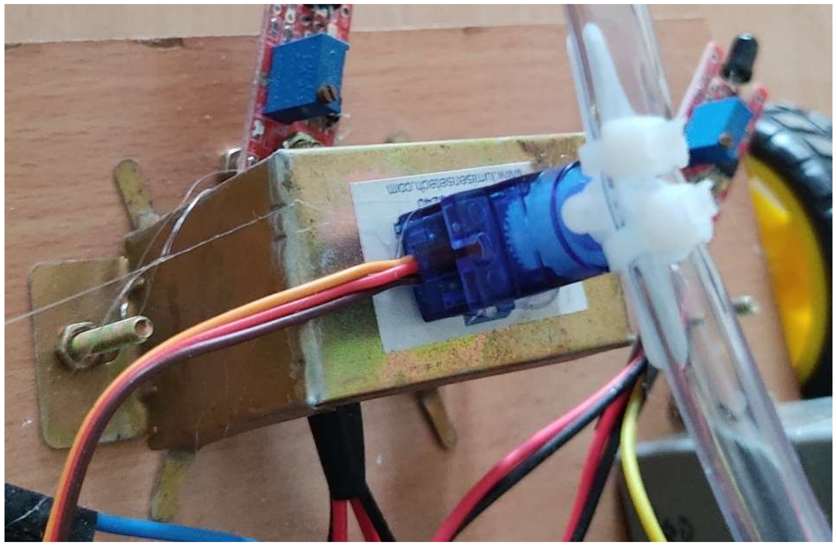

Figure 5.4 Servomotor ON

Figure 5.5 DC Motor And Pump

C) TEMPERATURE SENSOR AND GAS SENSOR

Additionally, the robot is equipped with a temperature sensor and a gas sensor to monitor the temperature and gas levels in the environment, providing crucial information for fire monitoring and safety.

When a temperature is 50 above the lcd display showing high temperature.

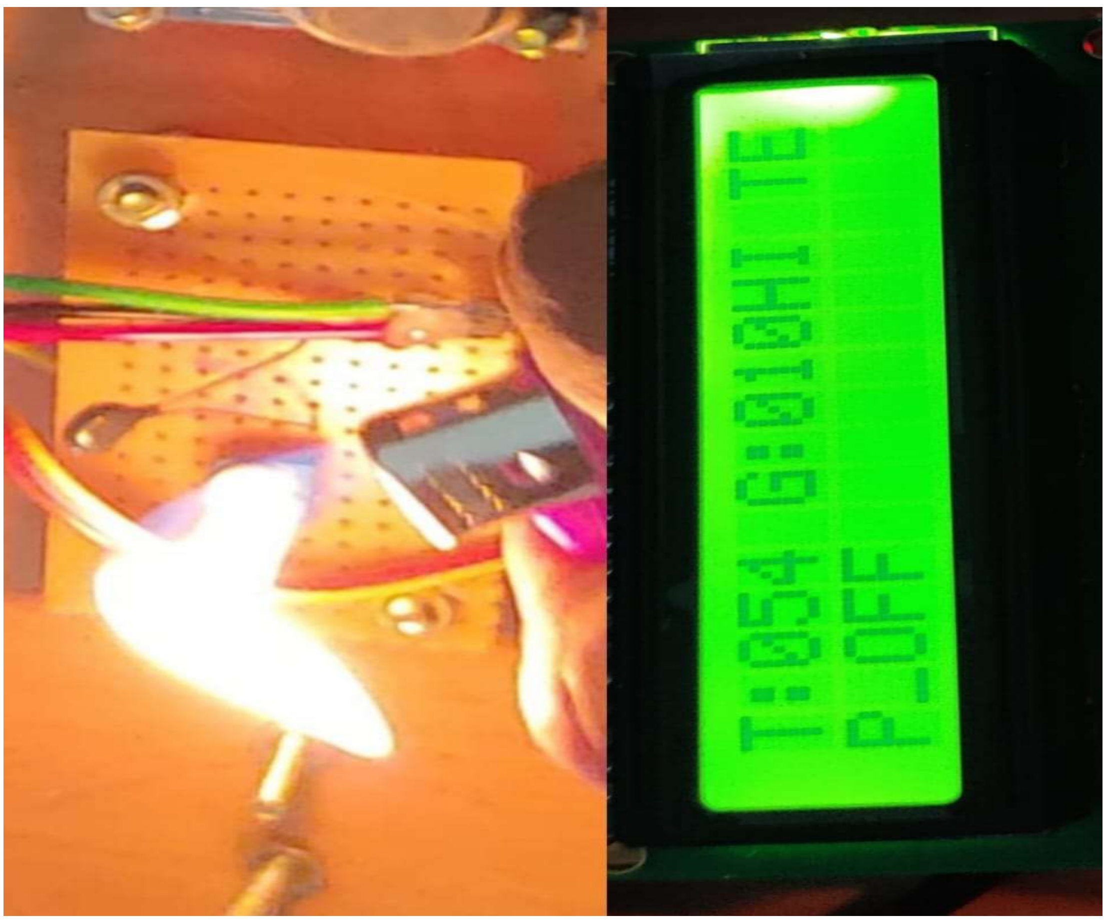

Figure 5.6 Temperature Sensor And Monitoring

When a gas is 100 above the lcd display showing high temperature.

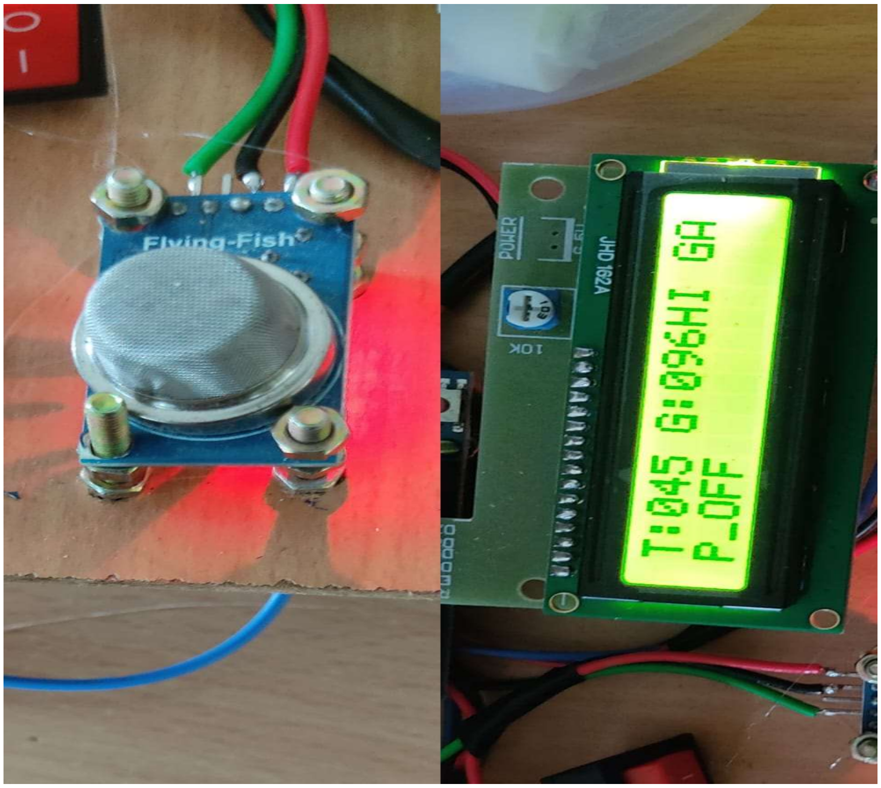

Figure 5.7 Gas Sensor And Monitoring

D) BLUETOOTH CONTROL BY APP

The sensor data is transmitted wirelessly via Bluetooth to a mobile application, allowing users to remotely monitor the environment and control the robot's movements and actions in app.

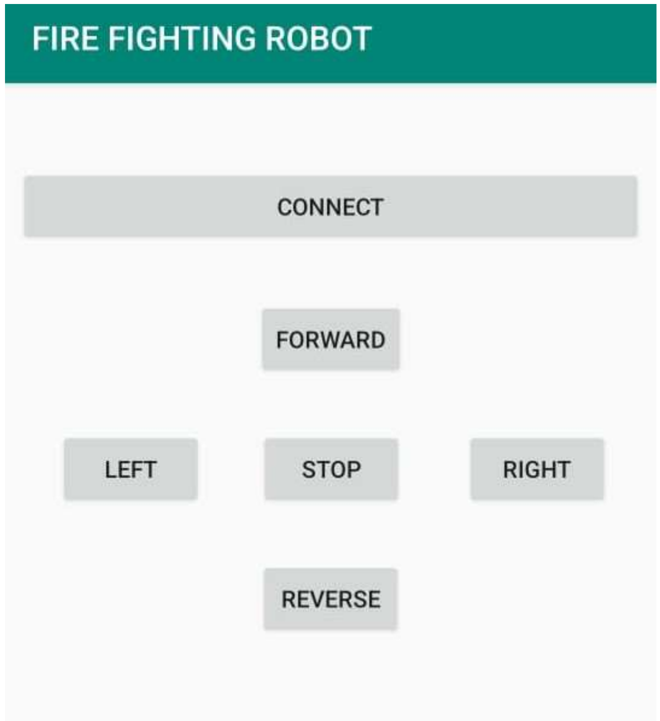

Figure 5.8 Bluetooth Control App

CHAPTER 6

CONCLUSION

- In conclusion, the development of a smart fire fighting robot with advanced sensors and wireless communication capabilities offers a significant advancement in fire emergency response systems.
- By addressing the limitations of existing systems, such as manual intervention, limited detection range, and delayed response times, this project aims to enhance safety and efficiency in fire management.
- The robot's ability to detect fires from multiple directions simultaneously, along with its automatic turning and water spraying capabilities, allows for quick and effective fire suppression.
- Additionally, the inclusion of temperature and gas sensors enables real-time environmental monitoring, providing valuable data for fire management and safety protocols.
- Furthermore, the remote monitoring and control features via a mobile application offer flexibility and ease of use for operators, allowing for quick adjustments and interventions as needed.
- This project's application in various settings, including industrial facilities, residential buildings, commercial spaces, hazardous environments, and emergency response situations, highlights its versatility and potential impact in enhancing fire safety measures.
- Overall, the proposed system represents a significant advancement in fire fighting technology, promising improved safety, reduced response times, and more efficient fire suppression capabilities.

6.1 FUTURE WORK

In the future work section of the design and implementation of the smart fire-fighting robot with remote monitoring and control capabilities, several key areas can be explored for enhancement. These include advanced sensor integration such as infrared cameras for improved visibility in smoke-filled environments and object recognition capabilities for hazard identification. Implementing machine learning algorithms for real-time fire detection and classification can enable the robot to differentiate between different fire types and respond effectively. Intelligent path planning algorithms, autonomous navigation systems like SLAM, and robust communication protocols can further optimize the robot's movement, autonomy, and remote operation reliability. Improving energy efficiency, enhancing human-robot interaction, exploring collaborative robotics, ensuring robustness and reliability through testing, and integrating with emergency services are also vital considerations for future development. Integrating these aspects can significantly enhance the robot's capabilities and effectiveness in firefighting scenarios.

APPENDIX

```
#include <LiquidCrystal.h>
LiquidCrystal lcd(8, 9, 10, 11, 12, 13);
#include <Servo.h>
Servo myservo;  //ceate 32 bit
int pos = 0;
#define rl1 4
#define rl2 5
#define rl3 6
#define rl4 7
#define r5 2
#define alm A2
int fire1 = A3;
int fire2 = A4;
int fire3 = A5;
unsigned a, at = 0,aa;
int temp, gas;
char s_val[20], count, rcv[100];
void (*resetFunc)(void) = 0;
void setup() {
  Serial.begin(9600);
  pinMode(rl1, OUTPUT);
  pinMode(rl2, OUTPUT);
  pinMode(rl3, OUTPUT);
  pinMode(rl4, OUTPUT);
  pinMode(r5, OUTPUT);
```

```
pinMode(alm, OUTPUT);
pinMode(fire1, INPUT);
pinMode(fire2, INPUT);
pinMode(fire3, INPUT);
pinMode(temp, INPUT);
pinMode(gas, INPUT);
myservo.attach(3);
myservo.write(90);
digitalWrite(rl1, LOW);
digitalWrite(rl2, LOW);
digitalWrite(rl3, LOW);
digitalWrite(rl4, LOW);
digitalWrite(r5, LOW);
digitalWrite(alm, LOW);
lcd.begin(16, 2);
lcd.setCursor(0, 0);
lcd.print("----------------");
lcd.setCursor(0, 1);
lcd.print("----------------");
delay(2000);
lcd.clear();
lcd.setCursor(0, 0);
lcd.print(" FIRE FIGHTING  ");
lcd.setCursor(0, 1);
lcd.print("     ROBOT      ");
delay(2000);
lcd.clear();
```

```
}
void loop() {
  /////////////////////////////////////////SENSOR/////////////////////////////////////////////////////
  temp = analogRead(A0) >> 2;
  gas = analogRead(A1) >> 2;
  lcd.setCursor(0, 0);
  lcd.print("T:");
  Lcd_Decimal3(2, 0, temp);
  lcd.setCursor(6, 0);
  lcd.print("G:");
  Lcd_Decimal3(8, 0, gas);
  if (temp > 50) {
    digitalWrite(alm, HIGH);aa=1;
    delay(1000);
    digitalWrite(alm, LOW);
    lcd.setCursor(11, 0);
    lcd.print("HI TEMP");
  } else if (gas > 90) {
    digitalWrite(alm, HIGH);aa=2;
    delay(1000);
    digitalWrite(alm, LOW);
    lcd.setCursor(11, 0);
    lcd.print("HI GAS");
  } else {
    lcd.setCursor(11, 0);aa=0;
    lcd.print(" NRML ");
  }
```

```
at++;
if(at>100){
  Serial.print(temp);
  Serial.print(",");
  Serial.println(gas);
  at=0;
}
//////////////////////////////////////FIRE DETECTION/////////////////////////////////////////////////
if (digitalRead(fire1) == HIGH) {
  lcd.setCursor(0, 1);
  a = 2;
  lcd.print("P_ON ");
  myservo.write(180);
  delay(1000);
  digitalWrite(r5, HIGH);
  digitalWrite(alm, HIGH);
  delay(1000);//myservo.write(90);
  delay(1000);
  digitalWrite(r5, LOW);
digitalWrite(alm, LOW);delay(1000);
myservo.write(90);

} else if (digitalRead(fire2) == HIGH) {
  lcd.setCursor(0, 1);
  a = 3;
  lcd.print("P_ON ");
  myservo.write(90);
```

```
  delay(1000);
  digitalWrite(r5, HIGH);
  digitalWrite(alm, HIGH);
  delay(1000);//myservo.write(90);
  delay(1000);
  digitalWrite(r5, LOW);
digitalWrite(alm, LOW);
} else if (digitalRead(fire3) == HIGH) {
  lcd.setCursor(0, 1);
  a = 1;
  lcd.print("P_ON ");
  myservo.write(0);
  delay(1000);
  digitalWrite(r5, HIGH);
  digitalWrite(alm, HIGH);
  delay(1000);//myservo.write(90);
  delay(1000);
  digitalWrite(r5, LOW);
digitalWrite(alm, LOW);delay(1000);
myservo.write(90);
} else {
  lcd.setCursor(0, 1);
  a = 0;
  lcd.print("P_OFF");
  digitalWrite(r5, LOW);
// digitalWrite(alm, LOW);
}
```

```
//////////////////////////////////BLUETOOTH///////////////////////////////////////
while (Serial.available()) {
  unsigned int rec = Serial.read();
  s_val[count] = rec;
  if (s_val[0] == '*') {
    count++;
  } else {
    count = 0;
  }
}
if (count > 1) {
  count = 0;
  if (s_val[1] == '1') {
    forward();
  }
  if (s_val[1] == '2') {
    reverse();
  }
  if (s_val[1] == '3') {
    left();
  }
  if (s_val[1] == '4') {
    right();
  }
  if (s_val[1] == '5') {
    stop();
  }
```

```
  }
}

void forward() {
  digitalWrite(rl1, LOW);
  digitalWrite(rl2, HIGH);
  digitalWrite(rl3, LOW);
  digitalWrite(rl4, HIGH);
  lcd.setCursor(6, 1);
  lcd.print("FORWARD");
}
void reverse() {
  digitalWrite(rl1, HIGH);
  digitalWrite(rl2, LOW);
  digitalWrite(rl3, HIGH);
  digitalWrite(rl4, LOW);
  lcd.setCursor(6, 1);
  lcd.print("REVERSE");
}
void left() {
  digitalWrite(rl1, LOW);
  digitalWrite(rl2, HIGH);
  digitalWrite(rl3, HIGH);
  digitalWrite(rl4, LOW);
  lcd.setCursor(6, 1);
  lcd.print(" LEFT  ");
}
```

```
void right() {
  digitalWrite(rl1, HIGH);
  digitalWrite(rl2, LOW);
  digitalWrite(rl3, LOW);
  digitalWrite(rl4, HIGH);
  lcd.setCursor(6, 1);
  lcd.print(" RIGHT ");
}
void stop() {
  digitalWrite(rl1, LOW);
  digitalWrite(rl2, LOW);
  digitalWrite(rl3, LOW);
  digitalWrite(rl4, LOW);
  lcd.setCursor(6, 1);
  lcd.print(" STOP  ");
}
void Lcd_Decimal3(unsigned char com, unsigned char com1, unsigned int val) {
  unsigned int Lcd_h, Lcd_hr, Lcd_t, Lcd_o;
  lcd.setCursor(com, com1);
  Lcd_h = val / 100;
  Lcd_hr = val % 100;
  Lcd_t = Lcd_hr / 10;
  Lcd_o = Lcd_hr % 10;

  lcd.setCursor(com, com1);
  lcd.write(Lcd_h + 0x30);
  lcd.setCursor(com + 1, com1);
```

```
  lcd.write(Lcd_t + 0x30);
  lcd.setCursor(com + 2, com1);
  lcd.write(Lcd_o + 0x30);
}
```

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