An-Najah National University

Faculty of Engineering & Information Technology

Computer Engineering Department

Hardware Graduation Project

Fire Fighter

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This report wouldn't be complete without giving credit to everyone who has been part of my school life. You have been there for me; guiding, cheering, and believing in me even when I didn't believe in myself. Thank you for making it possible for us to celebrate such an important event together.

Abstract

This piece of work details the construction of a self-driven robot car for spotting and putting out fires in a chemical warehouse. The compact water-filled vehicle can travel throughout a scaled-down warehouse with dual chambers and a lengthy hallway thanks to its built-in sensors. It moves towards a fire by itself when it finds one where it triggers an alarm on board before using the water tank to extinguish it. Moreover, if gas is detected, an alarm is sounded, an air extractor is switched on and notifications are sent to the warehouse manager's mobile through a dedicated app. This undertaking is about making provisions for instant responses to fire outbreaks and gas leak emergencies as a way of enhancing safety within chemical warehouses by speeding up and automating their control processes.

This project is chosen to solve the natural dangers of managing chemicals in warehouses. This project is necessary as it can improve fire safety in chemical storage facilities leading to preventing catastrophic events like fires and explosions. We want to provide a new idea that will not only identify these fires early enough but also put them off quickly and efficiently by fixing modern sensors on a smart fire engine.

This project needs several critical elements. It is necessary to come up with a strong sensor system that can sense gas leaks and fire outbreaks. There should be smooth cooperation between the sensor system, the fire truck, and the mobile application so that there are quick alerts and responses. Additionally, the vehicle should be self-governing and efficient in navigating to fires as well as putting them out to ensure effective emergency response.

This project endeavors to provide a unique set of characteristics specifically designed for chemical storage environments even if there may be other firefighting systems and applications. What makes our solution different from any others is the fact that we have combined advanced sensor technology with autonomous vehicle navigation plus real-time monitoring capacities which take care of specific problems related to fire safety within warehouses storing chemicals.

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Chapter 1

Introduction

A conventional method of fire safety in chemical storage facilities is dependent on manual intervention and static alarm systems. Such systems often cause delayed responses to gas leaks and fires. This, in turn, can worsen the risk of massive accidents that may result in extensive damage. To curb these challenges, we have invented an independent robot car to detect and fight fires as well as gas leaks in chemical warehouses.

1.1 Problem Statement

Many times, traditional fire preventing structures in chemical warehouses are considered ineffective as they depend on humans or stationary equipment. Because these installations are used, they can also prolong the time taken to identify or respond to fires. This in turn raises the chances of serious harm.

1.2 Objectives

The primary goal of this project is to design a self-driving car that can help prevent fires in places where industrial chemicals are kept. To achieve this goal, the car will be fitted with sensors for detecting fires and a tank for putting them out with water. Furthermore, the chemical warehouse will have gas sensors to find leaks and trigger safety measures as well as a mechanism for sending live alerts to a mobile app. All these different features working together aim at quickening reactions towards potential risks thus making sure working areas and items are safe.

1.3 Scope of Work

1. ***Sensor System*****:** Developing a robust system to detect fires and gas leaks accurately.
2. ***Autonomous Navigation*****:** Ensuring the car can navigate through the warehouse model efficiently.
3. ***Integration with Mobile App*****:** Implementing a seamless communication system for real-time alerts and monitoring.

1.4 Significance

This project will revolutionize fire safety in chemical storage facilities by incorporating a quick, self-governing reaction plan. Our solution deals with fire and gas leak hazards uniquely by combining state-of-the-art sensor technology, autonomous vehicle navigation as well as real-time monitoring capabilities. Moreover, it not only improves the speed and efficiency of emergency responses but also reduces risks of chemical storage significantly for a safer working environment for people and property.

June 27, 2024

Chapter 2

Constraints and Earlier Work

2.1 Constraints

1. ***Arduino Programming***: Limited experience in coding with Arduino Uno, particularly in managing concurrent tasks and ensuring real-time responsiveness, poses a challenge. This includes integrating sensor inputs, motor controls, and communication protocols effectively.
2. ***Integration with Blynk App***: Implementing communication between ESP8266 modules and the Blynk application for real-time monitoring and control presents a learning curve. Challenges may include setting up Wi-Fi connectivity, configuring data transmission protocols, and ensuring data security.
3. ***Signal Transmission from Fire/Gas Detection Points***: Establishing reliable signal transmission from fire or gas detection points (rooms) to the car robot involves overcoming potential obstacles such as signal interference, transmission range limitations, and environmental factors within the warehouse setting.
4. ***Autonomous Navigation***: Developing algorithms and mechanisms for the car robot to autonomously navigate to the location of the fire, or gas leakage, and return to its designated base after firefighting operations.
5. ***Speed Control***: Initial challenges included managing the speed of the car to prevent it from moving too quickly when advancing towards the fire, which has been addressed through adjustments and calibration of motor control algorithms.

2.2 Earlier Work

1. ***Basic Arduino Programming***: Previous coursework provided fundamental knowledge of Arduino programming syntax, digital and analog sensor interfacing, and motor control using Arduino IDE.
2. ***ESP8266 and IoT Applications***: Hands-on experience with ESP8266 modules in IoT applications, including setting up Wi-Fi connectivity, and integrating with mobile applications like Blynk for remote monitoring and control.
3. ***Sensor Integration***: Practical experience with IR flame sensors, gas sensors, ultrasonic sensors, and their interfacing with Arduino Uno. This includes calibration, data acquisition, and implementing threshold-based triggering for alert systems.
4. ***Mechanical Design and Prototyping***: Previous projects involving servo motors for precise movement and DC motors for propulsion provided insights into mechanical design considerations, including stability, durability, and motor power requirements.
5. ***Speed Control***: Initial challenges included managing the speed of the car to prevent it from moving too quickly when advancing towards the fire, which has been addressed through adjustments and calibration of motor control algorithms.

Chapter 3

Literature Review

Fire safety when dealing with industrial settings, mostly chemical warehouses, is very important because there might be big accidents. Usually, old ways of putting off fire depend on people and tools that are in one place. This can take a long time before they reach where the fire is, which exposes both people and their things to danger. But with technology growing day by day, things are changing. Some robots have been made to put out fires on their own. These machines use modern sensors, and they are designed in such a way that they can move from one place to another automatically. They also come with advantages over the traditional methods that have been there before. Most notably, such robots minimize the exposure of humans to risky environments as well as enhance general safety precautions in organizations where fires are prevalent. Combining various sensor technologies (e.g., IR flame sensors and gas detectors) into a system allows for the early detection of fires or gas leaks, which is essential for prompt action and mitigation. The application of Arduino Uno and ESP8266 microcontroller platforms in robotics has been widely reported to improve system adaptability as well as its real-time performance. These boards enable multiple sensors and actuators to be used together, thus simplifying decision-making in complex environments while also enhancing autonomous navigation capability, among others. According to previous research on autonomous robots, they must have strong communication systems so that information can be shared between them easily, even if they are far apart from each other. The Blynk system provides a user-friendly interface through which one can remotely monitor robots, giving immediate notifications and insights into their operations, which are very important during firefighting activities. Besides, sensor precision problems, environmental flexibility inadequacies, and integration complications call for careful system design and testing. To sum up, although there have been positive results so far in improving safety within industries through self-governing robotics advancement, successful firefighting robot deployments at chemical warehouses need the inclusive incorporation of sensing technologies, strong communication systems, and effective power management mechanisms. Therefore, this study provides a basis for knowledge of the technical environment surrounding the development process of creating an automatic firefighting machine for chemical warehouses.

Chapter 4

Methodology

4.1 Hardware Components

4.1.1 Arduino Uno

The Arduino Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller. In our project, the Arduino Uno has two main roles:

- In the warehouse model: It monitors the gas and flame sensors, controls the relay for the air extractor, and activates the buzzer.
- In the car: It monitors the flame sensors, controls the servo motor and water pump, drives the DC motors for movement, and monitors the distance sensors.

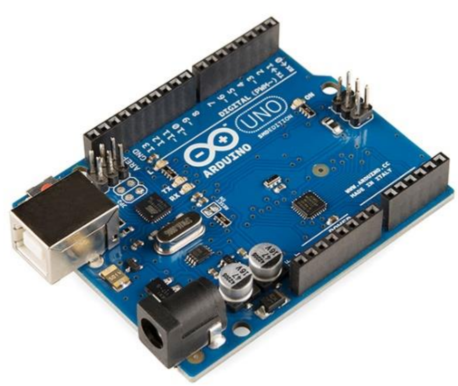

Figure 1.1 Arduino Uno

4.1.2 ESP 8266

The ESP8266 is a system-on-a-chip (SoC) Wi-Fi microchip designed for Internet of Things (IoT) applications by Espressif Systems. Due to its low cost, small size, and compatibility with embedded devices, the ESP8266 is widely used in IoT devices, despite being succeeded by the newer ESP32 microcontroller chip. In our project, we use two ESP8266 controllers. One is placed in the warehouse model to send the status of sensors, fans, and warning messages from the two rooms to the Blynk app. The other is located in the car robot, where it receives signals from Blynk and relays them to the Arduino Uno in the car, directing it to the appropriate room.

Figure 1.2 ESP8266

4.1.3 DC Motor

A DC motor, or direct current motor, is an electrical machine that converts electrical energy into mechanical energy by creating a magnetic field powered by direct current. When a DC motor is powered, a magnetic field is created in its stator. This field attracts and repels magnets on the rotor, causing it to rotate. To keep the rotor continuously rotating, the commutator, which is attached to brushes connected to the power source, supplies current to the motor's wire windings. In our project, we use four DC motors in the car, one for each wheel.

Figure 1.3 DC Motor

Figure 1.4 DC Motor with Wheel

4.1.4 Servo Motor

A Servo motor is a self-contained electrical device that moves parts of a machine with high efficiency and precision. In simpler terms, a servo motor is a brushless DC (BLDC) motor with a sensor for positional feedback. This allows the output shaft to be moved to a specific angle, position, and velocity that a regular motor cannot achieve. However, a servo motor is only one part of a closed-loop motion control system. A complete motion system includes an amplifier, control circuit, drive gears, potentiometer, shaft, and either an encoder or resolver, in addition to the servo motor. In our project, we used the servo motor by connecting it to the pump pipe to spray water at 180 degrees.

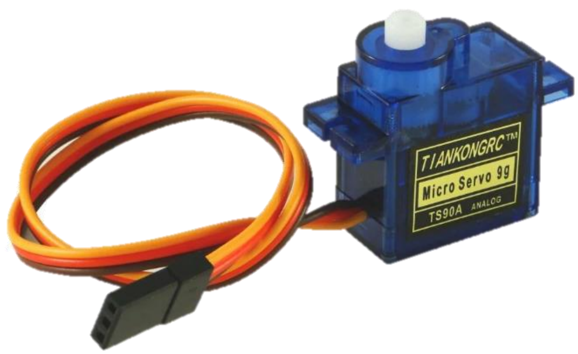

Figure 1.5 Servo Motor

4.1.5 Water Pump and Pipe

A water pump is used to move, compress, or transfer water from a lower level to a higher one. The main purpose of a water pump is to transfer water between two points. In our project, we use a water pump to take water from the tank in the car The pump is connected to a pipe that sprays the water and extinguishes the fire.

Figure 1.6 Water Pump

Figure 1.7 Pipe

4.1.6 Ultrasonic Sensor

An ultrasonic sensor is an instrument that measures the distance to an object using ultrasonic sound waves. It uses a transducer to send and receive ultrasonic pulses that relay back information about an object's proximity. In our project, we use two ultrasonic sensors in the car robot: one in the front and one on the right side. These sensors calculate the distance between the car and any obstacles when it moves forward and reverses to its place.

Figure 1.8 Ultrasonic Sensor

4.1.7 L298N H-bridge Module

The L298N H-bridge module allows you to control the speed and direction of DC motors with ease. It can be used with motors that have a voltage between 5 and 35V DC. The L298N is an integrated monolithic circuit, a high voltage, high current dual full-bridge driver designed to accept standard TTL logic levels and drive inductive loads such as relays, solenoids, and DC motors. In our project, we use the L298N H-bridge module in the car to control the speed and direction of the DC motors connected to the wheels, taking commands from the Arduino.

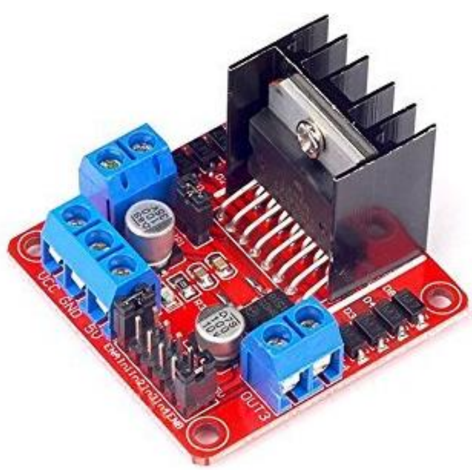

Figure 1.9 L298N H-bridge Module

4.1.8 Relay

The SRD-05VDC-SL-C is a 5V DC electromagnetic relay used to control high-power devices with a low-power signal. It acts as a switch, allowing a small voltage from a microcontroller (like an Arduino) to turn on or off devices such as motors, lights, or fans by connecting or disconnecting a higher power circuit. It also provides electrical isolation between the control and the high-power circuits. In our project, we use the relay to take a 5V signal from the Arduino to activate an extractor running on 12V in the warehouse model and to activate the water pump in the car.

Figure 1.10 Relay

4.1.9 IR Flame Sensor

The IR flame sensor is an infrared sensor used to detect the presence of a flame or fire. It works by sensing infrared light emitted from a fire or flame source. In our project, one sensor was used in each room of the warehouse for quick fire detection. Additionally, three sensors were placed in the front of the car to detect fires when approaching the room.

Figure 1.11 IR Flame Sensor

4.1.10 Extractor Fan

An extractor fan is a small, electric fan designed to remove unwanted air, such as smoke, fumes, or gas, from an area. It works by pulling air from the room and expelling it outside, ensuring proper ventilation and maintaining air quality. In our project, the extractor fan is used in the warehouse model to extract gas when a gas leak is detected. The fan is controlled by a relay that receives a 5V signal from the Arduino, activating the 12V fan to ensure the area is cleared of any harmful gases.

Figure 1.12 Extractor Fan

4.1.11 MQ-4 Gas Sensor

The MQ-4 gas sensor detects methane (CH_4) and natural gas concentrations in the air. It changes its resistance based on gas presence, which the Arduino measures to determine gas levels. In our project, the MQ-4 sensor detects gas leaks in the chemical warehouse model, sending a signal to the Arduino to trigger the alarm system and activate the extractor fan.

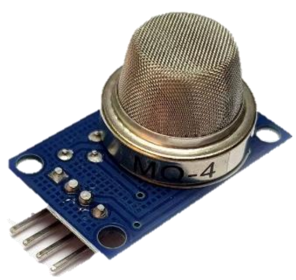

Figure 1.13 MQ-4 Gas Sensor

4.1.12 Buzzer

The buzzer is an audio signaling device that emits a loud sound when activated. In our project, the Arduino activates the buzzer in case of fire or gas leaks, providing an immediate audio alert to ensure a swift response to hazardous situations.

Figure 1.14 Buzzer

4.1.13 YWRobot Power MB-V2

The YWRobot Power MB-V2 is a power supply module, It can output both 5V and 3.3V, making it versatile for various electronic components and microcontrollers. The module typically accepts an input voltage from a USB source or a DC power jack (7V-12V), and it can provide a stable current suitable. In our project, lithium batteries with a total of 7.4V are used. We use two of YWRobot Power MB-V2 that regulate this voltage down to 5V to power all the components. This ensures reliable and consistent operation across the system.

Figure 1.15 MB-V2 Power Supply

4.1.14 Lithium Batteries

Lithium batteries are rechargeable batteries known for their high energy density and long lifespan. In our project, we use 7.4V lithium batteries, regulated down to 5V with the Power MB-V2 to power all components efficiently, ensuring smooth operation of sensors, motors, and microcontrollers.

Figure 1.16 Lithium Batteries

4.2 Structure Parts

4.2.1 Car Top View

- The fire-fighting car setup includes motors for movement, sensors for navigation and fire detection, a water pump for extinguishing fires, a servo motor for directing the water spray, and an ESP8266 module for communication.

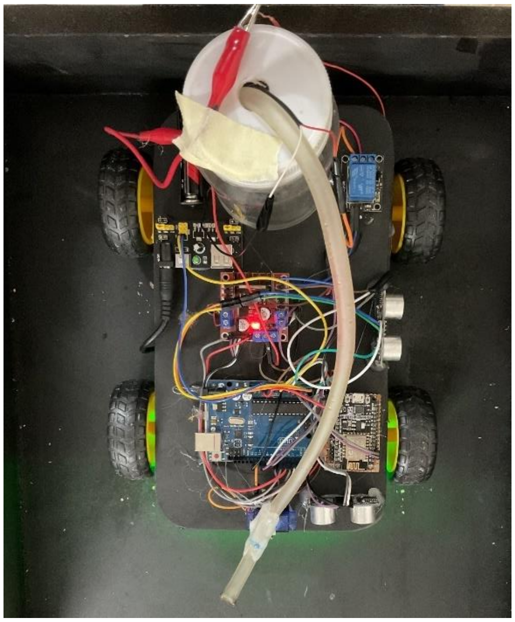

Figure 2.1 Car Top View

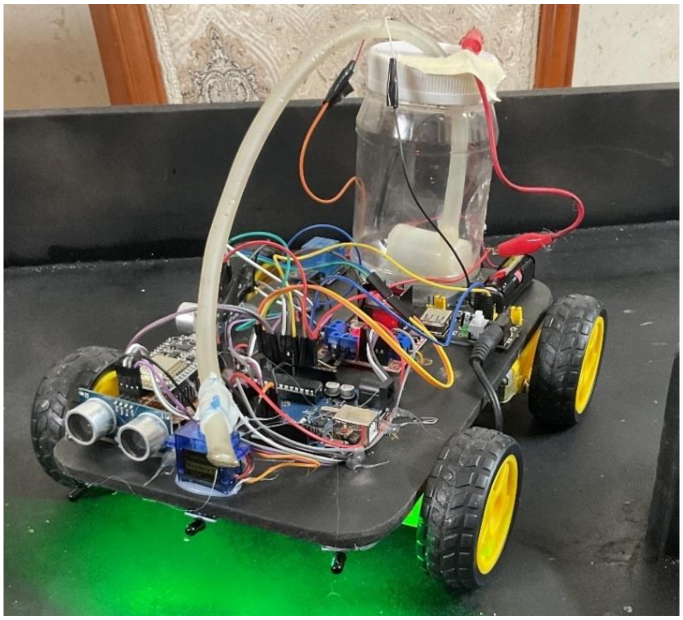

Figure 2.2 Car Front View

4.2.2 Car Bottom View

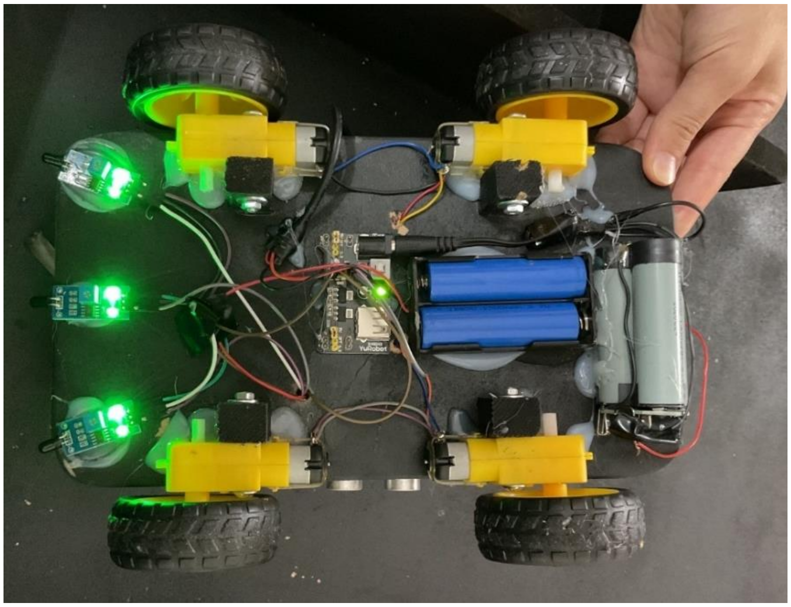

Figure 2.3 Car Bottom View

4.2.2 Warehouse Sample Rooms and Full Body

- The warehouse sample setup includes sensors for gas and fire detection, fans for ventilation, a buzzer for alarms, and relays for controlling high-power devices.

Figure 2.4 Warehouse Sample Room

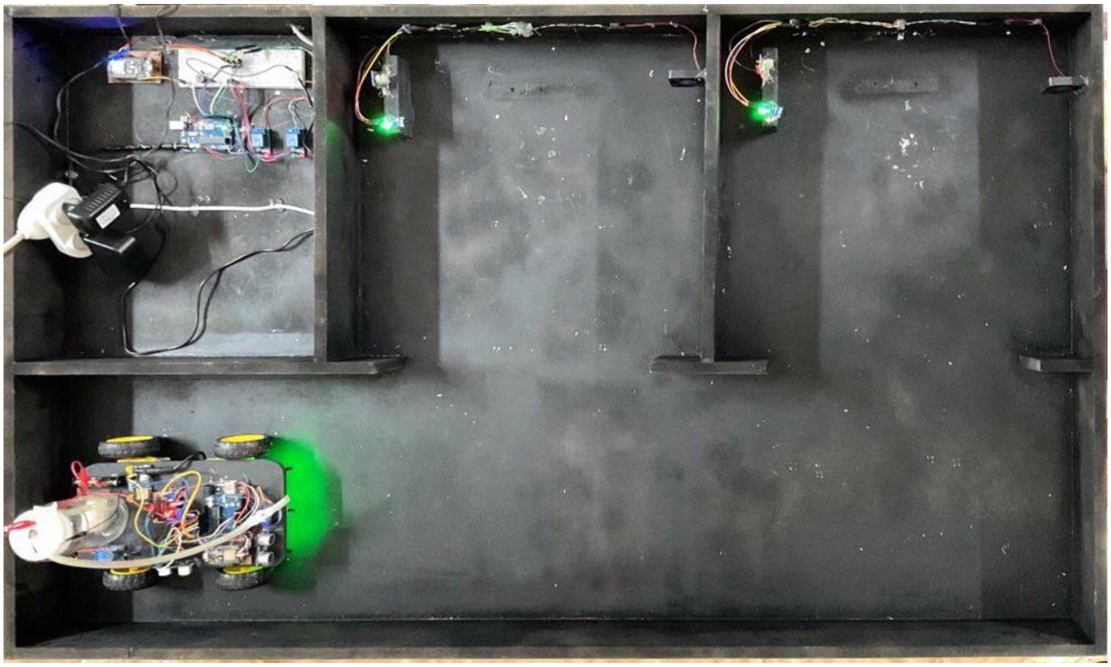

Figure 2.5 Full Warehouse Sample Body

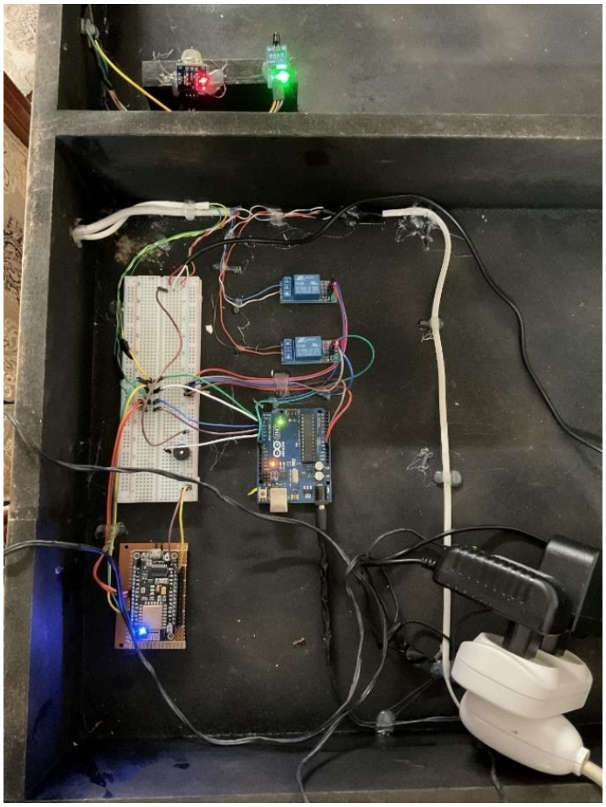

Figure 2.6 Warehouse Sample Body

4.3 Operation Process and Circuits

4.3.1 Operation Process

- **In Room 1 ("Nearby" Room)**

- **Gas Leak Detection:**

1. **Gas Sensor Activation**: When a gas leak occurs, the gas sensor sends a signal to the Arduino.
2. **Alarm Activation**: The Arduino activates the alarm, which remains on until the issue is resolved.
3. **Fan Activation**: Simultaneously, the Arduino activates the extractor fan in Room 1.
4. **Notification**: The gas sensor sends a signal to the ESP8266, which then sends a notification to the Blynk app, indicating a gas leak in Room 1. The fan status changes from "off" to "on" on the app, alerting the warehouse owner and sending an email notification.
5. **Resolution**: Once the gas leak is cleared and the air is clean, the alarm stops, and the fan status on the app changes from "on" to "off", turning off the fan.

- **Fire Detection:**

1. **Fire Sensor Activation**: When a fire is detected, the fire sensor sends a signal to the Arduino, activating the alarm.
2. **Notification**: The ESP8266 sends notifications to the Blynk app on the mobile device and signals the ESP8266 on the car about the fire in Room 1.
3. **Car Movement**: The ESP8266 on the car sends a signal to the Arduino on the car, indicating a fire in Room 1. The car moves forward until the distance sensor reads 62 cm (distance from the end of the corridor to the door of Room 1).
4. **Turning and Approaching Fire**: The car turns 90 degrees towards the door, and the fire sensors on the car detect the fire. The car moves towards the fire, stops in front of it, and activates the water pump and servo to spray water.
5. **Fire Extinguishing Process**: If the fire is not extinguished, the pump stops for less than a second, rechecks for the presence of fire, and repeats the spraying process until the fire is extinguished.
6. **Returning to Base**: After extinguishing the fire, the car moves back until the front distance sensor reads 48 cm (indicating the car is outside the room), turns back 90 degrees, corrects its direction, and moves backward until the front distance sensor reads approximately 1 meter. If the car is too close to the sides, the side distance sensor corrects its path.

- **In Room 2 ("Farther" Room)**

- The process is similar to Room 1 with slight differences in distance calibration:
  - The car moves forward until the distance from the car to the end of the corridor is 14 cm instead of 62 cm.

- **Corridor Fire Scenario**

  - If a fire occurs in the corridor:

    1. **Detection and Deployment**: The car moves directly toward the fire based on the flame sensors' readings.
    2. **Extinguishing and Return**: The car extinguishes the fire and then returns to its original position following the same reversal and path correction procedures described above.

This detailed workflow ensures that both rooms and the corridor are monitored and any detected fires or gas leaks are promptly addressed by the automated system.

4.3.2 Car Circuit

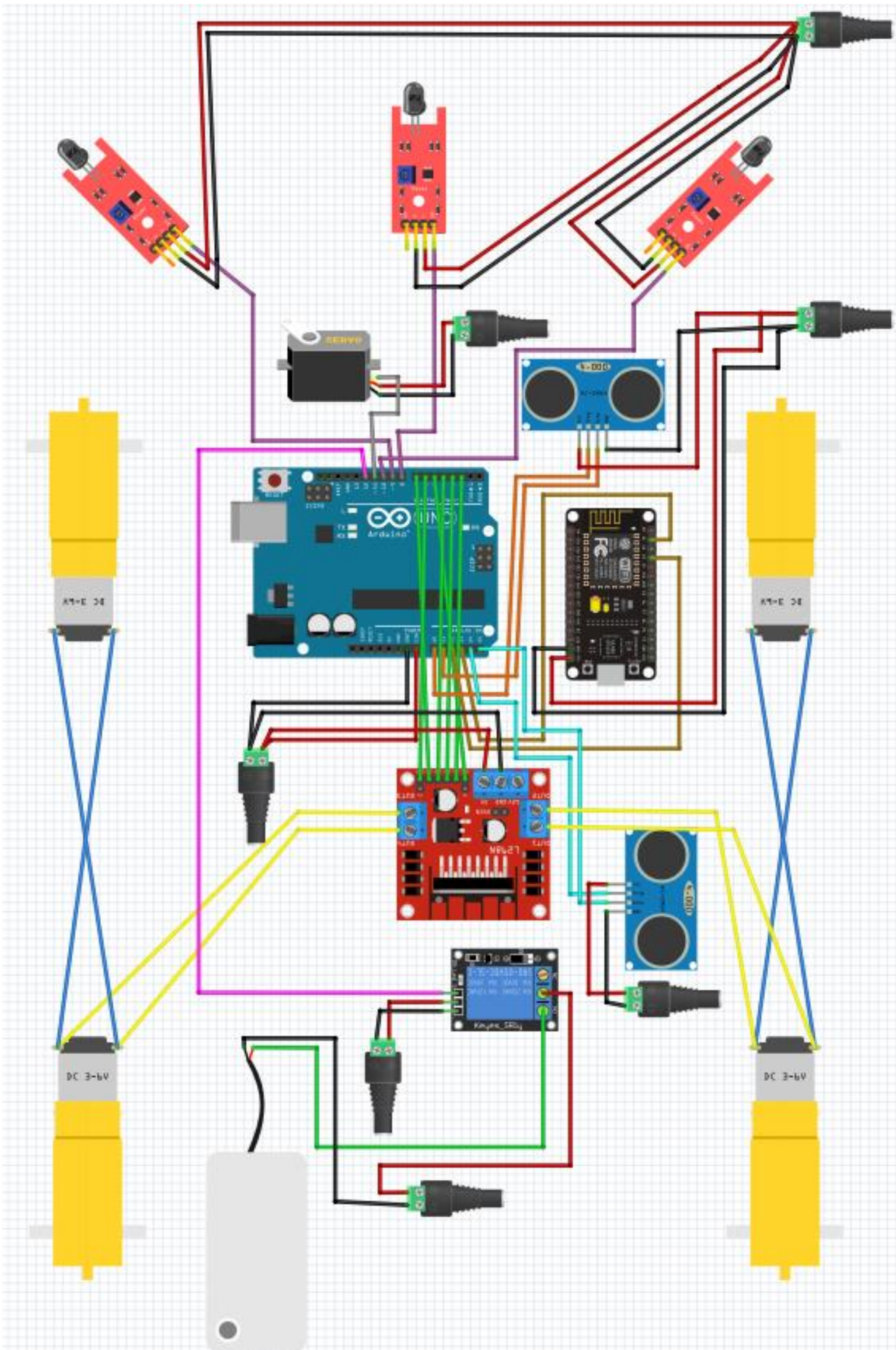

Figure 3.1 Car Circuit

4.3.3 Rooms Circuit

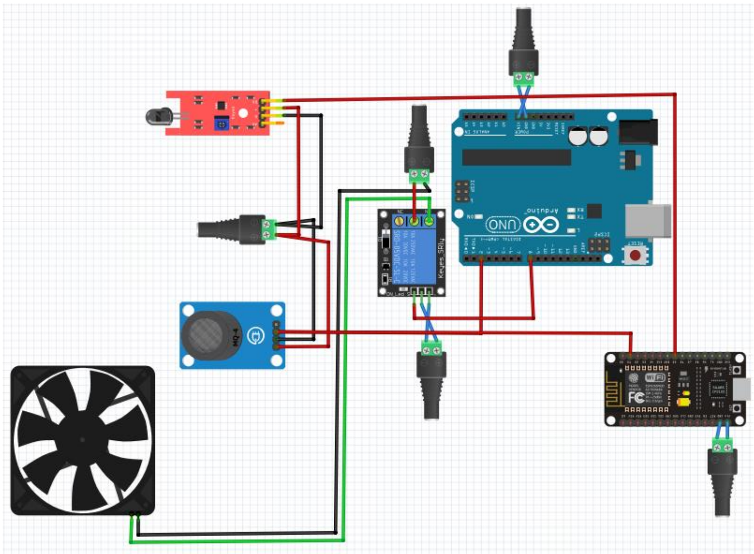

Figure 3.2 Rooms Circuit

4.3.4 Warehouse Sample Circuit with Rooms

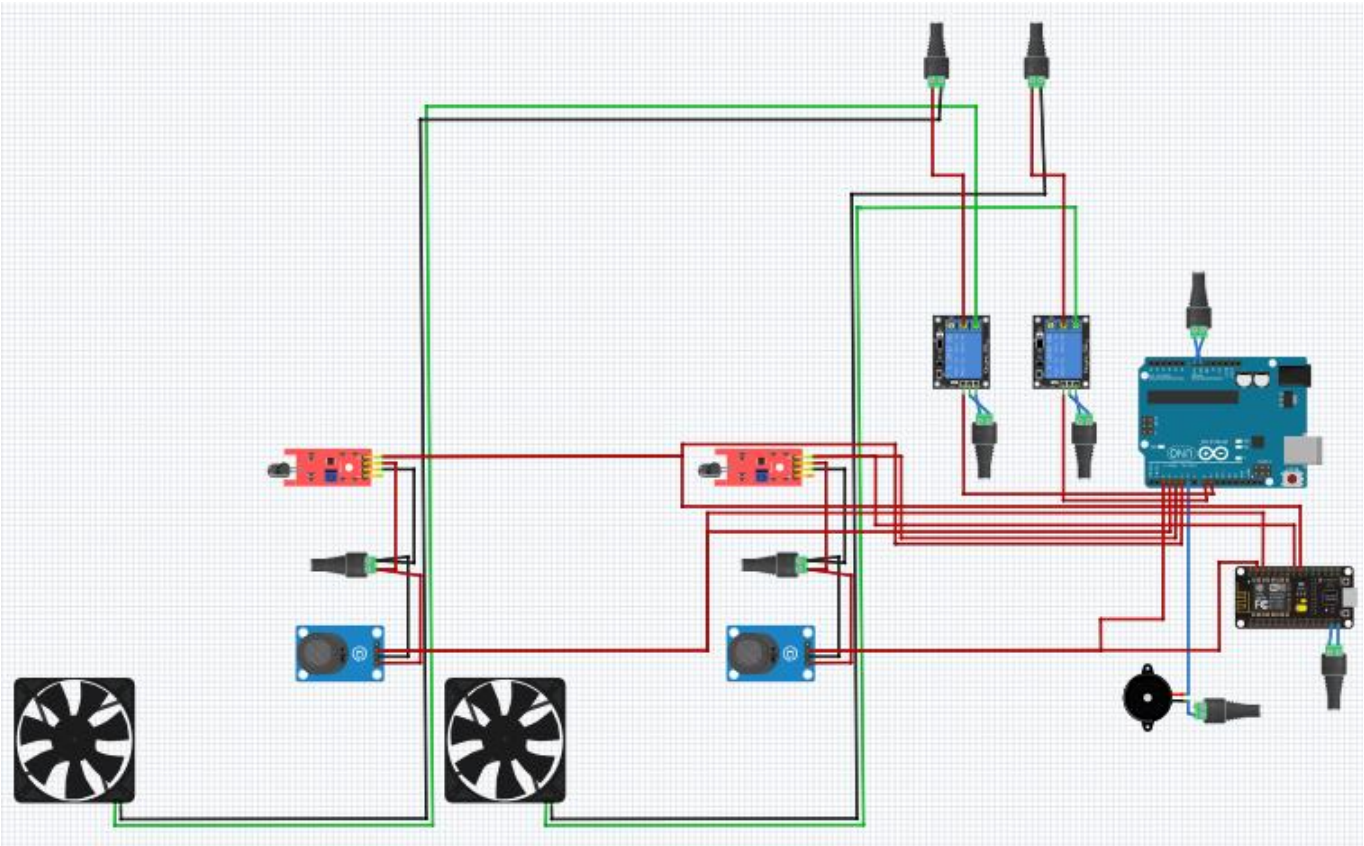

Figure 3.3 Warehouse Sample Circuit with Rooms

4.4: Mobile Application

The mobile application, integrated with the Blynk platform, provides a comprehensive monitoring and alert system for fire and gas leak detection. It automatically manages fan states, activates alarms, and sends real-time notifications to both the app and the warehouse manager's email, ensuring quick and effective responses to potential hazards in industrial chemical storage areas.

4.4.1 App Functionality

1. **Real-time Monitoring:**
   - The app continuously monitors the system’s status and provides real-time updates on critical events such as gas leaks or fires.
2. **Automatic Fan Control:**
   - The system automatically toggles the state of the fans (ON/OFF) in the affected sections based on gas leak detection. For example, if a gas leak is detected in the second section, the fan in that section will be turned on to ventilate the area.
3. **Alarm Activation:**
   - When a gas leak or fire is detected, the system activates an alarm to alert the warehouse manager.
4. **User Alerts and Notifications:**
   - The app sends notifications to the user's mobile device. In the case of a gas leak, the notification will specify the affected section.
   - Additionally, the app sends an email notification to the warehouse manager, providing details about the detected gas leak or fire.
5. **Fire Detection and Notification:**
   - If a fire is detected, the system sends a notification to the app and an email message to the monitor (warehouse manager), detailing the location of the fire.

4.4.2 App Design

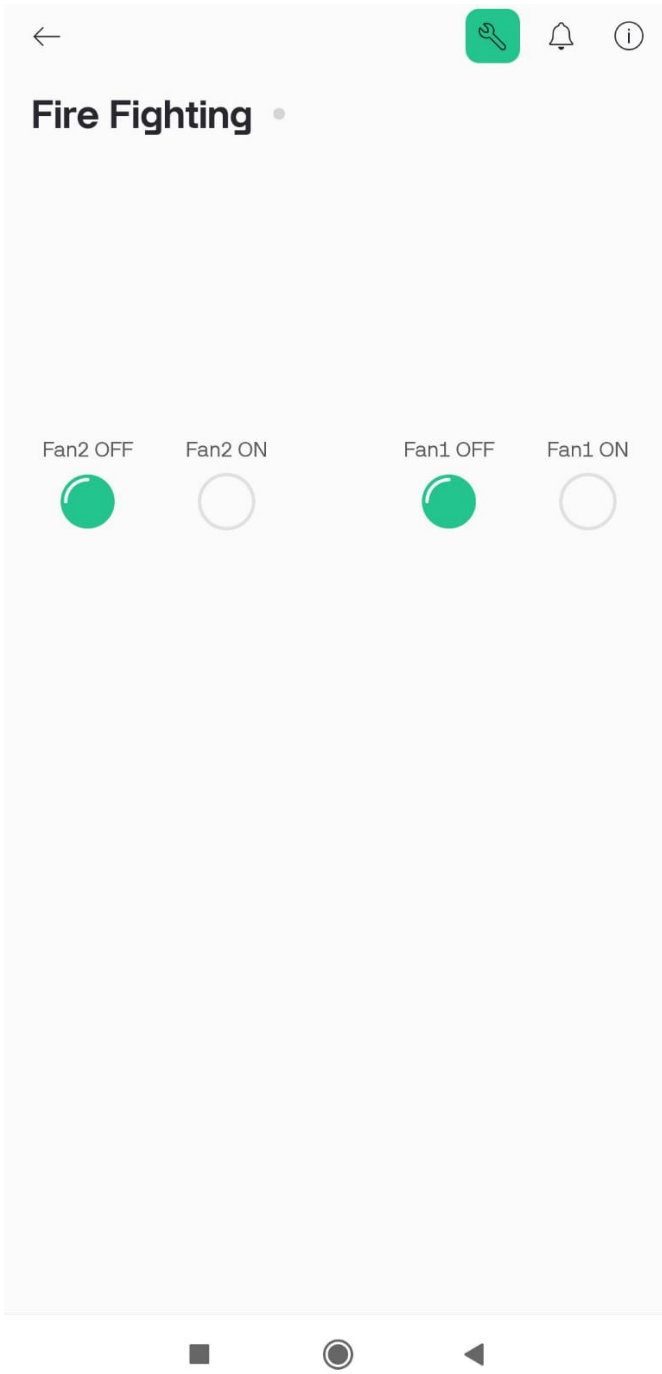

Figure 4.1 Mobile App Design

4.4.3 Gas Leak Notification

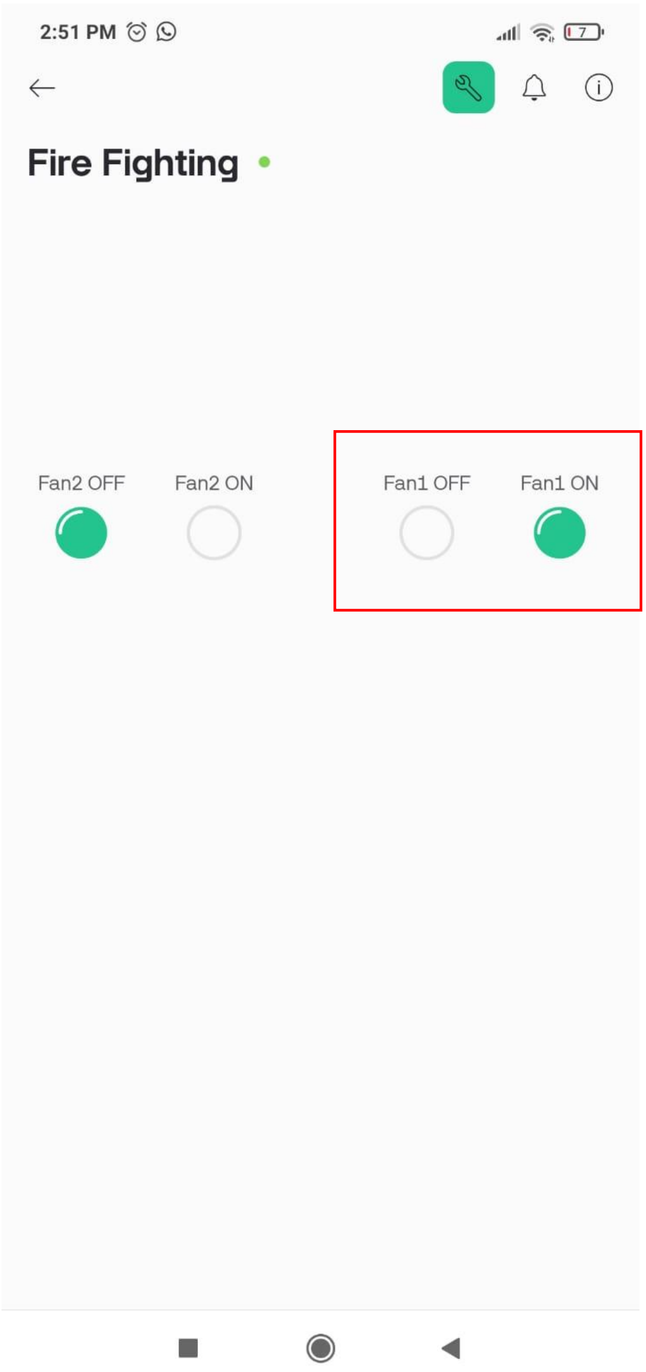

Figure 4.2 Switches the Fan's State

Figure 4.3 App Notifications for Gas Leaks

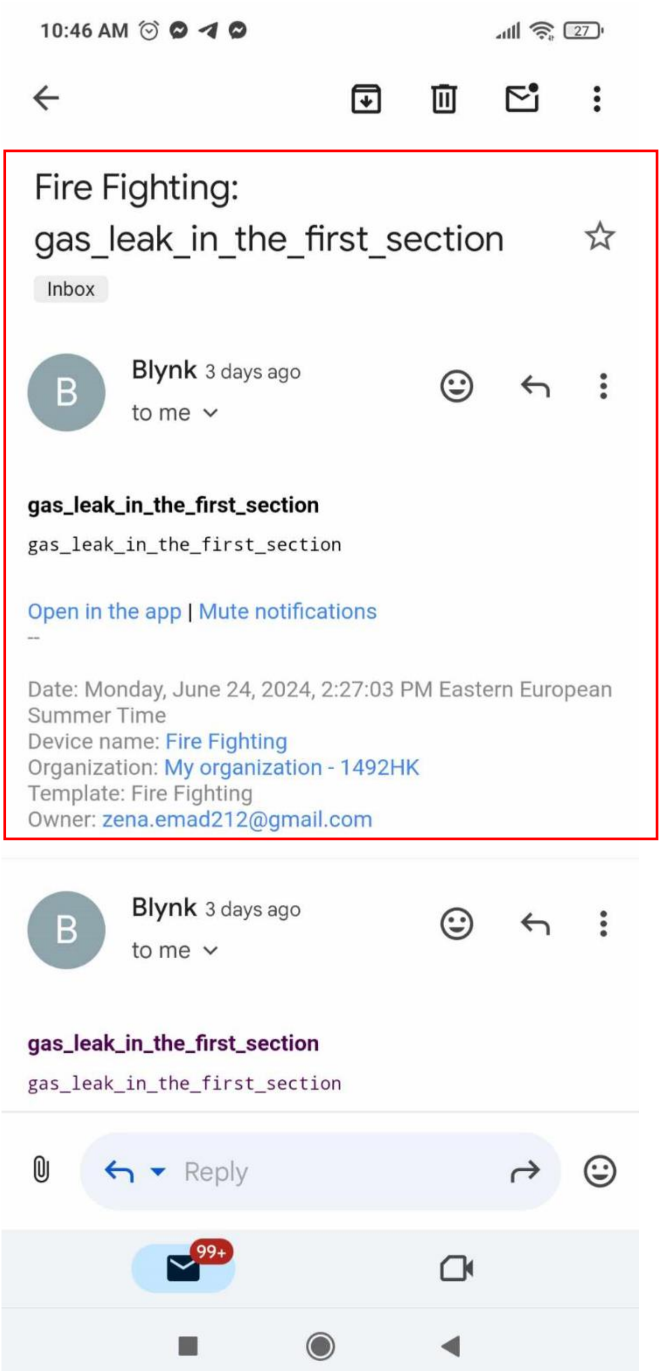

Figure 4.4 Email Notifications for Gas Leak

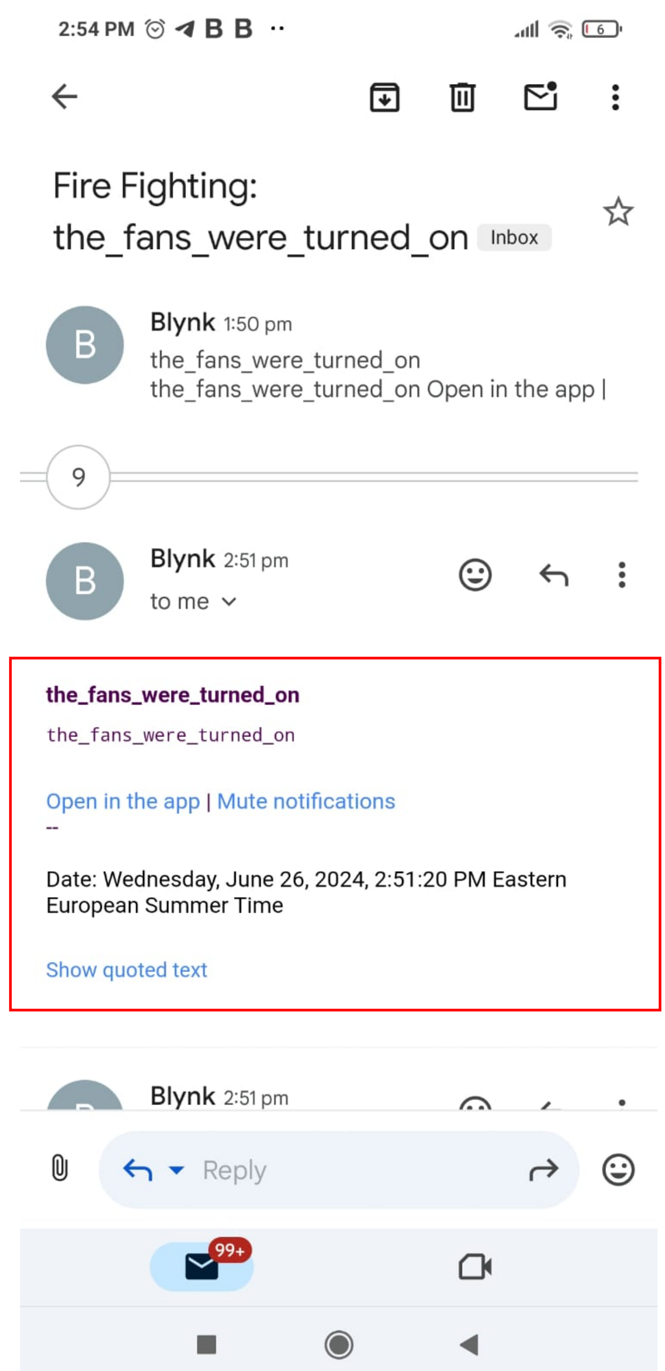

Figure 4.5 Email Notifications for Fan Activation

4.4.4 Fire Notification

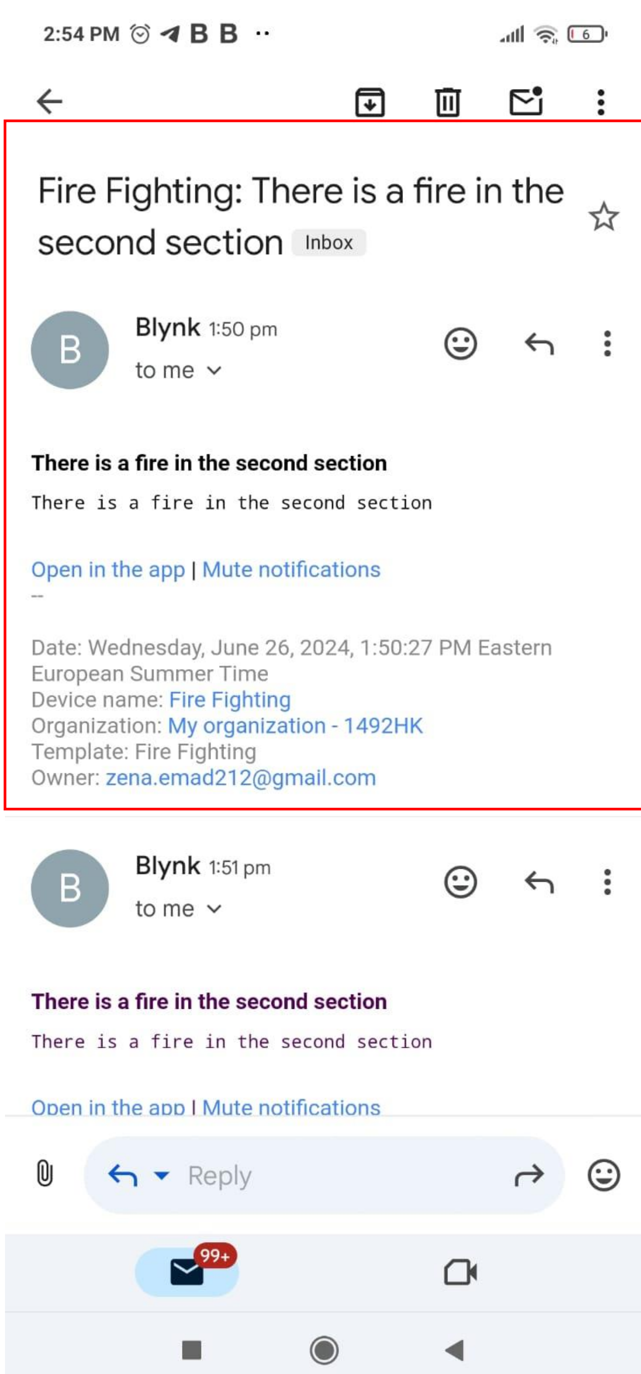

Figure 4.6 Email Notifications for Fire Emergencies

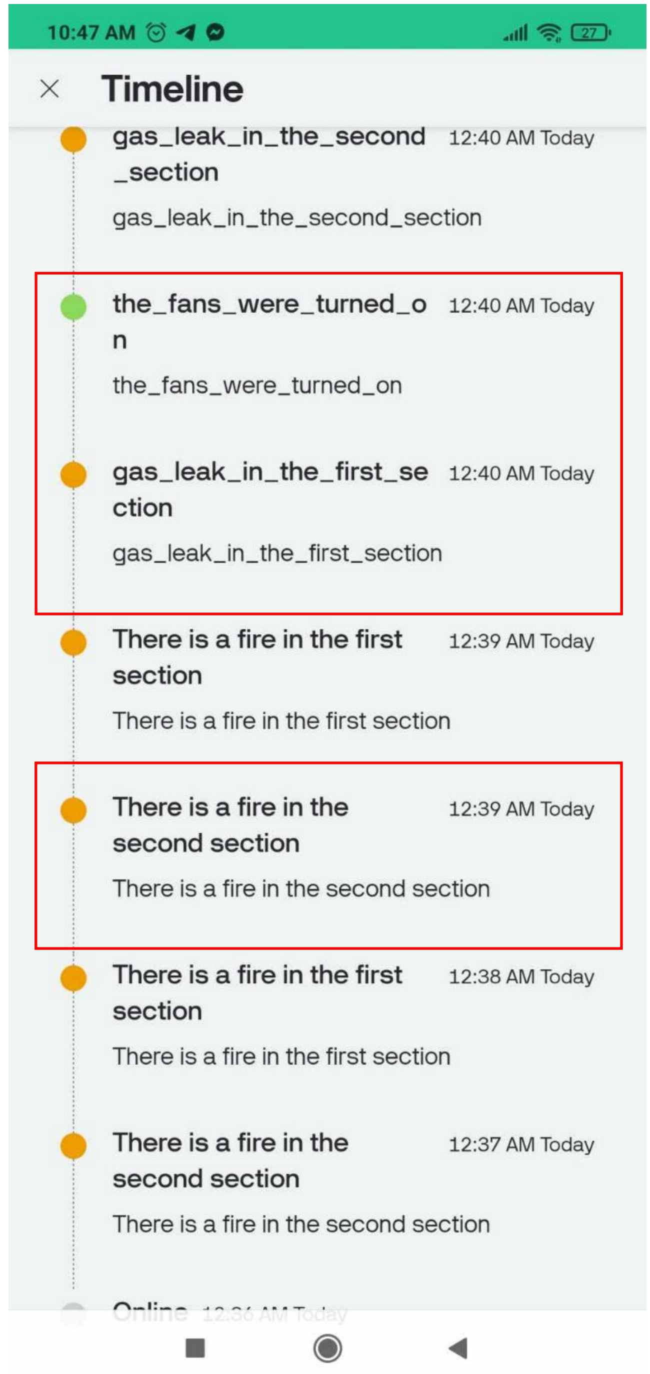

Figure 4.7 App Notifications

Chapter 5

Results and Analysis

Our system for detecting and responding to fires was made up of different parts that worked together well. Sensor data from the warehouse model and the car robot were communicated to the Blynk app by the ESP8266 microcontrollers. An Arduino Uno controlled the car robot which found its way to the fire locations accurately and extinguished them using IR flame sensors, a water pump, and a servo motor.

The MQ4 gas sensor was used in the warehouse model to effectively monitor gas levels while IR flame sensors were used for fire detection. When the extractor fan or water pump received signals from the Arduino, relays were able to switch them on and off at specific intervals which prevented overheating. To enable precise movement and obstacle avoidance of the car, DC motors were regulated by the L298N H-bridge module.

The Blynk application was used to perform an analysis of information and it detected gas leaks or fires immediately through up-to-date notices. Reliable performance was exhibited by the system as it could identify dangers and respond quickly to reduce harm.

Chapter 6

Conclusion

Through using IoT and robotics, an effective fire detection and response system was created by the project. It was found that integrating sensors, relays, and actuators which are controlled by microcontrollers and managed through a mobile application helped in monitoring and dealing with real-time fire hazards. Besides, the fact that the system can respond to fire incidents by itself after detecting them shows that it could be employed practically in ensuring industrial safety.

Recommendation

1. ***Upgrade Sensor Sensitivity***: Increase the ability of gas and fire sensors to detect small fires and gas leaks early.

2. ***Battery Management***: Longer operation times should be assured by introducing more efficient systems for monitoring batteries as well as preventing sudden power losses.

3. ***Reliable Communication***: Handle larger volumes of data between the Blynk app and ESP8266 with greater reliability under different network conditions through strengthening communication protocols.

Future Work

- ***Advanced Navigation:*** Complex terrain calls for employing advanced navigation algorithms and additional sensors that ensure accurate movement of the car robot without collision.

- ***Scalability:*** To apply it in a wide area, a system should be made more scalable hence more sensors should be integrated, and a response of be made.

- ***AI Integration:*** The artificial intelligence included should be able to predict future occurrences therefore using environmental information as a basis for judging when fire might break out.

- ***User Interface:*** Create a better user interface for the Blynk app which shows detailed analytics and control options to enhance interaction with users and manage the system well.

- ***Testing and Validation:*** The effectiveness and strength of the system need to be tested on various fields so different conditions should be put into consideration while carrying out this exercise feedback obtained from these tests will help us refine our designs accordingly.

Bibliography

- https://www.arduino.cc/reference/en
- https://docs.blynk.io
- https://www.make-it.ca/nodemcu-details-specifications/
- https://www.sparkfun.com/datasheets/Robotics/L298_H_Bridge.pdf
- https://components101.com/sensors/mq2-gas-sensor
- https://www.watelectronics.com/5v-single-channel-relay-module/
- https://protosupplies.com/product/ywrobot-breadboard-power-supply/
- https://handsontec.com/dataspecs/motor_fan/SG90-Servo.pdf