Fi-Ro: Fire Detection and Quick Response Robot using FT143 Detector, Network Mapping, and Notification System through the GSM Module and ATMEGA 2560

Glenda C. Morales, Jade B. Bermas, Dhesirie A. Aratia,
Dylan Andrei D. Gabriel, John Errol M. Mergal, Daryl Jane A. Rebito, and Niño R. Remegio
Quezon City University

Corresponding Email: mommyglendz@gmail.com, jade.bermas12@gmail.com, daryljane.rebito@gmail.com

Available Online: August 2024
Revised: June 2024
Accepted: June 2024
Received: July 2024

Volume 2 Issue 3 (2024)
DOI: 10.5281/zenodo.17066272
E-ISSN: 2984-7184
P-ISSN: 2984-7176
https://getinternational.org/research/

Abstract:

The implementation of autonomous robots for fire detection and suppression has become increasingly vital, particularly in critical infrastructures such as hospitals, where the need for efficient firefighting solutions is critical. However, many hospitals in the Philippines face challenges due to limited resources and outdated technologies. To address these issues, this study proposes an innovative solution: the Fire Detection, Alerting, and Quick Response robot system. By incorporating advanced technology such as the FT143 detector, network mapping, and GSM module with ATMEGA 2560, this system aims to provide precise fire detection, real time location identification, and efficient communication for firefighters via a web-based notification interface [1]. The primary goal is to significantly reduce response time and mitigate fire disasters, particularly in critical establishments like hospitals. The methodology involves designing and constructing a robot capable of promptly alerting responders upon fire detection and activating robot-based fire extinguishing mechanisms as a first response measure. This project represents a significant advancement in Fire Detection and Alarm System (FDAS) technology in the Philippines, offering a more integrated and technologically advanced approach to firefighting and emergency response in hospital settings. By implementing this system, the study seeks to enhance fire safety measures and improve emergency response capabilities, ultimately contributing to the protection of lives and infrastructure in the face of fire emergencies. The integration of autonomous robots in firefighting not only enhances the efficiency and effectiveness of response efforts but also addresses the challenges posed by limited resources and outdated technologies in critical infrastructures like hospitals, ensuring better protection and safety for all.

Keywords: *Fire detection, quick response, robot detector, network mapping, GSM module*

Recommended citation:
Morales, G. C., Bermas, J. B., Aratia, D. A., Gabriel, D. A. D., Mergal, J. E. M., Rebito, D. J. A., & Remegio, N. R. (2024). Fi-Ro: Fire Detection and Quick Response Robot using FT143 Detector, Network Mapping, and Notification System through the GSM Module and ATMEGA 2560. GUILD OF EDUCATORS IN TESOL INTERNATIONAL RESEARCH JOURNAL, 2(3), 20–53. https://doi.org/10.5281/zenodo.17066272

INTRODUCTION

In recent years, the implementation of autonomous robots across different fields has surged rapidly, and it plays a vital role in fire detection and suppression (Azeta et al., 2023). In the context of public safety and emergency preparedness, safeguarding human lives and vital infrastructure is a top priority. Amid the diverse array of potential emergencies that can imperil people and property, fires stand out as one of the most unpredictable and destructive threats (Liu, et al., 2018).

Firefighters play a vital role in ensuring the safety of both commercial and residential structures. In the Philippines, firefighting operations often experience prolonged durations due to limited resources and outdated technologies within the Bureau of Fire Protection (BFP) (Lagata et al., 2022). According to Kharisma (2021), there is a relationship between the time delay in evacuation and the number of injured and victims. This inadequate performance increases damage, making it essential to provide necessary fire safety in buildings.

Fire safety systems are fundamental preventative measures intended to offer building occupants immediate notice and instructions on how to escape the premises safely in the event of a fire (Perilla et al., 2018). Today's most immediate fire prevention devices are smoke detectors and prebuilt sprinkler systems. However, these kinds of systems do not provide the selective target and precision of the fire, which is why their effectiveness is minimal (Zaczek, et al., 2018.

Thus, the proponent decided to have a system, "Fi-Ro: Fire Detection and Quick Response Robot using FT143 Detector, Network Mapping, and Notification System through the GSM Module and ATMEGA 2560," that can help mitigate fire disasters. With its smoke and heat detection, utilization of Wi-Fi technology, real-time communication through a GSM module, and a website as the notification interface for firefighters, this system offers a critical lifeline in emergencies. The system represents a reliable first response by immediately putting out a fire using a multipurpose fire extinguisher and a quick notification for firefighters, which ultimately safeguards precious lives and the invaluable infrastructure of establishments.

Background of the Study

Fire alarm regulations and codes are designed to align with recognized safety standards, that consider the guidelines established by organizations such as the National Fire Protection Association (NFPA) or the International Fire Code (IFC). In the Philippine setting, the fire detection and alarm system installed in an establishment is regulated by the Bureau of Fire Protection (BFP).

Based on news published in the Philippine Information Agency this May 2023, fire incidents in the Philippines are up 40%. BFP data shows about 40% more documented fires between April 1 and April 26, 2023, than during the previous year. The BFP reports 1,332 documented fires in the country in April of this year, compared to just 953 fire incidents in April 2022 (Paunan, 2023).

Throughout the years of technological advancement, a common problem has been the prevalence of old-fashioned or traditional Fire Detection and Alarm Systems (FDAS) in various establishments, compromising the overall safety of occupants and assets. This outdated infrastructure contributes to the delayed communication between the establishment and the nearest fire station, creating a significant challenge in ensuring prompt responses to potential fire incidents. According to Kodur et al. (2019), the contributing factors include a lack of supervision and implementation of building codes, disabling or neglecting fire alarms, disregarding fire detectors, and insufficient resources allocated to maintain operational fire systems (e.g., inadequate water for sprinklers, expired fire extinguishers).

Another key issue to be addressed is the delayed response of firemen, a consequence of late communication between individuals affected by a fire and the emergency services. This delay in information exchange can have severe implications for lives and property. According to Kharisma (2021), fires that are not handled quickly cause many losses, both in the form of casualties and loss of property and life. This happens because of several factors, including the result of the delayed information obtained from the fire department or the owner's ignorance at the time of the fire, which results in the fire department's delayed arrival at the fire location (Kahanji, Walls & Cicione 2019).

Additionally, the incapacity to accurately determine the specific location of a fire within an establishment presents a problem in effective firefighting strategies. The ability to determine the accurate location of fire in an establishment depends on the type of fire detection and alarm system used in considering the establishment's size, type, and hazards. Schroll (2023) states that the most basic alarm system does not include detection. It has manual pull stations and sounds only a local alarm. This level of system is not what is typically used; it relies on an occupant to discover the fire, which can cause a significant delay. The conventional fire detection and alarm system is the most common in the Philippines. It provides a basic level of fire detection and localization; it doesn't offer precise information about the exact device that triggered the alarm (Industrial PH, 2023).

In general, fire safety is an important idea. Hospitals require more complicated fire suppression and evacuation procedures than other types of facilities in the presence of a fire, considering the possibility of multiple patients with limited mobility, staff, and outside guests (Brown, 2022). Considering this, the proponents acknowledge that fire detection and quick first response robots in the hospital are vital and decided to implement and test this capstone in Martinez Memorial Hospital. This medium-sized secondary hospital was founded in 1955 by the late general surgeon Dr. Antonio C. Martinez and his wife, Luz Agustin. It is located near the boundaries of the western Tondo district of Manila and the southwestern Maypajo district of the municipality of Caloocan Martinez Memorial Hospital (2023).

Once in the Philippines, the Philippine General Hospital (PGH) on Taft Avenue in Manila experienced a fire on its third floor that burned for about five hours on Sunday, according to the Bureau of Fire Protection (BFP). According to BFP Senior Inspector Hector Agadulin, the fire originated in the operating room' supply section on the third floor. It reached the second alarm at 12:58 a.m. and escalated to the third alarm just after 1:00 a.m. Agadulin stated that the fire was controlled around 2:46 a.m. and completely put out at roughly 5:41 a.m. The third floor of the hospital burned for about five hours and caused damages worth P300,000; the cause of the fire is still under investigation, the BFP added (Inquirer News, 2021).

Thus, to overcome these challenges, the proponents acknowledge the need for an innovative solution, integrating the advanced FT143 detector for precise fire detection, network mapping for real-time location identification, and a notification system through the GSM module and ATMEGA 2560 for more efficient communication through website as the notification interface for firemen, ultimately saving lives and preserving valuable establishments specifically hospitals.

Objectives of the Study

This capstone project aims to build and construct a Fi-Ro: Fire Detection and Quick Response Robot using the FT143 detector, network mapping, and notification system through the GSM Module and ATMEGA 2560. This is designed to alert responders quickly and activate the extinguisher as a first response once the detector senses fire inside its radius, reducing the time wasted. Specifically, it will delve into attaining the following specific objectives:

1. To design a roving robot with a microcontroller that will provide immediate response to preliminary fires.
2. To establish a one-way notification system using the GSM to send SMS notification alerts for establishment owners.
3. To establish an alerting system for the fire station.
4. To develop a website and auditory feedback module to the detector module as a notification system for firemen.
5. To assess and validate the operational efficiency of the Fi-Ro system, focusing on:

A. Functionality Testing

I. Fire Detection System

i. FT143 Detector

ii. Detector Module

II. Robot Mechanism

i. Navigation Module

ii. Fire Extinguishing Module

iii. Sensors

a. Ultrasonic Sensor

b. Digital Flame Sensor

c. Infrared Thermometer Sensor

III. Alerting System

i. Auditory Feedback Module

B. Accuracy Test

I. Sensing Capability

i. Navigation

a. Ultrasonic Sensor

b. MPU 6050

ii. Detector

iii. Digital Flame Sensor

iv. IR Thermometer Sensor

II. Communication Capability

i. Detector Module

ii. Auditory Feedback Module

iii. WiFi Module

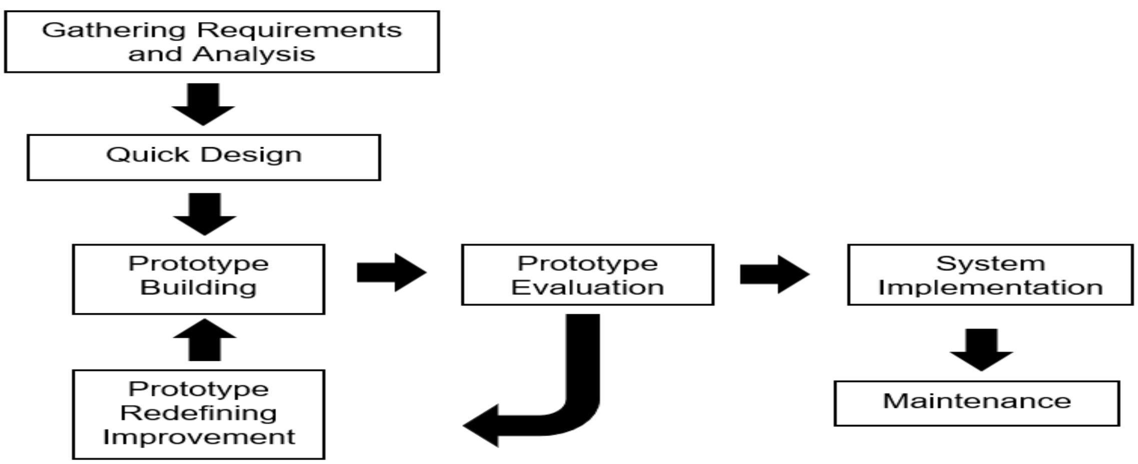
C. Portability Test
- i. Robot
- ii. Auditory Feedback Module
- iii. Website

Research Design

The researchers employed descriptive applied research to develop a comprehensive solution for our capstone project. The outcome will be a system that is quicker and more effective. The design of this system incorporates principles from the Prototyping Design Model.

Figure 3.1.

Prototyping Design Model



A. Gathering Requirements and Analysis

The researchers defined the essential data needed for crafting the prototype system. This system aims to assist the individuals and organizations identified in the significance of the study. The identification of components for the system has been completed, including specifying the required software necessitating a microcontroller with the model number ATMega2560 and its programming capabilities.

To ensure the effectiveness of the proposed system, its proponents conducted comprehensive studies on the required hardware and software, aiming to assess its efficiency. Proponents of this proposal sought information on the cost of the necessary mechanical and electronic components. The deployment of the system is planned through an interview process at Martinez Memorial Hospital in Caloocan City and Bureau of Fire Protection Firefighters, Quezon City Department.

B. Quick Design

The researchers suggested the development of a "Fi-Ro: Fire Detection and Quick Response Robot using FT143 Detector, Network Mapping, and Notification System through the GSM Module and ATMEGA 2560" to support the aging Fire Detection and Alarm System (FDAS) at Martinez Memorial Hospital in Caloocan City. The goal is to enhance the existing fire detection and alert system (FDAS) to meet current standards and incorporate new technology.

The Fi-Ro system will use the website as a notification medium for the fire department. The proponents formulated a strategy for positioning detectors and the robot within the room, aligning with the model setting's layout. The FT143's radial coverage spans 40-60 square meters, necessitating detectors to be spaced 6 meters apart. To accommodate the room's approximate length of 8.5 meters, the proponents opted for a configuration with one detector per room. The alert device’s power consumption is 312 watts per hour, while the FT143 control unit will utilize 192 watts per hour. This power distribution highlights the specific energy requirements for the overall robotic system and its central control unit.

The design phase visualized how the robot, sensor network, and communication systems would seamlessly integrate into the hospital’s infrastructure.

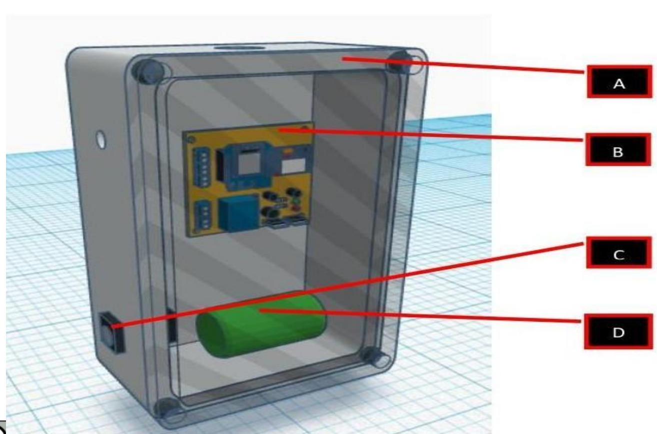
C. Prototype Building

The data acquired during the quick design phase serves as the foundation for constructing the initial prototype. This prototype functions as a test-bed model, showcasing the essential features required for the system to operate effectively. The researchers have created a prototype for a system designed to respond to fire incidents within a controlled setting, while also being capable of alerting and notifying the relevant authorities.

This functionality is crucial for minimizing the loss of lives and property. In this development stage, the focus extends beyond system functionality to include the necessary code implementation. Emphasizing the conceptual framework that the system follows, encompassing fire detection, map navigation, fire extinguishing, and notification, its ability to promptly detect and extinguish fires while simultaneously notifying authorities is of paramount importance.

Figure 3.2.

Fire Detection System where the fire detectors are connected.



A - Fire Detection System Plastic Enclosure

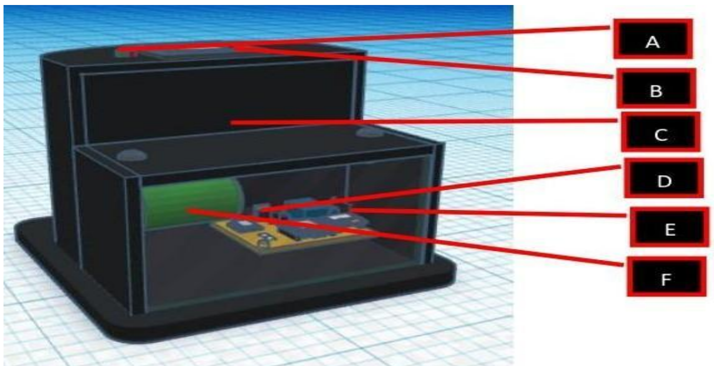
B - Fire Detection System PCB

C - DC Female Socket

D - Li Ion Battery

Figure 3.3.

Alerting System that will be installed in the Fire Station.



A - Indicator LED Lights

B - Speaker

C - Alerting System PVC Enclosure

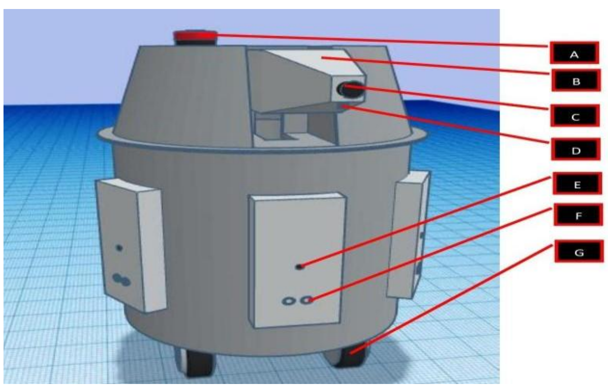
D - Alerting System PCB

E - ON/OFF Switch

F - Li Ion Battery

Figure 3.4 and 3.5.

The Fi-Robot parts



A - Siren Sound ALarm

B - Discharge Hose Handle

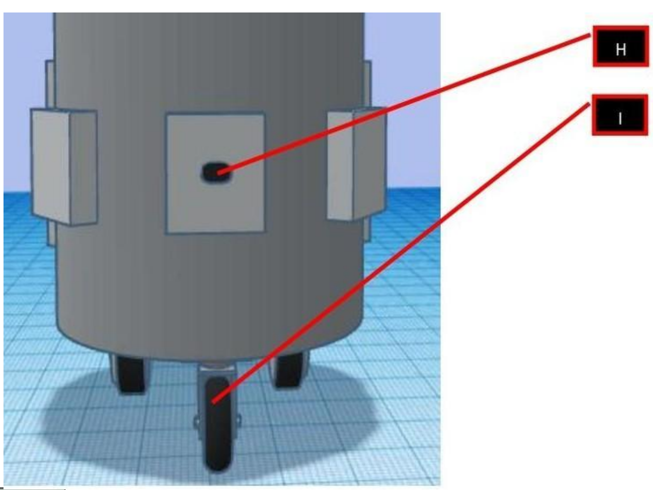
C - Fire Extinguisher Nozzle

D - IR Thermometer

E - Digital Flame Sensor

F - Ultrasonic Sensor

G - Hub Motor



H - Contact Charger Point

I - Cart Wheel

D. Prototype Evaluation

The developers have selected the participants for the system assessment, specifically involving Quezon City University's electronics engineering faculties to act as the authority (fire department) of our capstone project. The next step involves presenting the prototype in the designated model setting, and the assessment results will be carefully analyzed to identify the strengths and limitations of the prototype. Additionally, the researchers will actively gather feedback and suggestions from the participants and experts regarding the configuration of the model to facilitate further refinement of the prototype. The assessment findings will play a crucial role in determining whether there is a necessity for additional functionality to be incorporated into the built prototype.

E. Redefining Improvements

If the system's performance does not meet expectations, it becomes the responsibility of the researchers to make necessary modifications. The outcomes of the initial tests hold significant value in the long term, as they contribute to the ongoing improvement of the system. Extensive testing is essential to uncover methods for enhancing the system's effectiveness. Once the participants and experts who took part in the survey expressed satisfaction with its performance after a thorough testing phase, it is now time to proceed with the development of the final product. If the participants and future users' express satisfaction with the service, the testing of the system will commence after thoroughly examining and enhancing the specifications. This phase is crucial as testing and evaluations precede the placement of the prototype in the model setting, which takes place during the implementation phase. At this stage, further upgrades become evident as the system is used more consistently, and testing involves multiple trials. Over time, discussions will be conducted based on observations and testing outcomes. Functional testing is imperative for every component, including actuators, sensors, and microcontrollers. The prototype is slated to be implemented at Martinez Memorial Hospital in Caloocan City to ascertain the system's performance alignment with expectations, particularly its features such as fire detection, fire extinguishing, and notification functions, testing will be conducted within the prototype. The primary objective is to minimize damage resulting from fire-related incidents.

F. Testing Procedures

The prototype endeavors to achieve five primary objectives, each a vital milestone in its quest for operational efficiency. Firstly, it seeks to design a mobile robot equipped with a microcontroller, primed to swiftly respond to fires within the hospital's confines. Secondly, it aims to establish a digital platform comprising a website and an alerting device, intricately connected to the slave board of the FT143 detector, facilitating rapid notification of firefighters. Thirdly, it endeavors to create a unidirectional communication system utilizing GSM technology, enabling prompt SMS alerts to the hospital owner, detailing the fire's location. Fourthly, it strives to integrate an FT143 detector capable of detecting both smoke and heat, enhancing the system's fire detection capabilities. Lastly, it commits to rigorous testing and validation processes to ensure the operational efficacy of the Fi-Ro system, a critical step in its journey towards deployment. The proponents also set up a fixed environment for testing, where in, the starting location of the robot which is its charging station is denoted as *point A* and the location of the multisensor detector is denoted as *point B*. With this, the robot's ability to navigate and accurately extinguish a fire can be tested meticulously. Point

A to point B is designed to be 1 meter apart.

The prototype meticulously calculates the lifespan of its battery, a crucial element in sustaining its operations. Through the equation:

$H = PL/P \times 60 \times 6$ where H represents the battery's life in hours,

PL symbolizes the battery's capacity in watt-hours (Wh), and P denotes the power consumption in watts (W), the prototype unveils the secrets of its endurance. With a voltage input of 36 volts and a capacity of 9800mAh, the prototype's battery boasts a capacity of 432.8918 watt-hours (Wh). This computation yields a battery life of 48 minutes and 53 seconds, a testament to its resilience in the face of operational demands.

G. Implementation

The proposed system, named the "Fire Detection and Quick Response Robot using Multisensor Detector, Network Mapping, and Notification System Through the GSM Module and ATMega2560," is slated for delivery to the primary respondent, namely Martinez Memorial Hospital.

The Fi-Ro system is deployed in the unused room on the third floor of Martinez Memorial Hospital.

Figure 3.6.

Panoramic Shot of the Proposed Room

The robot will be placed on the third-floor hallway of the hospital. The proponents will put the robot near a power outlet. The device receiving the notification will likely occur in the fire department near the Martinez Memorial Hospital through a website. It will be alarmed by a sound triggered by the Fi-Ro system.

This collaborative approach ensured that the Fi-Ro system seamlessly became integral to Martinez Memorial Hospital's emergency response capabilities.

Implementation Plan

The proposed system named the "Fire Detection and Quick Response Robot using Multisensor Detector, Network Mapping, and Notification System Through the GSM Module and ATMEGA2560," will be initiated with an electrical power source of 36V lithium-ion battery for the Fi-Robot, 12V supply for the fire detector system and alerting system, both have a 12V battery as backup, and another 12V for the linear actuator in the fire extinguishing module.

Table 3.1.

Proponents' Implementation Plan

STRATEGY	ACTIVITIES	PERSON INVOLVE	DURATION
Approval of experts and authorities for testing	Evaluation and survey distribution	Proponents, Capstone Adviser, and MMH Admins	1 day
Setting up the proposed system	Installation of the prototype with complete modules	Proponents and MMH Admins	1 day
Information distribution	Demonstration on how to operate the Fi-Ro system.	MMH (Beneficiary) and Proponents	1 day

H. Maintenance

The maintenance phase commenced post-deployment, emphasizing continuous monitoring, updates, and optimizations. Certain elements, such as the fire extinguisher and system update (software and hardware), need regular checks. Such as fire extinguishers that need to be inspected at least once a month to ensure the pressure is at the recommended level, the pin or the seal is intact, and verify that there are no leaks, dents, rust, or chemical deposits. Likewise, to maintain optimal efficiency and effectiveness, robots might require periodic system updates. The frequency of these updates is contingent upon factors such as the intended purpose of the researcher or the establishment itself.

Representatives from the model setting at Martinez Memorial Hospital remained engaged in this phase, providing on-the-ground insights and feedback. This collaborative maintenance approach ensured the Fi-Ro system's sustained reliability and relevance in enhancing the establishments' fire safety and security.

Description of Respondents

The respondents were Firefighter, Electronics Engineers who would test and evaluate the study's functionality, accuracy, and portability. The proponents involved at least one (1) establishment owner (the beneficiary), one (1) firefighter/s provided by the Bureau of Fire Protection Quezon City Department and one (1) Engineer from Quezon City that is knowledgeable about wireless connections and microcontrollers in electronics projects. These were the respondents that the proponents gathered because of the background and knowledge that they could provide for this capstone project.

Instrumentation and Validation

This study used an interview, ocular visit, and observation as the main data-gathering instrument. The testing will take place in different locations to also test its mobility. The main testing site will be conducted in a vacant room of a resort and will be observed and analyzed by the proponents with its set up premises. Upon finishing the system, the proponents would ask professors and technical advisers for verbal feedback to better the project, which will be used to evaluate the whole system of "Fi-Ro: Fire Detection and Quick Response Robot using FT143 Detector, Network Mapping, and Notification System through the GSM Module and ATMEGA2560."

After doing the simulation trials and testing, the proponent asked the respondents for comments and suggestions/recommendations for the proposed capstone.

Data Gathering

The proponents conducted a site visit to Martinez Memorial Hospital commencing with a reception where the proponents presented a letter of approval from our adviser. Subsequently, the proponents were directed to engage with the Hospital Administration, and upon their guidance, proponents were given a brief history of the hospital's background. The said Hospital Admin gave the proponents a tour of the whole third level of the building where the capstone project will be installed and for the whole course of testing and trials. During this visit, proponents interviewed the safety personnel, inquiring about various aspects of Martinez Memorial Hospital.

The proponents also have the opportunity to go to the Bureau of Fire Department Quezon City Hall branch to interview a firefighter. The researchers gathered information about fire safety, usage of a fire extinguisher, parameters of fire intensity, and insights for the capstone project that will be created by the team of the student researchers. The proponents gave the interviewee a copy of questions that were asked during the recorded interview held in their office.

Software Requirements

For the software requirements in developing the "Fi-Ro: Fire Detection and Quick Response Robot using FT143 Detector, Network Mapping, and Notification System through the GSM Module and ATMega2560", the proponents will rely on a suite of essential programs. The Arduino IDE will serve as the primary programming environment for the ATMega2560 microcontrollers, utilizing C++ as the primary language for the robot. Additionally, Tinkercad will be employed for virtual hardware prototyping and designing the Fi-Ro. At the same time, AutoCAD will facilitate detailed and precise floor layouts and detector positioning in the project's model setting.

Table 3.3.

Comparison of Software for Primary Programming Environments

Software	Arduino IDE	Platform IO	Visual Micro
Price	Free and open source.	Free and open source.	Free (limited features) or paid version for extended features.
Platform Supported	Windows, macOS, and Linux.	Windows, macOS, Linux.	Windows.
Audience	Beginner to intermediate users.	Intermediate to advanced users.	Beginner to advanced users.

Support	Large and active community support.	Active community support and extensive documentation.	Responsive community support.
Training	Abundant online resources, tutorials, and official documentation.	Comprehensive online help, tutorials, and documentation.	Documentation and tutorials are available, especially integrated with Visual Studio.
Category	Integrated Development Environment (IDE) designed explicitly for Arduino development.	Cross-platform IDE for IoT development with support for various platforms beyond Arduino.	Visual Studio extension designed for Arduino development.

When evaluating Arduino IDE, PlatformIO, and Visual Micro for developing the Fi-Ro: Fire Detection and Quick Response Robot, Arduino IDE emerges as the optimal choice. Its user-friendly interface, extensive community support, and a wealth of online resources make it well-suited for beginners and intermediate users, aligning perfectly with the complexity of projects like Fi-Ro. Arduino IDE provides a solid foundation for microcontroller programming and the essential features necessary for building sophisticated applications such as the Fi-Ro system. Its seamless integration with the required components, including Multi-sensor Detectors, Network Mapping, GSM Module, and ATMega2560, ensures a smooth and efficient development process. Given these factors, Arduino IDE is the preferred platform for realizing the Fi-Ro project in hospital environments, offering a robust and accessible framework for innovative and impactful applications.

Visual Studio as Text Editor for Web Portal Development

Table 3.4.

Comparison of Software as Text Editors for Web Portal Development

Software	**Visual Studio**	**Apache Netbeans**	**DVT Eclipse IDE**
Price	Free Community edition, with paid Professional and Enterprise editions offering additional features.	Free and open-source.	Free and open-source.
Platform Supported	Windows, macOS (limited), and Linux (through Visual Studio Code).	Windows, macOS, Linux.	Windows, macOS, Linux.
Audience	Broad range, suitable for multiple programming languages and application types, including .NET, C++, C#, Python, and more.	Java developers support multiple languages.	Java developers, but supports various languages with plugins.

Support	Strong community support, official documentation, and Microsoft support for paid editions.	Active community support.	Active community support and a wide range of plugins.
Training	Comprehensive online resources, tutorials, and courses are available.	Documentation and tutorials are available.	Extensive online resources and documentation.
Category	General-purpose integrated development environment with many features, extensions, and language support.	General-purpose IDE with a focus on Java.	General-purpose IDE with strong Java support.

Considering the specific requirements for developing the Fi-Ro: Fire Detection and Quick Response Robot, Visual Studio stands out as the preferred choice. With its comprehensive features and extensive language support, Visual Studio provides a robust development environment suitable for creating intricate systems like Fi-Ro. Its compatibility with various programming languages, including those required for Multi-sensor Detector integration, Network Mapping, and the Notification System through the GSM Module and ATMega2560, makes it a versatile tool for this particular project. The availability of a free Community edition ensures accessibility to a broad audience, while its strong community support, official documentation, and Microsoft backing contribute to its reliability. For the intricate and diverse needs of Fi-Ro's development, Visual Studio's capabilities position it as the optimal choice for creating a sophisticated Fire Detection and Response Robot tailored for hospital environments.

Mapping algorithms

Mapping algorithms play a crucial role in our system by enabling accurate and efficient spatial analysis, allowing the robot to navigate its environment and understand its surroundings. These algorithms process data from sensors like ultrasonic, flame, and accelerometer sensors to create real-time maps of the robot's operational area. This mapping capability is essential for effective obstacle avoidance, precise object tracking, and optimized navigation, ultimately allowing the robot to respond to fire incidents quickly and safely.

MATLAB software

MATLAB software complements our system by providing powerful tools for algorithm development, simulation, and data analysis. Its extensive libraries and pre-built functions allow the proponents to prototype and test mapping algorithms efficiently, ensuring they meet the system's requirements. MATLAB's visualization capabilities also aid in interpreting data and assessing the robot's performance during different scenarios. By leveraging MATLAB, the proponents can streamline the development and optimization of mapping algorithms, enhancing the overall functionality and reliability of our system.

Modified Dijkstra's Algorithm

A pathfinding algorithm is a crucial technique in computer science and artificial intelligence, employed to determine the most efficient route between two points within a graph or grid. This methodology finds widespread application in diverse fields such as robotics, video games, and network routing. The primary objective is to seamlessly traverse a network comprising nodes and edges, ultimately reaching a destination while minimizing a designated cost or distance metric.

Modified Dijkstra's Algorithm stands out as a prominent pathfinding algorithm in this realm. Its fundamental purpose is to uncover the shortest path between two nodes in a graph. The algorithm achieves this by meticulously exploring all conceivable paths within the graph and then singling out the one characterized by the minimum total cost. This approach proves invaluable in scenarios where finding the optimal path is crucial, be it in robotic navigation, game character movement, or routing data across a network.

Within the context of Modified Dijkstra's Algorithm, the two critical nodes are the Starting node and the Target node. The Starting node is endowed with initial values of zero in all pertinent parameters, including G-value, H-value, and Angle. On the other hand, the Target node assumes non-zero values for H-value (equivalent to G-value) and Angle, with these values typically derived from a transceiver module. It's essential to note that all intervening nodes between the Starting and Target nodes possess unknown values.

In essence, Modified Dijkstra's Algorithm operates as a navigational guide through the intricacies of a graph, diligently calculating and selecting the most efficient path while considering the associated costs. This methodology, with its roots in graph theory, plays a pivotal role in enabling intelligent decision-making processes in various technological applications.

PlatformIO

PlatformIO is a versatile, cross-platform development environment that streamlines the process of building, testing, and deploying firmware for a wide range of microcontrollers and embedded systems. Its intuitive interface and comprehensive library of supported frameworks, boards, and sensors make it an excellent choice for developers of all skill levels. PlatformIO's integration with popular code editors like Visual Studio Code provides a seamless experience for coding, debugging, and managing projects.

In our system, PlatformIO offers a unified environment to develop and manage firmware for various microcontroller boards, including the Wemos D1 Mini. Its automated library management ensures that the proponents have access to the latest libraries and dependencies, simplifying the process of incorporating new hardware and features into our system. PlatformIO's robust build system and support for continuous integration help the proponents maintain efficient workflows, ensuring code quality and consistency across different components. Overall, PlatformIO's ease of use, extensive support, and advanced features make it an indispensable tool for our development process.

AutoCAD and Tinkercad

Table 3.5.

Comparison of Different Software for Creating 3D Model

Software	**AutoCAD**	**Tinkercad**	**FreeCAD**
Price	Commercial software with a paid license.	Free, web-based platform with some premium features.	Free and open-source.
Platform Supported	Windows, macOS.	Web-based, accessible from	Windows, macOS, Linux.

		browsers.	
Audience	Professional engineers, architects, and designers require precise 2D and 3D drafting.	Beginners and hobbyists interested in easy-to-use 3D modeling and design.	Users seeking a parametric 3D CAD modeler with an open-source approach.
Support	Comprehensive support from Autodesk, extensive community forums, and official documentation.	User-friendly interface with online support, tutorials, and a community forum.	Community-driven support, forums, and documentation.
Training	Various online and offline training resources, including tutorials and courses.	Well-suited for beginners with an intuitive learning curve and guided tutorials.	The learning curve for beginners, but extensive documentation and online resources are available.
Category	Professional-grade CAD software for detailed design and drafting.	Entry-level 3D modeling software, suitable for basic designs and educational purposes.	Open-source parametric 3D CAD software for a range of applications.

The choice of AutoCAD, Tinkercad, and FreeCAD for the Fi-Ro project depends on the specific requirements. Tinkercad's user-friendly interface and accessibility make it ideal for basic 3D modeling, especially in educational settings or for those new to CAD. AutoCAD, with its precision and comprehensive features, is crucial for more detailed and intricate aspects of the Fi-Ro design, ensuring accuracy in the robot's components. While FreeCAD is a viable open-source option, the preference for Tinkercad and AutoCAD stems from the balance they strike between simplicity and precision, meeting both the educational and technical demands of the Fi-Ro: Fire Detection and Quick Response Robot project.

Hardware Requirements

The proponents will design two modules and one circuit board: *Fire Detection System*, consisting of fire detectors, Sim800L, and Wemos d1 mini; *Alerting System*, consisting of Wemos d1 mini, Sim800L, and DF player; and a *circuit board inside the robot* where ultrasonics, IR sensor, IR Thermometer, hub motor, wifi module, and Atmega 2560 are all connected.

ATMega2560

The ATMega2560 aligns seamlessly with the project's IoT requirements, offering extensive GPIO connectivity. Its moderate processing power is well-suited for the specific demands of the Fi-Ro system, which involves real-time data processing and object tracking. With ample I/O pins and support for the Arduino IDE, the Arduino Mega combines versatility with ease of programming, making it an optimal choice for the Fi-Ro project's hardware. The ATMega2560's cost-effectiveness and growing community support further enhance its appeal, ensuring a well-supported and efficient development process.

Table 3.6.

Comparison of Microcontroller

Microcontroller	ATMega2560	Raspberry Pi	ESP32
Purpose and Use	Caters to projects demanding extensive I/O pins, memory, and processing capabilities beyond standard Arduinos.	Suitable for projects requiring more computing power, such as multimedia applications, servers, and desktop-like tasks.	Designed for IoT applications with built-in Wi-Fi and Bluetooth capabilities.
Processing Power	Running at 16 MHz, while the ESP32 features a dual-core microcontroller running at up to 240 MHz.	It offers processing power, making it capable of running an entire operating system.	Moderate processing power suits IoT applications and wireless communication tasks.
I/O Pins and Hardware Interfacing	Offers more I/O pins compared to the ESP32. The Mega has 54 digital I/O pins and 16 analog input pins, whereas the ESP32 has 34 GPIO pins.	Provides GPIO pins for hardware interfacing. Capable of interfacing with a wide range of peripherals.	Offers a variety of digital and analog pins along with built-in Wi-Fi and Bluetooth.
Connectivity	Limited built-in connectivity options. Can be extended using shields or modules.	Comes with built-in Ethernet and USB ports. Can connect to the internet and other devices directly.	Built-in Wi-Fi and Bluetooth capabilities. Ideal for wireless communication.
Programming Environment	Uses the Arduino IDE for programming. Known for its simplicity and ease of use.	It can be programmed using a variety of languages, including Python and C++. Offers a more traditional computing environment.	This can be programmed using the Arduino IDE or other platforms like PlatformIO. Suitable for users familiar with Arduino development.
Cost	Generally lower cost compared to Raspberry Pi.	Slightly higher cost due to its increased capabilities.	Cost-effective, especially considering its wireless capabilities and a

	The wide availability of affordable boards.	Still regarded as affordable for the features it offers.	reasonable price point.
Community and Support	Large and active community with extensive documentation. Wide range of libraries and contributed by community resources.	Large community with official support from the Raspberry Pi Foundation. Extensive documentation and third-party resources.	the growing community with active forums and support. Adequate documentation and resources for ESP32 development.

Wemos D1 Mini

The Wemos D1 Mini is a compact and affordable microcontroller board based on the ESP8266 chip, featuring built-in Wi-Fi capabilities. Its small size and versatility make it a popular choice for IoT projects where space is limited and wireless connectivity is essential. The board is easily programmable using the Arduino IDE, which simplifies the development process for users familiar with the platform. It provides an ample number of GPIO pins for interfacing with sensors, actuators, and other devices.

In our system, the Wemos D1 Mini serves as a central hub for managing data from various sensors and controlling actuators, all while communicating wirelessly. This allows our system to operate efficiently and effectively, streamlining the process of data collection, processing, and transmission. Its Wi-Fi capabilities enable seamless connectivity with the cloud and other networked devices, ensuring real-time updates and control for our application. Additionally, its cost-effectiveness and strong community support make the Wemos D1 Mini a reliable and accessible choice for our system.

Table 3.7.

Comparison of Wemos D1 mini

Factors	Wemos D1 Mini	Arduino Nano 33 IoT	ESP8266
Microcontroller	Based on the ESP8266 microcontroller	Features the Arm Cortex-M0+ processor, offering higher performance compared to 8-bit	Based on the ESP8266 microcontroller.

		microcontrollers.	
Connectivity	Integrated Wi-Fi capabilities, allowing easy connection to wireless networks and the internet.	Integrated Wi-Fi and Bluetooth Low Energy (BLE) capabilities.	Integrated Wi-Fi capabilities, similar to the Wemos D1 Mini.
Form Factor	Compact and small form factor, making it easy to integrate into projects with limited space.	Compact, similar in size to the classic Arduino Nano, making it suitable for smaller projects.	Larger than the Wemos D1 Mini, but still relatively compact.
GPIO Pins	Around 11 digital pins and 1 analog pin, suitable for basic to moderate projects. Programming Environment: Can be programmed using the Arduino IDE or other ESP8266 compatible IDEs.	Offers a variety of digital, analog, and PWM pins, with up to 14 digital I/O pins and 8 analog input pins.	Around 11 digital pins and 1 analog pin, similar to the Wemos D1 Mini.
Programming Environment	Can be programmed using the Arduino IDE or other ESP8266 compatible IDEs.	Uses the Arduino IDE, making it familiar to existing Arduino users.	Can be programmed using the Arduino IDE or other ESP8266 compatible IDEs.
Power	Typically operates at 3.3V, with a 5V input option available	Operates at 3.3V, with a 5V input option.	Typically operates at 3.3V, with a 5V input option available.
Cost	Generally affordable, providing a good balance between cost and capabilities.	Slightly more expensive than traditional Arduino boards due to the additional features.	Generally low-cost, making it an attractive option for budget projects.
Community and Support	Strong community and resources for ESP8266-based development.	Large and active community, with extensive resources available for development.	Strong community support, with a wealth of libraries and resources available for ESP8266-based development.

The Wemos D1 Mini is a great choice for IoT projects due to its integrated Wi-Fi capabilities, compact form factor, and affordability. It offers easy programming compatibility with the Arduino IDE, providing a smooth development process for users familiar with Arduino. With a strong community and abundant resources available, the board allows for efficient troubleshooting and guidance. Its sufficient number of GPIO pins, low power consumption, and user-friendly design make it ideal for projects with space and budget constraints. Overall, the Wemos D1 Mini strikes an excellent balance between cost and capabilities, making it a versatile option for a variety of applications.

Table 3.8.

Comparison of Accelerometer

Specifications	**MPU6050**	**ADXL**	**BNO**	**LSM**
Voltage	3.3v to 5v	2.0V to 3.6V	2.4V to 3.6V	2.16V to 3.6V
Power Consumption	<100µA	23 µA	155 µA	100 µA
Temperature Sensitivity	-40 to 85°C	-40 to 85°C	-40 to 85°C	-40 to 85°C
Type of Acceleration	Linear & Rotational	Linear	Linear, Rotational & Gravitational	Linear & Gravitational
Cost	₱80-150	₱90-200	₱1600-2500	₱700-800
Application	motion sensing, gesture recognition, orientation tracking and wearable devices	motion and tilt-sensing applications, Mobile devices, Gaming systems, and Disk drive protection	AR & VR systems, Robotics and drones, and Wearable Devices	GPS Navigation, Industrial Equipment, Compass and tilt-compensated

When evaluating accelerometers for the Fi-Ro: Fire Detection and Quick Response Robot project, the proponents considered several options, including MPU, ADXL, BNO, and LSM series. The MPU6050, chosen for its compatibility with the ATMEGA2560, offers a combination of gyroscope and accelerometer functionalities, providing precise motion sensing capabilities critical for Fi-Ro's object tracking and fire detection features. While the ADXL series by Analog Devices emphasizes low power consumption, the BNO series by Bosch Sensortec integrates additional sensors like magnetometers for more comprehensive orientation data. The LSM series, produced by STMicroelectronics, provides versatile sensor combinations. Ultimately, the MPU6050 stood out due to its proven reliability, extensive community support, and compatibility with the ATMEGA2560, making it the optimal choice for the Fi-Ro robot's accelerometer requirements.

BLDC Motor

The Brushless Direct Current (BLDC) Motor is the powerhouse for the Fi-Ro robot's mobility. Compared to its counterpart, the brushed DC motor, the BLDC motor offers higher efficiency, reduced maintenance, and improved control. These advantages make it the ideal choice for applications requiring smooth and responsive movement. The Fi-Ro system leverages the BLDC motor's capabilities to ensure the robot can navigate environments swiftly and responsively, enhancing its overall mobility and contributing to the system's effectiveness in responding to fire incidents.

BLDC Motor Driver (zs-x11h)

The BLDC Motor Driver (zs-x11h) is a critical component that complements the BLDC motor, providing the necessary control and power management. Its counterpart, the L298N motor driver, lacks the same level of efficiency and precision. The zs-x11h was chosen for its capability to handle the specific requirements of the Fi-Ro robot's propulsion system. Its advanced features, including current limiting and protection mechanisms, make it a reliable choice for ensuring the BLDC motor operates optimally, aligning perfectly with the system's need for responsive and controlled movement.

Extinguishing Module

The extinguishing module is a critical hardware component designed to quickly and effectively respond to fire incidents. It consists of a fire extinguisher attached to the robot, equipped with two linear motors for precise control. One the immediate release of the extinguishing agent when a fire is detected. The other linear motor manages the aiming of the nozzle, allowing the system to target flames accurately. This dual-motor setup provides the robot with the capability to rapidly deploy the extinguishing agent and control its distribution, linear motor is responsible for pressing the lever of the fire extinguisher, ensuring enhancing the system's effectiveness in containing and extinguishing fires.

Wi-Fi module

A Wi-Fi module is an essential hardware component that enables wireless connectivity for the system, allowing it to communicate with other devices and networks over Wi-Fi. This module facilitates real-time data transmission and reception, enabling the robot to receive updates and commands remotely and send alerts and data back to the central control system. The Wi-Fi module enhances the system's efficiency by enabling remote monitoring and control, as well as seamless integration with cloud-based platforms for data storage and analysis. Its ability to establish wireless connections also supports remote diagnostics and software updates, making it a crucial part of the system's overall functionality.

Linear Motor

The linear motor in our system plays a role in squeezing the lever of the fire extinguisher. It enables precise and controlled movement, ensuring an efficient first response to fire incidents by facilitating the rapid deployment of the extinguishing agent.

Digital Flame Sensor (SEN-014)

The Digital Flame Sensor (SEN-014) is another vital component contributing to the Fi-Ro system's fire detection capabilities. This sensor provides discrete digital signals, making it adept at detecting the presence of flames. It is a counterpart to the Analog Flame Sensor (KY026) and was chosen for specific scenarios where discrete binary signals are preferred. The selection of the MLE00572 sensor highlights the system's adaptability, allowing it to employ different flame sensors based on specific requirements. The use of this digital flame sensor aligns with the project's emphasis on versatility, ensuring that the Fi-Ro robot can effectively respond to various fire scenarios with precision and reliability.

Ultrasonic Sensor (HC-SR04)

The Ultrasonic Sensor (HC-SR04) is a critical component in the Fi-Ro system, contributing to the robot's ability to detect obstacles and measure distances. Its counterpart, infrared sensors, may lack the same reliability and precision in certain environmental conditions. The HC-SR04 sensor uses ultrasonic waves to gauge object proximity, ensuring the robot can navigate its environment safely and respond effectively to fire incidents. This choice aligns with the project's emphasis on obstacle avoidance, providing the Fi-Ro robot with the capabilities to move dynamically and respond to potential hazards.

SanDisk Ultra (HC-I)

The SanDisk Ultra (HC-I) microSD card is a high-capacity and high-performance storage solution, serving as a vital data storage component in the Fi-Ro system. Its counterpart, standard microSD cards with lower performance, may not meet the system's demand for efficient data storage and retrieval. The SanDisk Ultra microSD card was selected to ensure the Fi-Robot can easily access essential data. Its high capacity and fast read/write speeds enhance the system's overall performance, supporting the logging of critical information related to fire incidents and contributing to post-incident analysis and optimization.

Buzzer

In the "Fi-Ro: Fire Detection and Quick Response Robot" project, a buzzer plays a crucial role in providing auditory feedback. This component can alert individuals in the vicinity of fire incidents or system malfunctions, improving robot's ability to communicate critical information effectively. With the ability to generate clear and immediate sounds, the buzzer ensures that people can quickly become aware of the robot's activities and any potential dangers.

DF Player

The DF-Player is integrated into the "Fi-Ro: Fire Detection and Quick Response Robot" project to expand the system's auditory capabilities. This component allows the robot to play custom sounds or voice messages, which can significantly enhance its ability to alert people in various situations. By supporting different audio formats, the DF-Player contributes to the robot's adaptability and effectiveness in communicating critical alerts and instructions.

SIM800L

The SIM800L module brings advanced communication capabilities to the "Fi-Ro: Fire Detection and Quick Response Robot" project through GSM/GPRS technology. This versatile module enables the robot to send real-time notifications to designated contacts, facilitating remote monitoring and timely responses. It supports both voice and data communication, allowing the robot to effectively transmit alerts and receive commands from remote operators. The inclusion of the SIM800L module strengthens the Fi-Ro system's communication network and overall effectiveness in fire detection and response scenarios.

ATMEGA2560 Microcontroller

Table 3.9.

Specification of ATMEGA2560

Arduino Mega		
Components	**Specifications**	**Description**

Processors	CPU: 8-bit AVR microcontroller, operates at a clock speed of 16 MHz	The Arduino Mega is a high-performance microcontroller board designed for complex projects and applications. It features an 8-bit AVR microcontroller clocked at 16 MHz, providing up to 16 MIPS throughput. With 256 KB of flash memory, 8 KB of SRAM, and 4 KB of EEPROM, it offers ample storage for program code and data. The board includes 32 general-purpose working registers and a real-time counter with a separate oscillator for precise timing. In terms of connectivity, the Arduino Mega boasts four 8-bit PWM channels and four programmable serial USART ports, along with a controller/peripheral SPI serial interface. This allows seamless integration with a wide range of sensors, displays, and communication modules. The board operates at 5V and can handle a maximum current of 200mA, with GPIO pins capable of sourcing or sinking up to 20mA of current.
Memory	Flash Memory:256 kilobytes SRAM: 8 kilobytes EEPROM: 4 kilobytes	
Peripheral interfaces	Up to 16 MIPS Throughput at 16MHz 256k bytes (of which 8k is used for the bootloader) 4k bytes EEPROM 8k bytes Internal SRAM 32 × 8 General Purpose Working Registers Real Time Counter with Separate Oscillator Four 8-bit PWM Channels Four Programmable Serial USART Controller/Peripheral SPI Serial Interface	
Power management	Maximum current: 200mA Operating voltage: 5V GPIO output current: 20mA	

Table 3.10.

Specification of Conventional Photoelectric Smoke Alarm And Heat Detector

Conventional Photoelectric Smoke Alarm And Heat Detector		
Components	**Specifications**	**Description**
Operating Voltage	9 ~ 33V DC.	The conventional smoke detectors are designed to work with all conventional Panels. These detectors are low profile and have dual LED's for 360° visual indication. The blinking LEDs indicate normal operating conditions, whereas the steady state indicates fire status. It has a unique protocol chamber designed to sense smoke produced by a wide range of combustion sources. It has a unique drift compensation feature wherein the detector adjusts its regular reference based on environmental conditions.
Reset Voltage	Less than 1V.	
Standby Current	50 µA.	
Start up Time	60 Sec.	
Start up Current	170 µA	
Alarm Current	90 mA (max).	
Remote Output	15mA maximum open collector.	
Smoke Sensitivity	(1.96 ± 0.76) % / ft obscuration	
Air Velocity	0 - 4000 fpm.	
Operating Temperature	-10°C to 37.8°C	
Storage Temperature	-10°C to 60°C	
Humidity	0 - 95% RH, non-condensing	
Blinking Cycle	5 sec.	
Installation Space	5 meters.	

Table 3.11.

Specification of Ultrasonic Distance Sensor

PING Ultrasonic Distance Sensor		
Components	**Specifications**	**Description**
Range	approximately 1 inch to 10 feet (3 cm to 3 m)	PING)))™ ultrasonic sensor provides an easy method of distance measurement. This sensor is perfect for any number of applications that require you to perform measurements between moving or stationary objects.
Power requirements	+5 VDC; 35 mA active	
Communication	positive TTL pulse	
Dimensions	0.81 x 1.8 x 0.6 in (22 x 46 x 16 mm)	
Operating temperature range	+32 to +158 °F (0 to +70 °C)	

Project Structure and Organization

To envision the proposed system, the researchers created a 3D design for the FiRo system using the program TinkerCad. The figures below show that the FiRo system has all the necessary components. Both external and internal views are shown below.

Block Diagram

Figure 3.7.

Fi-Ro System Block Diagram

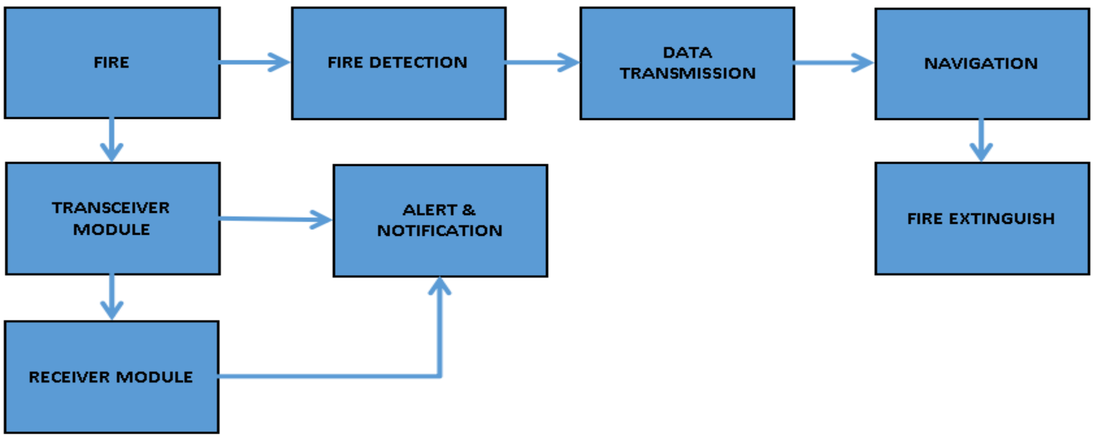


Figure 3.7 illustrates the network of interactions by the robot with its sensors, actuators, and central control unit. The sensors detect possible fire, which the Fi-Robot will then analyze to find the fire's location. The Fi-Robot will then determine its following action according to the fire intensity detected by the flame sensor integrated into the nozzle.

Figure 3.8.

Website Notification System Block Diagram

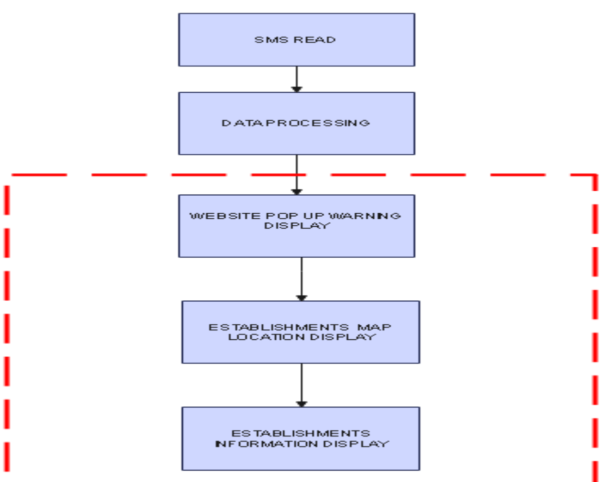


Figure 3.8 describes the system for the website integration/notification system. After sending out an

SMS signal to the control unit, the control unit will process the data which information regarding the fire incident will be transcribed to the website for the access of the users.

Figure 3.9.

Fi-Ro Alerting System Block Diagram

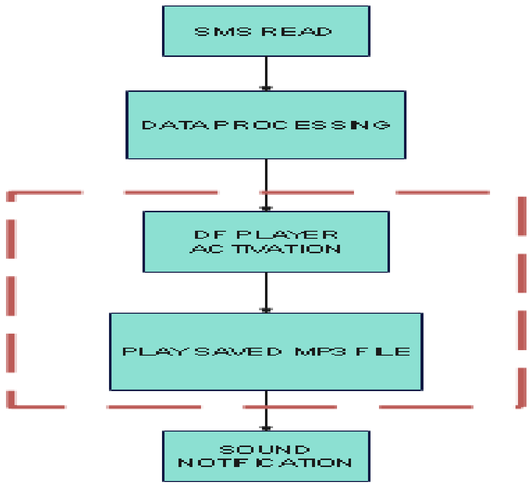
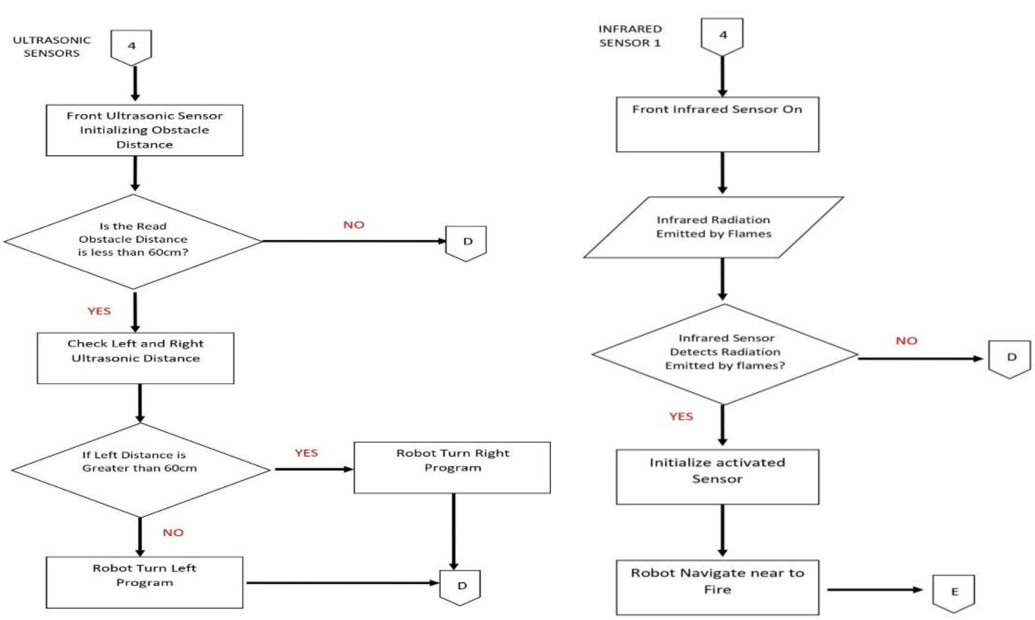


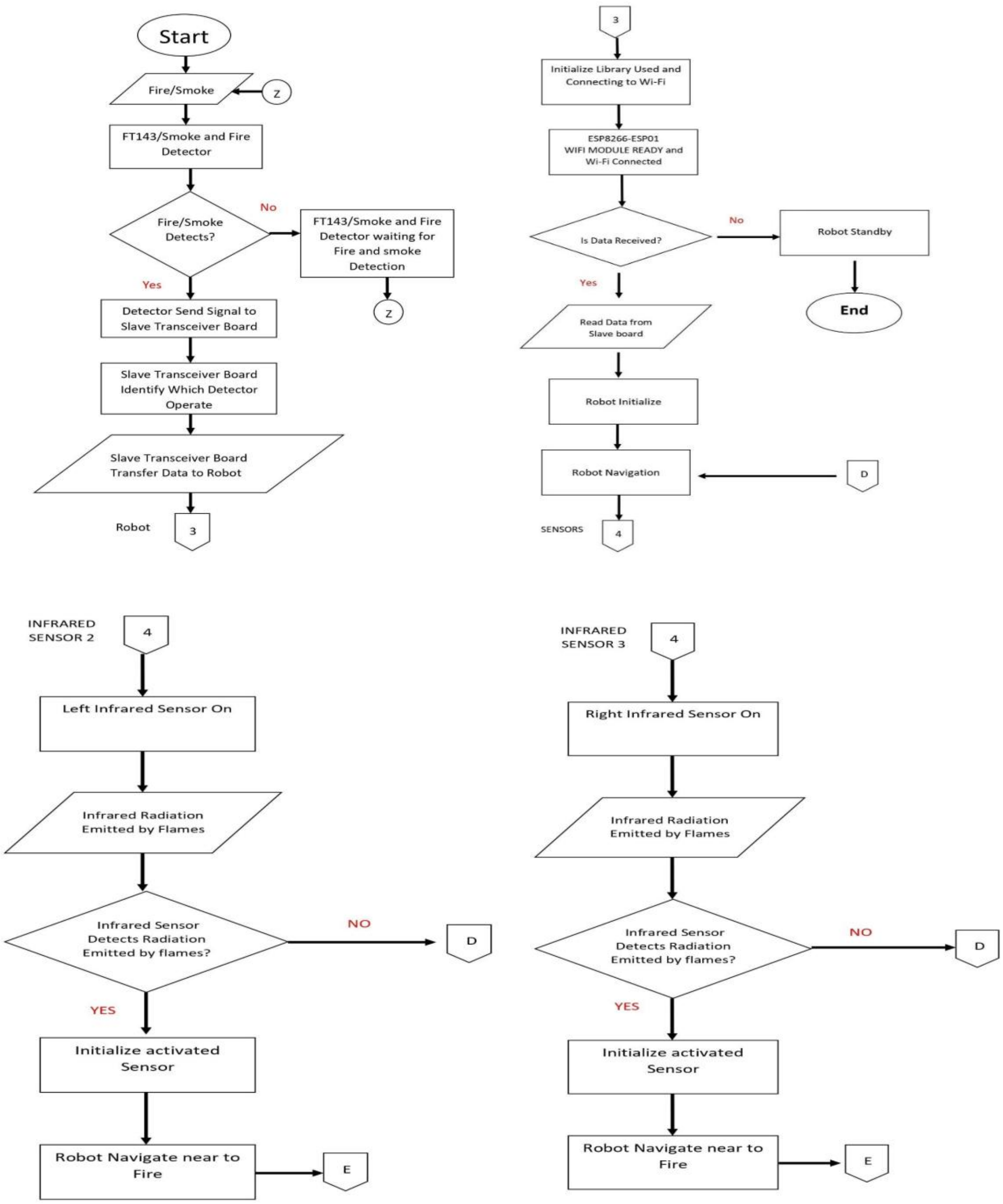
Figure 3.9 shows the flow of the notification system, which is responsible for giving out the notification function of the system. After receiving and processing the SMS signal, the control unit will send an instruction to the robot, which will then play an mp3 file through a speaker to notify people near the robot.

Flowcharts

Figure 3.10, 3.11, 3.12, 3.13, 3.14, 3.15, and 3.16.

the flowchart of the Fi-Ro System.





The figures above show the detailed flow of the whole Fi-Ro system, from the Fire Detection System to Alerting System, going to Robot Mechanism, until the extinguishing of the Fi-Robot.

Schematic Diagram

Figure 3.17.

Fi-Robot Movement Schematic Diagram

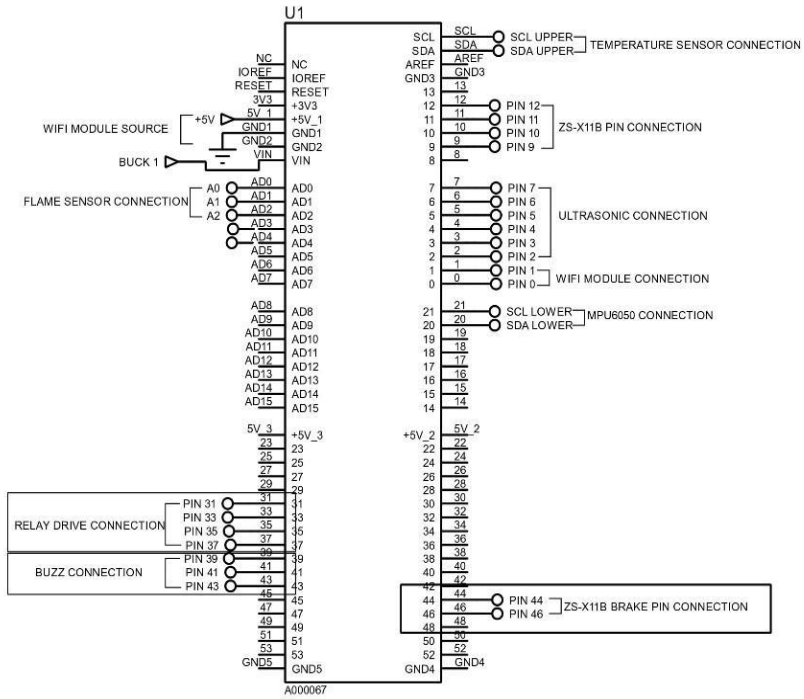


Figure 3.17 shows the schematic diagram of the Fi-Robot. It shows the connection of the following components to the ATMega2560: the flame and ultrasonic sensors; MPU6050; relay module; and the motor driver.

Table 3.12.

Components Label and Functions in Robot

LABEL NO.	TYPE	FUNCTION
U 1	**ATMEGA 2560**	This is the main microcontroller used to control the Robot and communicate to its slave boards
U 2	**ESP 01**	This is the Wifi module of the robot it receives the data coming from the slave board 1
S 1,2,3	**HC-SR04**	Ultrasonic sensor is used by the robot to sense any obstacle in its way navigating to the position of the fire
S 4,5,6	**SEN-014**	A 3 pin IR flame sensor is used by the robot to sense the position of the fire once it reaches the location of the multisensory detector that triggers due to sensed smoke/heat.
S 7	**MLX90640**	A sensor used by the robot to measure temperature of its surroundings; this is the indicator of robots fire extinguish system
S 8	**MPU6050**	A sensor used by the robot to calculate its velocity, acceleration and displacement when navigating to the location of the multi-sensor detector.

D 1	**ZS-X11**	BLDC 3 phase dc brushless motor controller used in the robot to control the its 3 phase motor, responsible in navigation
D 2	**RELAY DRIVER**	T BLOCK connection of relay modules to control the movement of the Linear motors
L 1,2,3	**SIREN SOUND**	This is the pin connection of the robot's siren sound
T 1,2	**POWER TERMINALS**	This is the power terminals for power source of the controller

Figure 3.18, 3.19, 3.20,3.21, 3.22, 3.23, 3.24, and 3.25.

the Fi-ro System Schematic in parts.

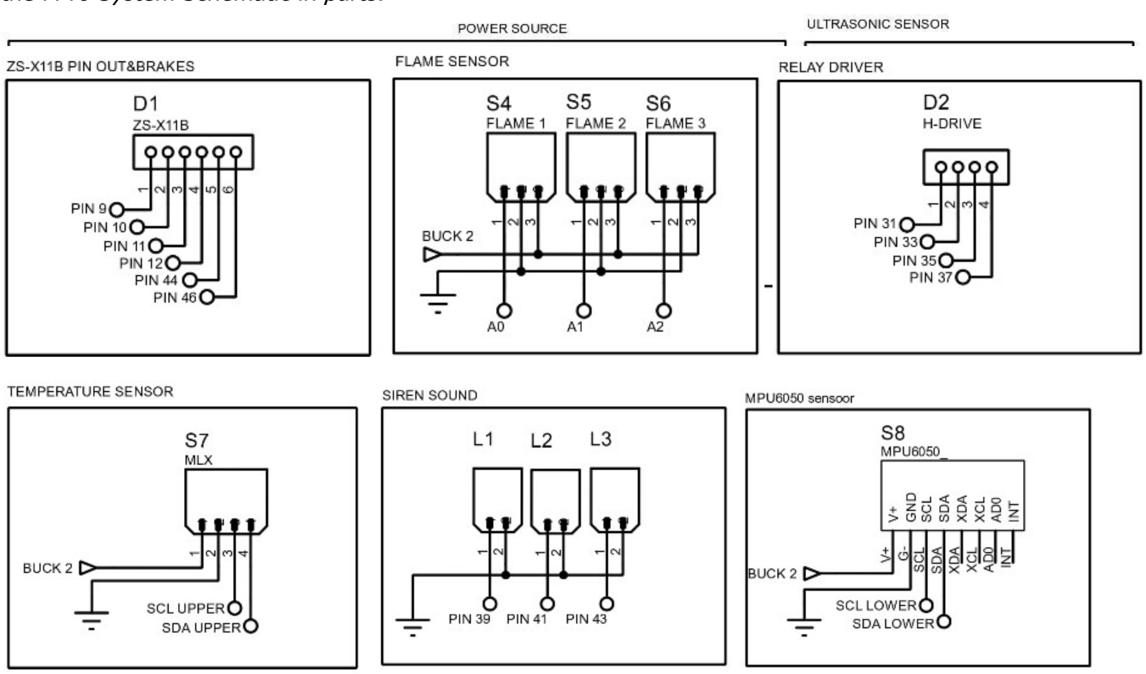


Table 3.13.

Label and Functions in Detector Module connection with FT143 detectors

LABEL NO.	TYPE	FUNCTION
U 3	**WEMOS-D1 MINI**	The slave board use to communicate to the master board which is the ESP WROOM-32 B that is used in the System
S 16,17,18	**FT-143**	A 4-wire conventional multi sensor detector capable of sensing Smoke and Heat with relay output and buzzer, it is used as the main Detector for this topic due to its capability to sense smoke and heat in one detector.
R 1,2,3	**Resistor**	Act as a EOL resistance or what do you call end of the line resistor, it is used to ensure that the photoelectric smoke detector in the FT143 will functioning very well
G2	**SIM800L module**	This is the main communication tool of the capstone project; it acts as the transmitter because it sends signals to the website and also the designated device for firemen.
P2	**Lm259s**	A step-down power supply module (buck converter), it is used to control the power source of the GSM modules of both MCU and Designated Device.

Figure 3.26.

Fi-Ro Detector Module connection for FT143 Schematic Diagram

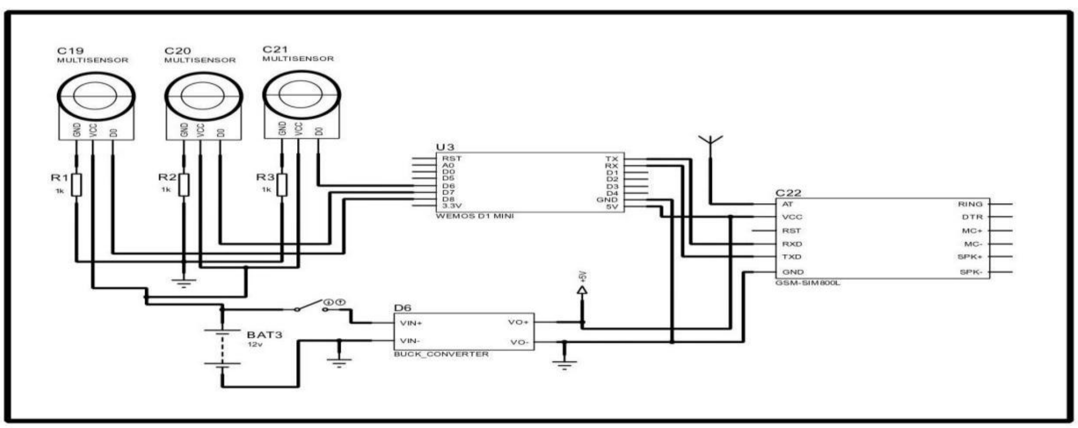


Table 3.14.

Components Label and Functions Auditory Feedback Module Connection in Alerting Device

LABEL NO.	TYPE	FUNCTION
U 2	**WEMOS D1 MINI**	The slave board is used to communicate with another slave board whos communicates to the master board

C3	**DFRO299**	A MP3 player module, used in the designated device for firemen, to play the recorded MP3 file saved to the SD card inserted to this after it receives a signal from Gsm module.
G1	**SIM800L module**	This module is used in the designated device for firemen as the receiver of another GSM module connected to the MCU.
P1,2	**Lm259s**	A step-down power supply module (buck converter), is used to control the power source of the GSM modules of both MCU and Designated Device.
LS1	**SPEAKER**	A 4-ohm stereo speaker in baffle it is used as the transducer in the designated device for the firemen's
BAT 3	**12v LI Ion**	Back up battery used for the Alerting Device module

Pictorial Diagram

Figure 3.27.

Fi-Ro FT143 connection to the Detector Module

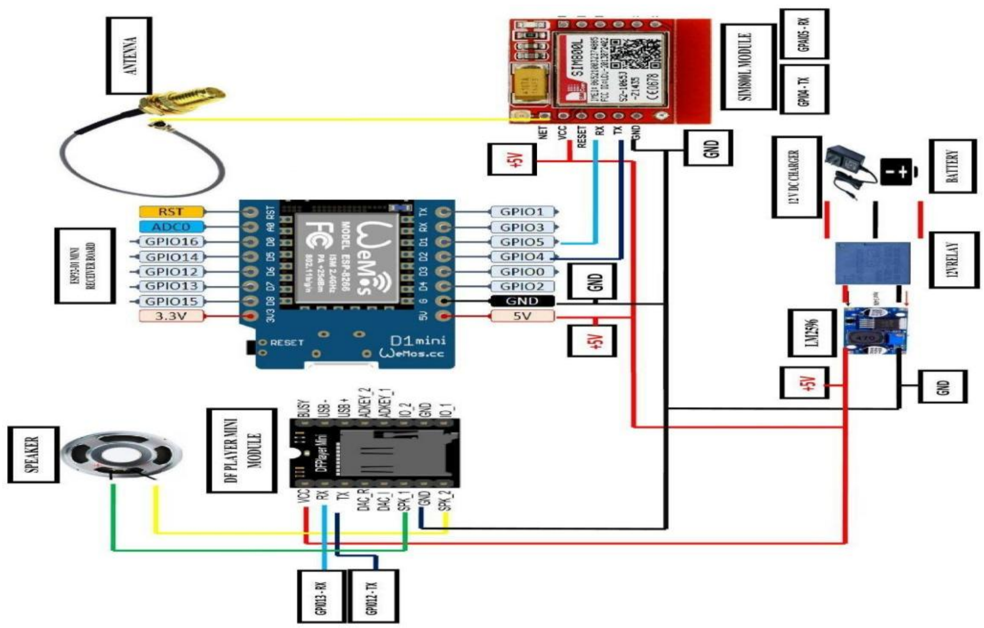


Figure 3.28.

Fi-Ro Auditory Feedback Module for Fire station

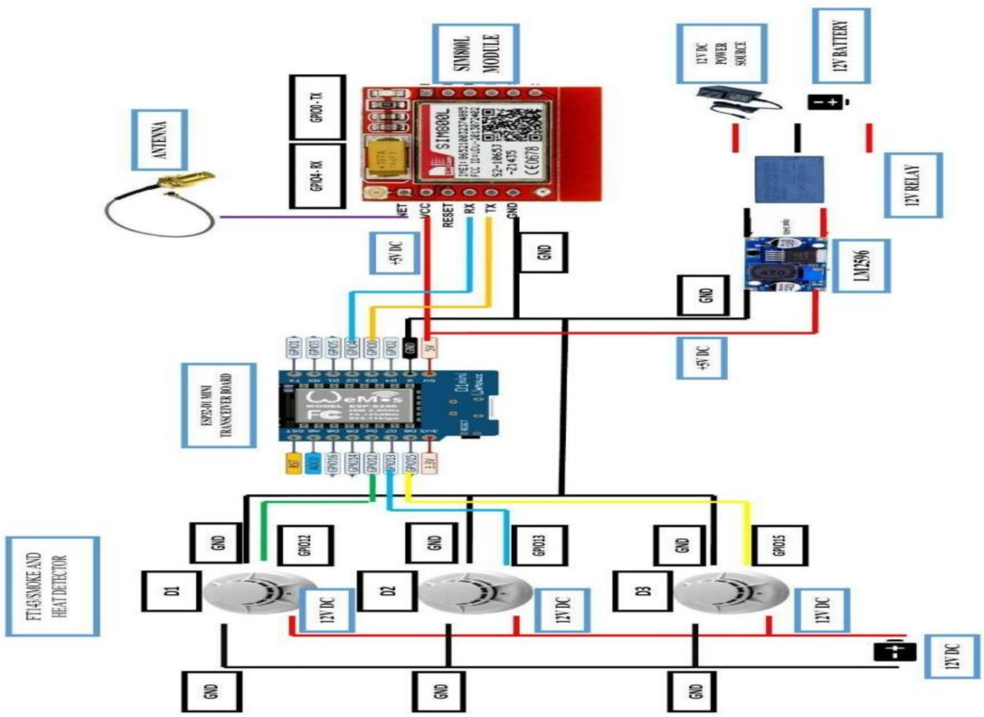
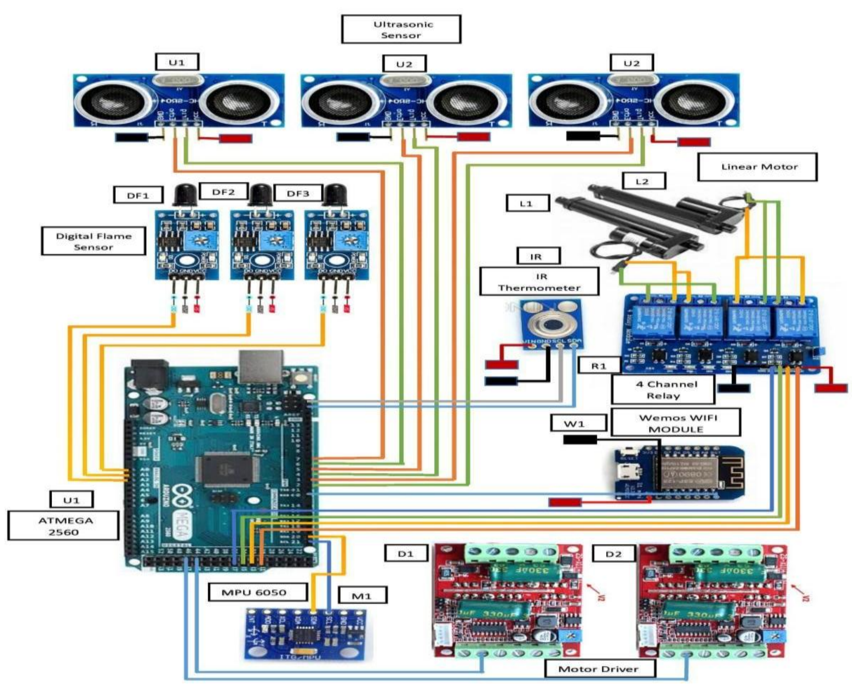


Figure 3.29.

Fi-Robot Pictorial Diagram for Robot Mechanism Circuit



The figures above show the actual circuit connection of the components connected to ATMEGA 2560.

Network Diagram

Figure 3.30.

Fi-Ro Network Diagram between Detector Module and Robot

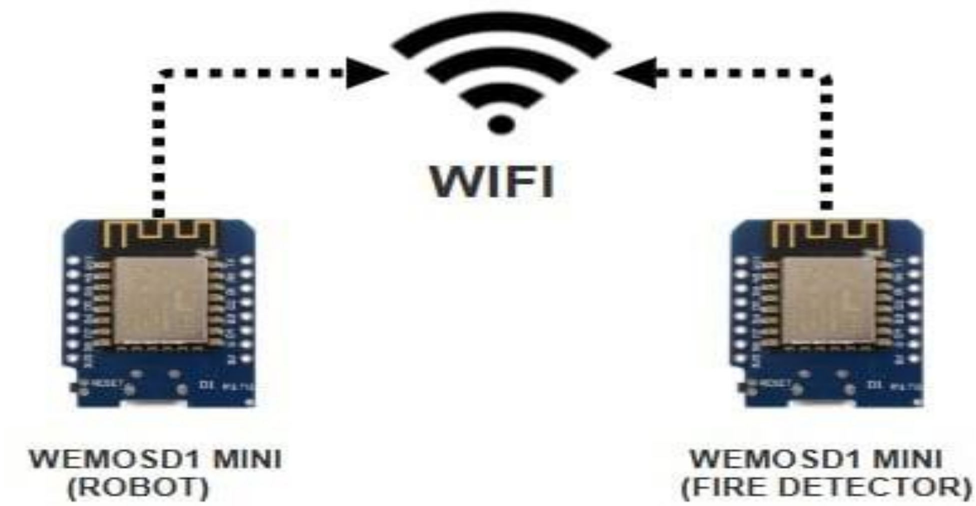
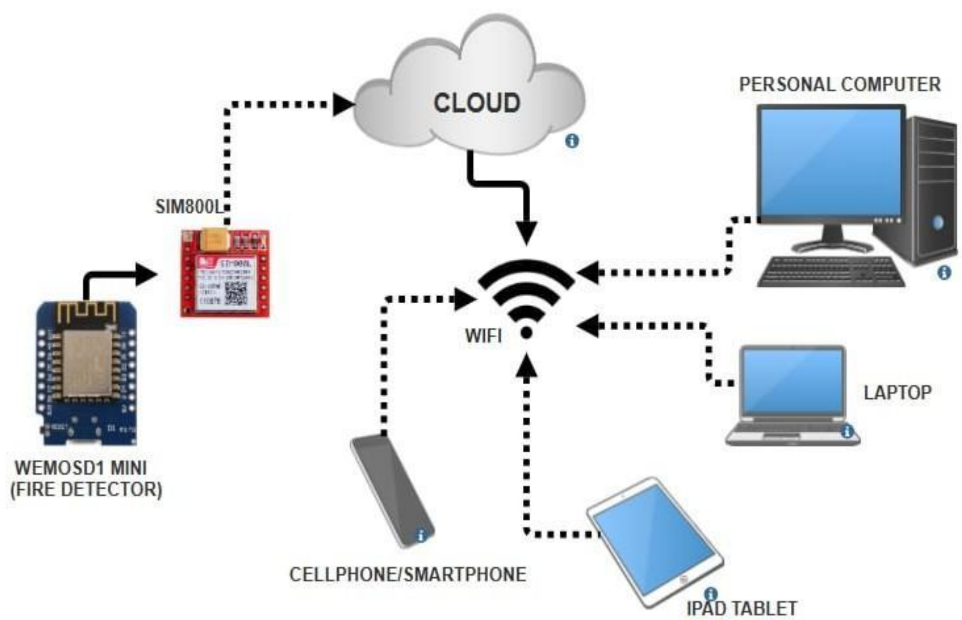


Figure 3.31.

Fi-Ro Network Diagram between Detector Module and Website



The figure above shows the visual representation of the components and connections within the Fi-Ro network.

CONCLUSION

1. Integrating a fire detection system, including heat, smoke and thermometer reading sensors, within the roving robot enables the swift identification of initial flames. Upon detection, the robot promptly alerts nearby individuals and fire authorities, facilitating rapid response and minimizing fire hazards. Moreover, the robot's efficient system integrates linear actuators to precisely position and activate a fire extinguisher, immediately suppressing detected fires. In summary, by leveraging the ATMEGA 2560 microprocessor and its subsystems, the roving robot effectively executes fire detection, alerting, and swift response functions, enhancing safety measures significantly.

2. Implementing a one-way notification system using GSM technology allows owners of designated establishments to receive fast and essential data about fire detection locations. This guarantees dependable and comprehensive coverage, regardless of location. It enables owners to. make well-informed decisions and take timely action, thereby improving the effectiveness and safety protocols of establishments.

3. Implementing a one-way notification system using GSM technology allows owners of designated establishments to receive fast and essential data about fire detection locations. This guarantees dependable and comprehensive coverage, regardless of location. It enables owners to make well-informed decisions and take timely action, thereby improving establishments' effectiveness and safety protocols.

4. The design of this website is user-friendly, allowing firefighters to access current information regarding ongoing incidents, and verify precise location particulars. In addition, an auditory feedback module incorporated into the detector module quickly offers firefighters audio notifications if fire-related occurrences are detected. The auditory feedback serves as an additional notification method, ensuring that firefighters are promptly notified of any emergencies, irrespective of whether they are actively observing the website or visual indicators. Implementing an integrated website and auditory feedback module enhances communication and cooperation among firefighters, resulting in increased efficiency in resource allocation and speedier reaction times in the face of fire situations.

References:

Azeta, J., Ayoade, I. A., Nwakanma, C. I., & Akande, T. (2023). Implementing a Prototype Autonomous Fire Detecting and Firefighting Robot. Preprints 2023. https://doi.org/10.20944/preprints202305.2010.v1

Brown, J. (2022). Fire Safety in Hospitals: What you should know. Coopers Fire. https://www.coopersfire.com/news/fire-safety-in-hospitals/

Kahanji, C., Walls, R. S., & Cicione, A. (2019). Fire spread analysis for the 2017 Imizamo Yethu informal settlement conflagration in South Africa. International journal of disaster risk reduction, 39, 101146.

Kharisma, R. S. (2021, May 5). Fire early warning using fire sensors, microcontroller and SMS gateway. Kharisma | Journal of Robotics and Control (JRC). https://journal.umy.ac.id/index.php/jrc/article/view/9999/5768

Kodur, V., Kumar, P., & Rafi, M. M. (2019). Fire hazard in buildings: review, assessment and strategies for improving fire safety. PSU Research Review, 4(1), 1–23. https://doi.org/10.1108/prr-12-2018-0033

Lagata, L. S., et al. (2022). Challenges encountered and insights of the Bureau of Fire Protection personnel towards responding fire incident. Mediterranean

Liu, H., et al. (2018). About automatic fire alarm systems research. 2010 2nd IEEE International Conference on Information Management and Engineering, IEEE Xplore, pp. 419-421, DOI: 10.1109/ICIME.2010.5477835.

Paunan, J.C. (2023) PH fire incidents up 40% -BFP. Philippine Information Agency. https://pia.gov.ph/news/2023/05/02/ph-fire-incidents-up-40-bfp

Perilla, F. S., et al. (2018). Fire Safety and Alert System Using Arduino Sensors with IoT Integration. ACM Digital Library..https://doi.org/10.1145/3185089.318512 1

Industrial PH. (2023). Fire Detection and Alarm System Philippines. Industrial PH. https://industrial.ph/fire-detection-and-alarm-philippines/

Inquirer News. (2021). Patients evacuated as fire hits PGH. INQUIRER.net. https://newsinfo.inquirer.net/1432333/fire-hits-pgh

Zaczek, B., et al. (2018). The XFIRE: A Novel Embedded Device for localized fire detection.and.suppression..Retrieved..July.26,.2015.from http://www.willworkforrobots.com/projects/xfire/PULSAR•265