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Development of Gas Leakage Monitoring Based on Smartphone Application

Muhammad Qhayyiem Isa[1], Aimi Syamimi Ab Ghafar[1]*

[1] *Department of Electrical Engineering Technology, Faculty of Engineering Technology*
University Tun Hussein Onn Malaysia, Muar 84600, Pagoh, Johor, Malaysia

*Corresponding Author: aimi@utm.edu.my
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Abstract

This project focuses on developing a gas leakage monitoring system with a smartphone app created using MIT App Inventor. The system integrates an MQ2 Gas Sensor, Piezo Buzzer, and NodeMCU ESP32, connected through Blynk and Node-RED. It offers real-time gas level monitoring and triggers alerts via the Piezo Buzzer in case of an issue. Data, including sensor readings, is sent to the Blynk app for online monitoring. This project addresses the need for an affordable and efficient gas leakage monitoring system, specifically designed to integrate with smartphones, ensuring safety across different environments. The success of the system lies in enabling users to actively monitor gas leakage through the application.

1. Introduction

In the contemporary landscape, the omnipresent threat of gas leaks across residential, commercial, and industrial settings underscores the critical need for robust detection systems to avert potential dangers such as injuries, property damage, and even fatalities. The escalating demand for reliable and efficient gas leak detection solutions is driving the imperative to enhance safety measures and prevent accidents stemming from gas leaks. Traditional fire alarm systems, comprising smoke detectors, manual call points, alarm sounders, flashers, and control panels, have formed the bedrock of safety protocols.[1] These systems are now undergoing a transformation to adapt to diverse environments and detect specific gases.

Recognizing the dynamic nature of safety standards and regulations, there is a growing need for scalable and adaptable gas leak detection systems that can be effectively deployed in different settings. Our research responds to this demand by pioneering the development of a comprehensive gas leakage monitoring system seamlessly integrated with a smartphone application. This innovative approach seeks to revolutionize the paradigm of gas leak discovery and control. Leveraging sophisticated algorithms and machine learning techniques, the system meticulously analyzes environmental data acquired from external sensors, including gas concentrations, temperature, and humidity.

In addition to providing users with real-time updates and warnings about potential gas leaks, the system boasts a spectrum of features designed to enhance user experience and safety protocols. This includes but is not limited to historical data tracking, empowering users to review past trends; visualization of gas distribution maps for a comprehensive understanding of potential risk areas; and remote monitoring options that offer a proactive stance in preventing gas-related incidents. Such capabilities not only facilitate informed decision-making but also contribute significantly to the overall safety infrastructure across various settings, aligning seamlessly with the evolving needs of safety standards and regulations.

2. Related Work

This section looks into what's already known about gas leakage monitoring systems, especially those using smartphones. We focus on the Internet of Things (IoT), which is like smart technology connecting things. The review explores how IoT can make gas monitoring systems better by improving communication, networks, and security. We also check out how easy it is for users to understand and customize the system. This helps us understand how to use the latest technology to create a safer and more user-friendly gas leakage monitoring system with our smartphones

Table 1 *Comparison of past project*

No.	Title (Ref no.)	Features	Software/Hardware
1	A Wireless Home Safety Gas Leakage Detection System[2]	The gas detection system checks for harmful gases like LPG. If there's a leak, it beeps, sends an SMS, and can book gas automatically and it can also call fire stations if there's a fire. If gas levels are high	The gas detection system has sensors, a buzzer, and a device called Arduino GSM shield to check for gas issues and give alerts through SMS, and it can also book gas automatically.
2	Interfacing Flame Sensor with Arduino[3]	This project is about spotting fires early using a flame sensor with an Arduino, focusing on thermal radiation instead of just temperature or smoke	For early fire detection, we use a flame sensor connected to an Arduino. It's simple. The system focuses on thermal radiation and sends alerts to Ubidot's dashboard, letting you know about possible gas leaks. Easy and effective.
3	Wireless sensor network system for LPG gas leakage detection system[4]	The system uses LabVIEW and the MQ-2 gas sensor to detect gas leaks, showing the info with a simple rating. It runs on an Arduino with GSM for monitoring, and Zigbee lets you check on a PC.	LabVIEW and MQ-2 sensor find leaks. Arduino manages hardware, using GSM for monitoring and Zigbee for PC checking. Simple – LabVIEW rates leaks, Arduino handles, GSM/Zigbee communicate.
4	Prototype of Gas Warning Monitoring Application Using Mobile Android Smartphone[5]	This research intends to make a leak detection device on gas-based raspberry pi installation connected to android application so that the SMK3 team can monitor the condition of the warehouse without having to repeatedly come to the site.	The study utilizes Raspberry Pi and Android phones to create a basic gas leak detector, utilizing hardware sensors and software to send real-time gas monitoring alerts.
5	A comprehensive system for detection of flammable and toxic gases using IoT[6]	The study proposes a comprehensive IoT system for detecting flammable and toxic gases using Arduino.	The study proposes an IoT system using Arduino for gas detection, integrating sensors, control room, and site locations, with software managing real-time monitoring and emergency response.

Comparing existing gas leakage monitoring projects is essential for understanding advancements. This analysis identifies strengths and weaknesses, highlighting areas for improvement. It helps evaluate the effectiveness and cost-efficiency of the new smartphone application-based system. The project will use MIT App Inventor, focusing on addressing limitations and enhancing safety measures in gas-related environments.

3. Methodology

3.1 Software

The project focuses on a MQ2 gas sensor data collection system and Blynk integration. The system initializes by adding libraries and initializing variables like Gas Value, Gas Sensor, and Buzzer. It connects to a Wi-Fi network and the Blynk server, and if the gas concentration exceeds a predefined threshold of 1800[4], the system activates a buzzer and displays gas values on the Blynk dashboard. Node-RED enhances the system's versatility by reading data from the Blynk platform every 2 seconds and publishing it to an HTTP page. The user interface is built using MIT App Inventor, which responds dynamically to gas concentrations, ensuring user safety, fostering a secure monitoring environment and easy to use. [7]

3.2 System Block Diagram

Based on Figure 1, the gas leakage monitoring system uses a block diagram structure with a power supply, MQ2 Gas Sensor, Piezo Buzzer, ESP32 for data processing, Blynk platform for real-time monitoring, Node-RED for data flow, and MIT App Inventor for user interface. The system measures gas concentrations, alerts users, and responds to varying gas concentrations. The system aims to enhance user safety by providing immediate gas concentration feedback, enabling timely interventions and alerts in case of potential gas leaks.

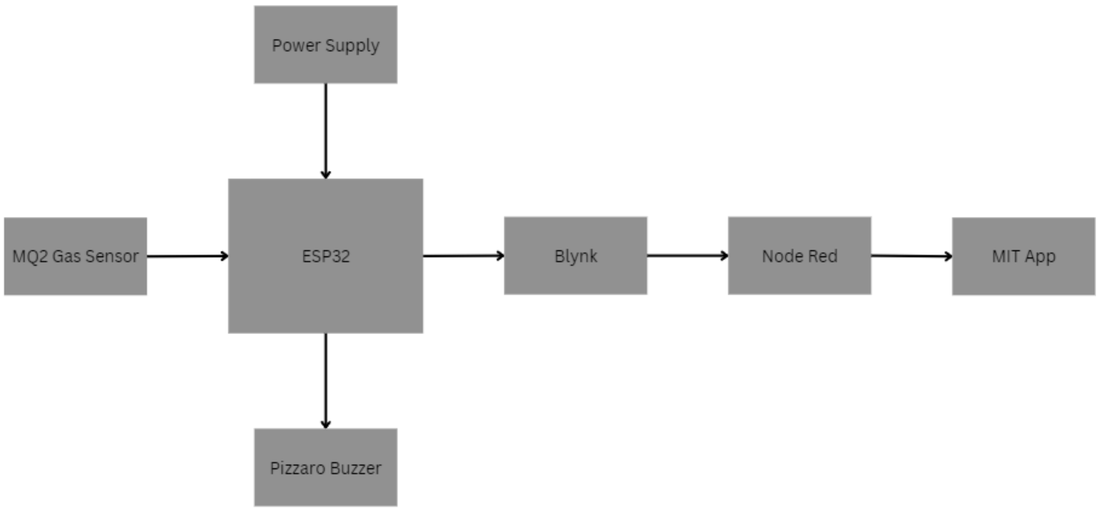

Fig. 1 *Block Diagram of the Project*

3.3 System Flowchart

The MQ2 gas sensor data collection and Blynk integration system begins with adding the required library and initializing variables based on Figure 2. The system then configures the MQ2 sensor as an input and the Buzzer as an output. It establishes a connection to the Wi-Fi network and the Blynk server. If the system is turned on, it reads data from the MQ2 gas sensor and activates the buzzer when the gas concentration exceeds the predefined threshold of 1800. Node-RED enhances the system's versatility by reading data from the Blynk platform every 2 seconds and publishing it to an HTTP page, enabling remote monitoring and analysis. The user interface is constructed using MIT App Inventor, providing a secure login page for secure access. The system responds dynamically to gas concentrations, signaling Gas Status 1 if the concentration exceeds 1800ppm, and Gas Status 0 if it is 1800ppm or below. The threshold is set to 1800 for home and workplace use, aiming to enhance user safety and foster a secure monitoring environment.

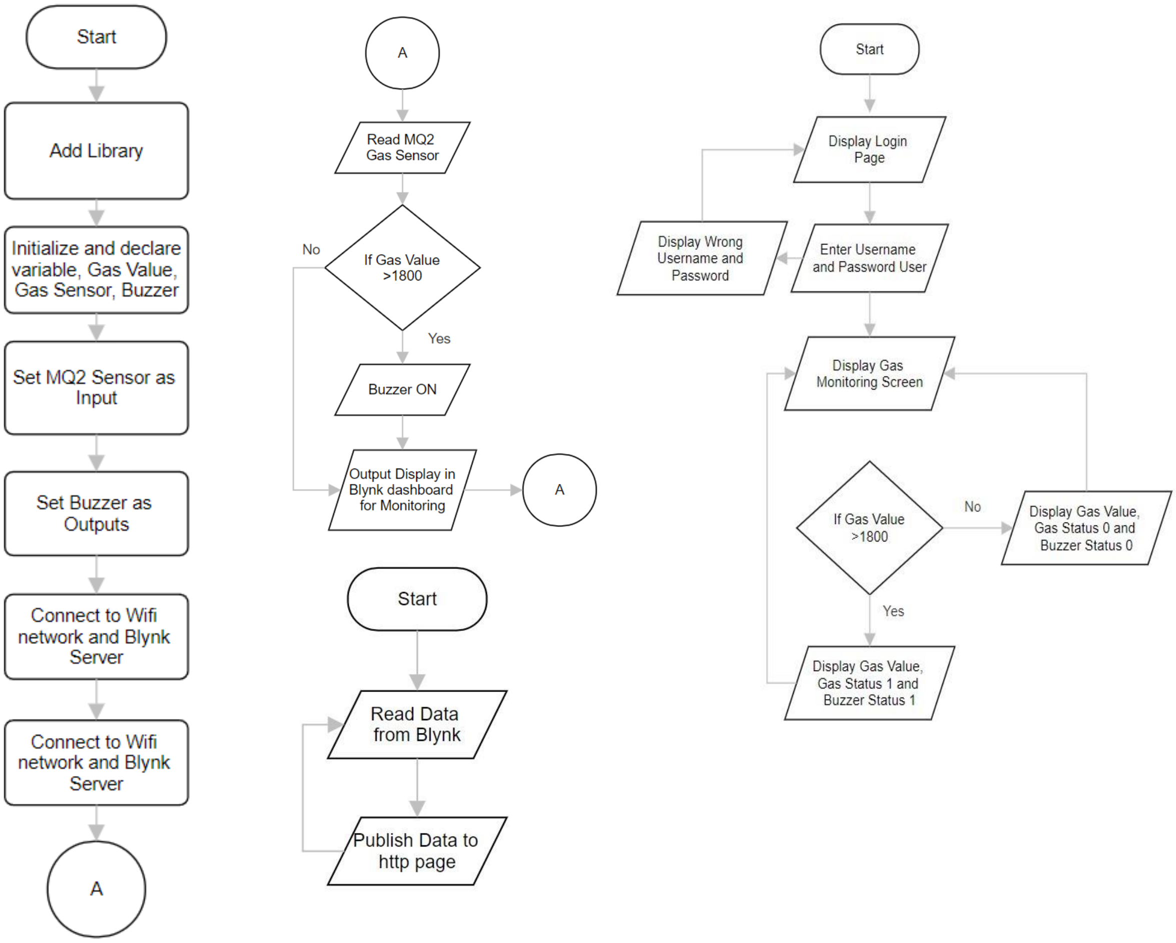

Fig. 2 *System Flowchart*

4. Result and Discussion

The implementation and operation of Development of Gas Leakage Monitoring Based on Smartphone Application will be illustrated in this chapter. In this section, the actual results of the Development of Gas Leakage Monitoring Based on Smartphone Application are presented in more detail, together with supporting data to confirm the results acquired during the tests.

4.1 Gas Leakage Monitoring System

The prototype layout for gas leakage monitoring represents a cutting-edge advancement in safety technology, aiming to enhance the detection and prevention of potential gas leaks in various environments. Figure 3.1 provides a comprehensive insight into the design with its detailed 3D views, allowing stakeholders to visualize the intricacies and spatial arrangements of the monitoring system. In Figure 4, top views of the design offer a bird's-eye perspective, enabling a thorough examination of the placement of sensors and the overall system architecture. Additionally, Figure 5, the side view of the design, provides crucial information on the vertical integration and structural elements, crucial for assessing the system's stability and adaptability to different settings. These figures collectively serve as invaluable references for engineers, designers, and decision-makers, facilitating a holistic understanding of the gas leakage monitoring prototype's physical characteristics and functionality.

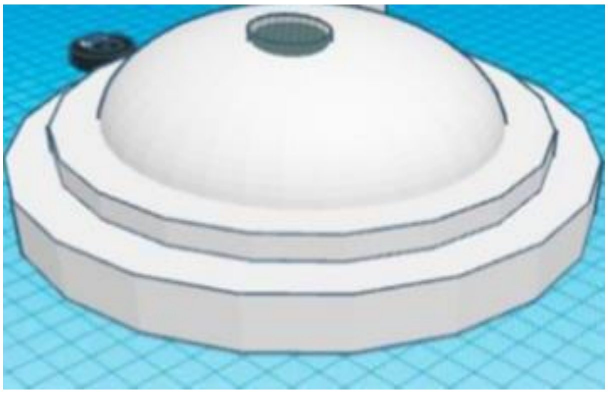

Fig.3 *3D View of the Design*

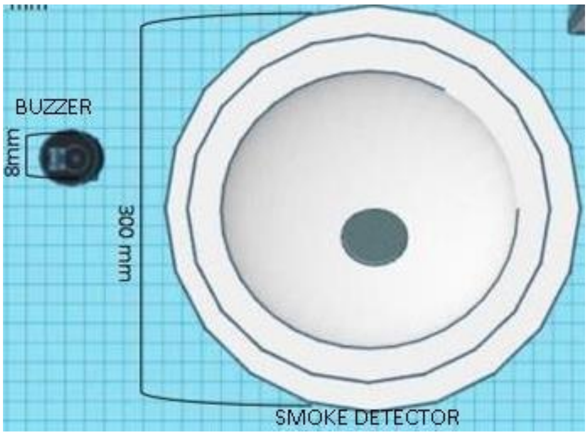

Fig. 4 *Top View of the Design*

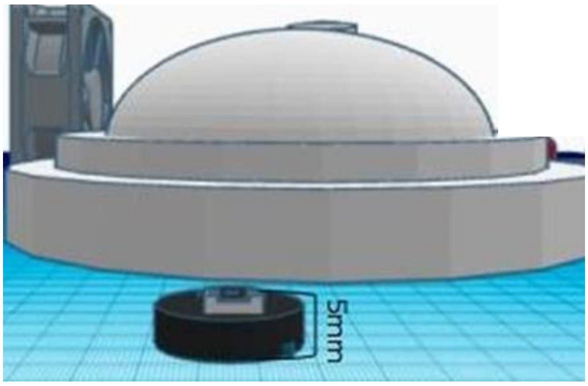

Fig. 5 *Side View of the Design*

4.2 Integration of Motion Detection System to Blynk Application

Based on Figure 6 and 7, there are 3 widgets were place in the Blynk Dashboard which is a Gauge, and 2 LED that each widget represented different DataStream. Gauge widget that was placed their work as Gas Value with DataStream(V0). The Gauge will show the current value that capture by the MQ2 Gas Sensor. Meanwhile the 2 LED there that are displayed as Gas Sensor with DataStream(V1) and Buzzer with DataStream(V2) will remain off as long the Gas Value not surpass 1800ppm.

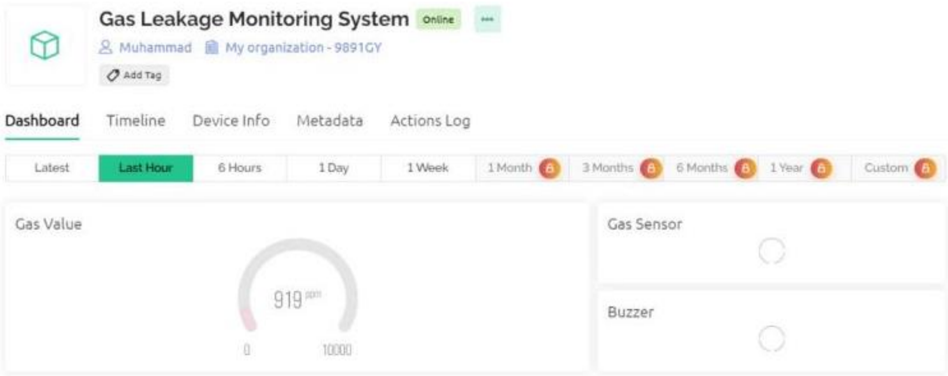

Fig. 6 *Blynk Dashboard shows before threshold more then 1800ppm*

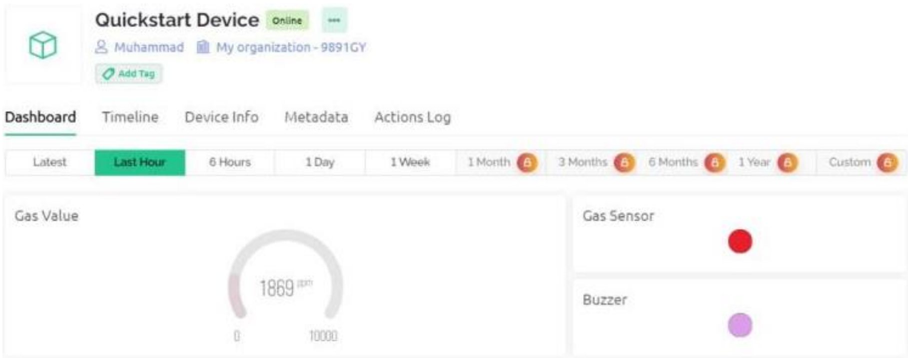

Fig. 7 *Blynk Dashboard shows after threshold more then 1800ppm*

4.3 Integration of Data Blynk to Node Red

In Node-RED, the configuration in Figure 8 involves setting up connections to Blynk.cloud with predefined AUTH token and template IDs from Blynk. The initial step establishes timestamp connections to pins V0, V1, and V2. Each of these pins holds specific data related to gas monitoring. For instance, V0 is associated with the gas values, V1 with gas status, and V2 with buzzer status. Subsequently, the data from each pin is directed to separate function nodes. In the V0 function, the data is labeled as "v," in V1 as "g," and in V2 as "b." Each function node is connected to its respective debug node, allowing for the inspection of data at different stages.

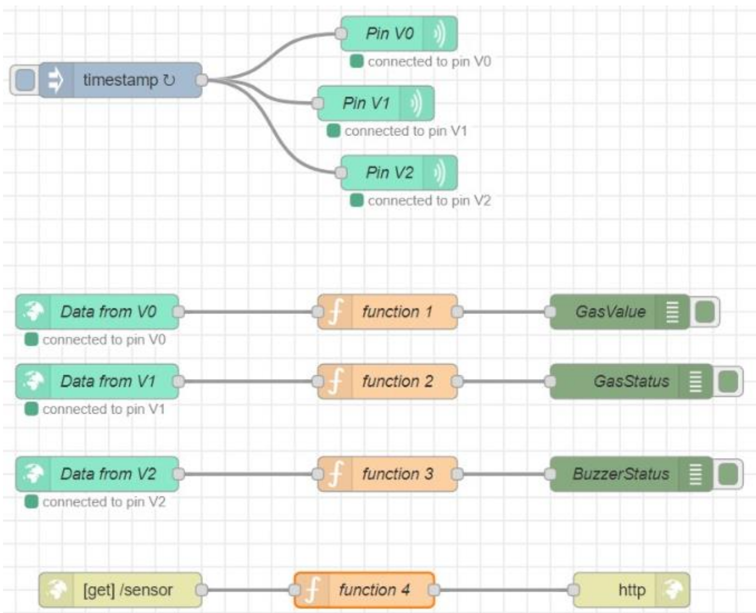

Fig. 8 *Node Red Flows*

The final connection of the Node-RED setup involves routing data from all three pins through a function node called "4," which consolidates each pin's data and directs it to an HTTP response node. This configuration ensures the processed data is sent as an HTTP response, completing the communication loop with Blynk and facilitating further analysis or integration with external systems.

4.4 Smartphone Application

The MIT App Inventor is a user-friendly gas leakage monitoring system that features a homepage with a logo for visual identification in Figure 9. When the gas concentration exceeds 1800, the interface dynamically updates, displaying "1" as a potential risk and "on" as an alert. This responsive interface provides timely and comprehensible information, enabling swift decision-making in case of a gas leak. The MIT App Inventor enhances user awareness and safety in gas monitoring scenarios through its tailored interfaces.

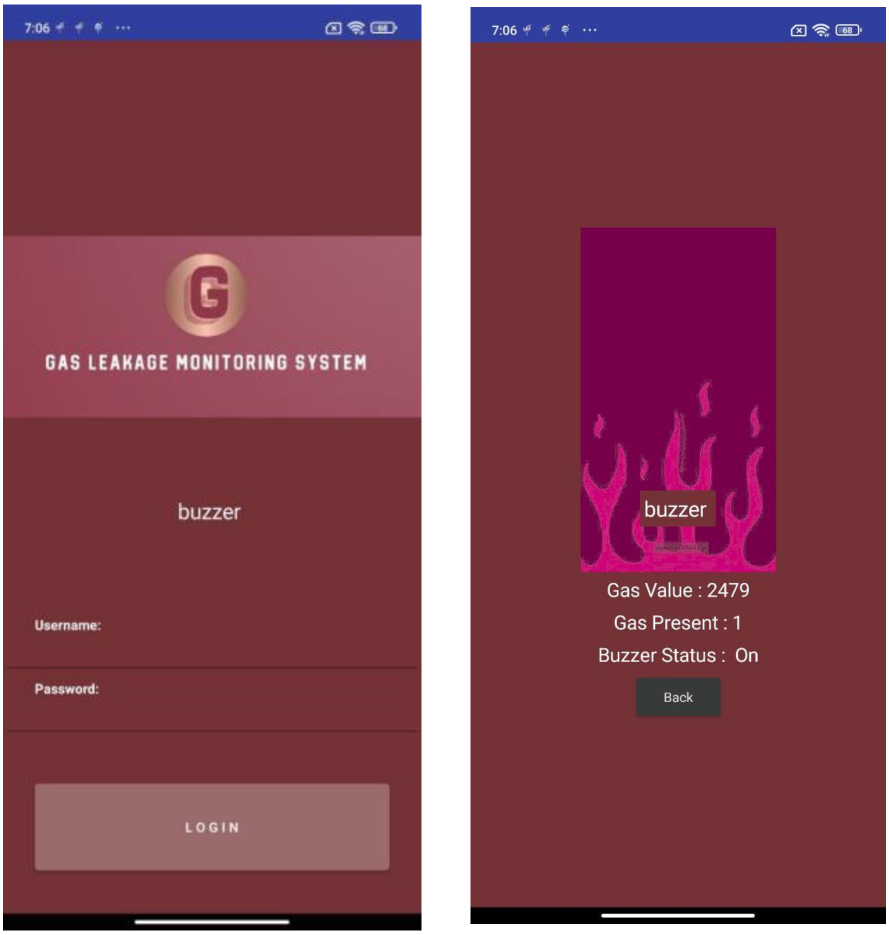

Fig. 9: *MIT App Inventor Screen 1 and Screen 2 (a) First picture; (b) Second picture*

5. Data Analysis

The provided table 2 encapsulates the System Usability Scale (SUS) scores gathered from a diverse pool of 15 participants who actively engaged in the evaluation of the gas leakage monitoring system, centered around a smartphone application. Each participant conscientiously rated the system's usability through a spectrum of ten questions, utilizing a nuanced scale that ranged from 1 (indicating minimal satisfaction) to 5 (signifying high satisfaction). The SUS scores, individually ranging from 45.0 to 87.5, provide a nuanced portrayal of participant sentiments, reflecting the diverse perspectives on the system's effectiveness. Notably, the calculated average SUS score of 74.17 points towards a generally positive reception, affirming that the gas leakage monitoring system succeeds in delivering a user-friendly and accessible experience. This detailed breakdown of participant feedback serves as a valuable resource, offering insights into specific areas of commendation and potential refinement within the gas leakage monitoring system, guiding future iterations and improvements.

Table 2 *SUS Score Table*

Participant	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	10	SUS Score
1	4	2	3	4	5	1	2	3	4	5	87.5
2	3	1	4	2	5	3	4	2	5	1	57.5
3	5	4	3	2	1	5	4	3	2	1	45.0
4	2	3	4	1	5	2	3	4	1	5	80.0
5	1	2	3	4	5	1	2	3	4	5	87.5
6	4	5	1	2	3	4	5	1	2	3	65.0
7	3	2	4	1	5	3	2	4	1	5	67.5
8	5	1	3	2	4	5	1	3	2	4	65.0
9	2	3	4	5	1	2	3	4	5	2	80.0
10	1	5	2	3	4	1	5	2	3	4	72.5
11	4	2	3	4	5	1	2	3	4	5	87.5
12	3	1	4	2	5	3	4	3	4	5	57.5
13	5	4	3	2	1	5	4	3	2	1	45.0
14	2	3	4	1	5	2	3	4	1	5	80.0
15	1	2	3	4	5	1	2	3	4	5	87.5
Average	3.07	2.33	3.07	2.33	3.87	2.6	3.33	2.4	3.07	3.33	74.17

5.1 Discussion

The Gas Leakage Monitoring App project's results and discussions are presented in Chapter 4. Participants' feedback, measured through System Usability Scale (SUS) scores, indicates the app's user-friendly nature. The discussion includes suggestions for improvements and highlights the successful integration of hardware components like the ESP32 microcontroller, MQ2 gas sensor, and Piezo Buzzer. Key components contributing to the project's success include connectivity via Blynk, data processing using Node-RED, and smartphone access through MIT App Inventor. The chapter provides a clear overview of the project's outcomes and future considerations.

6. Conclusion

In conclusion, the creation of a gas leakage monitoring system based on a smartphone app is a significant step forward in improving safety precautions. The system offers real-time monitoring, quick detection, and fast notifications for gas leaks by integrating hardware components such as gas sensors, LEDs, buzzers, and the use of smartphone technology. The system's capacity to deliver precise gas readings, track data trends, and permit rapid reaction helps to overall safety and risk reduction in gas leakage situations. Furthermore, the smartphone application's simplicity and accessibility make it a practical alternative for monitoring gas levels in a variety of contexts. Based on the findings of this project, several recommendations can be made for future development. Firstly, continuous research and development efforts should be invested in refining the accuracy and sensitivity of the gas sensors to detect even minor leaks. Secondly, expanding the capabilities of the smartphone application, such as integrating advanced data analytic or incorporating machine learning algorithms, can further enhance the system's effectiveness. Additionally, considering the compatibility of the application with different smartphone platforms and improving user interface design can ensure broader usability. Lastly, conducting comprehensive field testing and validation in diverse environments would validate the system's reliability and enable refinement based on real-world scenarios

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