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IoT-Based Smart Fire Alarm Navigation System

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Abstract

This work aims to solve the problems caused by negligence and a delayed reaction in fire-related accidents by creating an IoT-Based Smart Fire Alarm Navigation System. The suggested system integrates a few sensors, such as temperature, gas, and GPS modules, using Arduino technology to identify and address fire dangers in residential structures. The Arduino IDE software is used to code the Arduino Mega platform, which is the system's central component and allows smooth communication between different parts. The primary goals of this study are to establish an alert system that alerts both firemen and inhabitants in real-time, as well as the development of an IoT-based Smart Fire Alarm Navigation System and an assessment of its functioning performance. Users may get warnings and incident data via cell phones. The system's utilization of Wi-Fi modules guarantees remote monitoring and notification capabilities. The study emphasizes the significance of prompt and well-informed reactions to fire occurrences to minimize the spread of flames and lower related losses. Additionally, to facilitate communication with the fire department, the system automatically logs important details about fire occurrences, including the date, time, and location. This data is then kept in an online cloud storage service. To sum up, this research advances the technology for home fire safety and provides a workable and effective way to counteract the problems caused by neglect and late reporting. By reducing the effect of home fires on lives and property, deploying the IoT-based Smart Fire Alarm Navigation System can significantly improve response times.

1. Introduction

Nowadays, home fires are now a prevalent topic in the daily newspaper. In Malaysia, home fires can cause death and serious injuries. Inattention is one of the leading contributors to residential fire fatalities in Malaysia (Tan et al., 2016). For example, when the cooking time requires a long time, the person in charge forgets the dish is still at the stove, thus allowing the furnace to catch fire. Other unanticipated causes of domestic fires include short-circuit wires, lightning strikes, and flammable gases. Numerous methods, such as fire alarm systems and smoke detectors, have been developed to prevent domestic fires from spreading (Ehsan et al., 2022). However, this method does not notify the homeowner if they are away from their home.

IoT-Based Smart Fire Alarm Navigation System is the system that detects smoke from fire strikes in a residential building to help victims escape from fire accidents by alarming the people in the residential building, notifying victims via smartphone that a fire accident has occurred, and displaying the location of the residential building through the smartphone. This system automatically stores information about the fire accident when a fire strike happens in the building. The data information consists of the date, time, and location of the incident, which then can be stored in cloud storage service online, along with the collaboration of the fire department (Sao et al., 2019).

Fire can occur anywhere and at any time, regardless of our awareness. In the twinkling of an eye, it can destroy lives and property. The disease could quickly expand to neighboring areas if the housing consists of terraces or apartments. The home's environment is also crucial because it will either exacerbate the fire's spread or limit its spread. If nobody notices what has occurred, a large conflagration area will result. If fire suppression efforts are delayed, the site is likely to expand. Losses of life and property will increase.

The second statement of the issue is that residents often don't report incidents to the fire department in plenty of time because they are unaware of their severity. A firefighter who is expected to put out the blaze may be delayed if this occurs.

To solve this issue, we must create a remote-controllable system that can be operated using a mobile phone. This system can assist us in controlling from a distance or in a situation not in our home region (Shahriyar et al., 2008).

The goal of the fire detection systems is to notify everyone in the event of a crisis so that we can take quick action to safeguard each other, the public, and the organization's workers (Dong WH et al., 2016). Although fire alarms are a common sight in public spaces, workplaces, and businesses, they are often disregarded until an emergency arises, at which point they may potentially save lives (Pathak D et al., 2021). Ultrasonic sensors are designed to alert individuals inside buildings to the possibility of a fire and advise them to leave immediately upon hearing the alarm sound (Solanki MS et al., 2020). The fire alarm system could have had a remote signal device installed, which would notify the emergency services via a central rail station. The "brain" of both fire detection systems seems to be the Automatic Fire Alarm Panel (Fire alarm system., 1974). It serves as the central hub for all detecting signals to be attached to or provides users with a status indication.

Addressable fire alarm systems use multiplex technology and digital encoding to pinpoint the location of alarms and device problems more precisely (P. G. Smith., 1977; B. E. E. Moore et al., 1913). A system's fire alarm devices are all configured with distinct addresses (P. G. Smith., 1977). The device address appears on the main control panel when the detectors are triggered, indicating precisely where area the detectors have been activated (P. G. Smith., 1977). For a big facility, addressable fire alarms are necessary.

Fig. 1 *Wireless fire alarm*

Wireless fire alarm systems are easy to install (John I. Reed., 2010). Hardwire installation between the panel and the devices is not required for these systems. This implies that installing the systems anywhere without any disruptions is likewise simple. This system is a complete analog addressable fire alarm system that does not need a cable and has numerous special features despite its simple design (S. F. Roca et al., 2006). A wireless fire alarm device with a built-in smoke detector, home alarm, and battery is shown in Fig. 1 (Honeywell., 2008).

2. Methodology

In Fig. 2, this process is outlined in the block diagram. It begins with the MQ-2 gas sensor to detect the gas and the LM 35 temperature sensor to detect the environmental temperature. The flow chart explains the flow of this work. When the switch is on, Arduino is activated. An Arduino Mega microcontroller controls the IoT-based fire alarm navigation. Fire detection relies on implementing a microcontroller program that detects temperature variations according to a fire's characteristics (A. H. Altowaijri et al., 2021). Temperature elevation resulting from fire may be detected using an Arduino Mega microcontroller.

Furthermore, the device is capable of detecting smoke emitted by fires (H. Singh et al., 2021). When the temperature exceeds 63 degrees Celsius, the system will initiate the LM35 temperature sensor and the MQ2 smoke sensor. These sensors will detect smoke levels above 346 ppm caused by a fire. When a buzzer is activated, the Global Positioning System (GPS) will notify the IoT application, BLYNK, located at the fire headquarters, providing precise position information. Fig. 3 is a flowchart diagram illustrating the process flow of the sensor work in the work (N. Hanafi et al., 2020).

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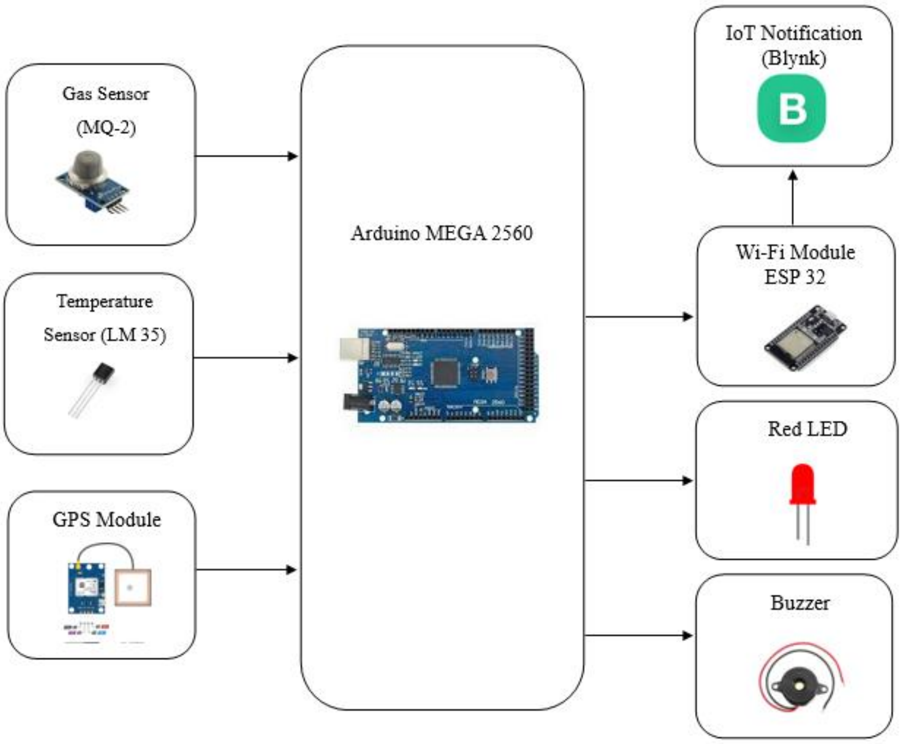


Fig. 2 *Block diagram of IoT-based smart fire alarm navigation system*

3. Results and Discussion

The main objective of this section is to provide a comprehensive examination of the device prototype's functionality. Additionally, this section will assess the prototype's performance and usability. The gas sensor will be tested to determine the appropriate distance for gas detection. One additional test that will be conducted during the device prototype testing process pertains to the gas type that the chosen gas sensor can detect. This topic will also address the assessment of the data acquisition in the Blynk application. The Blynk application interface will also be covered and explained in detail. Finally, this subject will provide an explanation of the device's coding and schematic circuit design.

3.1 MQ-2, LM 35 and Neo-6M GPS Sensor Measurement

MQ-2 sensor detects gases such as Liquefied Petroleum Gas (LPG), Propane, Methane, and Hydrogen. The MQ-2 gas sensor, which detects when the gas is detected and sends data via Blynk apps, is seen in Fig. 4(a). The temperature sensor (LM35) tested on the lighter requires a high temperature, as shown in Fig. 4(b). The Neo-6M GPS sensor receives data regarding the geographic location, including latitude and longitude, as shown in Fig. 4(c).

3.2 Circuit Design and Software Design

Fig. 5 shows the circuit installation for this prototype, featuring essential components like the gas sensor, temperature sensor, GPS module, and two microcontrollers: the Arduino Mega 2560 and ESP32. These components play vital roles in the device's functionality. The Arduino Mega 2560 is the primary controller, orchestrating the device's operations and ensuring optimal performance. The gas sensor collects gas data and triggers alerts when gas levels exceed 346 PPM. Upon detecting high gas levels, the buzzer and red LED are activated, and a notification is sent to alert the user about the nearby gas or fire hazard. This comprehensive setup integrates various components to create an effective safety monitoring system.

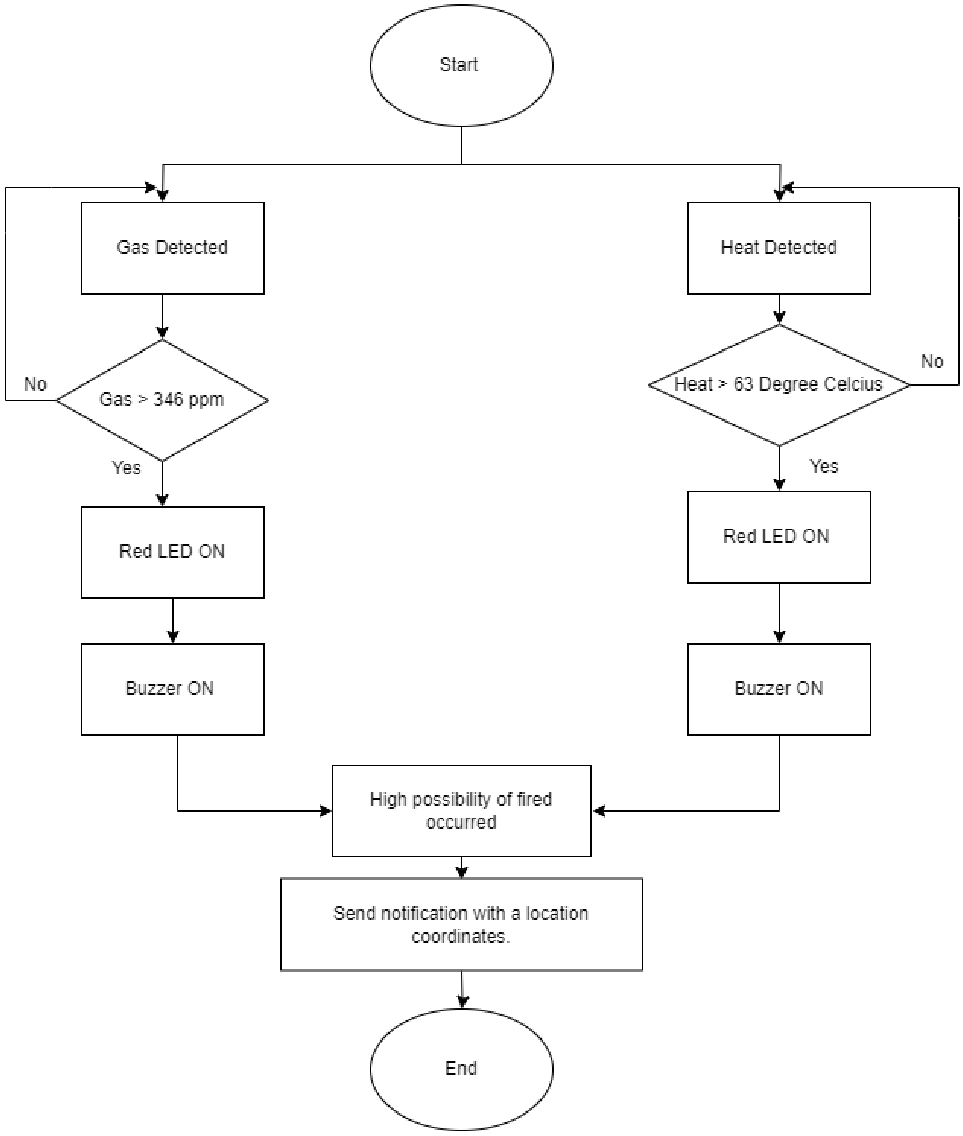
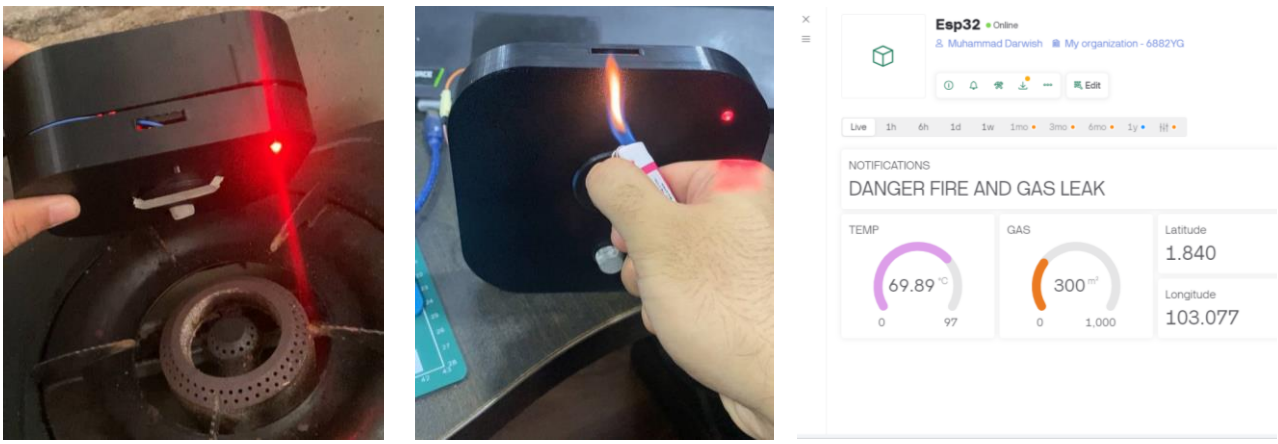


Fig. 3 *The process flow of the sensor in the work*



(a) (b) (c)

Fig. 4 *(a) MQ-2 sensor tested on LPG gas; (b) Temperature sensor (LM35) tested on the lighter; (c) Temperature sensor (LM 35), Gas sensor (MQ-2), and GPS sensor (Neo-6M GPS module) reading testing value via Blynk application*

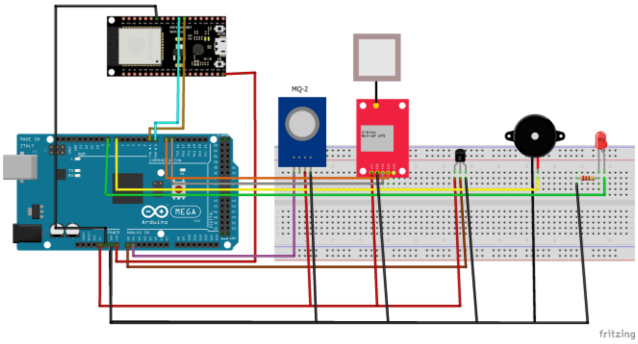
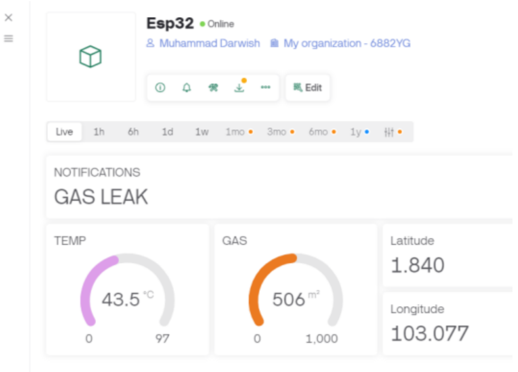
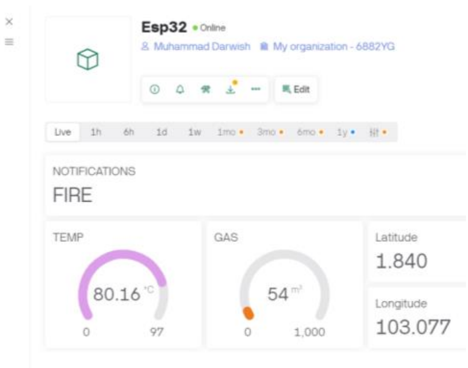


Fig. 5 *The circuit design for the prototype*

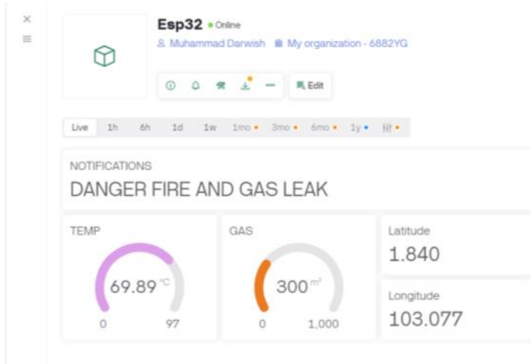
Fig. 6(a) depicts the gas data captured by the Blynk application, where the gauge meter reflects the gas levels, accordingly showing low values for low gas concentrations and high values when gas levels reach the caution threshold. If the gas concentration exceeds 346 ppm users will receive a notification indicating a breach of the safety limit. Similarly, Fig. 6(b) showcases temperature data, with notifications with navigation sent if temperatures exceed 63 degrees Celsius, signifying a potential fire hazard. When gas and temperature levels surpass their respective safety limits, users receive an alert indicating a critical situation involving fire and gas leaks, as illustrated in Fig. 6(c).



(a)



(b)



(c)

Fig. 6 *(a) Data from the Blynk application when gas detected; (b) Data from the Blynk application when fire detected; (c) Data from the Blynk application when fire and gas detected*

The following interface to be discussed is the alert system, which is designed to notify users based on specific criteria related to gas concentration and temperature levels. This system ensures that users receive critical alerts when necessary, enhancing the safety and effectiveness of the device.

Users will receive notifications if any of the following conditions are met the gas concentration surpasses 346 PPM, the temperature increases beyond 63 degrees Celsius, or both parameters exceed their respective thresholds simultaneously. These notifications serve as vital alerts, informing users about potential gas leaks, fire detections, or a combination of hazards in any monitored area. The alert system is crucial for ensuring that users respond promptly to dangerous situations, thereby preventing harm and mitigating risks.

Fig. 7 illustrates the format of the alert notifications that are sent to users. These notifications include detailed information about the detected hazard and provide navigation links for further action. The design of these notifications is user-friendly, ensuring that critical information is easily accessible and understandable.

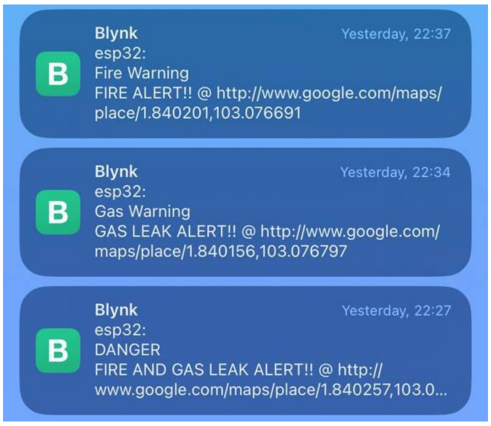
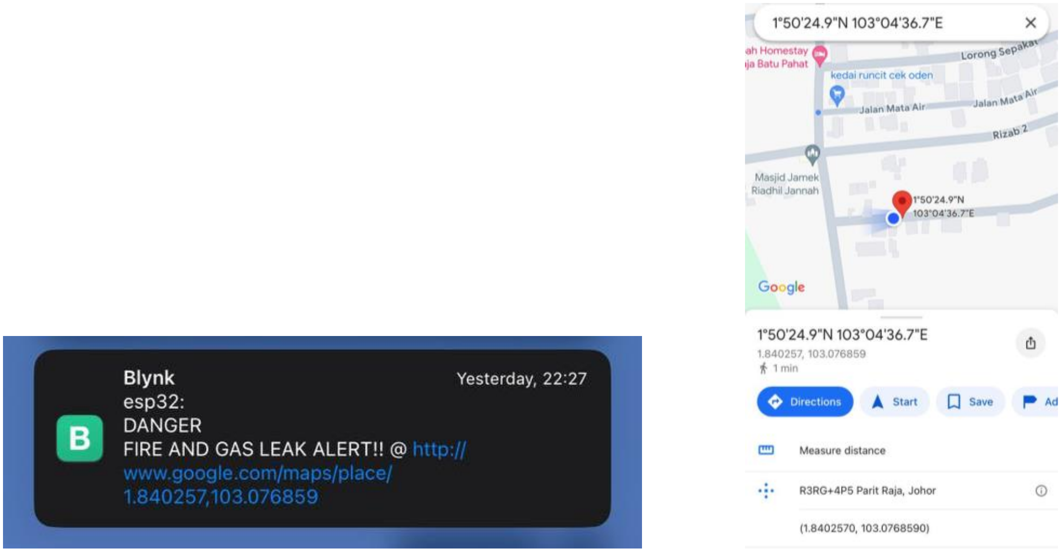


Fig. 7 *Alert notification with navigation for the user*

Furthermore, as shown in Fig. 8(a), users have the ability to click on the links provided within the notifications. This feature allows users to view the exact location of the detected hazard using Google Maps, enhancing the practicality and responsiveness of the alert system. Fig. 8(b) depicts how the exact location is displayed on Google Maps, providing users with precise information about where the gas leak, fire, or both have been detected. This functionality is essential for enabling users to take immediate and informed actions based on the alerts received.



(a) (b)

Fig. 8 *(a) Navigation link; (b) Google Maps*

Overall, the alert system is a key component of the device's functionality, providing timely and accurate notifications to ensure user safety and facilitate quick responses to potential hazards. Fig. 9 illustrates the Blynk application as accessed via a smartphone. Blynk is an IoT platform that allows users to monitor and control their connected devices through a user-friendly mobile interface.

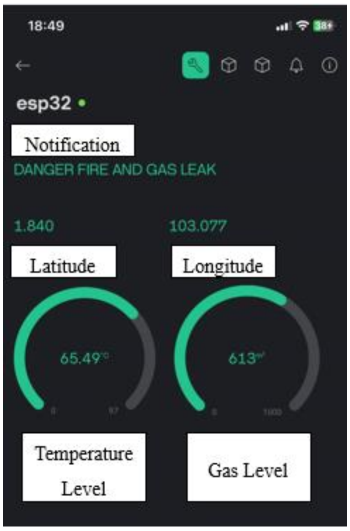


Fig. 9 *Blynk application via phone*

3.3 The Suitable Distance

The prototype's first test aimed to find the ideal range or distance for the sensors' effective detection of gas and fire. The test results are shown in Table 1. The gas and fire sources were positioned between 1 and 20 cm from the temperature and gas sensor.

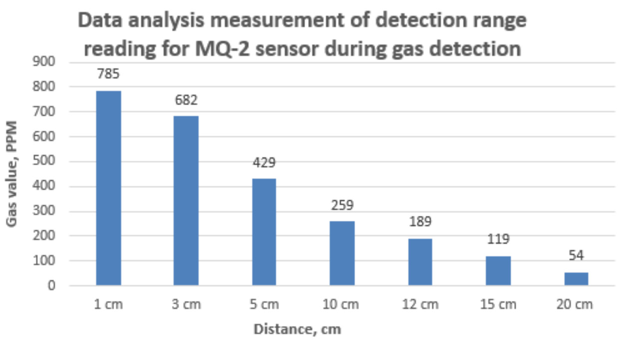
During testing, the gas sources were positioned at specified distances from the sensor, which was located at the prototype's base. The gas sensor noticed the presence of fire and gas when the gas source released these substances. The Blynk application was used to show the sensor data once it was sent to a microcontroller.

Bar graphs representing the data analysis of the detection range and temperature readings for the MQ-2 sensor and the LM 35 temperature sensor, respectively, are shown in Fig. 10(a) and Fig. 10(b). The data shown in these figures shows that sensor readings rise in proximity to the gas source and decrease in distance from the fire. These graphic depictions provide important information on sensor performance about proximity, which is necessary for maximizing sensor calibration and placement in practical applications where precise gas and fire detection is critical.

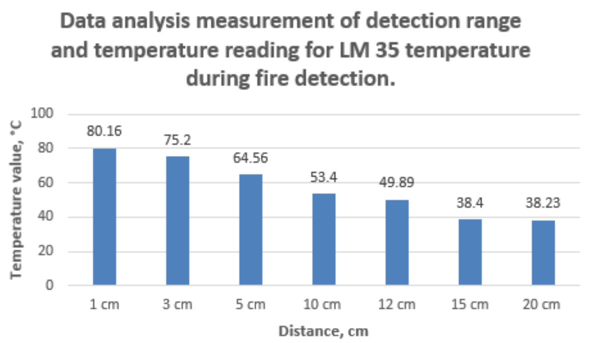
This testing stage offers vital information for figuring out the sensors' effective working range for gas and fire detection. Based on environmental factors and proximity to any threats, the results will direct the placement and calibration of sensors in practical applications, guaranteeing optimum performance.

Table 1 *Data analysis measurement of detection range and temperature reading for MQ-2 sensor and LM 35 temperature during gas and fire detection.*

Range	Gas (ppm)	Temperature(°C)
1 cm	785	80.16
3 cm	682	75.20
5 cm	429	64.56
10 cm	259	53.40
12 cm	189	49.89
15 cm	119	38.40
20 cm	54	38.23



(a)



(b)

Fig. 10 *(a) The data analysis measurement of detection range reading for MQ-2 sensor during gas detection; (b) The Data analysis measurement of detection range and temperature reading for LM 35 temperature during fire detection.*

4. Conclusion

The IoT-based smart fire alarm navigation system has been successfully developed and tested, demonstrating its functionality and reliability through rigorous prototype testing. The system effectively measures and monitors key parameters such as gas concentration, temperature, and location coordinates using a gas sensor, temperature sensor, and GPS module integrated with a microcontroller. Data collected from these sensors is displayed in the Blynk application, providing real-time monitoring capabilities. The prototype device not only detects gas leaks and temperature changes and coordinates location but also sends alert notifications with navigation instructions to users when these parameters exceed predefined thresholds. This system ensures timely detection and response, enhancing safety by continuously monitoring critical environmental conditions.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the paper's publication.

Author Contribution

The authors attest to having sole responsibility for the following: planning and designing the study, data collection, analysis and interpretation of the outcomes, and paper writing.

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