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IoT-Based Early Warning Detection System for LPG Leakage Using Raspberry Pi

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Abstract: Liquefied Petroleum Gas (LPG) is one of the household things in daily life. LPG, on the other hand, is extremely combustible. Many accidents have occurred as a result of LPG leaking. A detection and monitoring system is quite widespread in the industrial field. However, this approach is still uncommon in the domestic market. Since LPG is commonly used in homes, an early warning detection system for LPG leakage is critical. This project seeks to solve this problem by creating a device that uses a sensor and an exhaust fan connected to a Raspberry Pi 4. This system will detect the LPG leakage through the sensor while activating the alarm and exhaust fan. This system simultaneously alerts the user using a real-time message to the authorized users through Telegram Messenger on their smartphones. Users will be able to utilise this device to prevent accidents caused by gas leaks, allowing accidents to be prevented. This LPG leakage detection system has been developed successfully that is suitable to be used in a small confined area such as the kitchen. This system ensures safety and prevents explosions due to gas leakage.

Keywords: IoT, MQ-2, Raspberry Pi, LPG, Telegram Bot, Exhaust Fan

1. Introduction

The country has around 30 million LPG customers, accounting for roughly 40 percent of the population. Just a few guidelines have been implemented for the gas spillage recognition framework. The existing frameworks provide a warning that is primarily meant to distinguish a gas spillage in a home or company [1].

The previous systems could only detect gas leaks using software that would be integrated into an Android smartphone [2]. There are some disadvantages to this approach. For example, if a user is not an Android user, the app will not send any notifications. Furthermore, no component in this device prevents or reduces the concentration of gas or fire. As a result, additional equipment, such as an exhaust fan, is required to make accident prevention more efficient, quick, and precise.

Internet technologies can let devices communicate more quickly. The device can supply a solution to any existing difficulties by employing this connectivity on a daily basis. As a result, we

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suggest the IoT-Based Early Warning Detection System for LPG Leakage using Raspberry Pi as a solution to the problem. It will continuously monitor the presence of combustible gas in the air. It is expected that with this technology, the number of future incidents will be decreased and that substantial losses will be avoided.

2. Methodology

2.1 System Design

The major goal of this study is to design an LPG detection system based on small single-board computers and the IoT. To achieve this purpose, a Raspberry Pi is used with MQ-2 gas sensor for LPG detection. The block diagram of the LPG detection system using the IoT is shown in Figure 1.

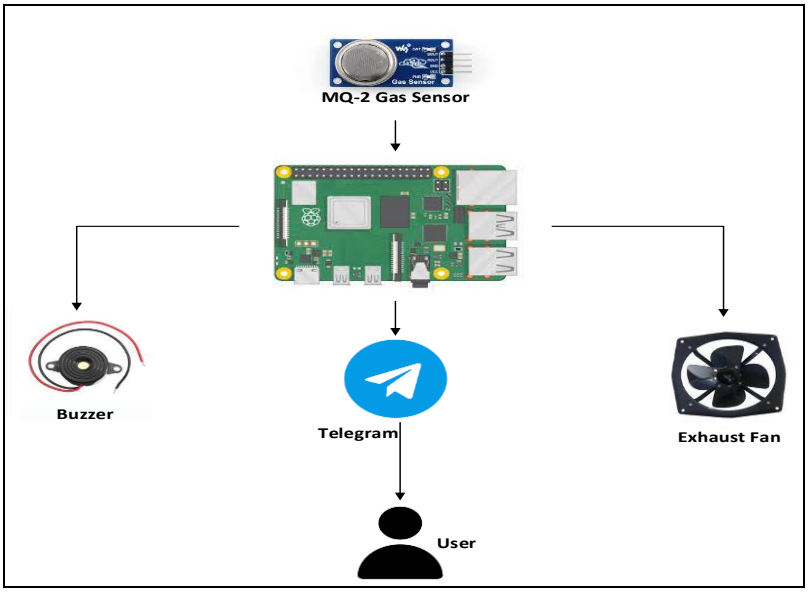

Figure 1: Block diagram of the system architecture.

The function of the components will be described below:

• MQ-2 Gas Sensor
The key characteristics of the MQ-2 sensor are its high sensitivity and quick response time, allowing measurements to be obtained as quickly as possible. It can detect natural gas concentrations between 200 and 5000 ppm [3].

• Raspberry Pi
It is a powerful small sized single board computer can be used for many applications. It also can be used with only HDMI monitor alone.

• Telegram
Telegram is a messaging app like WhatsApp, but Telegram can create bots. It has an API (Application Programming Interface) bot that allows the human and machines to talk to it.

• Buzzer
A buzzer, often known as a beeper, is a mechanical, electromechanical, or piezoelectric audio signalling device. It converts electrical energy into sound energy using a transistor and a capacitor.

• Exhaust Fan
The exhaust fan is used to reduce the gas concentration [4] and remove it from the room.

When LPG leakage over the threshold value is detected by MQ-2 sensor, it will send the input to Raspberry Pi. After that, Raspberry will trigger the buzzer and exhaust fan to flow out the gas from

the room and reduce its concentration. At the same time, Raspberry will also send an alert to the user through Telegram Messenger as shown in Figure 2.

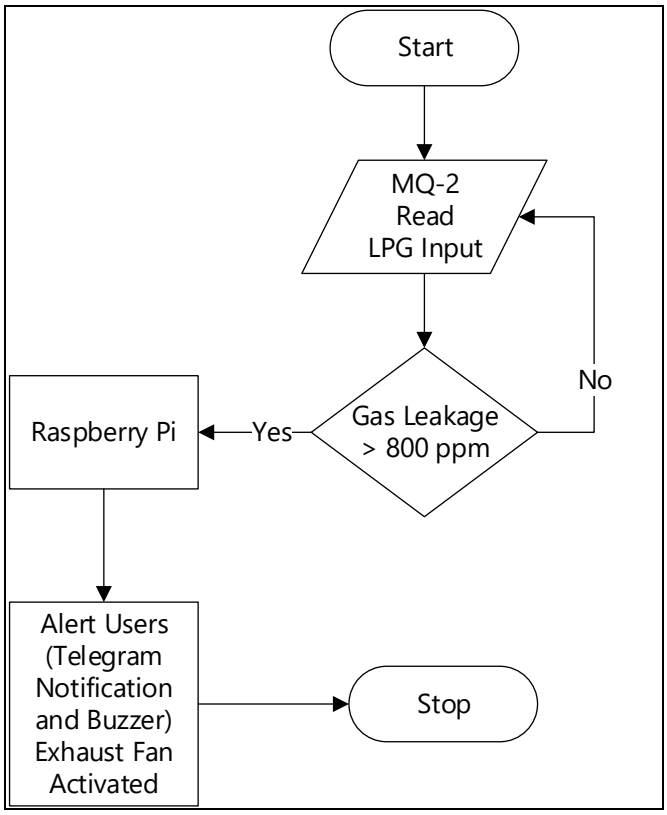

Figure 2: Flowchart of the project.

2.2 Circuit Design and Connection

This section will go over the process of designing the prototype in further detail. Fritzing Software was used to create the circuit diagram for this project. Each link must be appropriately wired to ensure that the device is running efficiently. The circuit diagram of the system is shown in Figure 3.

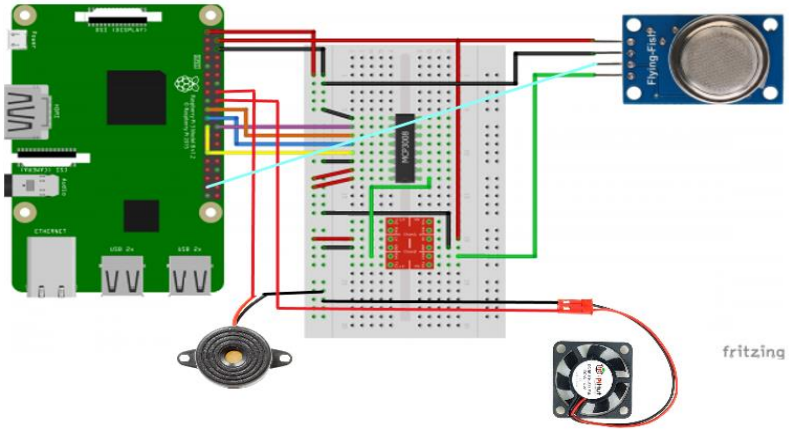

Figure 3: Circuit diagram of the project.

2.3 Hardware Development

Figure 4 represents the completed prototype for the project. There are two openings for LPG to go through. The LPG will enter through one hole near the MQ-2 sensor and exit through the hole where the exhaust fan has been installed. A buzzer and a red LED serve as a physical alarm to alert people nearby.

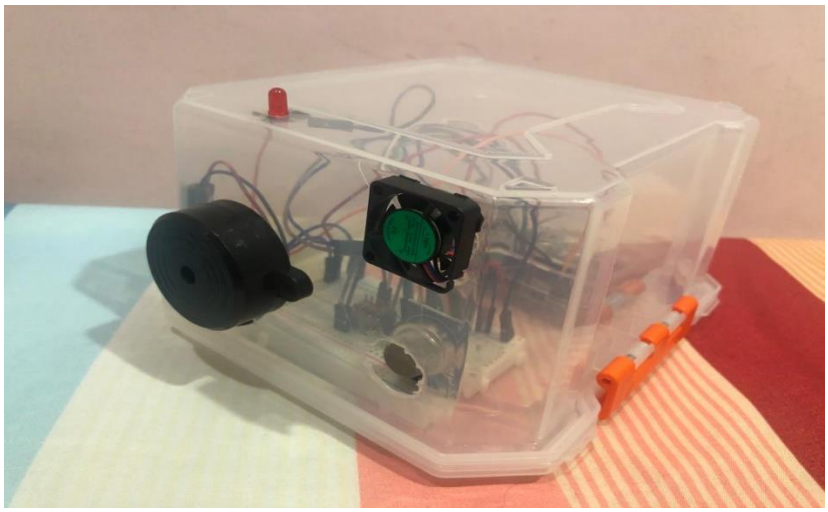

Figure 4: Prototype for the project.

3. Results and Discussion

3.1 Experimental Results

Table 1 illustrates the LPG data collected in a small confined area. This was done in the kitchen space, which was 400cm × 320cm × 320cm (length × width × height). The testing took place at a location near the stove. The gas sensor has been installed at the specified distance. After that, a 60-second timer was set. The stove was then turned on, allowing the LPG gas to spill into the surrounding area. The readings shown on the monitor have been recorded. The experiment was done three times to calculate an average data set.

Table 1: LPG data collection in the kitchen area.

	CLOSED AREA (400 cm * 320 cm * 320 cm)			
	1ST	2ND	3RD	AVERAGE
10 cm	488	495	497	493.33
20 cm	356	379	349	361.33
30 cm	222	243	231	232
40 cm	110	112	109	110.33
50 cm	98	99	100	99

LPG readings at distances of 20 cm and above did not average 400 ppm in 60 seconds. In comparison, over a distance of 10 cm, LPG readings average near 500 ppm. Based on the data acquired, it can be concluded that the gadget should be positioned at a distance of 10 cm for greater precision.

Next, the project prototype was positioned near the kitchen stove to test the configuration between Raspberry Pi without a monitor and the Telegram message when the user activated the bot, as illustrated in Figure 5 and Figure 6.

Figure 5: Prototype testing.

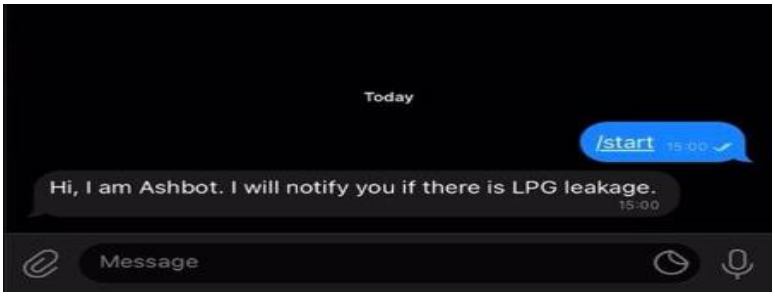

Figure 6: Telegram notification after it is activated.

After activating Telegram bot, the stove will be purposefully left with gas leaking by extinguishing the flames. Figure 7 and Figure 8 demonstrate that the prototype has been activated, and Telegram will notify the user when LPG levels exceed 800 ppm.

Figure 7: Prototype reacted to LPG above 800 ppm.

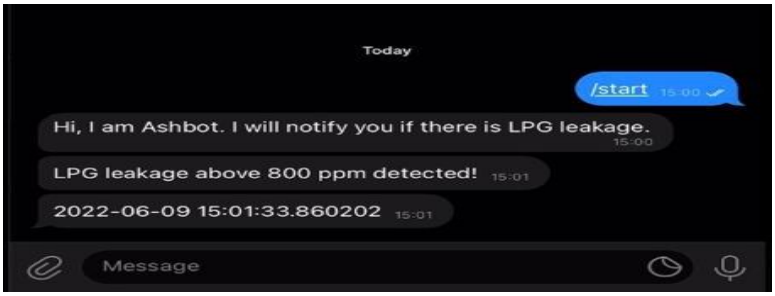

Figure 8: Telegram notification when LPG exceeds limit.

When the LPG concentration surpasses 800 ppm, the buzzer activates and the red LED illuminates as a warning sign. At the same time, the exhaust fan will be triggered to remove the gas

from the confined space and reduce its concentration. Telegram, on the other hand, will deliver notifications to the user simultaneously.

3.2 Discussions

The prototype was purposefully tested with a direct LPG source to reach its maximum limit which is 800 ppm for analysing the time it takes for the user to receive the message with various internet speed and the percentage of LPG eliminated by the exhaust fan. This test was repeated five times, as shown in Table 2 and Table 3.

Table 2: Data collection of time for user to get notified.

Test no.	Time for user to get notified (second) Internet Speed		
	0.1-10 (Mbps)	11-20 (Mbps)	21-100 (Mbps)
1	0.9	0.5	0.1
2	1.1	0.7	0.1
3	1.5	0.6	0.2
4	1.0	0.6	0.1
5	0.9	0.5	0.1

Table 3: Data collection of LPG concentration eliminated.

Test no.	LPG level upon exhaust fan activation (ppm)		LPG concentration eliminated (%)
	Before	After	
1	910	327.60	64
2	1024	276.48	73
3	817	383.99	53
4	1175	246.75	79
5	804	329.64	59

According to the data collected, most mobile internet users have internet speeds ranging from 0.1 Mbps to 10 Mbps. While the internet speed over Wi-Fi is 11 Mbps or higher depending on the plan purchased. It can be determined that users will be notified about LPG leaks possible in a short as 2 seconds if they have internet connectivity even on mobile internet.

In terms of LPG concentrations reduced once the exhaust fan is enabled, all of the tests have an elimination rate greater than 50% but less than 80%. This is due to the low power and small size of the exhaust fan employed in this project as a prototype. The usage of an exhaust fan is crucial since it aids in the removal of gas in the event of a leak [5].

4. Conclusion

In conclusion, this project has successfully established a connection between Raspberry Pi 4 and MQ-2 gas sensor to detect LPG leakage. This system also starts the exhaust fan for ventilation to minimise the concentration of LPG. Moreover, this system has been integrated with a feature to automatically alert users through Telegram Messenger and trigger alarm to alert people nearby. Physical and non-physical alerts are both triggered at the same time. Last but not least, this project can contribute to minimising and preventing accidents like explosions or in case of fire by providing users with early warning. The user is also notified when they are not at home via Telegram. This will allow the user to contact others to investigate the gas leak.

5. Recommendation for Future Work

In today's world, LPG is widely used, and the risk of utilizing it is also substantial. It is possible to make progress by implementing an alert to the local fire department, which will assist in delivering a rapid reaction and make it easier to improve safety. A portable robot capable of distinguishing various gas focuses can be created for industrial purposes. Expansion of the load cell can also be used as a weight sensor, which detects the amount of gas in the barrel and also detects heavyweight gas in the chamber pipe, sending out alert signals via Telegram and LCD. Last but not least, the DC motor rotates to close the cylinder valve. To prevent further cylinder leaking, the LPG regulator attached to the cylinder will be shut off automatically using a DC motor.

Acknowledgement

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