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IoT Based Carbon Monoxide Monitoring and Warning System Application in Vehicles

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Abstract

Nowadays, frequent incidents occur of poisoning of carbon monoxide gas inside cars, with most of the reported cases resulting in death. The goal of this work is to create and improve existing systems related to carbon monoxide leaks to alert the car user, monitor carbon monoxide levels, and ventilation support in car cabins. The system includes a gas sensor to identify the level of carbon monoxide gas, at which instance a control action is taken MQ-7 sensor was implemented as the carbon monoxide sensor in the system. The carbon monoxide level can be monitored on LCD and mobile phones that display on Virtuino IoT applications. When the carbon monoxide reading reaches the threshold level, the buzzer will ring and if the user does not reset the system, the system will open the car window and immediately send the SMS of the car location to emergency contact. A test was conducted on two types of cars with different car sizes to test the system response. The results show that the small car size will respond slightly faster than the larger car size. The time response between the two types of cars is acceptable and still in safe range. These implementations of this work imply that this technology has the potential to reduce the tragedies that occur of poisoning of carbon monoxide gas inside of cars by providing monitoring, alerting, and ventilation support that allows people to be in safe conditions in car cabins.

1. Introduction

When breathed in significant quantities, the colourless, odourless gas known as carbon monoxide (CO) can be hazardous. It is created when fuels including coal, wood, kerosene, natural gas, oil, propane, and coal are not completely burned. Because it replaces oxygen in the blood and depletes the heart, brain, and other essential organs of oxygen, carbon monoxide is toxic when inhaled. When carbon monoxide is inhaled, it mixes with haemoglobin in the blood to generate carboxyhemoglobin, which significantly reduces hemoglobin's ability to carry oxygen to body tissues and essential organs. This reduces the blood's ability to carry oxygen. This obstructs the body's organs' ability to get oxygen. Due to insufficient oxygen transport to the brain, weariness, headaches, disorientation, and dizziness are the most frequent side effects of CO exposure. Short-term CO exposure can exacerbate a person's cardiovascular illness by impairing their body's already impaired capacity to adapt to the elevated oxygen demands of exercise, effort, or stress [1].

One of the major sources of carbon monoxide (CO) is motor vehicle exhaust fumes. Exhaust gas that leaks out before the catalytic converter has high CO concentrations, and out-of-tune or misfiring engines produce elevated concentrations of carbon [2]. Carbon monoxide leaking from the exhaust system can enter the vehicle through holes or windows or doors, and inhaling a certain concentration can be dangerous. The common causes of carbon monoxide poisoning are staying or sleeping in a vehicle with the engine running, running a vehicle in a closed space, and running a vehicle with faulty exhaust and holes in the car body. Carbon monoxide poisoning is responsible for many deaths and hospitalizations each year. Some motor vehicle-related carbon monoxide poisoning cases in Malaysia cause serious health problems and death. Four 21-year-old women were resting in their minivan at a petrol station in Sama Gagah on mainland Penang when they were suspected to have inhaled carbon monoxide on Thursday, September 17, 2020. The carbon monoxide was believed to have seeped into their vehicle due to a faulty air conditioning system, killing three of the college students who had gone out for an outing while awaiting graduation. The fourth student, a pharmacy student, was the sole survivor and remained in critical condition on Saturday, September 19, 2020, at a hospital in Kuala Lumpur [3].

There are several carbon monoxide detection products sold on the market. But its functionality is very limited, it can only detect readings and display carbon monoxide levels. There have also been several works undertaken to upgrade existing carbon monoxide detection systems. Among the research works that have been done is using a sensor to detect carbon monoxide levels and using an Atmel 89c51 to process the data. Then if the carbon monoxide reading is at a dangerous level it will send a warning message to the authorized user [4]. There are limitations and disadvantages of carbon monoxide detectors against past research works that have been done. Limits on the network to send information through a limited Bluetooth connection. In addition, no system can help with ventilation in the car cabin. To address these challenges, a GSM module equipped with a SIM card is employed to transmit the MQ-7 sensor values from the microcontroller to the cloud. Subsequently, the data is forwarded to a mobile application for visualization and display. Next, use the relay to control the opening of the window and sound the buzzer if the carbon monoxide level is at a dangerous level to help ventilate the vehicle cabin. In addition, sending vehicle location information to authorized users.

2. Methodology

2.1 Block diagram

Fig. 1 shows the block diagram of the IoT based carbon monoxide monitoring and warning system application in vehicles. It shows the system is controlled by using an Arduino Mega 2560 as the main controller unit. The main component of this system is the MQ-7 carbon monoxide sensor that acts as input for carbon monoxide levels. Alongside the USB 5V power supply to power up the system and push buttons are used as input to reset the system. The Neo-M6 GPS module acts as location detection. All the input will be sent to Arduino Mega 2560 to be analyzed and processed. The processed signal will be sent to the output, which is I2C LCD 16x2, buzzer, and SIM900A GSM module. The I2C LCD 16x2 will display the level of carbon monoxide in ppm value. The buzzer acts as an alarm when the carbon monoxide level reaches the threshold value. The SIM900A GSM module will send the MQ-7 sensor value to the ThingSpeak cloud and send Virtuino IoT applications to display on mobile phones. In addition, it also will send location messages to emergency contacts.

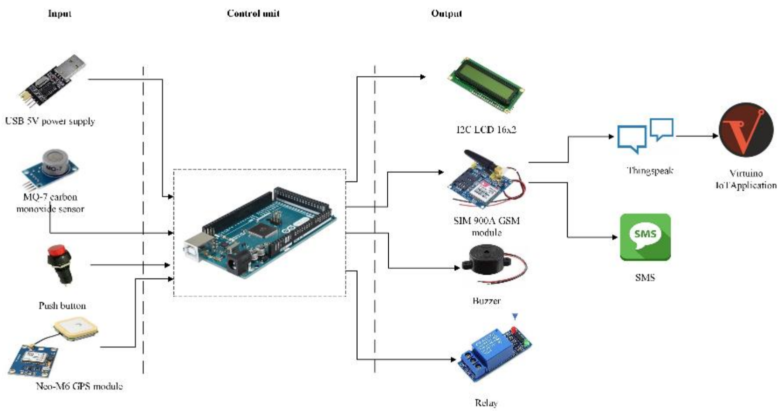


Fig. 1 *Block diagram of the IoT based carbon monoxide monitoring and warning system application in vehicles*

2.2 Flowchart

The flowchart of the process flow of the system operation is shown in Fig. 2. The system is operated when the car ignition is turned on. Then it will heat up for 60 seconds then it will display the carbon monoxide level on LCD and simultaneously send the carbon monoxide level to ThingSpeak cloud and from the cloud will send the carbon monoxide level to Virtuino IoT applications. If the carbon monoxide level reaches the threshold value which is 30 PPM, the buzzer will be ringing. After 30 seconds the buzzer rings and the reset button is not pressed, the system will send the GPS location to the target contact and at the same time will open the car window. Other than that, if the buzzer rings, then the reset button is pressed, and the system will be reset for 60 seconds.

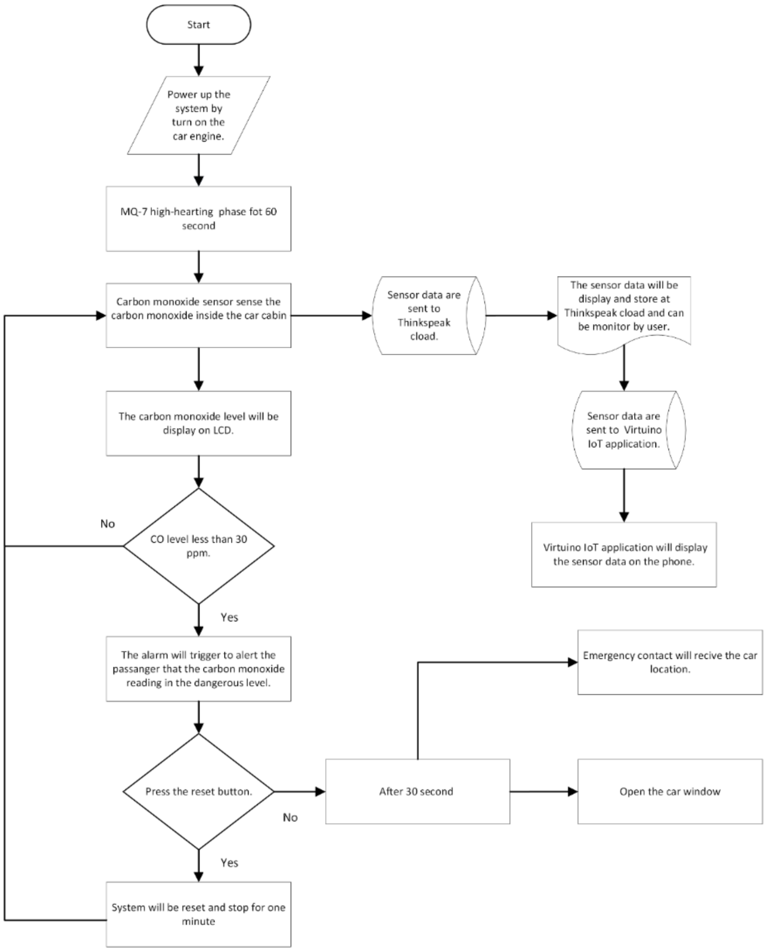


Fig. 2 *The process flow of the system operation*

2.3 Circuit diagram

Fig. 3 shows the real application of circuit connection of the IoT Based Carbon Monoxide Monitoring and Warning System Application in Vehicles. Each component is tested after purchase to make sure all the components are working well.

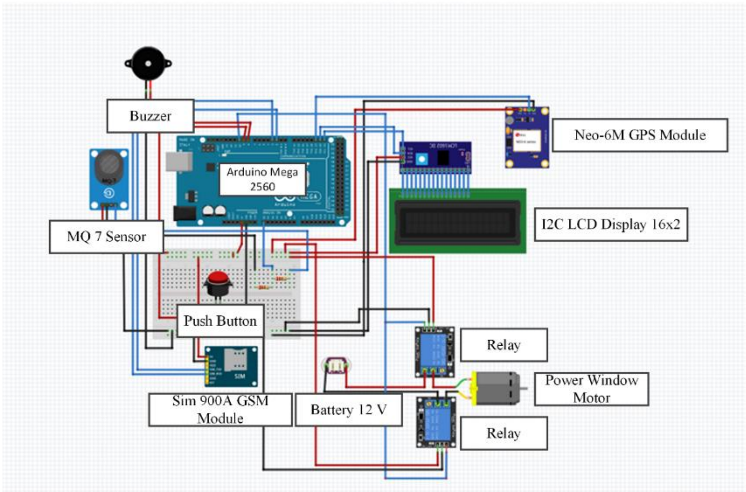


Fig. 3 *Circuit diagram of the system*

2.4 Experiment setup

The initial testing for the system will be performed in two types of cars with different car cabin sizes. The types of cars used are sedan and hatchback. The test was performed to observe the time response of the system and the functionality of the system. The test was conducted by channeling the carbon monoxide from the exhaust to the front window and rear window and the air conditioning is on. The test will be performed twice, and the average result will be used as the final test for each condition is set.

3. Result and Discussion

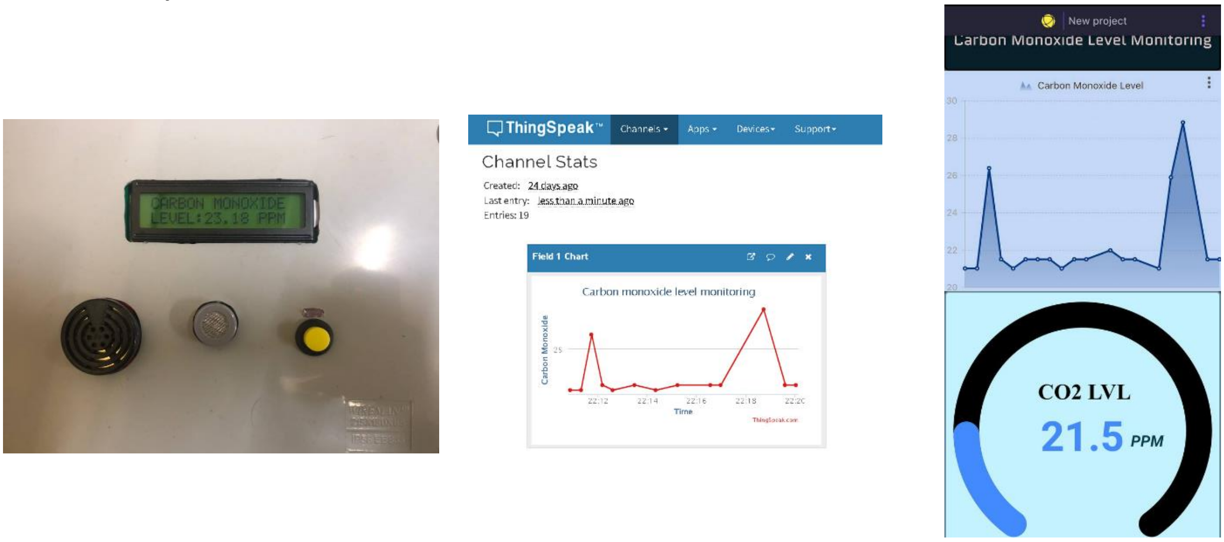
3.1 Observation from the system

As summarized in Table 1, the system was tested in multiple conditions to see each of the conditions. During the testing phase, the system underwent a thorough evaluation aligned with the predefined flowchart to assess its functionality. The initiation of the system occurred following the connection to a 5V power supply via USB to turn on the system. Then the MQ-7 sensor needs to be heated up for 30 seconds before the starts sensing the carbon monoxide.

Table 1 *System observation*

Condition	Observation
Carbon Monoxide level below 30 PPM	Display CO level
Carbon Monoxide level above 30 PPM	Display danger CO level and buzzer ringing
Carbon Monoxide level above 30 PPM after 30 second	Display window open, buzzer ringing, send GPS location to target user and open window
Carbon Monoxide level above 30 PPM and the reset button is pressed	Display system reset for 60 second

By integrating a carbon monoxide monitoring system with an LCD, ThingSpeak, and the Virtuino IoT application shown in Fig. 4, users can efficiently track and visualize real-time carbon monoxide levels. The LCD provides immediate on-site visibility, allowing individuals to stay informed about air quality in their surroundings. Simultaneously, ThingSpeak, a cloud-based IoT platform, enables remote monitoring and data storage, ensuring that users can access historical information and trends. The integration with the Virtuino IoT application enhances the user experience by providing a user-friendly interface for mobile devices, facilitating seamless monitoring and control from anywhere.

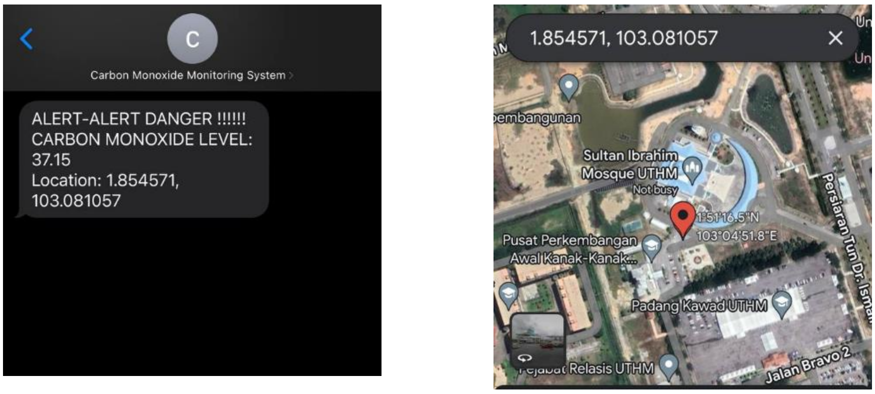


(a) **(b)** **(c)**

Fig. 4 *(a) LCD Display; (b) ThingSpeak Cloud; (c) Virtuino IoT Applications*

3.2 Result in locating the GPS location

Once the coordinates are obtained by the target contact, they can be entered into Google Maps to visualize the exact geographical point on the map by searching the location received from the message. This process allows the target contact to see the specific path or location associated with the provided coordinates, providing a detailed and interactive map display. Fig. 5 below shows the result of the message location and coordinates displayed on Google Maps.



(a) **(b)**

Fig. 5 *(a) Receive SMS GPS coordinate location; (b) Coordinate display on Google maps*

3.3 Time response of the system

Table 2 shows the result of the time response of the system condition based on the carbon monoxide channel through the rear and front windows between car types.

Table 1 *Time response of the system result*

Condition	Test 1 (minutes)	Test 2 (minutes)	Average (minutes)
Hatchback car CO channeled in front window	0.49	0.52	0.505
Hatchback car CO channeled in the rear window	1.21	1.19	1.20
Sedan car CO channeled in front window	1.10	1.07	1.805
Sedan car CO channeled in the rear window	1.25	1.27	1.26

The average of each condition obtained result of each car type is calculated to get the average time response of each car type using equation 1. The value of X is the average carbon monoxide channelled through the front window and the value Y average carbon monoxide channelled through the rear window. The result is shown in Table 3

$$Time\ response\ (Minutes) = \frac{X + Y}{2} \tag{1}$$

Table 3 *Time response of the system results in each car type*

Car type	Time response (minutes)
Hatchback car	0.825
Sedan car	1.533

Based on the results obtained for the time response from Table 3 For Carbon Monoxide channeled through the front window, Perodua Axia has a faster response time (0.49 and 0.52 minutes in Test 1 and Test 2 respectively) compared to Proton Persona which took 1.10 and 1.07 minutes respectively. Similarly, for Carbon Monoxide channeled through the rear window, Perodua Axia also responded faster with times of 1.21 and 1.19 minutes compared to Proton Persona's times of 1.25 and 1.27 minutes.

The average time taken is calculated for each type of car to the time response to the system. This value helps decide whether the system can respond to various sizes of area or not. The calculated average response time for Hatchback cars is 0.825 minutes, while for Sedan cars, it is 1.533 minutes. The system exhibits a slightly longer detection time for carbon monoxide leakage in Sedans compared to Hatchbacks, with a marginal difference of 0.708 minutes. However, this time differential falls within an acceptable range, affirming the system's efficiency for use in both Hatchback and Sedan vehicles.

4. Conclusion

In conclusion, IoT based carbon monoxide monitoring and warning system applications in vehicles have successfully achieved their objectives. Additionally, the system can be used to save people who are in the car from carbon monoxide poisoning by alerting the people inside the car. This system detects the carbon monoxide level inside the car cabin and alerts the driver and passenger. This detector used is an MQ-7 sensor to detect carbon monoxide gas and when the sensor reading reaches threshold value it will trigger the buzzer. The MQ-7 sensor value was sent to the ThingSpeak cloud to store the carbon monoxide level data. This system also can monitor the level of carbon monoxide in mobile applications and display it on LCD. This system is also capable of sending alert text messages of GPS location will be sent to the target contact based on the informed condition mentioned previously. The use of this system could go towards creating a safer life in the cabin of the car, emphasizing the importance of technology in protecting life from silent but deadly threats such as carbon monoxide poisoning.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

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

References

[1] California Air Resources Board. Carbon Monoxide & Health | California Air Resources Board. (n.d.). https://ww2.arb.ca.gov/resources/carbon-monoxide-and-health

[2] Homepage: Iowa State University Extension and outreach home. Homepage | Iowa State University Extension and Outreach Home. (n.d.). https://www.abe.iastate.edu/extension-and-outreach/carbon-monoxide-poisoning-vehicles-aen-208/

[3] H. Auto, “Three Malaysians die in suspected carbon monoxide poisoning in their vehicle,” The Straits Times, 19-Sep-2020. [Online]. Available: https://www.straitstimes.com/asia/se-asia/three-malaysians-die-in-suspected-carbon-monoxide-poisoning-in-their-vehicle. [Accessed: 06-May-2023].

[4] V.Ramya, Palaniappan, B., K.Karthick, & Prasad, S. (2012). Embedded system for vehicle cabin toxic gas detection and alerting. Procedia Engineering, 30, 869–873. https://doi.org/10.1016/j.proeng.2012.01.939