Progress in Engineering Application and Technology Vol. 1 No. 1 (2020) 206-217

PEAT

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/peat
e-ISSN : 0000-0000

Carbon Monoxide and Air Quality Monitoring System with MATLAB GUI for Smart Home Application

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DOI: https://doi.org/10.30880/peat.2020.01.01.023
Received 01 August 2020; Accepted 12 November 2020; Available online 02 Month 2020

Abstract:Carbon monoxide and air quality monitoring system is the practical technique to measure the carbon monoxide level as well as to monitor the air quality in a real time. The system will close down dangerous home appliances that potentially leaking the CO gas and might cause levels high enough to result in CO poisoning. The sensor will be installed at the potential spot and detect the presence of the gas. The sensor will send the data to the microcontroller to be processed and the microcontroller will execute the command action. MATLAB GUI is used to communicate with the microcontroller. By using MATLAB GUI, the critical level can be changed to safe without any hardware modification of the device. If sensors reading exceed the critical level or set point, MATLAB will send signal to the microcontroller to switch on the alarm, switch off the power supply equipment, and turn on the exhaust fan as well as opening the windows for ventilation purposes. Therefore, this project is a new method on carbon monoxide (CO) gas detection and air quality monitoring systems.

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Keywords: Smart Home, Carbon Monoxide, Air Quality, Arduino, Sensor, MATLAB GUI.

1. Introduction

A smart home is a home that incorporates advanced automation systems to provide the monitoring and control over the building's functions. It might automatically control lighting, temperature, multi-media, security, window and door operations, as well as many other functions [1]. Such a home is said to be safe means that existing home appliances and the environment are dependable for home users to live in [2]. For achieving the comfort living, life safety, highly security as well as efficiency the smart home development concept has incorporates the appropriate technology. It is call the smart home technology. Smart home technology achieves these goals building an environment which consists of a variety of smart home systems. It is named as home security system, home appliances, home entertainment system, home communication system, lighting and climate control system, respectively. Figure 1 shows the smart home elements which are demonstrated the smart home overall idea.

Figure 1: Smart home elements [2]

In this study, the work is focused on the home environment detector which is Carbon Monoxide (CO), CO detector and air quality monitoring system. Carbon Monoxide can be a serious problem for homeowners. Any home appliances that burns fuel such as gas furnace, gas stove, and gas hot water heater creates carbon monoxide during the burning process [3].

There are various cases of bad air quality of CO leakage problem and killed a numbers of peoples. In March 2004, a carbon monoxide leak from a gas furnace left two families suffering the effects of carbon monoxide poisoning. The leak began in one family's basement, spread throughout the house and into a neighbour's home. The leak resulted in the carbon monoxide poisoning and death of a 14-year-old girl, who lived in the home where the leak originated [4]. In 2005, exhaust fumes from a power generator leaked into the house through a crack in a door for several hours caused three children were taken to the hospital and treated for carbon monoxide poisoning. The children included a 7-year-old boy and two girls, ages 4 and 11 [4] .In year 2008, the leakage of carbon monoxide has been reported

in Johor Baharu where the couple inhaling carbon monoxide gas resulting from gas problem of excessive carbon monoxide filled the car with exhaust extraction system that has been modified [5].

As the time passes, a number of works related with CO gas leakage detection have been implemented, among these some were theoretical research approach and successfully demonstrated in practical field to detect the leakage with an effective approaches. A work was done by Brodetsky and Savic [6] which monitored leakage continuously, but not surveyed for further analysis. Another gas leakage detection system was proposed by [7]. This method can be used from ground and aerial vehicles, and was also successfully installed on autonomous robots. However this method is too expensive. Others related work on the air montoring system are discussed in [8]-[20].

This article presents the development of carbon monoxide and air quality monitoring system using arduino mega as a microcontroller with MATLAB GUI. The system consists CO gas sensor, dust sensor, humidity sensor and temperature sensor. It works in automatic or manual mode and has a capability to turn on/off the electrical appliances likes power supply, exhaust fan and alarm. The MATLAB is used to perform three important tasks: (1) to command the microcontroller output, (2) to read the data from the CO gas sensor, and (3) to plot the data in real time. In particular, we will employ the IO package from MathWorks. To do this, we may need to setup the COM port in the IO setup block to match the location where the Arduino board is connected. This model reads the gas data via an analog read on the microcontroller's analog pin. These data are then converted from analog to digital. The raw analog data is expressed in numbers of bits.

The system development and the discussion on the results obtained are presented in Section 2 to 3. Finally, section 4 concludes the work.

2. Mathodology

2.1 Flowchart of the system

The flow chart of CO detection system and automatic air quality monitoring is shown in Figure 2. Initially, the system displays the values of CO, temperature, humidity and dust in real time. When the sensor detects a change in parameters to a high value the fan will turn on, the window will open and the electrical appliance switch will be turned off to allow ventilation in the house to return to normal. In addition, this system is also able to operate manually.

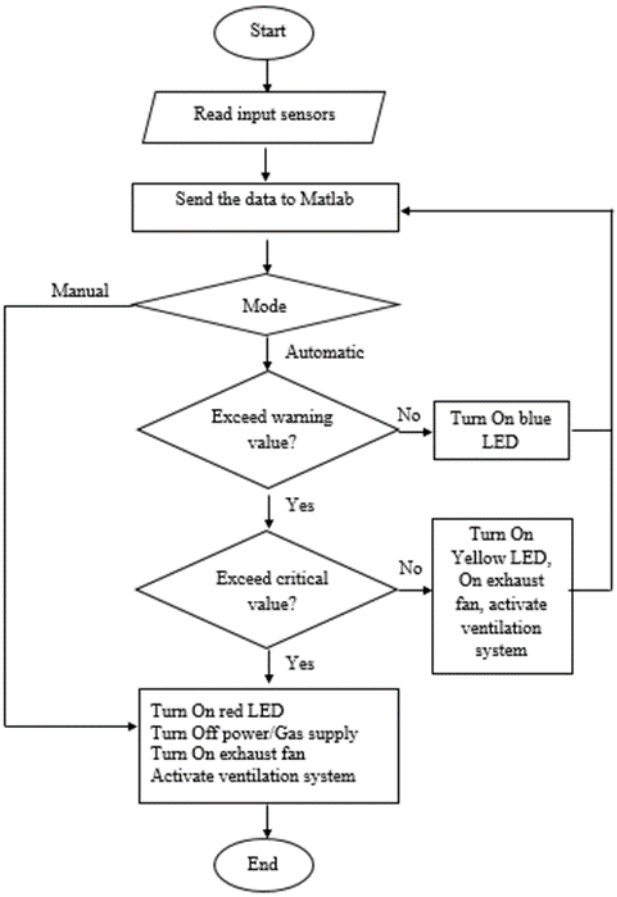

Figure 2: Flow chart of the carbon monoxide and air quality monitoring system

2.2 Block diagram of the project

Figure 3 shows the overall operating diagram of the CO gas detection system and air quality monitoring on the GUI MATLAB and electrical appliances in the home. Four sensors act as data input to MATLAB. MATLAB will read the data from these sensors and plot these data in real time. MATLAB will ask arduino to automatically control the electrical appliances in the house. Arduino will respond by processing and comparing data from MATLAB. This allows the motor and relay switch to be turned on or off which can control electrical appliances, wall fans and home windows.

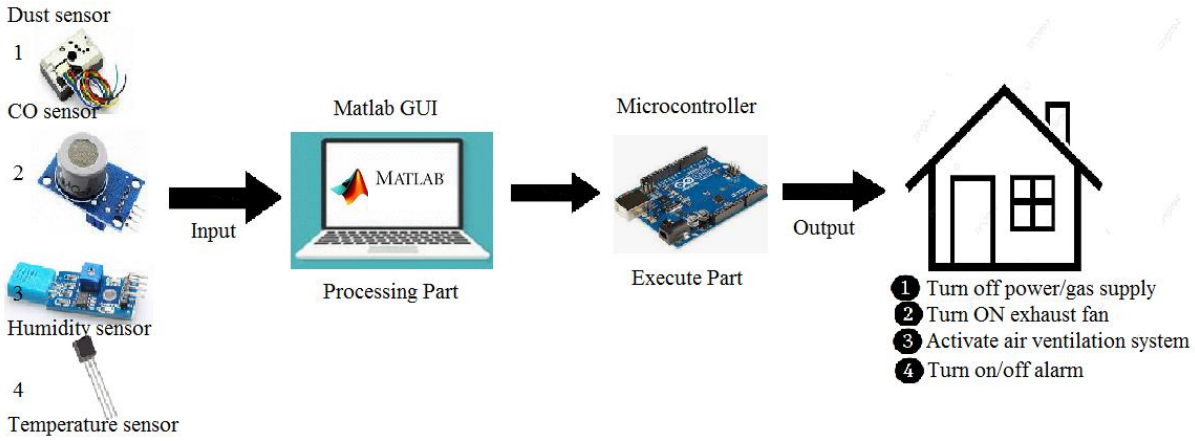

Figure 3: Block diagram of the project

2.3 Bill of materials

Table 1 displays the list of electronic components, hardware and wires used to complete this project. Proper installation of components allows the CO detection system and air quality monitoring to function properly and not easily damaged.

Table 1: Bill of Materials (BOM)

No.	Components	Quantity
1	Arduino Mega board	1
2	Power window motor	2
3	CO Sensor	1
4	Dust Sensor	1
5	Humidity sensor	1
6	Temperature sensor	1
7	Exhaust fan	1
8	Power Supply Unit	1
9	Relay unit	1
10	Light Emitting Diode (LED)	3
11	Breadboard (small)	1
12	Jumper Wire	20
13	Screw and nails	15

2.4 Carbon monoxide sensor (MQ7)

MQ7 gas sensor is used in this project as shown in Figure 4. A gas sensor is a device that can detect the presence or concentration of gas in the atmosphere. The sensor produces a difference for the measured gas potential depending on the gas concentration. This difference changes the internal resistance value of the sensor and is measured as the output voltage. The value of gas concentration can be estimated based on this voltage value.

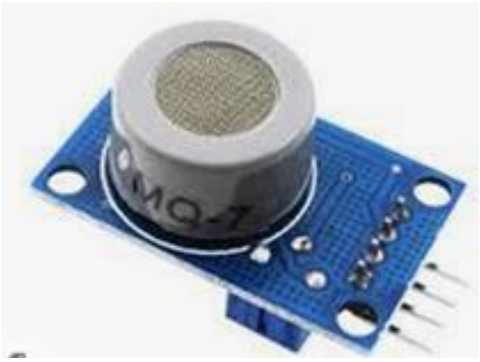

Figure 4: Carbon monoxide sensor

2.5 Dust Sensor

Sharp GP2Y1010AU0F dust sensor is used in this project (Figure 5). It is capable of detecting, measuring and monitoring haze in the air, detecting house dust, cigarette smoke and can be designed as

an automatic air purifier. The dust in the air is detected by the infrared transmitter diode and phototransistor found in the body of this sensor.

Figure 5: Dust sensor

2.6 Humidity Sensor and Temperature Sensor

The humidity and temperature sensors (Figure 6) used in this project are AM2001 and LM35 respectively. Both sensors produce analog value from the output and received by the microcontroller.

Figure 6: Sensors to detect (a) Humidity; (b) Temperature

2.8 Arduino Mega Board

The Arduino Mega 2560 (Figure 7) is a microcontroller built based on the Atmega2560 microcontroller. The board can be connected to a computer via a USB cable and uses the battery to turn it on. The advantage is a simple, fast and flexible circuit connection.

Figure 7: Arduino mega board

2.9 Exhaust fan

Exhaust fan used in this project (Figure 8) as a model for cleaning environment air from the presence of CO gas and dust. It requires a power supply of 12 V and receive the input signal from relay that

connected to the Arduino. In this work, the exhaust fan can inhale hot air to be removed and replaced with fresh air manually and automatically.

Figure 8: Exhaust fan

2.10 Relay module

Relay module (Figure 9 and Figure 10) is used as a drive and switching circuit due to the small voltage of the Arduino output pin from 3 V to 5 V. This value is not enough to turn on devices that require a higher power supply such as motors, exhaust fans and other devices.

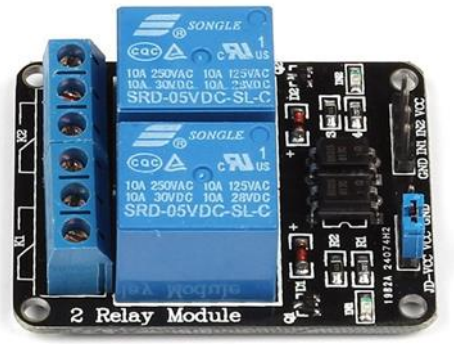

Figure 9: Relay module (250VAC)

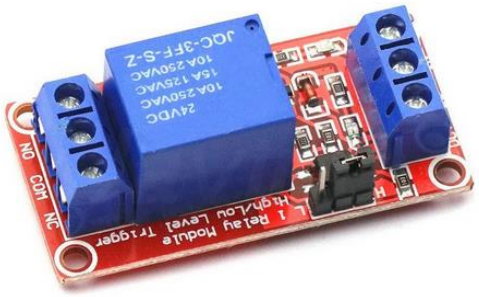

Figure 10: Relay module (24VDC)

2.11 Modes of operation and threshold level

Operation modes and the threshold level of the system are given in Table 2, Figure 11, Figure 12 and Table 3, respectively.

Table 2: System's operation mode

Automatic Mode	Manual Mode
Output such as exhaust fan, ventilation system are activated automatically	The system is under user monitoring and all control is depends on the user

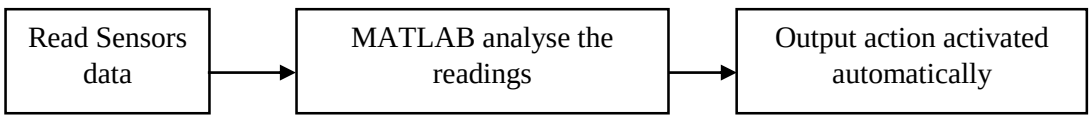

Figure 11: Automatic mode block diagram

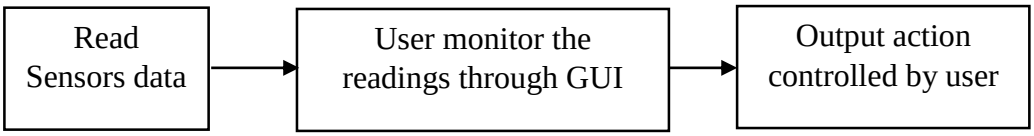

Figure 12: Manual mode block diagram

Table 3: Threshold level classification

LED	Concentration of Carbon Monoxide, x	Fan	Buzzer
Blue	x<35 PPM	Off	Off
Yellow	35<x<100PPM	On	Off
Red	X>100PPM	On	On

3. Results and Discussion

3.1 Real time graph

(a) Carbon monoxide

Figure 13 shows the real time graph for carbon monoxide reading from MQ7 sensor. The CO reading is measured in ppm value. The normal of CO reading is between 0 to 10 ppm.

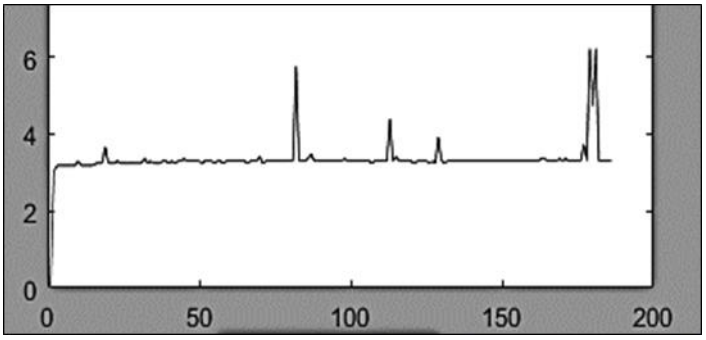

Figure 13: Carbon Monoxide Graph

(b) Dust

Figure 14 is the measurement results of the dust reading in real time graph. The sensor reading depends on the number of particles in air such as dust and smoke. Safe reading for dust is between 0 to 0.2 mg/m^3.

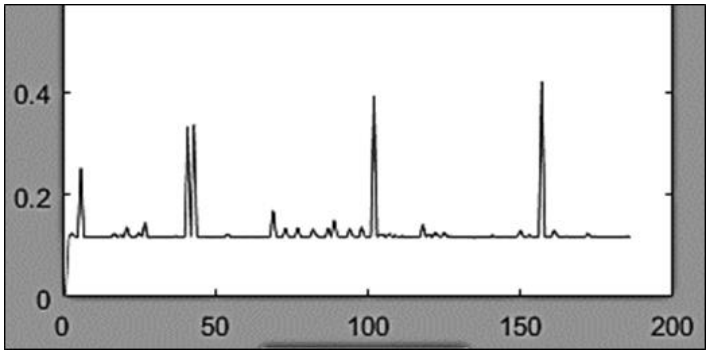

Figure 14: Carbon Monoxide Graph

(c) Temperature and humidity

The measurement results of the temperature and humidity are presented in Figure 15 and Figure 16, respectively.

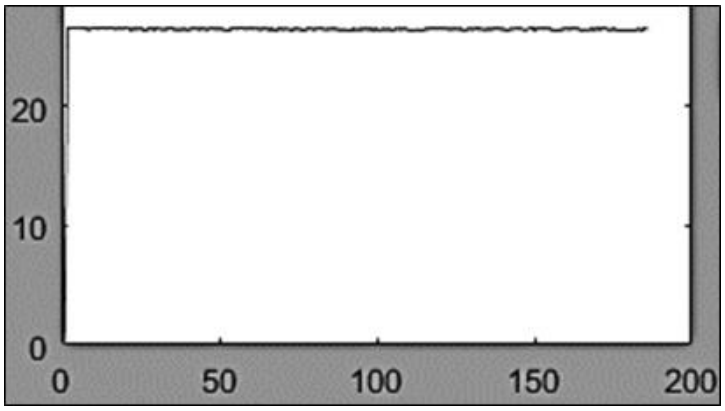

Figure 15: Temperature graph

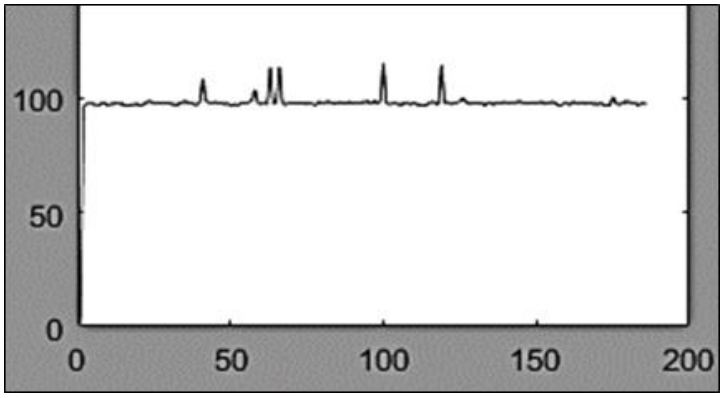

Figure 16: Humidity graph

3.1 MATLAB GUI

In Figure 17, a complete monitoring view of the demonstration of the developed system is shown. At the bottom left, there are automatic and manual buttons for the user to select. Button on/off window, on/off wall fan and on/off power supply are located at the top right. The text showing the condition of the windows, fan and power supply is also displayed on the GUI. There are four graphs on the GUI display for CO, dust, temperature and humidity. CO levels and warnings for dust and haze are also included in the GUI display.

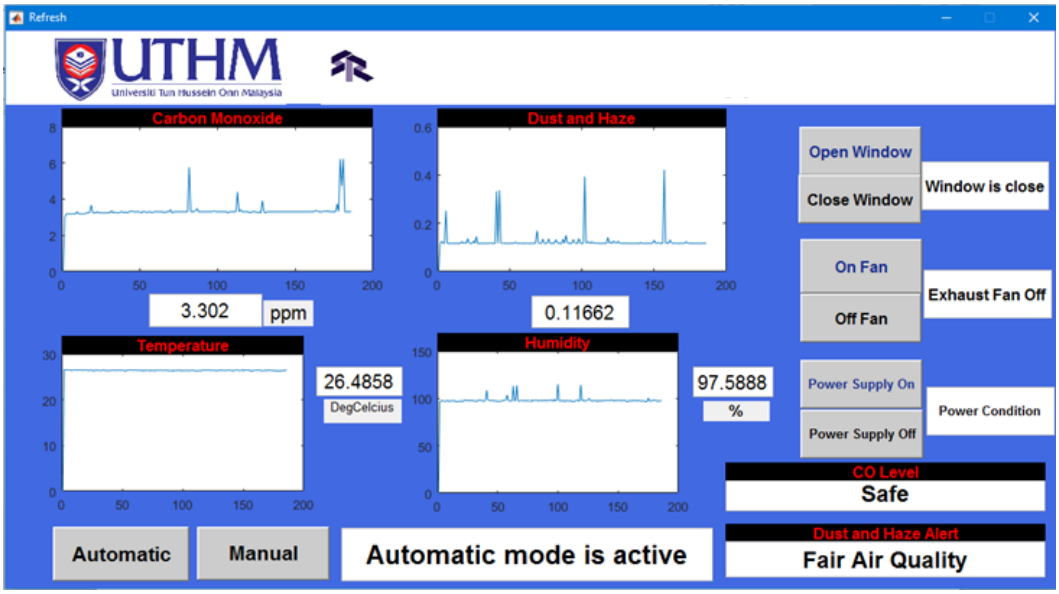

Figure 17: Monitor view of the carbon monoxide and air quality system

3.2 Sensor node

Figure 18 shows the position of the sensors that are ready to be installed and tested. The arduino board and sensors are integrated and placed in a translucent casing measuring 5 cm × 5 cm. The output of the arduino is connected to a relay which can then activate the alarm, wall fan and power supply. Component and appliances such as wall fans, windows and alarms can be turned on or off when the sensor reading exceeds a predetermined threshold value.

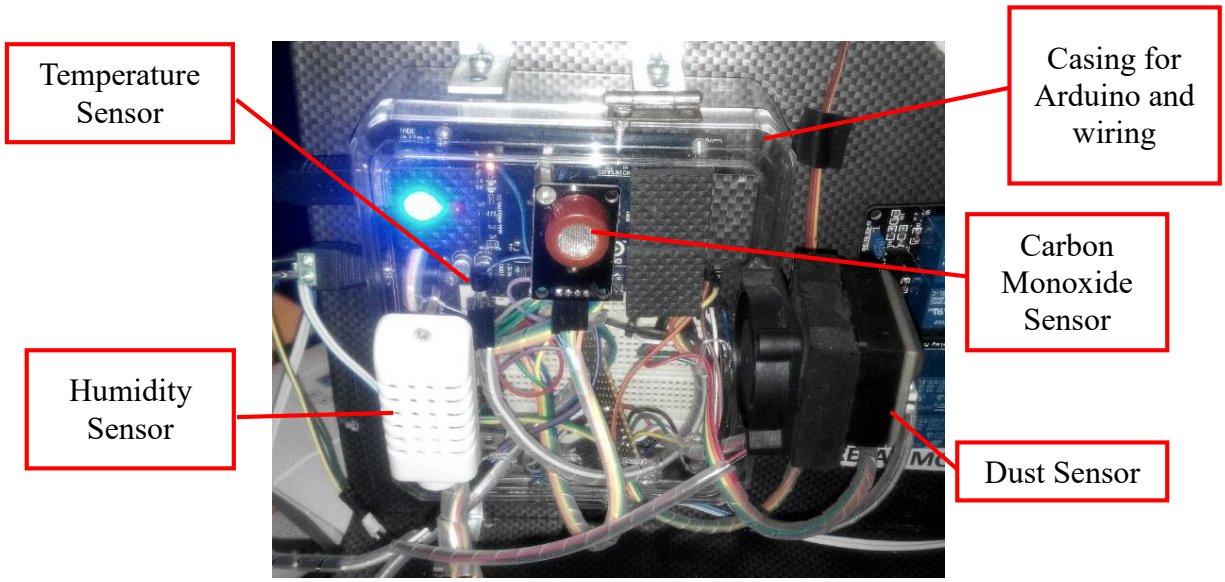

Figure 18: Sensors node

3.3 Hardware prototype

Figure 19 shows the complete prototype developed. It has been tested and the results are shown in Figure 17 and Figure 18.

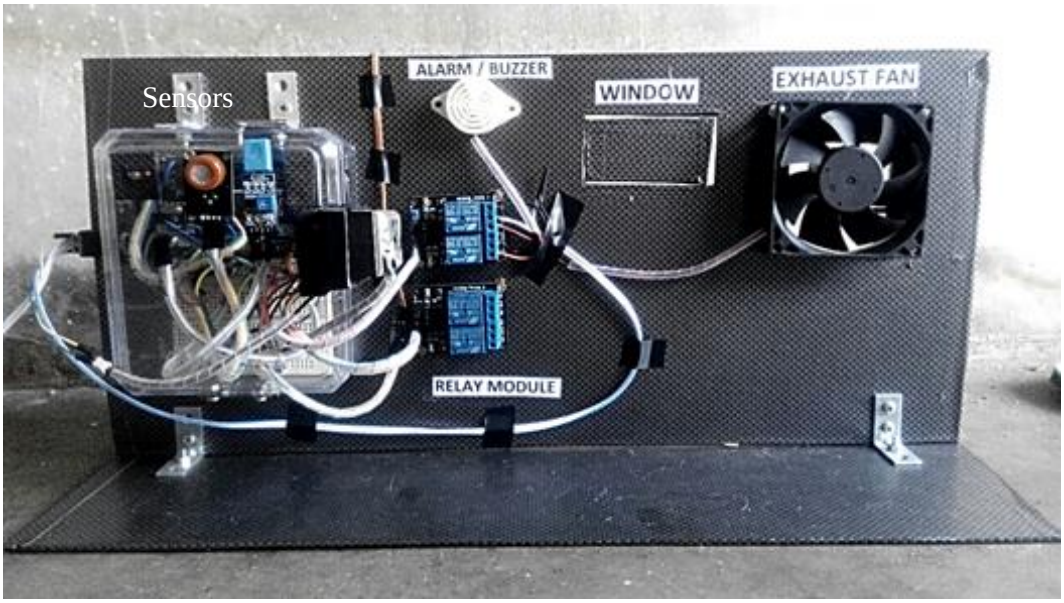

Figure 19: Prototype of the project

4. Conclusion

The proposed prototype is suitable for monitoring CO gas leaking as well as indoor air quality monitoring. This automation system is integrated of a set of sensors such as CO sensor, haze sensor, temperature, and humidity, respectively. The sensor will send the data to the microcontroller to be processed and the microcontroller will execute the command action. The corresponding measured CO level and the air quality (i.e. haze, temperature and humidity) are found to be in good agreement with the actual value. The system is capable to turn the electrical appliances on and off automatically. In conclusion, the data demonstrate that the system indeed provides the desired environmental detector for smart home application.

Acknowledgement

This research was made possible by funding from TIER1 grant vot H169. The authors would also like to thank the Faculty of Electrical and Electronic Engineering, Universiti Tun Hussein Onn Malaysia for its support.

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