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A comprehensive system for detection of flammable and toxic gases using IoT

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ABSTRACT

The majority of the existing gases constitute a risk to the health of humans and the environment in general. There is a wide range of diseases that can arise as a result of exposure to toxic and dangerous gases, which can be a cause of death or serious health problems. More so, deadly explosions may occur as a result of leakages of such gases. However, such consequences can be avoided when these dangerous gases are not detected early. Many researchers have proposed different kinds of systems for the detection of gas leakage, but most of the proposed systems were mainly designed to detect LPG gas. Therefore, in this study, a system is proposed for detecting different kinds of flammable and toxic gases. The gases that are detectable by the proposed system include smoke, Ethanol, CNG Gas, Methane, toluene, propane, Carbon Monoxide, acetone, Hydrogen Gas, and Formaldehyde. The system can detect gases efficiently and release evacuation alarms simultaneously, then send SMS for emergencies. The proposed system is ready to use and can be installed at any work location.

Keywords: IOT, LPG, Tracking System, Arduino Uno, Toxic Gases

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1. Introduction

A wide range of gases can be regarded as toxic gases that can pose a threat to the lives of people. Most of these gases are usually used close to work sites. The use of toxic gases is accompanied by several risks including explosions from pipes equipment, cylinders, and appliances that are overheated, damaged, or poorly maintained. Another risk associated with the use of toxic gases is poisoning from carbon monoxide and burns caused by contact with hot surfaces or flame. For instance, Liquefied petroleum gas (LPG or LP gas), which has been a mixed flammable hydrocarbon gas is often employed as fuel in cooking applications, heating appliances, and vehicles [1-3]. The gases contained in the LPG include 2% of pentane, 50% of butane, and 48% propane combined [4, 5]. The consequence of uncontrolled leakage of various gases can be grave on the health and lives of humans as well as the entire environment, e.g., suffocation can result from leakage or release of carbon oxides, whereas explosions can arise from the leakage of LPG [6]. Annually, several lives are consumed by accidents that occur as a result of gas leakage, in addition to the financial losses recorded by firms [7]. Another example is Toluene which can have adverse effects on the health of humans, irritating the throat, nose, and eyes; dizziness, dry of chapped skin, headache, anxiety, confusion, and feeling of drowsiness [8]. If humans inhale a large amount of carbon monoxide, it replaces the oxygen in the red blood cells, thereby preventing oxygen from getting to the organs and tissues [9]. For this reason, it becomes necessary to develop an all-inclusive system that can detect most toxic gases. With such systems, the lives of people and the environment can be secured and protected. Even though numerous systems have been proposed this wise, majority of them are designed to detect the only leakage of LPG [10-14]. Thus, this research seeks to fill this gap by proposing an all-inclusive system that can detect a wide range of toxic and flammable gases like smoke, ethanol, Hydrogen Gas, Methane, toluene, Carbon Monoxide, Propane, CNG Gas, acetone, HyFormaldehyde and Hydrogen. Internet of Things (IoT) stands for a digital network of connected platforms, systems, machines, and devices that are enabled through smart sensors that employ the use of the internet to communicate without the intervention of humans [15-19]. There are so many opportunities that are associated with the Internet of Things (IoT), particularly, for real-time applications such as LPG monitoring systems [20], real-time sensing systems[21], healthcare system [22-24], smart lighting systems [25-27], tracking systems [28-30], smart education [31, 32], and so on. The IoT is a classic description of the next generation of the internet, which makes it possible to access physical things [33, 34]. Given the opportunities offered by the internet of things, it can be exploited and employed in the control and discovery of Off-gases. This can be considered as a major contribution of IoT. The rest of this study is structured as follows: Section 2 describes the projected system's components. In Section 3, the projected method presented in section 2 is illustrated. The consequences and discussion are provided in Section 4 of this paper and then followed by the conclusion, which is provided at the end of the paper.

2. Related works

In this section, relevant prior works about liver disease prediction are reviewed as presented in Table 1.

Table1. Shows the gas detection embedded systems

Embedded system	Kind of detected gas
V Ramya, B %J International Journal of Distributed Palaniappan and Parallel Systems [10]	LPG and propane
Ana MC Ilie and Carmela Vaccaro [11]	LPG, temperature, and humidity
Rahul Kurzekar, Hardik Arora and Rahul Shrestha [12]	LPG
Alan Macker, et al.[13]	LPG and temperature
Husam Kareem [14]	LPG
Our proposed system	Smoke, Ethanol, CNG Gas, Methane, toluene, propane, Carbon Monoxide, acetone, Hydrogen Gas, and Formaldehyde.

Many studied have been proposed various systems to detect various kinds of Flammable and Toxic Gases. For example, in [10], an embedded system has proposed for detecting toxic gases such as LPG and propane. Where the system sends an SMS alert message if the level of LPG exceeded the normal level that is LPG more than1000ppm or Propane more than 10000ppm. The PIC 16F877 Microcontroller has used to control the processes whereas MQ-2 and MQ-7 sensors have employed for detecting the LPG and propane levels respectively. However, the PIC 16F877 Microcontroller has been considered as contemporary processes controller compare to modern controller devices such as Arduino. Another work has been proposed by [11] to detect methane gas in parts of the natural gas storage location. A system was proposed for measuring the air and water quality, then based on those measures detect the level of methane. To build such a system the author used a low-cost sensor (MQ-4 gas sensor) and Arduino UNO microcontroller. The DHT11 sensor was used also for measuring temperature and humidity.

Rahul Kurzekar, Hardik Arora and Rahul Shrestha [12] also proposed another embedded system to sense and monitoring the level of liquefied petroleum gas (LPG). The authors used an ATmega16 microcontroller to manage the system and the MQ-6 LPG sensor was used to measure the level of gas. HC-05 Bluetooth module was used to forward the data that are measured to the smartphone to control the system. Although the authors used a smartphone to control the system, however it not reliable especially when the smartphone is far from the controller system. Different systems have been proposed by [13, 35]. The system has dual functions, measures the LPG gas level in the LPG cylinder, and detects a gas leak. Many components are used to build the system. For example, the Arduino Mega2560 microcontroller has used to control the system whereas (MQ4) Sensor and Temperature Sensor (LM35) were used to measure the level of CH4, Natural gas, and used to measure a temperature respectively. Furthermore, a load cell has employed for measuring a weight of LPG cylinder.

Husam Kareem [14] has also introduced a cost-effective and energy-efficient real-time monitoring the system that capable to detect LPG gas, specifically those used for stove cooker. The author used Arduino

Mega to manage the operating of the whole proposed system. (MQ-6) is also used to detect the leak of LPG gas. In case there is any leak, a system will send SMS for two authorized persons. LCD was also used to show the leakage location. In spite, the excellent performance for the above-mentioned proposed embedded systems, however, there is still the necessity to develop a comprehensive detect system for various Flammable and Toxic Gases. In this work, therefore we proposed a comprehensive system appropriate for most Flammable and Toxic Gases.

3. System components

3.1. Sensors: Numerous sensors are available for the measurement of the level of different types of gases. However, one of the most robust sensors is the MQ which is more suitable for the sensing of the concentrations of Alcohol, LPG, Propane, Smoke, Methane, Hydrogen, Carbon Monoxide that are present in the air. The MQ series of Sensors used in the sensing of gas possesses a small heater that is embedded within it alongside an electrochemical sensor. These sensors are sensitive to numerous kinds of gases and are employed indoors at room temperature. More so, it is possible to calibrate the MQ series sensors according to the level of risk posed by each kind of gas. These sensors produce an analog signal as their output, and the use of an analog input of the Arduino can be employed in reading the signal. The sensors which are used in our system are listed in Table2.

Table 2. Shows the list of MQ-used sensors.

Sensor Type	Detectable gas
MQ-4	Methane, CNG Gas 300 ppm to 10,000 ppm
MQ-6	LPG, butane gas 300-10000ppm
MQ-7	Carbon Monoxide 10 to 10,000 ppm
MQ-8	Hydrogen Gas 100-10000ppm
MQ138	Benzene, Toluene (500 ppm Peak), Alcohol, Acetone, Propane, Formaldehyde 1 to 100ppm benzene Toluene 10 to 100ppm Methanol 5 to 100ppm Alcohol 30 to 300ppm Acetone 10 to 300ppm Formaldehyde 1 to 10ppm

3.2. Arduino Uno

The Arduino Uno refers to an open-source microcontroller board for Microchip ATmega328P microcontroller which was innovated by Arduino.cc. [36, 37]. A board is furnished with collections of analog and digital input/output (I/O) pins that may connected to various shields and other circuits [38]. In addition, a board also contains 14 digital Input/Output pins (six capable of PWM output), 6 analog Input/Output pins, and can be programmed with the Arduino IDE, through a type B USB cable. Using external 9-volt battery or a USB cord can be employed in powering the board. Batteries ranging from 7 to 20 volts can also be used in powering the board. Figure 1 presents the used Arduino in our system.

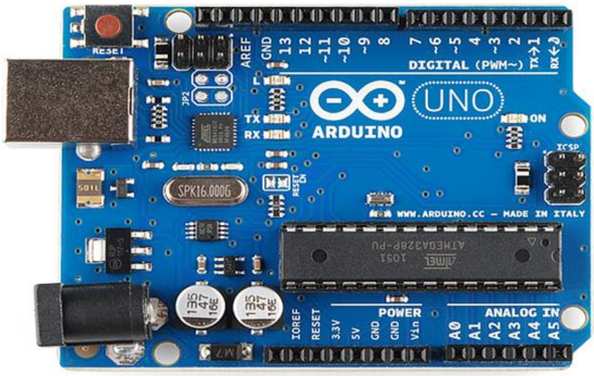

Figure 1. Shows the ARDUINO MICRO

3.3. GSM modem

A GSM module or modem refers to a hardware that has the data link to a remote network through GSM network. The modem is made up of a GSM module that is powered by communication interfaces such as (USB 2.0, RS-232, etc.) and a power supply circuit for a computer. A GSM modem can solely be a modem device with a USB, serial, or Bluetooth connection, or it can be a mobile phone that has the capabilities possessed by GSM modem capabilities. It can be seen from Figure 2, that the use of SIM800A Quad Band GSM/GPRS Module with RS232 Interface was employed in the system proposed in this study.

Figure 2. Shows the SIM800A Quad-Band GSM/GPRS Module with RS232 Interface

3.4. BreadBoard

A breadboard is a prototype and circuit testing tool. The breadboards have two long rails on each side, each with a vertical connection downwards (red rail for power and blue rail for ground). This is where engineers generally plug into the power supply and ground so that the rail as a power and ground connection can be easily used. There are groups of horizontal 5-hole lines in the center of the board. Each of these lines is connected horizontally to the circuit itself (5-hole connection). It is even possible to connect one group to another to make a 10-hole connection, etc.

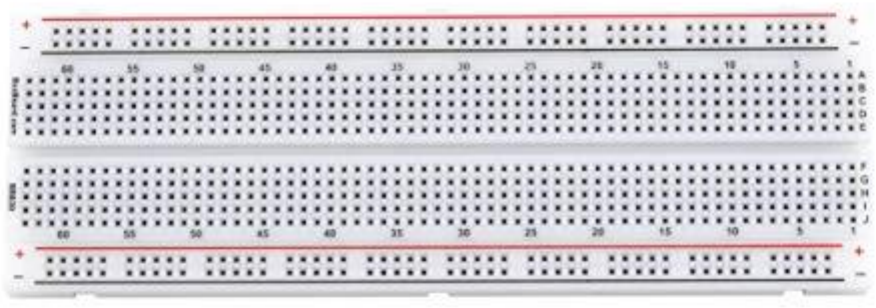

Figure 3. Show the breadboard

3.5. Software

Given the critical role played by the Arduino platform as the key component of a system that is designed to control the whole system's operation, the use of the Arduino IDE software was employed in the development and evaluation of the system proposed in this study. The IDE refers to a software application that makes provision for key facilities required by computer programmers for software development.

3.6. Piezo buzzers

Piezo buzzers can be described as simple devices that can be used in generating fundamental tones and beeps. Their operation involves the use of a piezo crystal, which is a unique material that can change shape when the application of voltage is made to it. In an event that the crystal is pushed against a diaphragm, in the same fashion as a tiny speaker cone, it can generate a pressure wave that can be heard by the human ear as a sound. A "piezo buzzer" refers to the small speaker that can be directly connected to an Arduino. The LPB2413W1003-TA-12- 33-R model of piezo buzzer has been used in this study.

Figure 4. LPB2413W1003-TA-12-33-R Piezo buzzers model

3.7. Other components

The other components used in the development of the proposed system include an LCD monitor for human surveillance and display of the sensors' reading and every location, then speakers as alarm devices for the launching of the evacuation notice.

4. The Proposed Model

The proposed model for the detection of different dangerous gases is illustrated in this section. The steps used in the development of the model are presented in Figure 4.

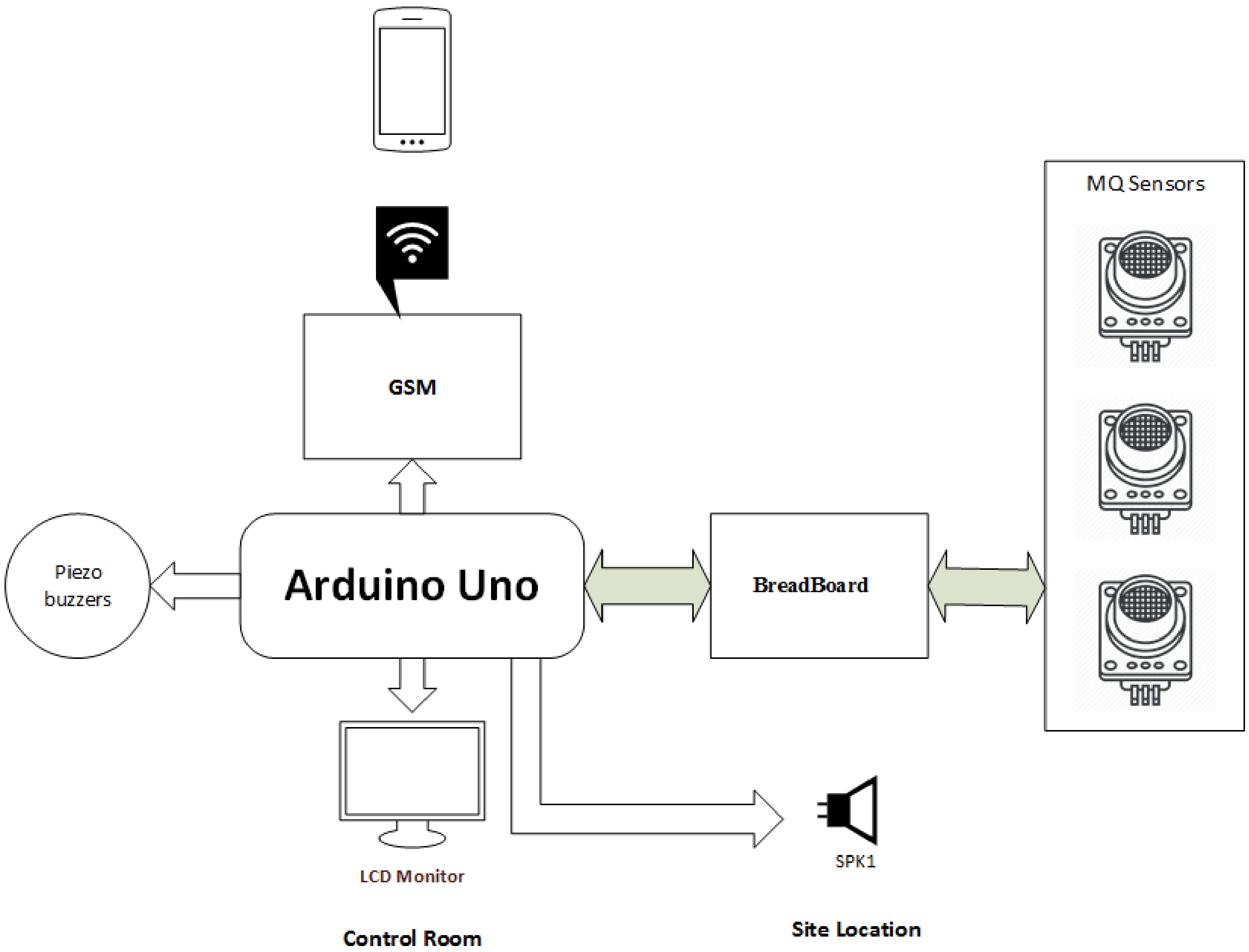

Figure 5. Illustrates the proposed detection system

Figure 5 shows that there is a direct connection between every component and the Arduino which is regarded as the core component of a projected system. The suggested system is made up of two major parts, including the site location and control room. It can be observed from Figure 5 that the Arduino and LCD are based in the control room; the level of gases can be shown on the LCD. The use of piezo buzzers and GSM is employed as extra tools for security and assistance to send messages and raise alarms in the case of an emergency. The alarm speakers and sensors are located on-site. The site location could a house, laboratory, or factory, etc. Through the sensors, the Arduino is provided with a wide range of reading levels of gases every minute. These sensors are connected to the Arduino via a breadboard connected by cables to minimize the transmission time while preventing signal interference which may lead to loss of data. As mentioned before those sensors are capable to sense a wide range of toxic and flammable gas based on the threshold risk limit of the type of gas. When the sensor detects a high level of any gas, then it raises an alarm for the vacation of the premises, while SMS is sent to emergency for assistance. In addition, the address of the location where the high level of gas is detected is also included in the SMS, thereby increasing the reliability of the proposed system. The algorithm of our system is presented below.

Algorithm
Step 1 Assign analog pin to each MQ GAS Sensor in Breadboard
Step 2 Define and initialize Setup Function for each GAS sensors
Step 3 Read GAS Sensors Values

Step 4 If GAS sensor value is Greater than Threshold value than Print High
Step 5 If the GAS sensor value is less than the Threshold value then Print Low.
Following is the code that is used to make the gas sensor work with psuedocode.

```
int red_led=12;//point to gas leak
int green_led=11;// point to normal situation
int buzz=13;// point to gas leak
int smokeA0 = A0;//indicates sensor is connected to A0
int smokeA1 = A1;//indicates sensor is connected to A1
int smokeA2 = A2;//indicates sensor is connected to A2
int smokeA3 = A3;//indicates sensor is connected to A3
int smokeA4 = A4;//indicates sensor is connected to A4

int sensorThres=400;//The threshold value
void setup()
{
pinMode(red_led,OUTPUT);//red led as output
pinMode(buzz,OUTPUT);// buzz as output
pinMode(green_led,OUTPUT);//green led as output
pinMode(A1,INPUT);//sensor as input
Serial.begin(9600);//starts the code
}
void loop()//loops
{
gas_avalue0=analogRead(smokeA0);//reads sensor value
if (gas_avalue0 > sensorThres)//sees if it reached threshold value
{
digitalWrite(red_led, HIGH);//turns on red led
digitalWrite(green_led, LOW);//turns off green led
digitalWrite( buzz, HIGH);//turns on buzzer
}
gas_avalue1=analogRead(smokeA1);//reads sensor value
if (gas_avalue1 > sensorThres)//sees if it reached threshold value
{
digitalWrite(red_led, HIGH);//turns on red led
digitalWrite(green_led, LOW);//turns off green led
digitalWrite( buzz, HIGH);//turns on buzzer
}
gas_avalue2=analogRead(smokeA2);//reads sensor value
if (gas_avalue2 > sensorThres)//sees if it reached threshold value
{
digitalWrite(red_led, HIGH);//turns on red led
digitalWrite(green_led, LOW);//turns off green led
digitalWrite( buzz, HIGH);//turns on buzzer
}
gas_avalue3=analogRead(smokeA3);//reads sensor value
if (gas_avalue3 > sensorThres)//sees if it reached threshold value
{
digitalWrite(red_led, HIGH);//turns on red led
digitalWrite(green_led, LOW);//turns off green led
digitalWrite( buzz, HIGH);//turns on buzzer
}
gas_avalue4=analogRead(smokeA4);//reads sensor value
if (gas_avalue > sensorThres)//sees if it reached threshold value
{
digitalWrite(red_led, HIGH);//turns on red led
digitalWrite(green_led, LOW);//turns off green led
digitalWrite( buzz, HIGH);//turns on buzzer
```

```
}

{
digitalWrite(red_led, HIGH);//turns on red led
digitalWrite(green_led, LOW);//turns off green led
digitalWrite( buzz, HIGH);//turns on buzzer
}

else//if it hasn't reached the threshold value
{
digitalWrite(red_led, LOW);//turns red led off
digitalWrite(green_led, HIGH);//turn green led on
digitalWrite( buzz, LOW);//turns buzzer off
}
delay(100);//delay 0.1 sec
}
```

5. Conclusion

In this work, an all-inclusive system of gas detection has been introduced. The system can detect a wide range of gases that are regarded as hazardous to the lives of people as well as their environment. The gases that are detectable by the proposed system include butane gas, Hydrogen gas, butane, smoke, methane, LPG, Carbon Monoxide, CNG gas, propane, toluene, acetone, alcohol, and Formaldehyde. Using system is not limited to a particular location, and as such, it can be installed at laboratories, a house, etc. The development of the proposed system involved the use of cheap as well as low energy consumption equipment, thereby enabling the affordability of the system to many individuals and organizations. Therefore, the projected system performance is better as compared with previously proposed in other studies, given its ability to detect a wide range of gases at a low cost.

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