Sensing Harmful Gases In Industries Using IOT And WSN

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Abstract- *The need for smart home warning systems is in high demand nowadays as they are used to warn owners about undesired situations that could happen while they are far awayfrom their homes. This paper aims to present the design and implementation of an Arduino based smart home warning system. In this system, Arduino Uno microcontroller has been used with several compatible sensors (DHT22, MQ2, and camera), actuators (buzzer and relays with attached water valve, air fan, and light bulb), and GSM as a wireless communication medium to enable the interaction between users and the proposed system. The experimental results of using the proposed system show that a variety of undesired events can be detected efficiently. Fire, gas leakage, and housebreaking situations can be detected and users get notified about them via SMS messages, emails with attached pictures, etc. Besides, some proper actions can also be performed by the proposed system including stopping fire via water and decreasing gas concentration via air ventilation. The proposed system is very useful to prevent losses in resources and human life caused by unwanted events.*

I. INTRODUCTION

Nowadays, sensor-based smart home systems (e.g., warning systems) are in high demand and widely used due to the advent and evolution of microcontrollers, sensors, and actuators technologies. These systems are used to monitor indoor environments to give homeowners live updates about undesired activities and unwanted conditions that could happen when they are far away. The aim of smart home warning systems is to interpret the sensory data gathered from the surrounding environment in order to perform some proper actions. For example, fire in houses could occur for many reasons such as the burning of materials, gases, and electric circuits and it could cause severe accidents [1]. To remain safe from fire, a fire alarm system is a must for every residential house. Fire alarm systems are very useful to warn users about this unwanted event and to prevent losses in resources and human life that could happen as a result of it. Another example is gas leakage. The Liquefied Petroleum Gas (LPG) is the most used gas for cooking in houses. It is used in cylinders and may blast because of leakage [2]. Residents in many cases do not know that there is gas leaking. Thus, they may light up a fire which causes blast. This situation can be avoided by installing a gas leakage detection system. Also, crime is rampant these days. Therefore, installing security systems in houses is crucial [3]. Such systems can detect any movements that could happen due to a thief entering a house. The fire and gas leakage detection systems are required alongside the motion based security system. This type of automatic home safety and security warning systems can save people from dangerous accidents. The components of any home warning system are a microcontroller with some compatible sensors, actuators, modules, and shields [4]. Usually, such systems start with monitoring the surrounding environment and then perform some proper actions in response to the aforementioned unwanted events that could happen while owners away. The monitoring process is achieved via sensors such as temperature sensors, gas sensors, and motion sensors. While performing proper actions are performed using actuators such as buzzers, lights, and relays. To interact with smart home warning systems, a communication medium is required. Wireless communication (e.g., GSM, Bluetooth, and WiFi) is vastly used in this context. Of course, selecting the appropriate communication medium is subject to several factors including cost, range, and availability [5]. In this paper, an Arduino based smart home warning system that can detect safety and security unwanted situations is proposed and implemented. The system can notify users about house fire, gas leakage, and housebreaking. Also, it can perform some proper actions as a response to the aforementioned unwanted situations to prevent losses in human life and resources.

The rest of the paper is structured as follows. Section 2 presents the most relevant works for this study. Section 3 presents the design and implementation of the proposed system. Finally, some conclusions are given in Section 4.

II. RELATED WORKS

This section briefly presents the most relevant works to this study. To highlight the features (“*” indicates that the feature is implemented) of the proposed system compared to other related works, the analysis of these studies is presented in Table 1. It can be noted that the studies [6-7, 9, 14-15]

proposed home safety systems that detect both fire and gas leakage only. The system in [8] only detects fire while the systems in [13, 19] only detect gas leakage. The aforementioned studies did not consider home security. The studies in [10-12, 16] only considered home security. Thus, they did not address home safety. The study [18] is the onlyone considered both home safety and security (fire detection, gas leakage detection, and motion detection). Our proposed system also addresses both home safety and security as in [18]. However, our system is more accurate and the detection range is wider than [18] because our system uses the DHT22 sensor for fire detection instead of the DHT11 sensor. It is worth mentioning that the DHT22 sensor is more precise, more accurate, and provides a wider detection range compared to the DHT11 sensor. Also, our system is the only one uses a camera with a built-in motion detection feature to capture pictures in case of any unwanted situation. Our system stores the captured pictures and other sensors data on a MicroSD card instead of a computer that is used in [6, 9, 12]. Using a MicroSD card as data storage is more convenient. Regarding notifying homeowners about thehappening of undesired situations, our proposed system provides more notifications compared to all other studies. Some of these notification alerts are unique including blinking a real AC light bulb, sending emails with attached pictures. Most of the related studies [6-7, 9-13, 16-17, 19] do not perform any proper action in response to dangerous situations. It can be noted that our system performs more proper actions compared to all other studies including using an AC ventilation fan. One of the most important other unique features of our proposed system is that the user can stop the working of the entire system remotely via sendingan SMS.

TABLE I. ANALYSIS OF RELATED WORKS

Factors		[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	This work
Safety	Fire detection	*	*	*	*					*	*			*		*
	Gas leak detection	*	*		*				*	*	*			*	*	*
Security	Motion detection					*	*	*				*		*		*
Data storage	Computer	*			*			*								
	MicroSD card															*
Notifications	Buzzer	*	*	*		*	*	*	*	*	*	*	*		*	*
	SMS		*		*		*		*	*		*	*	*	*	*
	LCD								*	*					*	
	Voice call										*					*
	AC light bulb															*
	Email with picture															*
Actions	Solenoid valve			*						*	*			*		*
	Fire extinguisher										*					
	AC Ventilation fan															*
Stopping the system remotely																*
Accuracy																*
Detection range																*

III. THE PROPOSED SYSTEM

To understand the work of the proposed system and its functionalities; the system's software, hardware, and operation are listed and explained in detail in the following subsections.

A. System's Software

In this section, the programming language and related software libraries that have been employed in the implementation of the proposed system are briefly presented:

- **Arduino programming language:**

The language [20] has been used to program the functionalities of the entire system. It is worth mentioning that Arduino IDE version 1.8.10 has been used for this system.

- **DHT22 sensor library:**

The library [21] has been used to read data from the used DHT22 sensor.

- **MQ2 sensor library:**

The library [22] has been used to read data from the used MQ2 sensor.

- **Camera sensor library:**

The library [23] has been used to read data from the used camera sensor.

- **MicroSD card library:**

The library [24] has been used to read and write from/to the used MicroSD card module.

- **SIM900 GSM/GPRS library:**

The library [25] has been used to facilitate the work of the used wireless communication shield.

It is worth mentioning that there is no need to use software libraries to work with the used buzzer and relay modules because the Arduino programming language itself provides built-in functions including tone(), noTone(), and digitalWrite() to operate these devices.

B. System's Hardware

The proposed system uses an Arduino microcontroller, sensors, and actuators to perform its functional tasks as shown in Figure 1.

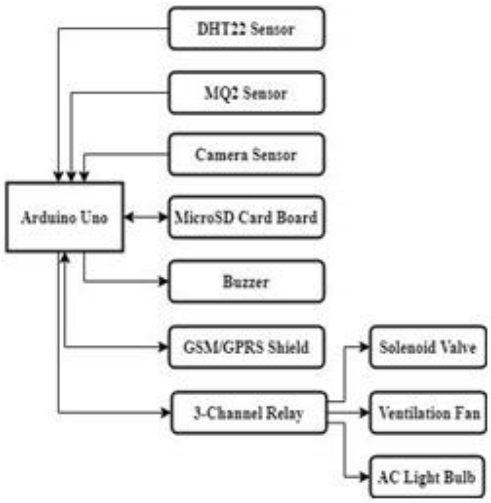

Figure 1. System's hardware components.

The details of the used hardware components are presented below:

- **Arduino Uno:**

It is an open-source microcontroller board based on the ATmega328P as shown in Figure 2 and it is developed by "Arduino.cc". The board has 14 digital I/O pins (6 which are PWM), 6 analog I/O pins, and is programmable with the Arduino programming language. Arduino pins can be interfaced to various sensors, actuators, modules, and shields to provide more functionality. Also, it can be powered by a USB cable or by an external 9V power supply, though it accepts voltages between 7V and 20V. In this system, the microcontroller board has been used to control the functionality of the entire system with its hardware components.

Figure 2. Arduino Uno board.

- **DHT22 Sensor Module**:

It is a low-cost digital humidity and temperature sensor as shown in Figure 3. In this system, the sensor has been used to measure the temperature in the surrounding air to detect fire. The temperature range of DHT22 is from -40 to 80 °C with a ±0.5°C accuracy. The DHT22 module has three pins and it is interfaced with the used Arduino Uno as presented in Table 2.

Figure 3. DHT22 sensor module.

TABLE II. DHT22 AND ARDUINO UNO CONNECTIONS

No.	DHT22 Pins	Corresponding Arduino Pins
1	VCC	5V
2	GND	GND
3	Data	Digital Pin 6

- **MQ2 Sensor Module**:

It is a gas detection sensor as shown in Figure 4. In this system, the sensor has been used to detect LPG (Liquefied Petroleum Gas) gas which is used for gas heaters and cookers. The MQ2 module has four pins (three of them were used for this system) and it is interfaced with the used Arduino Uno as presented in Table 3.

Figure 4. MQ2 sensor module.

TABLE III. MQ2 AND ARDUINO UNO CONNECTIONS

No.	MQ2 Pins	Corresponding Arduino Pins
1	VCC	5V
2	GND	GND
3	Digital Out	Not Used
4	Analog Out	Analog Pin 0

- **TTL Serial JPEG Camera**:

It is an image acquisition device as shown in Figure 5. The main features of this camera are: pictures can be taken at different sizes (640x480, 320x240 or 160x120), captured pictures are pre-compressed which makes them small and suitable to be stored on MicroSD cards, auto-brightness, auto-contrast, and has built-in motion detection. In this system, the camera has been used to capture images when an undesired event occurs. The camera has six pins (four of them were used for this system) and it is interfaced with the used Arduino Uno as presented in Table 4.

Figure 5. TTL serial JPEG camera module.

TABLE IV. CAMERA AND ARDUINO UNO CONNECTIONS

No.	DHT22 Pins	Corresponding Arduino Pins
1	VCC	5V
2	GND	GND
3	Data	Digital Pin 6

- **Buzzer Module**:

It is an audio signaling device as shown in Figure 6 that produces a range of sound tones depending on the input frequency. In this system, the buzzer has been used to play a sound tone as a notification alarm. The buzzer module has three pins and it is interfaced with the used Arduino Uno as presented in Table 5.

Figure 6. Buzzer module.

TABLE V. BUZZER AND ARDUINO UNO CONNECTIONS

No.	Buzzer Pins	Corresponding Arduino Pins
1	VCC	5V
2	GND	GND
3	Signal	Digital Pin 5

- **MicroSD Card Module:**

It is an Arduino-compatible storage device as shown in Figure 7. In this system, the MicroSD card module has been used to store images captured by the used camera. The module has eight pins (six of them were used for this system) and it is interfaced with the used Arduino Uno as presented in Table 6.

Figure 7. MicroSD card module.

TABLE VI. MICROSD AND ARDUINO UNO CONNECTIONS

No.	MicroSD Pins	Corresponding Arduino Pins
1	5V	5V
2	GND	GND
3	CLK	Digital Pin 13
4	DO	Digital Pin 12
5	DI	Digital Pin 11
6	CS	Digital Pin 10
7	3V	Not Used
8	CD	Not Used

- **3-Channel Relay Module**:

A 3-channel 5V relay module is a switching device as shown in Figure 8 that controls high current and highvoltage devices directly from a microcontroller output. Each channel of the relay can switch up to 10Amps and up to 250V. In this system, the 3-channel relay module has been used for three purposes which are: (a) to operate a ventilation fan to clear the smoke or leaked gas (b) to operate a solenoid valve to extinguish fire via inletting water from a water tank used for this purpose(c) to continuously blink a light bulb. The relay module has six pins (five of them were used for this system) and it is interfaced with the used Arduino Uno as presented in Table 7.

Figure 8. 3-Channel relay module.

TABLE VII. 3-CHANNEL RELAY AND ARDUINO UNO CONNECTIONS

No.	Relay Pins	Corresponding Arduino Pins
1	VCC	5V
2	GND	GND
3	Digital In 1	Digital Pin 9
4	Digital In 2	Digital Pin 8
5	Digital In 3	Digital Pin 7
6	RGND	Not Used

The ventilation fan as shown in Figure 9 is a device used to pull out (creates movement of the air from inside to outside) the air in rooms via fans or blowers. In this system, the fan has been used to clear the smoke or leaked gas.

Figure 9. AC ventilation fan.

The solenoid valve as shown in Figure 10 is a valve switch controlled by an electromagnet. In this system, a Normally Closed (NC) valve has been used; which means if pressurized water supplied to an NC solenoid valve, water will not flow through the valve. If a suitable power supplied to the valve, the valve will open and the water will flow.

Figure 10. Solenoid valve.

- **SIM900 GSM/GPRS Shield:**

It is a wireless communication shield device as shown in Figure 11 that provides a way to use the cell phone network to send and receive data (e.g., voice call, SMS, and GPRS data over TCP/IP, HTTP, etc.) from a remote location. In this system, the GSM shield has been used to send SMS, to make a call to the house owner, and to send picture data to his/her email in case of an unwanted event is detected. Besides, the house owner can also send back an SMS message to stop the work of the entire system. The shield has three pins and it is interfaced with the used Arduino Uno as presented in Table 8. It is worth mentioning that the shield must be powered from a 5V-9V external power supply. Also, the power supply should be able to source at least 2A of current; otherwise, the shield will keep shutting down.

Figure 11. SIM900 GSM/GPRS shield.

TABLE VIII. GSM /GPRS AND ARDUINO UNO CONNECTIONS

No.	Relay Pins	Corresponding Arduino Pins
1	GND	GND
2	RX	Digital Pin 1
3	TX	Digital Pin 0

C. System's Operation

The internal operation of the proposed system is shown in Figure 12. The system starts with reading and checking each attached sensor. When there is fire, the DHT22 sensor will detect a rapid increase in temperature. If the temperature exceeds 50 °C, it means there is fire. The LPG gas is detected by using the MQ2 sensor by measuring the gas concentration in the air. The used library provides a built-in function for this purpose. The camera sensor is used to detect any movement that could happen in the monitored area. In case of detecting a safety or security threat, the system will activate different types of alarms. Sending SMS messages, sending emails with attached pictures, making owner call, playing buzzer, and blinking bulb will be activated as common alerts and notifications for all the unwanted situations. The ventilation fan will be activated only in case of fire or gas leak detection to clear the smoke or leaked gas. While the solenoid

valve will be activated only in case of fire in order to stop it. It is worth mentioning that the flow of operations is iterative and pictures will be continually taken and stored in the used MicroSD card module to be sent to the owner. The entire system can be stopped only when an SMS message is received from the house owner.

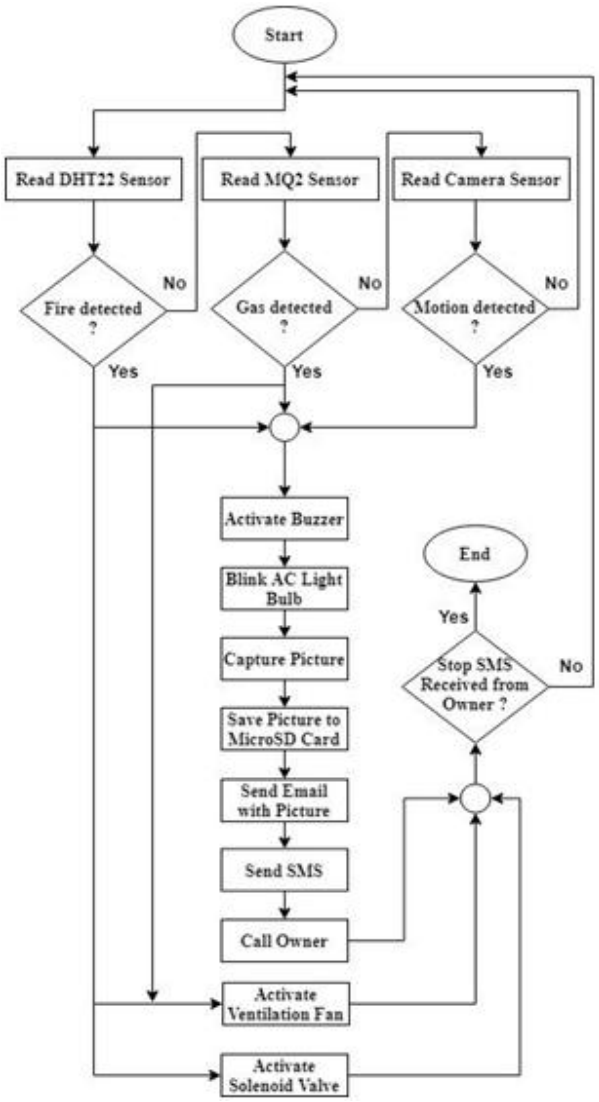

Figure 12. System's operation flowchart.

IV. CONCLUSIONS

An Arduino based smart home warning system has been proposed and implemented in this paper. The proposed system allows homeowners to monitor their homes while they are far away. The most dangerous situations (fire, gas leakage, and housebreaking) can be detected by using the proposed system. Homeowners can be notified about these situations via SMS messages, emails with attached pictures, mobile calls, etc. Moreover, several proper actions can also be performed by the proposed system such as stopping fire via water and decreasing gas concentration in the air via a fan. The proposed system is very useful to prevent housebreaking by detecting movements caused by thieves. The system proposed in this study has expanded the functionalities of previous related works and presented its unique advantages and features. For the future work, providing GPS coordinates will be very useful when the SMSs and emails are intended to be sent to a police station or a fire station. This feature will enable the policemen or firefighters to easily locate the house facing problems.

REFERENCES

[1] Daily Star Editorial."Gas Leakage Death Count!", Internet: https://www.thedailystar.net/backpage/savar-couple-burnt-death- after-gas-leak-kitchen-1342015, accessed on 01/03/2020.

[2] V. Ramya and B. Palaniappan, "Embedded system For Hazardous Gas detection and Alerting," in Proc. of International Journal of Distributed and parallel system (IJDPS), vol. 3, no. 3, pp. 287 -300, 2012.

[3] S. Chiang, C. Huang and K. Chang, "A Minimum Hop Routing Protocol for Home Security Systems Using Wireless Sensor Networks," in *IEEE Transactions on Consumer Electronics*, vol. 53, no. 4, pp. 1483-1489, 2007.

[4] A. Nayyar and V. Puri, "A review of Arduino board's, Lilypad's & Arduino shields," 3rd International Conference on Computing for Sustainable Global Development (INDIACom), 2016, pp. 1485- 1492.

[5] W. Anani, A. Ouda and A. Hamou, "A Survey Of Wireless Communications for IoT Echo-Systems," *2019 IEEE Canadian Conference of Electrical and Computer Engineering (CCECE)*, 2019, pp. 1-6.

[6] S. Sharma, K. Chand, D. Sharma and P. Guha, "Development of an early detection system for fire using Wireless Sensor Networks and Arduino," *2018 International Conference on Sustainable Energy, Electronics, and Computing Systems (SEEMS)*, Greater Noida, India, 2018, pp. 1-5.

[7] F. Nurpandi, A. Musrifalr and I. Rizaldi, "Prototype Residence Monitoring and Automation System Using Microcontroller Arduino," *2018 International Conference on ICT for Smart Society (ICISS)*, Semarang, 2018, pp. 1-5.

[8] R. I. Rashid, S. M. Rafid and A. Azad, "An Automated Fire Suppression Mechanism Controlled using an Arduino," 2018 IEEE
Distributed Computing, VLSI, Electrical Circuits and Robotics (DISCOVER), Mangalore (Mangaluru), India, 2018, pp. 49-54.

[9] S. K. Bhoi *et al*., "FireDS-IoT: A Fire Detection System for Smart Home Based on IoT Data Analytics," *2018 International Conference on Information Technology (ICIT)*, Bhubaneswar, India, 2018, pp. 161-165.
[10] S. S. Syazlina Mohd Soleh, M. M. Som, M. H. Abd Wahab, A. Mustapha, N. A. Othman and M. Z. Saringat, "Arduino-Based Wireless Motion Detecting System," 2018 IEEE Conference on Open Systems (ICOS), Langkawi Island, Malaysia, 2018, pp. 71-75.
[11] D. R. Chandrappa, H. R. Pavan, M. V. Sagar and M. Dakshayini, "IoT Security Solution to Avoid Theft," *2018 International Conference on Wireless Communications, Signal Processing and Networking (WiSPNET)*, Chennai, 2018, pp. 1-3.
[12] A. E. Kashef and N. Barakat, "Intelligent Alarm System to Protect Small, Valuable Items," 2018 International Conference on Computer and Applications (ICCA), Beirut, 2018, pp. 326-330.
[13] A. Samiha, F. H. Sarker, R. N. K. Chowdhury, A. K. M. R. R. Habib and R. Rahman, "Ogrodut: GSM based Gas Leakage Detection and Ventilation System using Arduino and Servo Motor," 2019 International Energy and Sustainability Conference (IESC), Farmingdale, NY, USA, 2019, pp. 1-6.
[14] P. Ghosh and P. K. Dhar, "GSM Based Low-cost Gas Leakage, Explosion and Fire Alert System with Advanced Security," 2019 International Conference on Electrical, Computer and Communication Engineering (ECCE), Cox'sBazar, Bangladesh, 2019, pp. 1-5.
[15] M. R. Habib et al., "Quick Fire Sensing Model and Extinguishing by Using an Arduino Based Fire Protection Device," 2019 5th International Conference on Advances in Electrical Engineering (ICAEE), Dhaka, Bangladesh, 2019, pp. 435-439.
[16] P. Mahalakshmi, R. Singhania, D. Shil, and A. Sharmila, “Home Security System Using GSM,” in Advances in Intelligent Systems and Computing, vol. 906, 2019, pp. 627–634.
[17] M. Škrgić, U. Drakulić, and E. Mujčić, “Smart Home System - Remote Monitoring and Control Using Mobile Phone,” in International Symposium on Innovative and Interdisciplinary Applications of Advanced Technologies (IAT), vol. 59, 2019, pp. 409–419.
[18] S. Amit, A. S. Koshy, S. Samprita, S. Joshi and N. Ranjitha, "Internet of Things (IoT) enabled Sustainable Home Automation along with Security using Solar Energy," 2019 International Conference on Communication and Electronics Systems (ICCES), Coimbatore, India, 2019, pp. 1026-1029.
[19] V. Suma, R. R. Shekar and K. A. Akshay, "Gas Leakage Detection Based on IOT," 2019 3rd International conference on Electronics, Communication and Aerospace Technology (ICECA), Coimbatore, India, 2019, pp. 1312-1315.
[20] https://www.arduino.cc/en/Main/Software
[21] https://github.com/adafruit/DHT-sensor-library
[22] https://github.com/labay11/MQ-2-sensor-library
[23] https://github.com/Seeed-Studio/Camera_Shield_VC0706
[24] https://www.arduino.cc/en/reference/SD
[25] http://peter.turczak.de/XModem.zip