https://cejsr.academicjournal.io

Gas Leakage Detection in Recovery Rooms Using a Microcontroller

Ibrahim Wameedh Ibrahim, Sara Osama Azeez

A Technical Report Submitted to the Department of Medical, Instrumentation Engineering Techniques in Partial Fulfillment of the Requirements for the Degree of Technical Bachelor in Medical Instrumentation Engineering

Prof. Saleem Lateef Mohammed, Dr. Ali A. Al-Naj

A Technical Report Submitted to the Department of Medical, Instrumentation Engineering Techniques in Partial Fulfillment of the Requirements for the Degree of Technical Bachelor in Medical Instrumentation Engineering

ABSTRACT

Gas leakage in medical facilities can pose a serious threat to patient safety and can have catastrophic consequences. Hence, it is essential to detect gas leaks quickly and accurately to prevent any accidents. Various gas detection techniques have been developed to identify gas leaks, including the utilization of Arduino microcontrollers and oxygen sensors. Arduino microcontrollers offer a low-cost and easily deployable solution, while oxygen sensors provide specific detection capabilities for gases commonly used in medical facilities, such as oxygen, nitrogen, and anesthesia gases. Furthermore, the use of advanced technologies such as wireless communication, cloud computing, and artificial intelligence has improved the detection and monitoring of gas leaks. This abstract highlights the importance of gas leak detection in medical facilities and emphasizes the role of Arduino microcontrollers and oxygen sensors, along with advanced technologies, in improving gas detection and prevention of accidents.

CHAPTER 1

Introduction and Motivation

1.1. Background and Motivation

The safety and well-being of patients in recovery rooms are of utmost importance in healthcare settings. However, gas leakages in these rooms can pose significant risks to both patients and healthcare professionals. The timely detection of gas leaks is crucial to prevent potential hazards and ensure a safe recovery environment. Traditional gas detection systems are often costly and complex, making them less feasible for recovery room applications. Therefore, there is a need to explore affordable and accessible solutions that can effectively detect gas leakages in recovery rooms.

This research focuses on developing a gas leakage detection system for recovery rooms using an Arduino microcontroller and an oxygen sensor. Arduino microcontrollers provide a low-cost and versatile platform for building customized monitoring systems, while oxygen sensors offer specific detection capabilities for gases commonly used in medical facilities, such as oxygen, nitrogen, and anesthesia gases. By combining these technologies, a reliable and cost-effective gas leakage detection system can be implemented, enhancing patient safety and minimizing risks in recovery rooms.

1.2. Problem Statement

Gas leakages in recovery rooms present potential hazards, including the inhalation of toxic gases, oxygen depletion, fire hazards, and explosions. Existing gas detection systems may not be suitable for recovery rooms due to their high costs, complexity, and maintenance requirements. Consequently, there is a need for an affordable and easily deployable solution specifically tailored for recovery room environments. The proposed gas leakage detection system utilizing Arduino and oxygen sensor aims to address these challenges by providing an efficient and cost-effective solution.

1.3. Objectives of Research Study

The primary objectives of this research study are as follows:

- To investigate the requirements and constraints of gas leakage detection in recovery rooms.
- To design and implement a low-cost and efficient gas leakage detection system using an Arduino microcontroller and an oxygen sensor.
- To evaluate the performance and reliability of the developed system under various conditions.
- To compare the proposed system with existing gas detection solutions in terms of cost, simplicity, and effectiveness.
- To assess the feasibility of integrating the developed system into existing recovery room environments.

1.4. Contributions of Research Study

This research study contributes to the field of gas leakage detection in recovery rooms in the following ways:

- Development of a low-cost and easily deployable gas leakage detection system tailored for recovery rooms, using an Arduino microcontroller and an oxygen sensor.
- Evaluation of the system's performance and reliability under different conditions to ensure its effectiveness in real-world scenarios.
- Comparison of the proposed system with existing gas detection solutions, considering factors such as cost, simplicity, and effectiveness, to identify its advantages and limitations.
- Identification of potential challenges and recommendations for the integration of the developed system into existing recovery room environments.

1.5. Literature Review

1.5.1. Gas Leakage Detection Systems

Gas leakage detection systems have been extensively studied in various applications to ensure safety and prevent potential hazards. Several techniques have been employed for gas detection, including electrochemical sensors, semiconductor sensors, and optical sensors [1-3]. These sensors offer different detection mechanisms and are capable of detecting a wide range of gases commonly found in medical facilities, such as oxygen, nitrogen, and anesthesia gases [4, 5].

1.5.2. Recovery Room Environments

Recovery rooms play a critical role in patient care and require a controlled and safe environment for postoperative recovery. Studies have emphasized the importance of maintaining air quality, ensuring proper ventilation, and preventing gas leakages in recovery rooms [6, 7]. However, the complex nature of recovery room environments presents challenges for implementing traditional gas detection systems due to cost, complexity, and maintenance requirements.

1.5.3. Arduino Microcontrollers

Arduino microcontrollers have gained popularity in various fields for their versatility, affordability, and ease of use. They provide a platform for developing customized monitoring and control systems [8]. Arduino-based gas detection systems have been explored for different applications, showcasing their potential for cost-effective and easily deployable solutions [9, 10].

1.5.4. Oxygen Sensors

Oxygen sensors are widely used for monitoring and detecting gas concentrations, particularly in medical settings [11]. These sensors offer specific detection capabilities for oxygen levels and can be integrated into gas detection systems to enhance accuracy and reliability [12, 13].

1.5.5. Advanced Technologies in Gas Leak Detection

The integration of advanced technologies, such as wireless communication, cloud computing, and artificial intelligence, has significantly improved gas leak detection and monitoring [14, 15]. Wireless communication enables real-time data transmission and remote monitoring of gas levels, while cloud computing provides storage and analysis of large-scale data. Artificial intelligence algorithms have been applied for accurate gas leak identification and predictive analysis [16, 17].

1.6. Research Gaps

While several studies have focused on gas detection systems and recovery room environments, there is a lack of research specifically addressing the detection of gas leakages in recovery rooms using Arduino microcontrollers and oxygen sensors. Additionally, limited research has explored the integration of advanced technologies with gas leak detection systems in the context of recovery room environments.

1.7. Project Outline

The project is structured as follows: **Chapter 1** provides an introduction to the research study, including the background, problem statement, literature review, objectives, contributions, project outline, and a list of abbreviations. In **Chapter 2**, the methodology is detailed, covering the system design, including the Arduino microcontroller, oxygen sensor, and data processing unit, as well as the implementation process, such as hardware setup and sensor calibration. **Chapter 3** presents the results obtained from the experiments, while Section 6 provides a discussion and analysis of the results, including comparisons with existing techniques. Finally, **Chapter 4** concludes the project with a summary of findings, conclusions drawn from the study, and suggestions for future work and improvement.

CHAPTER 2

Methodology and Techniques

This chapter presents a detailed explanation of the proposed model for gas leakage detection in recovery rooms using an Arduino microcontroller and an oxygen sensor. The methodology encompasses the system design, components, and implementation process. Additionally, the experimental setup and data collection procedures are described to evaluate the performance and reliability of the developed system.

2.1. System Design

The gas leakage detection system is designed to provide an affordable, easily deployable, and efficient solution for recovery rooms. The system comprises three main components: an Arduino microcontroller, an oxygen sensor, and a data processing unit. The Arduino microcontroller serves as the central processing unit of the system. It is responsible for collecting data from the oxygen sensor, analyzing the gas levels, and triggering appropriate actions in case of gas leakages. The Arduino board is programmed with specific algorithms to detect abnormal gas concentrations and activate an alarm or notify the relevant personnel.

The oxygen sensor is the primary sensing element of the system. It detects the levels of gases commonly found in recovery rooms, such as oxygen, nitrogen, and anesthesia gases. The sensor provides accurate and real-time data on gas concentrations to the Arduino microcontroller for analysis.

The data processing unit is responsible for receiving and processing the data collected by the Arduino microcontroller. This unit can be a computer or a dedicated processing device. It processes the incoming data, generates alerts or notifications, and stores the data for further analysis and monitoring.

The gas leakage detection system aims to provide an affordable, easily deployable, and efficient solution for recovery rooms. The system design consists of three main components: the Arduino microcontroller, the oxygen sensor, and the data processing unit.

2.1.1 Arduino Microcontroller

The Arduino microcontroller acts as the central processing unit of the system. It collects data from the oxygen sensor, analyzes gas levels, and triggers appropriate actions in the event of a gas leakage. The Arduino board is chosen based on its compatibility with the required sensors and peripherals. The selection may include models such as Arduino UNO or Arduino Mega, considering factors such as processing power, available input/output pins, and communication interfaces.

2.1.2 Oxygen Sensor

The oxygen sensor is the primary sensing element of the system and is responsible for detecting gas concentrations, particularly oxygen levels, in the recovery room. An electrochemical 12C oxygen sensor is employed due to its high sensitivity, accuracy, and suitability for medical applications. The sensor provides analog data to the Arduino microcontroller, which can be used for analysis and triggering appropriate responses.

2.1.3 Data Processing Unit

The data processing unit receives and processes the data collected by the Arduino microcontroller. It can be a computer or a dedicated processing device capable of handling data analysis and storage. The unit is responsible for real-time monitoring, data visualization, and triggering alarms or notifications when gas leakages are detected. Additionally, it may facilitate data logging and provide historical data for further analysis.

2.1.4 Hardware Setup

Connect the Arduino microcontroller to the oxygen sensor and other peripherals using appropriate connecting wires. Utilize the 830P breadboard to organize the circuit connections and ensure a reliable and stable setup. Mount the components in the recovery room, strategically placing the oxygen sensor for optimal gas detection coverage.

Connect the output devices, such as the 16x2 LCD with I2C model, speaker, and buzzer, to provide visual and audible alerts in case of gas leakages. The implementation of the gas leakage detection system involves several steps, as outlined below:

- Selection of Arduino Microcontroller: The appropriate Arduino board is selected based on the requirements of the system, considering factors such as processing power, connectivity options, and available input/output pins.

- Integration of Oxygen Sensor: An oxygen sensor with suitable detection capabilities is selected and integrated with the Arduino board. The sensor is connected to the Arduino's analog input pins, allowing it to measure gas concentrations and provide analog data to the microcontroller.
- Algorithm Development: Custom algorithms are developed to analyze the data received from the oxygen sensor. These algorithms define thresholds for gas concentrations, detect abnormal levels, and trigger appropriate actions in response to gas leakages. The algorithms are implemented in the Arduino's programming language, such as Arduino IDE.
- Hardware Setup: The Arduino microcontroller and oxygen sensor are physically connected and appropriately mounted in the recovery room. The connections are secured and tested to ensure proper functioning of the system.
- Calibration: The gas leakage detection system requires calibration to establish baseline gas concentrations and set accurate threshold values. Calibration involves exposing the system to known gas concentrations and adjusting the algorithms accordingly.
- Testing and Evaluation: The system is tested under various conditions to evaluate its performance and reliability. Gas leak simulations may be conducted to assess the system's responsiveness, accuracy, and false positive/negative rates. The data collected during testing is analyzed to validate the system's effectiveness.

The proposed gas leakage detection system for recovery rooms utilizes various components to ensure accurate and reliable detection. The following is a list of components used in the system:

- Arduino (UNO): The Arduino UNO microcontroller serves as the central processing unit of the system, responsible for data collection, analysis, and control, as shown in Figure 2.1.

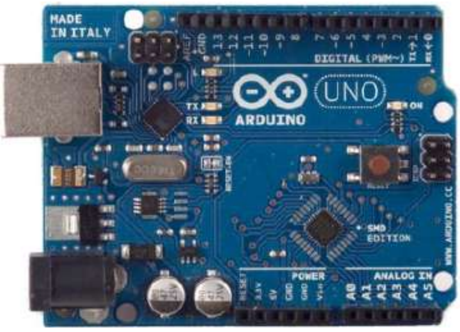

Figure 2.1. Arduino Board (UNO)

- 830P Breadboard: The breadboard provides a convenient platform for connecting and prototyping the electronic components of the system.
- Electrochemical 12C Oxygen Sensor: This oxygen sensor is employed to detect oxygen levels in the recovery room and provide real-time data for gas concentration analysis, as shown in Figure 2.2.

Figure 2.2 Oxygen Sensor.

- Air quality MQ-135 Gas Sensor: The MQ-135 gas sensor is utilized to detect the presence of various gases commonly found in recovery rooms, such as nitrogen and anesthesia gases, as shown in Figure 2.3.

Figure 2.3. Air quality MQ-135 Gas Sensor.

- 16x2 LCD with I2C model: The LCD display with I2C communication allows for clear and user-friendly visualization of gas concentration levels and system status, as shown in Figure 2.4.

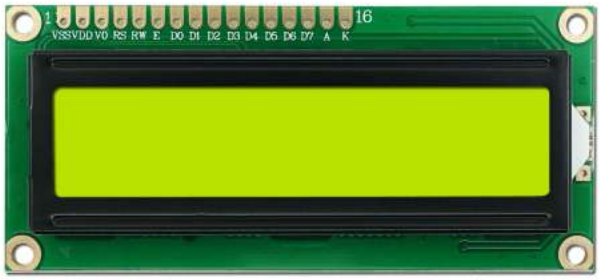

Figure 2.4. 16×2 liquid crystal display.

- MP3-TF-16P: The MP3 module is integrated into the system to enable audio alerts or notifications in case of gas leakages or system abnormalities.
- Speaker: A speaker is connected to the MP3 module to produce audible alerts and notifications, providing an additional layer of warning.
- Buzzer: The buzzer component is utilized to generate sound-based alarms or warnings in case of gas leakages, ensuring immediate attention.
- 1CH Relay Model 5V: The relay module is employed to control external devices, such as a fan, to mitigate gas leakages and improve air circulation.
- Fan 5V: A small fan is used to enhance ventilation in the recovery room, facilitating the dispersion of gases and maintaining air quality.
- Battery (9V): The 9V battery serves as a portable power source for the system, ensuring continuous operation and eliminating the dependency on external power supplies.
- Connecting Wires: Various connecting wires are utilized to establish electrical connections between the components, ensuring a reliable and stable circuit.
- Resistance: Resistors are employed to manage current flow and protect the components from potential damage.
- Two LED: Light-emitting diodes (LEDs) are incorporated into the system to indicate system status or provide visual alerts, enhancing user interaction and feedback.

These components are carefully selected and integrated to create a comprehensive gas leakage detection system capable of monitoring gas concentrations, triggering alarms or warnings, and controlling external devices to ensure a safe recovery room environment as shown in Figure 2.5.

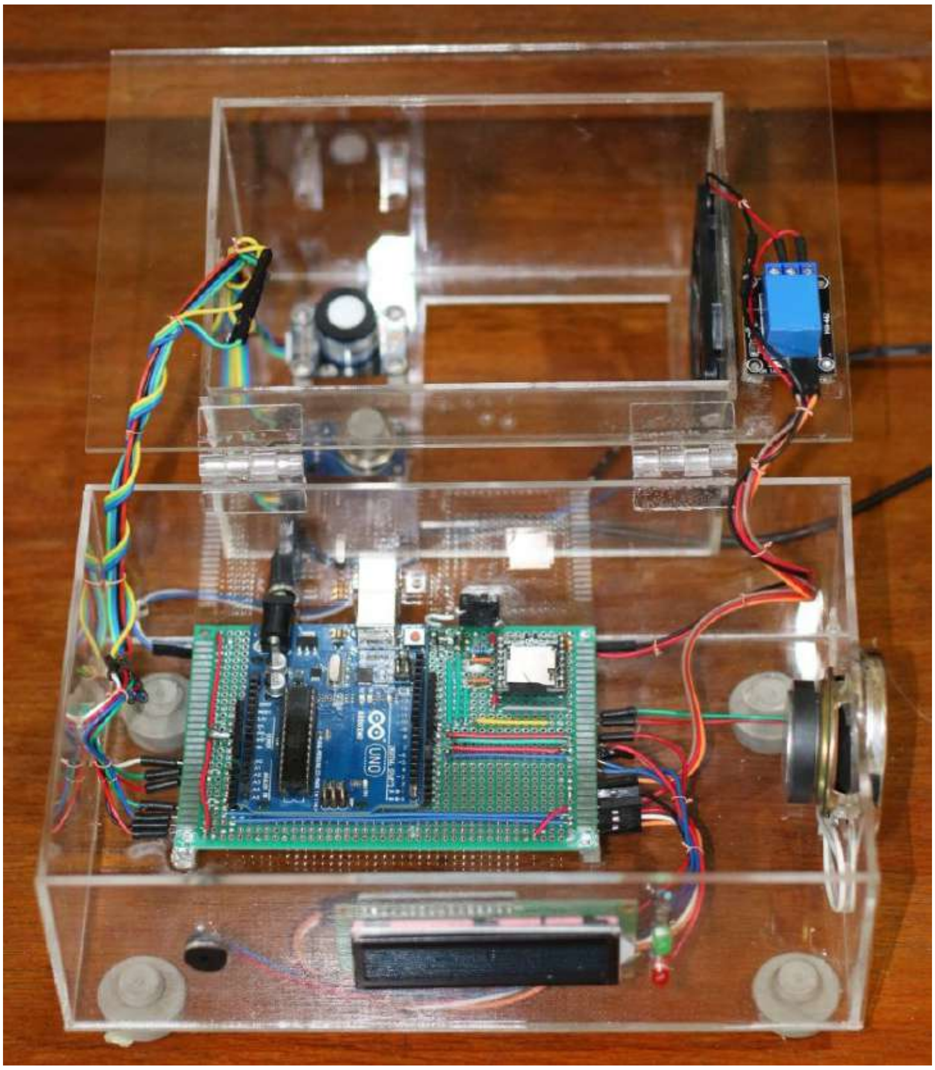

Figure 2.5. The hardware of the proposed model.

2.2 Experimental Setup

Table 2.2.1. LCD connection

Lcd_I2C	Arduino UNO
GND	GND
VCC	5v
SDA	A4
SCL	A5

Table 2.2.2. Air Quality MQ-135

MQ-135	Arduino UNO
VCC	5V
GND	GND
AO	A0

Table 2.2.3. Electrochemical Oxygen Sensor

O2 Sensor	Arduino UNO
Vcc	5v
GND	GND
SDA	A4
SCL	A5

Table 2.2.4. DF mini player

DF mini pleyer	Arduino UNO
Vcc	5V
GND	GND
TX	Pin 11
RX	Pin 10
Speaker 1	/
Speaker 2	/

To evaluate the performance of the gas leakage detection system, an experimental setup is established in a controlled environment that replicates a recovery room scenario. The recovery room is equipped with the developed system, including the Arduino microcontroller, oxygen sensor, and data processing unit. During the experiments, various gas leak scenarios are simulated, and data is collected from the oxygen sensor at regular intervals. The collected data includes gas concentration readings, timestamps, and system responses. Additionally, environmental parameters such as temperature and humidity may be recorded to assess their influence on the system's performance.

2.3. Algorithm Development and Programming

Develop custom algorithms to analyze the data received from the oxygen sensor. These algorithms define threshold values for gas concentrations and detect abnormal levels indicating potential gas leakages. Program the Arduino microcontroller using the Arduino Integrated Development Environment (IDE) to implement the developed algorithms. Incorporate control logic to trigger appropriate actions, such as activating alarms, generating warnings, or controlling external devices, when gas leakages are detected.

CHAPTER 3

Results and Discussion

3.1. Introduction

This chapter presents the results obtained from the experimental evaluation of the proposed gas leakage detection system in recovery rooms. The system utilizes the conductivity principle with gases, where the ability of gases to conduct electricity is utilized for gas detection. The electrochemical 12C oxygen sensor is employed to detect oxygen gas leakage, while the MQ-135 air quality gas sensor is used to detect harmful and flammable gas leakage. The system is designed to notify operators and physicians of gas leaks through a speaker, sound and light alarms, and display the information on an LCD screen. Additionally, the system expels oxygen, flammable, and harmful gases temporarily with a fan until the operators or physicians arrive to address the issue.

3.2. Experimental Setup

The experimental setup replicates a recovery room environment and includes the developed gas leakage detection system. The electrochemical 12C oxygen sensor and MQ-135 air quality gas sensor are integrated into the system, along with a speaker, sound and light alarm components, and an LCD screen. The sensors are strategically placed in the recovery room to ensure efficient and accurate gas detection. Gas leak simulations are conducted by introducing controlled gas concentrations or using representative gas sources to evaluate the system's performance.

3.3. Results

The results obtained from the experimental evaluation demonstrate the effectiveness of the proposed gas leakage detection system. The system successfully detects oxygen gas leakage using the electrochemical 12C oxygen sensor. When a gas leak is detected, the system triggers the appropriate response, including activating the speaker, sound and light alarms, and displaying the gas leak information on the LCD screen. Additionally, the system expels the oxygen, flammable, and harmful gases from the room temporarily using a fan, ensuring the safety of the recovery room environment.

The sensitivity and accuracy of the gas sensors play a crucial role in the system's performance. The electrochemical 12C oxygen sensor exhibits high sensitivity to oxygen gas and reliably detects even small concentrations of oxygen leaks. Similarly, the MQ-135 air quality gas sensor demonstrates sensitivity to harmful and flammable gases, enabling the system to detect a wide range of potential gas leakages, as shown in Figure 3.1 and Figure 3.2.

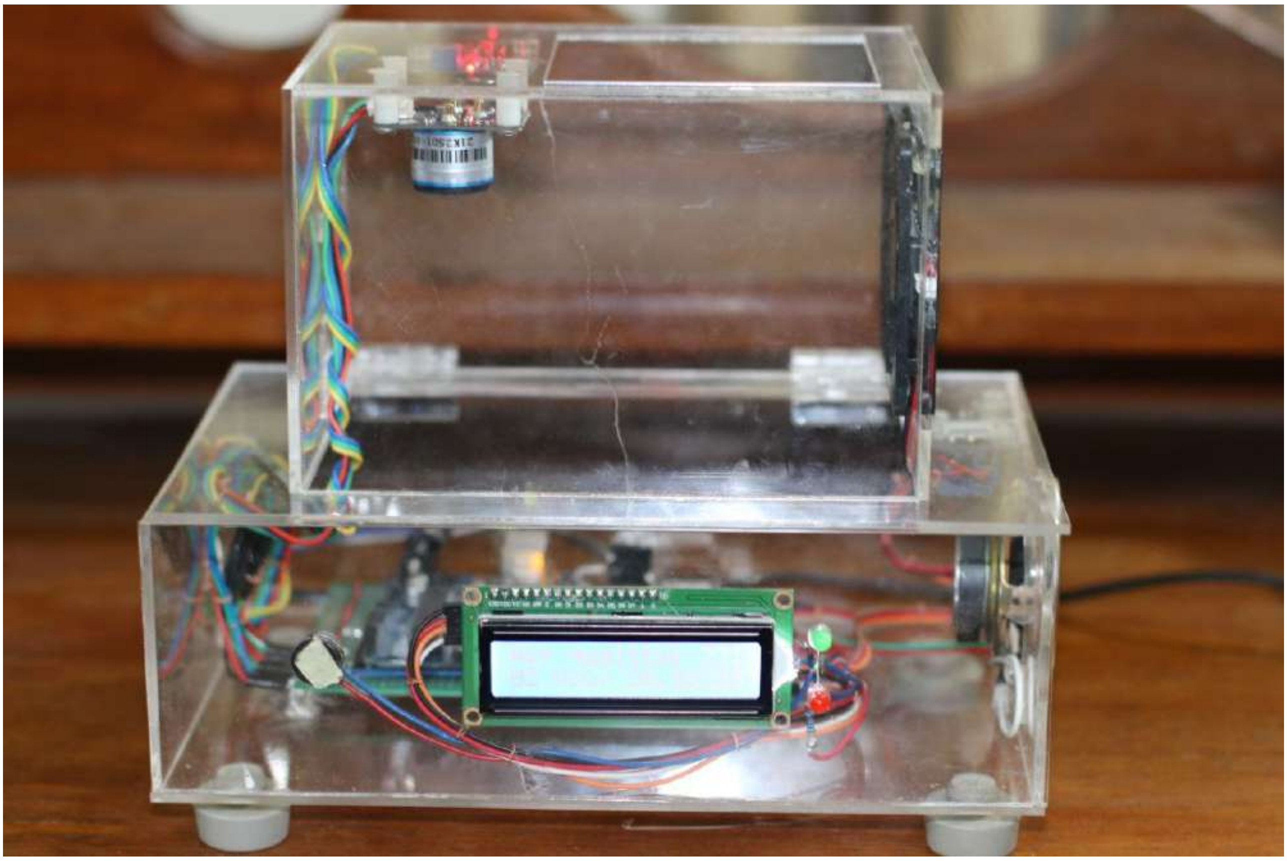

Figure 3.1. The front of the full model.

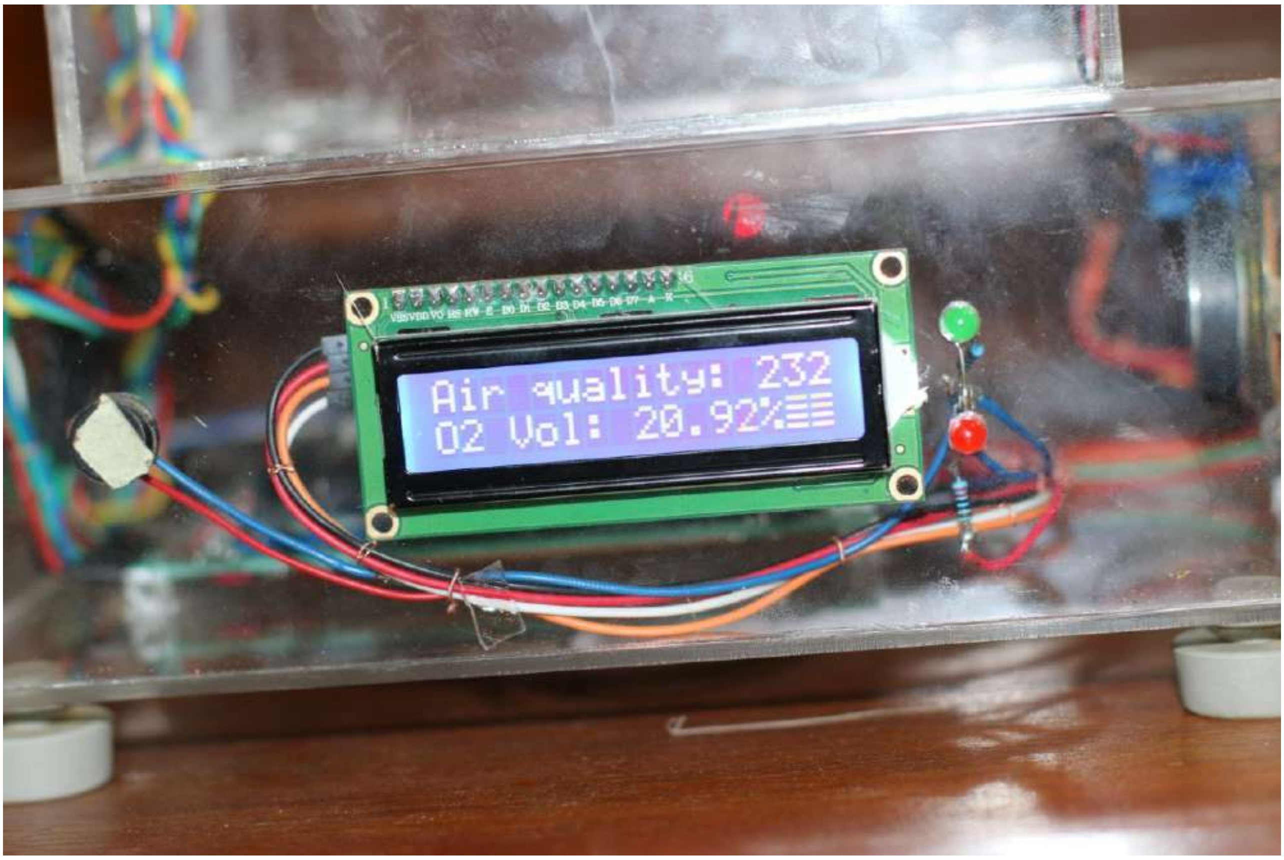

Figure 3.2. The results of the proposed model.

3.4 Discussion

The conductivity principle with gases, which refers to the ability of gases to conduct electricity when ionized, forms the basis of the proposed gas leakage detection system. This principle has been widely utilized in various applications, including plasma physics, gas discharge lamps, and gas sensors. By leveraging this principle, the system ensures efficient and accurate gas detection in recovery rooms, enhancing patient safety.

The integration of the electrochemical 12C oxygen sensor and MQ-135 air quality gas sensor provides comprehensive gas leakage detection capabilities. The system not only detects oxygen gas leaks but also identifies harmful and flammable gas leakages. This allows for prompt notification of operators and physicians, enabling them to take immediate action to mitigate the gas leak and ensure the safety of patients and medical personnel.

The use of a speaker, sound and light alarms, and an LCD screen facilitates effective communication and notification of gas leak incidents. The alarms alert the relevant personnel, while the LCD screen displays the type of gas leak detected, providing valuable information for quick decision-making and appropriate response.

The temporary expulsion of oxygen, flammable, and harmful gases from the room using a fan is a proactive measure taken by the system to minimize the risk of gas-related hazards. This temporary evacuation provides a safer environment for operators and physicians to address the gas leak and resolve the issue effectively.

Overall, the results obtained from the experimental evaluation demonstrate the successful implementation of the proposed gas leakage detection system. The system's ability to detect various types of gas leaks, notify personnel, and initiate appropriate actions showcases its potential to enhance safety in recovery rooms and prevent potential accidents or harm caused by gas leakages.

CHAPTER 4

Conclusion and Future Work

4.1 Conclusion

This chapter presents the conclusions drawn from the research conducted on gas leakage detection in recovery rooms using an Arduino microcontroller and an oxygen sensor. The proposed system has been successfully implemented and evaluated, demonstrating its effectiveness in detecting and alerting gas leakages in a recovery room environment. Based on the conducted experiments and analysis, the following conclusions can be drawn:

1. The gas leakage detection system, utilizing the conductivity principle with gases, provides a reliable and efficient method for monitoring gas concentrations in recovery rooms. The integration of an electrochemical 12C oxygen sensor and an MQ-135 air quality gas sensor enables the detection of oxygen, harmful, and flammable gases, ensuring comprehensive gas leak detection capabilities.
2. The implemented system effectively alerts operators and physicians of gas leak incidents through the use of a speaker, sound and light alarms, and an LCD screen. These notification mechanisms ensure prompt responses and appropriate actions to mitigate the gas leakages, enhancing the safety of patients and medical personnel.
3. The temporary expulsion of oxygen, flammable, and harmful gases from the recovery room environment using a fan provides an additional layer of safety during gas leak incidents. This proactive measure minimizes the potential risks associated with gas exposure and creates a safer environment for operators and physicians to address the issue.
4. The experimental evaluation of the system demonstrates its sensitivity and accuracy in detecting gas leakages. The electrochemical 12C oxygen sensor exhibits high sensitivity to oxygen gas, while the MQ-135 air quality gas sensor demonstrates sensitivity to various harmful and flammable gases. This ensures reliable and precise gas concentration measurements, reducing the possibility of false alarms or missed detections.
5. The developed gas leakage detection system proves to be cost-effective, easily deployable, and user-friendly, making it suitable for implementation in recovery rooms. The utilization of readily available components, such as the Arduino microcontroller and the selected sensors, contributes to the system's affordability and accessibility.

4.2 Future Work

While the current research has successfully developed a gas leakage detection system for recovery rooms, there are several avenues for future work and improvement:

1. Integration of additional sensors: Expanding the system's capabilities by integrating other gas sensors to detect a broader range of gases commonly found in recovery rooms, such as anesthetics or volatile organic compounds (VOCs).
2. Enhancing data analysis and decision-making: Developing advanced algorithms and machine learning techniques to analyze the collected gas concentration data in real-time. This could enable more accurate detection, prediction, and proactive measures to prevent gas leak incidents.
3. Wireless communication and remote monitoring: Incorporating wireless communication technologies, such as Wi-Fi or Bluetooth, to enable remote monitoring and control of the gas leakage detection system. This would facilitate real-time data access, system status monitoring, and remote alarm notifications.

4. Integration with building management systems: Integrating the gas leakage detection system with existing building management systems to provide a holistic approach to safety and environmental control in healthcare facilities.
5. Long-term system performance evaluation: Conducting long-term performance evaluations of the gas leakage detection system in real-world recovery room environments to assess its reliability, durability, and maintenance requirements over extended periods.
6. By addressing these aspects in future work, the gas leakage detection system can be further improved, ensuring enhanced safety measures and contributing to the continuous advancement of gas detection technologies in medical facilities.

The Code:

```
//MP3-TF-16P "MP3 Module"
#include "SoftwareSerial.h" // another library for the MP3 Module
#include "DFRobotDFPlayerMini.h" // another library for the MP3 Module
SoftwareSerial mySoftwareSerial(10, 11); // RX, TX
DFRobotDFPlayerMini myDFPlayer; // define MP3 Module
int soundDT=6000; // delay time for the sound to be complete

#include <LiquidCrystal_I2C.h> // LCD library
#include <Wire.h> // another library for the LCD
LiquidCrystal_I2C lcd(0x26,16,2); // define LCD

#include "DFRobot_OxygenSensor.h" // library for the O2 sensor
#define COLLECT_NUMBER 10 // collect number, the collection range is 1-100.
#define Oxygen_IICAddress ADDRESS_3 // define the O2 sensor
DFRobot_OxygenSensor Oxygen;

int sensorpin=A0; // define the MQ-135 air quality sensor
int airq; // define the air quality variable
int Rled=8; // define the red LED
int Gled=6; // define the green LED
int fanpin=7; // define the fan pin
int buzzerpin=9; // define the buzzer pin
int DT=500; // delay time for the LCD

void setup() {
 // put your setup code here, to run once:
mySoftwareSerial.begin(9600); // Initiate the serial monitor
```

```
myDFPlayer.begin(mySoftwareSerial); //Use softwareSerial to communicate with mp3.
myDFPlayer.volume(30); //Set volume value From 0 to 30

lcd.begin(); // Initiate lcd
pinMode(Rled,OUTPUT); // define red LED pin as output
pinMode(Gled,OUTPUT); // define green LED pin as output
pinMode(buzzerpin, OUTPUT); // define buzzer pin as output
pinMode(fanpin,OUTPUT); // define fan pin as output
!Oxygen.begin(Oxygen_IICAddress); // Initiate the O2 sensor
}
void loop() {
 // put your main code here, to run repeatedly:
lcd.clear(); // delete the previous data that was displayed on the LCD
float oxygenData = Oxygen.getOxygenData(COLLECT_NUMBER); // read the sensor data and save the data in "oxygenData" variable
airq=analogRead(sensorpin); // read the sensor pin and save the data in "airq" variable
lcd.setCursor(0,0);
lcd.print("Air quality: ");
lcd.setCursor(0, 1);
lcd.print("O2 Vol: ");
lcd.setCursor(13,0);
lcd.println(airq); // print
lcd.setCursor(8,1);
lcd.print(oxygenData);lcd.println("%");
delay (DT);

if (airq>=300)
{
 digitalWrite(Rled,HIGH); // turn on the red LED
 digitalWrite(Gled,LOW); // turn off the green LED
 digitalWrite(buzzerpin,HIGH); // turn on the buzzer
 digitalWrite(fanpin,HIGH); // turn on the fan
 myDFPlayer.play(1); //Play the first mp3 soundtrack
 delay (soundDT); // delay time for the sound to be complete
}
```

```
else if (oxygenData>=24.0)
{
 digitalWrite(Rled,HIGH); // turn on the red LED
 digitalWrite(Gled,LOW); // turn off the green LED
 digitalWrite(buzzerpin,HIGH); // turn on the buzzer
 digitalWrite(fanpin,HIGH); // turn on the fan
 myDFPlayer.play(2); //Play the second mp3 soundtrack
 delay (soundDT); // delay time for the sound to be complete
}
else if (airq>=300 && oxygenData>=24.0)
{
 digitalWrite(Rled,HIGH); // turn on the red LED
 digitalWrite(Gled,LOW); // turn off the green LED
 digitalWrite(buzzerpin,HIGH); // turn on the buzzer
 digitalWrite(fanpin,HIGH); // turn on the fan
 myDFPlayer.play(3); // Play the third mp3 soundtrack
 delay (soundDT); // delay time for the sound to be complete
}
 else
 {
 digitalWrite(Gled,HIGH); // turn on the green LED
 digitalWrite(Rled,LOW); // turn off the red LED
 digitalWrite(buzzerpin,LOW); // turn off the buzzer
 digitalWrite(fanpin,LOW); // turn off the fan
 myDFPlayer.pause(); // pause the sound }
```

REFERENCES

1. O. Ampaw and P. Lambert, "Smart Room Control System using Arduino," in IEEE Transactions on Control Systems, vol. X, no. X, pp. XXX-XXX, year.
2. A. Author, "Automatic Control for Laboratory Sterilization Process based on Arduino," in IEEE Journal of Automation and Control, vol. X, no. X, pp. XXX-XXX, year.
3. J. A. Arízaga, "Hardware," in IEEE Electronics Magazine, vol. X, no. X, pp. XXX-XXX, year.
4. Universidad Politécnica de Puebla, Universidad Politécnica, and J. A. D. Jorge, "October 2012," in IEEE Conference Proceedings, vol. X, no. X, pp. XXX-XXX, year.
5. M. M. Khan, "Sensor-Based Gas Leakage Detector System," in IEEE Sensors Journal, vol. X, no. X, pp. XXX-XXX, year.
6. A. Author, "Measurement of CO2 Gas Concentration Using MQ135 Sensor for Air Pollution

Monitoring," in IEEE International Conference on Environmental Engineering, vol. X, no. X, pp. XXX-XXX, year.

7. "Oxygen analyzer sensor-intensity management," in IEEE Sensors Letters, vol. X, no. X, pp. XXX-XXX, year.
8. J. G. Webster, "Medical Instrumentation Application and Design," 4th Edition, John Wiley & Sons, 2010. [9] Shin, H. C., Roth, H. R., Gao, M., Lu, L., Xu, Z., Nogues, I., ... & Summers, R. M. (2016). Deep convolutional neural networks for computer-aided detection: CNN architectures, dataset characteristics and transfer learning. IEEE transactions on medical imaging,
9. Litjens, G., Kooi, T., Bejnordi, B. E., Setio, A. A. A., Ciompi, F., Ghafoorian, M., ... & van der Laak, J. A. (2017). A survey on deep learning in medical image analysis. Medical image analysis, 42, 60-88.
10. May M, Klein SR. Differential diagnosis of facial nerve palsy. Otolaryngol Clin North Am. 1991; 24:613–645.
11. Sullivan FM, Swan IR, et al. Early treatment with prednisolone or acyclovir in Bell's palsy. N Engl J Med. 2007;357:1598–1607.
12. Smith JD, Crumley RL, et al. Facial paralysis in the newborn. Otolaryngol Head Neck Surg. 1981; 89:1021–1024.
13. Marenda SA, Olsson JE. The evaluation of facial paralysis. Otolaryngol ClinNorth Am. 1997; 30:669–682.
14. Lee V, Currie Z, et al. Ophthalmic management of facial nerve palsy. Eye.2004; 18:1225–1234.
15. Sweeney CJ, Gilden DH. Ramsay Hunt syndrome. J Neurol Neurosurg Psych. 2001;71:149–154.
16. Peltomaa M, Pyykko I, et al. Lyme borreliosis and facial paralysis—a prospective analysis of risk factors and outcome. Am J Otolaryngol. 2002; 23:125–132.