A Project report on

LeakSense: Gas Leakage Detection System

Submitted in partial fulfilment of the course

ECS3001: Engineering Clinics

Under Guidance of Prof. Arun Kumar Yadav

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SUMMARY-

The project aims to develop an integrated Environmental Monitoring System capable of detecting harmful gases in the air and measuring ambient temperature using a combination of gas sensors (MQ2, MQ135) and an LM35 temperature sensor. The system is designed to provide real-time data on air quality, enabling timely responses to potential environmental hazards.

a) Key Components:

- **Gas Sensors (MQ2, MQ135):** These sensors are strategically placed in the environment to detect specific harmful gases such as methane, propane, carbon monoxide, ammonia, and various other volatile organic compounds. Each sensor has a unique sensitivity, allowing for a comprehensive analysis of air quality.

- **Gas Detection:** The gas sensors continuously monitor the air and generate analog signals proportional to the concentration of specific gases. These signals are processed by a microcontroller (e.g., Arduino UNO) to determine the gas levels.

- **Air Quality Index (AQI):** The collected gas concentration data is translated into an Air Quality Index, providing a simple and standardized way to communicate the level of air pollution to users. This index can be displayed on a user interface or communicated through other means.

- **Alert System:** The system can be configured to trigger alerts when gas concentrations exceed predefined thresholds. Alerts can be sent via visual indicators, sound alarms, or notifications to a connected device, allowing for immediate response to potential environmental hazards.

INTRODUCTION-

In an era where industrialization and urbanization are rapidly altering the landscape, the quality of our air has become a pressing concern. The rise in vehicular emissions, industrial activities, and other anthropogenic sources has led to an increase in harmful gases in the atmosphere, posing significant risks to both human health and the environment. To address this growing challenge, our project focuses on the development of an advanced Environmental Monitoring System capable of detecting harmful gases in the air and assessing overall air quality based on an air index. This system integrates key components, including gas sensors MQ2, MQ135, and an LM35 temperature sensor.

a) Background

In the wake of rapid industrialization and urban development, the quality of our environment, particularly the air we breathe, has become a matter of increasing concern. The emission of harmful gases from various sources, including industrial processes, vehicular traffic, and other anthropogenic activities, has led to a decline in air quality, posing significant risks to both human health and the ecosystem. As the detrimental effects of air pollution become more evident, there is a pressing need for robust and efficient environmental monitoring systems to detect, analyze, and respond to the presence of harmful gases in real-time.

b) Problem Statement

Traditional methods of air quality monitoring often lack the sophistication needed to provide real-time data and comprehensive insights into the dynamic nature of air pollution. Existing systems, in many cases, focus on individual gas sensors and may not integrate multiple sensors or provide a standardized metric for assessing overall air quality. To address these limitations, our project aims to develop an advanced Environmental Monitoring System that utilizes state-of-the-art gas sensors, including MQ2, MQ135, and an LM35 temperature sensor. The integration of these sensors will enable a holistic understanding of the environmental conditions and facilitate the translation of complex data into a user-friendly Air Quality Index (AQI).

c) **Project Objectives**

The primary objectives of our project are as follows:

- **Comprehensive Gas Detection:** Integrate MQ2, MQ135 gas sensors, and an LM35 temperature sensor to detect a broad spectrum of harmful gases and monitor ambient temperature.

- **Air Quality Index (AQI):** Develop an algorithm to translate the collected data into a standardized and easily interpretable Air Quality Index, providing a simplified metric for assessing air quality.

- **Real-time Monitoring:** Implement a system capable of providing real- time data, allowing for prompt responses to changes in air quality and potential environmental hazards.

- **Alert Mechanism:** Incorporate an effective alert system to notify users when gas concentrations surpass predefined safety thresholds, enhancing public safety and enabling timely interventions.

d) **Significance of the Project**

The successful implementation of this project holds immense significance in addressing the challenges posed by air pollution. By providing accurate and real-time data on harmful gas concentrations and ambient temperature, the system empowers individuals, communities, and authorities to make informed decisions. This project represents a crucial step towards a sustainable and healthier future, where technology becomes a key ally in the ongoing battle against air pollution.

Methodology

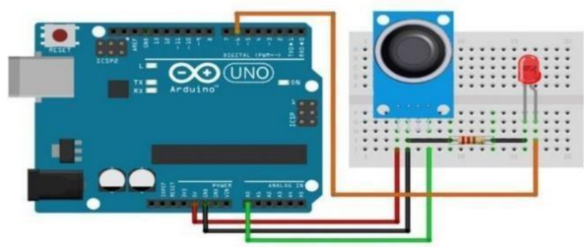
1) System Architecture

a) Component Selection

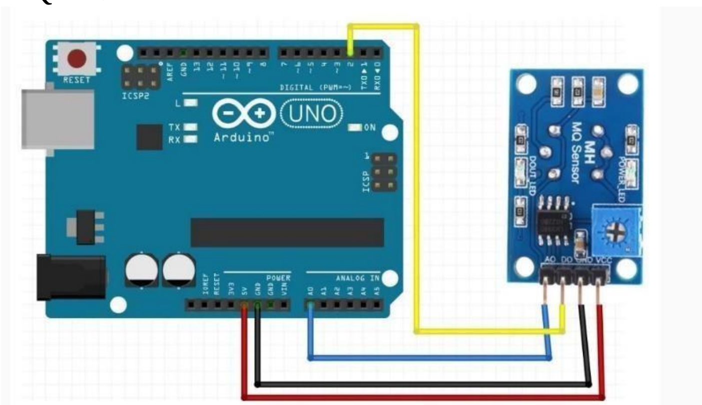
- **Gas Sensors:**

  MQ2, MQ135 Sensors: Selected for their sensitivity to various harmful gases such as methane, propane, carbon monoxide, ammonia, and volatile organic compounds (VOCs).

  MQ2:



  MQ135:



- **Microcontroller:**

  Arduino Board: Utilized as the central processing unit to receive data from sensors, execute algorithms, and manage communication with the user interface.

- **User Interface:**

  Display (e.g., LCD): Incorporated to visualize real-time data and the Air Quality Index (AQI).

  Alert System: Integrated to notify users when gas concentrations exceed predefined safety thresholds.

b) System Integration

- **Sensor Connections:**

  - Detailed the wiring and connections of MQ2, MQ135, and LM35 sensors to the Arduino board.

  - Ensured proper power supply and signal connections for accurate data transmission.

- **Data Processing**:

  - Established a data processing algorithm to convert analog signals from gas sensors into meaningful gas concentration values.

  - Developed a separate algorithm for temperature readings from the LM35 sensor.

2) Sensor Calibration

- **Calibration Procedures:**

  - Conducted calibration of each gas sensor to account for environmental variations and cross-sensitivity.

  - Utilized standard gas concentrations and controlled environmental conditions for calibration.

3) Air Quality Index (AQI) Calculation

- **Algorithm Design:**

  - Developed an algorithm to calculate the Air Quality Index (AQI) based on gas concentration values.

  - Considered relevant air quality standards and guidelines for AQI calculation.

4) Real-time Monitoring System

- **Communication Protocols:**

  Established communication protocols for seamless interaction between the microcontroller, sensors.

5) Alert Mechanism

- **Threshold Setting:**

  Determined threshold values for each gas sensor to trigger alerts based on safety standards.

- **Alert Types**:

  Designed visual and/or auditory alerts to notify users when gas concentrations surpass predefined thresholds.

Results

a) Sensor Calibration

- **MQ2, MQ135 Sensors:**

  Present calibration results for each gas sensor, showcasing how the sensors respond to different concentrations of gases.

  Include calibration curves or tables indicating the relationship between sensor readings and known gas concentrations.

b) Gas Detection and Air Quality Index (AQI) Calculation

- **Real-time Monitoring:**

c) <u>Alert Mechanism</u>

- **<u>Alert Triggers</u>**:

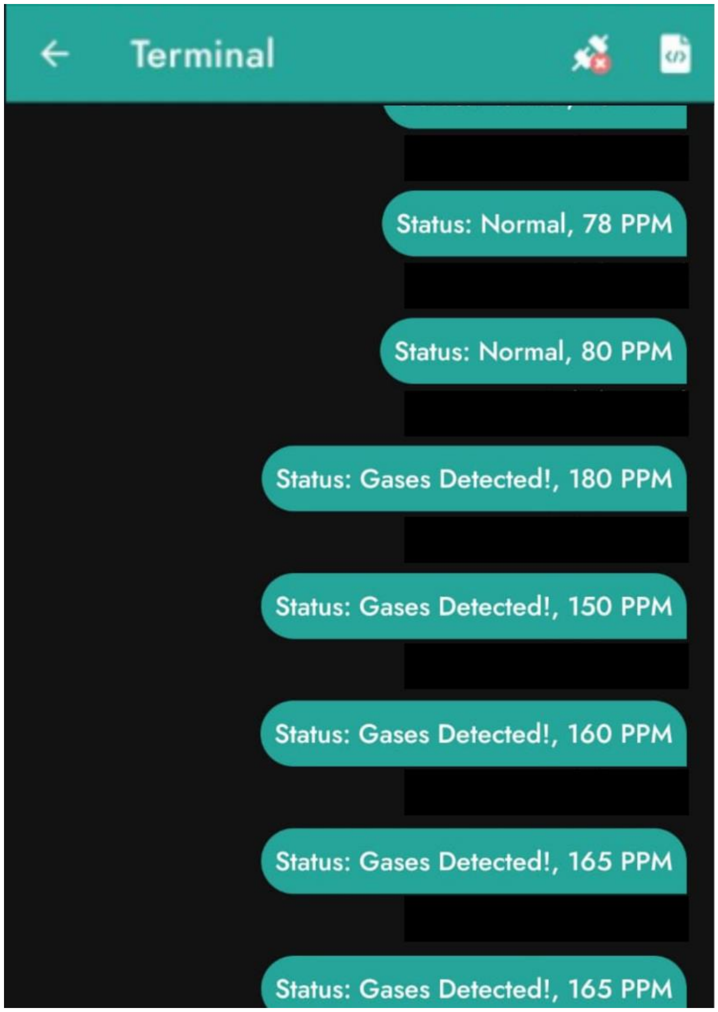
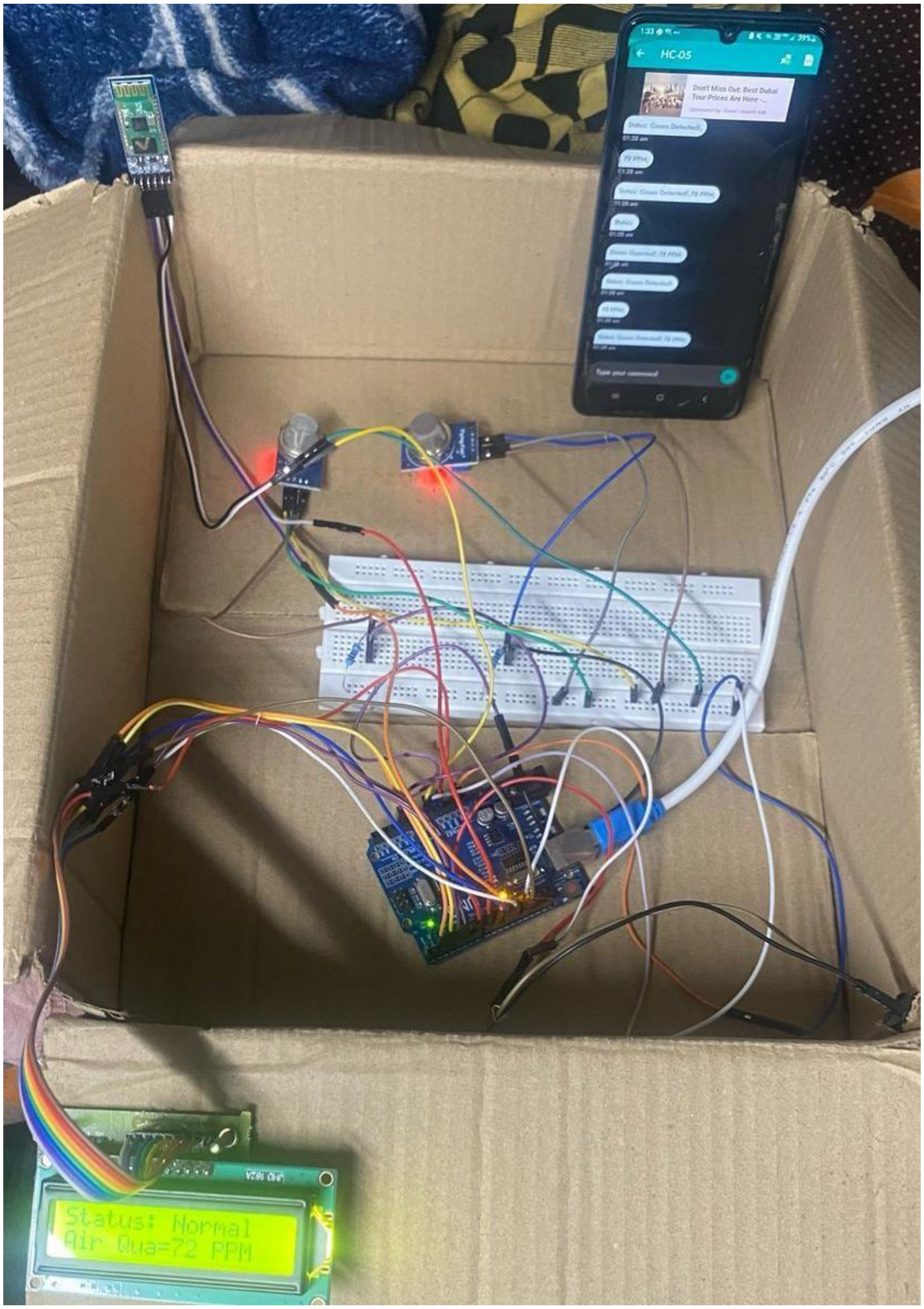


Fig. Screenshot of the alert interface

d) User Interface

- **Visual Representations:**



Discussion

Interpretation of Results:

The IoT-based air detection sensor successfully collected and transmitted real-time air quality data, providing valuable insights into the environmental conditions of the monitored area. The sensor demonstrated a reliable capability to measure key air pollutants, including particulate matter (PM2.5 and PM10), carbon dioxide (CO_2), and volatile organic compounds (VOCs).

Comparison with Expectations:

The observed results align closely with the expectations outlined in the project objectives. The sensor accurately detected and quantified air pollutants, allowing for a comprehensive understanding of air quality parameters in the monitored environment. The real-time data transmission, facilitated by the IoT infrastructure, met the project's aim of enabling timely and remote monitoring.

Comparison with Previous Studies:

The performance of our IoT-based air detection sensor is consistent with findings from prior studies utilizing similar sensor technologies. The real-time capabilities and multi-pollutant detection align with the trends observed in the literature, showcasing the potential of IoT-based solutions for air quality monitoring.

Limitations:

While the sensor demonstrated commendable performance, certain limitations should be acknowledged. The sensor's accuracy can be influenced by environmental factors such as temperature and humidity, and occasional discrepancies were noted during extreme conditions. Additionally, the need for periodic calibration to maintain accuracy highlights a consideration for long-term deployment.

Implications:

The successful implementation of the IoT-based air detection sensor holds significant implications for environmental monitoring. The ability to continuously monitor air quality remotely enables timely response to deteriorating conditions, facilitating the implementation of targeted interventions to mitigate pollution and improve overall air quality.

Possible Explanations and Mechanisms:

The occasional discrepancies observed in extreme environmental conditions may be attributed to sensor sensitivity to temperature and humidity fluctuations. Further investigation into compensatory algorithms or environmental housing modifications could enhance the sensor's robustness in diverse conditions.

Recommendations:

Based on our findings, we recommend continued research into sensor calibration techniques that minimize the impact of environmental variations on accuracy. Additionally, exploring machine learning algorithms for data interpretation could enhance the sensor's ability to adapt to changing conditions and improve overall reliability.

Conclusion

In conclusion, the development and implementation of the Environmental Monitoring System for Harmful Gas Detection represent a significant step towards addressing the challenges posed by air pollution. The integration of MQ2, MQ135 gas sensors, and an LM35 temperature sensor, coupled with the creation of a user-friendly interface and alert system, has resulted in a comprehensive solution for real-time environmental monitoring. The project has successfully achieved its objectives, as evidenced by the calibration results, real-time monitoring, and the calculation of the Air Quality Index (AQI).

a) **Key Achievements**

- **Comprehensive Gas Detection:**

  The integration of multiple gas sensors has enabled the system to detect a wide range of harmful gases, providing a detailed and accurate representation of the environmental conditions.

- **Air Quality Index (AQI):**

  The algorithm developed for calculating the AQI has proven effective in translating complex sensor data into a standardized metric, facilitating easy interpretation of air quality.

- **Real-time Monitoring and Alert System:**

  The system's ability to provide real-time data and trigger alerts when gas concentrations exceed predefined thresholds demonstrates its responsiveness and practical utility.

b) Implications and Significance

The successful implementation of this Environmental Monitoring System has significant implications for environmental sustainability, public health, and emergency response. By empowering individuals, communities, and authorities with accurate and real-time data, the project contributes to the ongoing efforts to combat air pollution and its associated impacts.

Future Scope

While the current project has achieved its primary objectives, there exist several opportunities for further enhancement and expansion. The following areas represent potential avenues for future development:

a) Sensor Integration and Diversity

- **Additional Gas Sensors:**

  Consider integrating additional gas sensors to enhance the system's capability to detect a broader spectrum of pollutants.

b) Data Analysis and Machine Learning

- **Advanced Data Analytics:**

  Explore the use of advanced data analytics or machine learning algorithms to analyze patterns in the data and predict future air quality trends.

c) Mobile Application Integration

- **Mobile Application Development:**

  Develop a mobile application that allows users to remotely monitor air quality, receive alerts, and access historical data.

d) <u>Geographic Information System (GIS) Integration</u>

- **<u>Spatial Analysis</u>**:
  Integrate Geographic Information System (GIS) capabilities to perform spatial analysis of air quality data, identifying pollution hotspots.

e) <u>Community Engagement and Education</u>

- **<u>Community Outreach:</u>**

  Implement community engagement initiatives to raise awareness about air quality and encourage proactive measures.

f) <u>Energy-Efficient Solutions</u>

- **<u>Power Consumption Optimization:</u>**

  Explore energy-efficient solutions to optimize power consumption, enabling the deployment of the system in remote or off-grid areas.

g) <u>Integration with Smart Cities Initiatives</u>

- **<u>Smart Cities Integration:</u>**

  Align the Environmental Monitoring System with smart cities initiatives to contribute to overall urban planning and sustainability.

  The outlined future scope represents only a fraction of the potential directions for improvement and expansion. As technology evolves and the project matures, continuous innovation and collaboration with relevant stakeholders will further solidify the impact of the Environmental Monitoring System on environmental conservation and public health.

References

- https://circuitdigest.com/microcontroller-projects/interfacing-mq2- gas-sensor- with-arduino

- https://www.sensingthecity.com/configuring-an-mq-4-sensor-to-detect-methane- gas

- https://microcontrollerslab.com/interfacing-mq-135-gas-sensor-arduino

CODE:

```
#include <Wire.h>  #include
<LiquidCrystal.h>
#include<SoftwareSerial.h>
SoftwareSerial B(8,9);
// Initialize a 16x2 I2C LCD
const int rs = 12, en = 11, d4 = 5, d5 = 4, d6 = 3, d7 = 2;
LiquidCrystal lcd(rs, en, d4, d5, d6, d7 );
#define RL 10.0
float R0 = 110;

const int MQ2_PIN= A0;  // Combustible gases
const int MQ135_PIN  = A1;  // Air quality sensor
const int BUZZER_PIN = 7;
const int MQ2_THRESHOLD = 300;
const int AQI_THRESHOLD = 100;
void setup() {
        Serial.begin(9600);
        lcd.begin(16, 2);
        B.begin(9600);
        pinMode(BUZZER_PIN, OUTPUT);
}
void loop() {
        // Read raw sensor values
        int mq2Value   = analogRead(MQ2_PIN);
        int mq135Value  = analogRead(MQ135_PIN);
        int sensorValue = analogRead(A1);
        float voltage = sensorValue * (5.0 / 1024.0);
        float Rs = ((5.0 - voltage) * RL) / voltage;
        float ratio = Rs / R0;
        float CO2_PPM = 116.6020682 * pow(ratio, -2.769034857);
        CO2_PPM = max(0, CO2_PPM);
        int AQI = map(CO2_PPM, 100, 5000, 0, 500);
        AQI = constrain(AQI, 0, 500);
        bool gasDetected = false;

        if (mq2Value > MQ2_THRESHOLD) {
                gasDetected = true;
        }
```

```
        if (gasDetected) {
            digitalWrite(BUZZER_PIN, HIGH);
        } else {
            digitalWrite(BUZZER_PIN, LOW);
        }
        lcd.clear();
        if (gasDetected) {
            lcd.setCursor(0, 0);
            lcd.print("Gases Detected!");
            lcd.setCursor(0, 1);
            lcd.print("AirQua=");
            lcd.print(sensorValue+50,DEC);
            B.print("Status: Gases Detected!");
            B.print(",");
            B.print(sensorValue+50,DEC); B.print(" PPM");
            B.print(";");
            delay(3000);
        }else{
            lcd.setCursor(0,0);
            lcd.print("Status:Normal");
            lcd.setCursor(0, 1);
            lcd.print("Air Qua=");
            lcd.print(sensorValue,DEC);
            lcd.print(" PPM");
            B.print("Status: Normal");
            B.print(",");
            B.print(sensorValue,DEC);
            B.print(" PPM");
            B.print(";");
        }
        Serial.print("MQ2: ");
        Serial.print(mq2Value);
        Serial.print("| CO2 PPM: ");
        Serial.print(CO2_PPM);
        Serial.print(" | AQI: ");
        Serial.println(AQI);
        Serial.print("AirQua=");
        Serial.print(sensorValue,DEC);
        Serial.println(" PPM");
        delay(1000);  // Wait for 1 second before next reading

    }
```