Air Quality Monitoring

D. Sainiveditaa[1], K. Dharshini [2], S. Gomathijeyavarthini[3], M. Jothiga and V. Jasmine Maria[4]

Anna University Regional Campus, Madurai

Abstract.

Air quality monitoring is essential for assessing environmental conditions and the health of individuals in both indoor and outdoor settings. This project presents the design and implementation of an air quality monitoring system that integrates multiple sensors for data collection and utilizes the Firebase platform for data storage and retrieval. The system is built using Raspberry Pi as the data acquisition device, and sensors including the BME280 for temperature, humidity, and pressure, the SI1145 for UV index, and the CCS811 for carbon dioxide (CO2) and volatile organic compounds (VOC) measurements. The project details the interfacing of these sensors with the Raspberry Pi and the creation of a Python script to collect sensor data. This data is then securely transmitted to the Firebase Realtime Database, allowing for remote access and visualization. The web interface displays real-time air quality data, including temperature, humidity, UV index, CO2 concentration, and VOC levels. The project serves as a valuable tool for air quality monitoring, with applications in various domains, including environmental monitoring, indoor air quality assessment, and health management. The integration of Firebase facilitates data accessibility and analysis, making it a versatile solution for real-time air quality assessment. This project demonstrates the feasibility of utilizing readily available sensors and cloud platforms to create a cost-effective and scalable air quality monitoring system, with the potential for further expansion and integration into smart environments and IoT applications.

1. Introduction:

In recent years, concerns surrounding air quality have gained significant attention due to their profound impact on public health and environmental well-being. Monitoring and managing air quality have become critical aspects of sustainable urban development and health care strategies. Air quality monitoring systems allow us to collect and analyse data related to various atmospheric parameters, providing valuable insights into the presence of pollutants and their concentrations. This project endeavours to create an efficient and cost-effective air quality monitoring system that leverages cutting-edge sensor technologies and modern data transmission methods.

The system integrates various sensors, including the BME280 for temperature, humidity, and pressure measurement, the SI1145 for UV index readings, and the CCS811 for the quantification of carbon dioxide (CO2) and volatile organic compounds

(VOCs). The data collected from these sensors are transmitted to a Firebase Realtime Database, providing remote access to real-time air quality information. The primary objectives of this project are to design a robust hardware setup for sensor integration, develop a software system for data collection and transmission, and create a user-friendly web interface for visualizing air quality data. By achieving these goals, we aim to contribute to the growing field of air quality monitoring, enabling individuals and communities to access accurate and up-to-date information about their surroundings.

This project report comprehensively details the methodology, results, and discussion related to the development and implementation of the air quality monitoring system. It also discusses the potential applications, accuracy, and reliability of the system, emphasizing its significance in environmental conservation and public health management.

2. Project Objectives:

- To measure UV radiation in the atmosphere.
- To measure suspended particulate matter in the environment.
- To measure Carbon-di-oxide (CO_2), Ozone (O_3), Volatile organic compounds, temperature, humidity and pressure in the environment.
- To create a web application to display the data in real-time to the users.

3. Methodology:

The successful implementation of the air quality monitoring project involves the following key phases:

3.1. Sensor Selection and Integration:

3.1.1. Sensor Selection:

The project utilizes three primary sensors for air quality monitoring:

1. BME280: A digital sensor from Bosch Sensor Tec that provides temperature, humidity, and pressure measurements.
2. SI1145: A UV sensor manufactured by Adafruit that measures UV index.
3. CCS811: A gas sensor from AMS AG specifically designed for CO2 and VOC measurements.

3.1.2. Sensor Integration:

The sensors are connected to a Raspberry Pi microcontroller. The BME280 is interfaced using the I2C protocol, while the SI1145 and CCS811 are also connected via I2C. The sensors are powered through the Raspberry Pi's 3.3V GPIO pins, and their data pins are connected to specific GPIO pins.

3.2. Data Collection:

3.2.1. Sensor Data Readings:

The Python programming language is used to collect data from the sensors. Sensor-specific libraries and Adafruit's Circuit Python libraries are utilized for interacting with the sensors. The programme used to implement the system in Raspberry Pi is given below.

```
import time
import requests
import board
import busio
import adafruit_bme280
import adafruit_si1145
import adafruit_ccs811
# Firebase project configuration
FIREBASE_URL = 'airqualitymonitoring-1ad53.firebaseapp.com'
FIREBASE_AUTH = 'AIzaSyA9kVZFHpicT1HrIHSvKuZvP1EFdtN_1yw'
# Initialize the sensors
    i2c = busio.I2C(board.SCL, board.SDA)
    bme280 = adafruit_bme280.Adafruit_BME280_I2C(i2c)
    si1145 = adafruit_si1145.SI1145(i2c)
    ccs811 = adafruit_ccs811.CCS811(i2c)
    def send_sensor_data(temperature, humidity, pressure, uv_index, co2, tvoc):
    data = {
        "temperature": temperature,
        "humidity": humidity,
        "pressure": pressure,
        "uvIndex": uv_index,
        "co2": co2,
        "tvoc": tvoc
    }


    firebase_url = f'{FIREBASE_URL}/.json?auth={FIREBASE_AUTH}'
```

```
18.      try:
      a. response = requests.post(firebase_url,
         json=data)
      b. if response.status_code == 200:
            i. print("Firebase Response: Data sent
               successfully")
      c. else:
            i. print("Error in Firebase POST
               request")
19.      except Exception as e:
      a. print(f"Failed to send data to Firebase:
         {str(e)}")


20.      while True:
21.      # Read sensor data
22.      temperature = bme280.temperature
23.      humidity = bme280.relative_humidity
24.      pressure = bme280.pressure
25.      uv_index = si1145.read_uv ()
26.      if not ccs811.data_ready:
      a. continue
27.      co2 = ccs811.eco2
28.      tvoc = ccs811.tvoc
29.      # Send sensor data to Firebase
30.      send_sensor_data(temperature, humidity,
    pressure, uv_index, co2, tvoc)


31.      time.sleep(10)  # Adjust the delay as
    needed for your specific application
```

3.2.2. Data Sampling:

Data readings are sampled at regular intervals (e.g., every 10 seconds) to ensure continuous monitoring of the environment.

3.3. Data Transmission:

3.3.1. Firebase Integration:

To facilitate remote data access and real-time monitoring, the project uses Firebase, a cloud-based NoSQL database and application development platform by Google. Firebase provides an easy-to-use API for storing and retrieving sensor data.

3.3.2 Transmission to Firebase:

A Python script sends the sensor data to a Firebase Realtime Database. The script constructs a JSON payload containing temperature, humidity, pressure, UV index, CO_2 levels, and TVOC readings.

3.4. Web-Based Data Visualization:

3.4.1. Flask Web Application:

A Flask-based web application is developed to visualize the collected data. The Flask framework facilitates the creation of a web interface for data presentation.

```
from flask import Flask, render_template, request
import requests

app = Flask(__name)

# Firebase project configuration
FIREBASE_URL = "https://your-firebase-database-url.firebaseio.com.json"  # Replace with your Firebase Realtime Database URL

@app.route('/')
def display_data():
    try:
        # Fetch data from Firebase
        response = requests.get(FIREBASE_URL)
        data = response.json()

        # Extract sensor data
        temperature = data.get('temperature', 'N/A')
        humidity = data.get('humidity', 'N/A')
        uvIndex = data.get('uvIndex', 'N/A')
```

```
            co2 = data.get('co2', 'N/A')
            tvoc = data.get('tvoc', 'N/A')

            return render_template('index.html', temperature=temperature, humidity=humidity, uvIndex=uvIndex, co2=co2, tvoc=tvoc)
        except Exception as e:
            return str(e)

    if __name__ == '__main__':
        app.run(debug=True)
```

3.4.2. HTML Template:

An HTML template is created for displaying sensor data, including temperature, humidity, UV index, CO2 levels, and TVOC readings.

3.4.2. Dynamic Data Rendering:

The Flask application dynamically fetches data from the Firebase database and renders it on the web interface.

4. Applications:

The proposed project has a wide range of potential applications. Here are some common applications where air quality monitoring can be valuable. Tracking air quality in urban areas to assess pollution levels and their impact on public health. Providing data for urban planning and decision-making regarding traffic management and industrial regulations. Monitoring indoor air quality in homes, offices, and public buildings to ensure a healthy and comfortable environment. Alerting occupants to potential issues such as high CO2 levels and poor ventilation. Ensuring worker safety by monitoring air quality in industrial facilities where employees may be exposed to harmful gases and particulates. Preventing workplace accidents and health issues. Monitoring air quality in nature reserves, forests, and protected areas to assess the impact of air pollution on ecosystems. Contributing to environmental research and conservation efforts. Providing individuals with real-time air quality information to help manage allergies and respiratory conditions. Offering insights into the quality of the air people are breathing during outdoor activities.

The above project can be used to support scientific research and educational programs focused on air quality and environmental science. Providing valuable data for academic institutions and researchers. Integrating air quality monitoring into Internet of Things (IoT) networks to create smart cities. Enhancing city infrastructure with data-driven insights for sustainability and improved quality of life. Collecting data to assess the impact of air quality on climate change and global warming. Contributing to a better understanding of environmental factors related to climate change. Creating early warning systems for residents to prepare for air quality-related health hazards, such as smog or haze. Promoting public safety during environmental crises.

Engaging local communities in citizen science projects where individuals can contribute to air quality data collection. Fostering environmental awareness and community involvement. Using historical air quality data to develop predictive models for forecasting air quality conditions. Offering timely alerts and recommendations for residents. Supporting emergency response teams during natural disasters, industrial accidents, or environmental emergencies. Offering critical data for decision-making during crisis situations. The versatility of air quality monitoring systems makes them valuable across various sectors, from healthcare and environmental conservation to urban planning and safety management. Depending on the specific sensors and data analysis capabilities, these systems can be tailored to suit diverse applications and contribute to healthier and more sustainable communities.

5. Reliability:

The reliability of the sensors used in the proposed system is of major importance to ensure the accuracy and consistency of the data collected. Reliability considerations are crucial, particularly when the collected data may influence critical decisions, public health, or regulatory compliance. The reliability of the sensors heavily depends on their quality and calibration. Well-established sensor manufacturers, like Bosch for BME280 and AMS AG for CCS811, often provide high-quality sensors with known performance characteristics. These sensors may come with factory calibration data, ensuring accurate readings. The accuracy of a sensor refers to how closely it measures the true value. The precision indicates how consistently it produces the same result. Reliability requires both high accuracy and precision. Calibrating and maintaining the sensors is essential to ensure they continue to meet their specified accuracy. Environmental conditions can affect sensor reliability. Changes in temperature, humidity, and pressure, for instance, can impact sensor accuracy. Ensuring that the sensors are placed and operated within their specified environmental ranges is vital. Over time, sensors may experience drift, where their accuracy slowly degrades. Understanding the rate of drift and having a calibration and maintenance schedule in place is important for long-term reliability. Some sensors may be sensitive to multiple gases or environmental factors. Cross-sensitivity can lead to false readings if other gases or conditions are present. Proper sensor selection and data correction techniques can help mitigate these issues.

6. Conclusion:

Our project has successfully demonstrated the feasibility and potential of a comprehensive system for real-time air quality assessment. By integrating advanced sensors, microcontroller platforms, and cloud-based data storage, we have created a versatile and reliable solution that can find applications in various domains, from environmental conservation to public health management.

The primary objectives of this project were to design, develop, and implement a functional air quality monitoring system that integrates data from multiple sensors, including the BME280, SI1145, and CCS811, and makes the data accessible through a user-friendly web interface. Through rigorous methodology and practical implementation, we have achieved these goals.

The project's significance lies in its ability to provide valuable insights into air quality, temperature, humidity, UV index, carbon dioxide levels, and volatile organic compounds. The resulting data can be used for a multitude of applications, including urban planning, industrial safety, environmental research, and personal health management.While the system's reliability in terms of sensor accuracy and data consistency has been addressed through proper sensor selection, calibration, and maintenance, it is essential to acknowledge that there are potential areas for improvement. Continuous monitoring of sensor performance, regular calibration, and data validation should be integral to ensure data accuracy and system reliability.

Moreover, the open-source nature of this project allows for further enhancements and adaptations to suit specific needs. Future work in this field may involve expanding the range of sensors to capture additional environmental parameters, improving the user interface, enhancing data analysis techniques, and integrating machine learning algorithms for predictive air quality modeling.

In the rapidly evolving landscape of environmental monitoring and the Internet of Things, this project contributes to the growing body of knowledge in the field of air quality assessment. It underscores the importance of accessible and real-time air quality data and encourages continued efforts to enhance the reliability and applicability of such systems.

In closing, this project serves as a testament to the potential of modern sensor technologies in addressing pressing environmental and health challenges. It is our hope that this work not only provides practical insights but also inspires further innovation in air quality monitoring, ultimately contributing to healthier and more sustainable communities.