JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Air Pollution Monitoring system using IoT

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Abstract : **The Internet of Things (IoT) has emerged as a powerful tool for addressing global environmental challenges, including pollution. This research paper explores the application of IoT technology in pollution measurement, focusing on its potential to provide real-time, accurate, and widespread monitoring of various pollutants. By leveraging a network of interconnected sensors, IoT devices can collect data on air quality, water quality, and noise pollution, enabling informed decision-making and effective pollution mitigation strategies. This paper reviews existing literature on IoT-based pollution monitoring systems, discusses the key components and challenges involved, and presents a case study of a successful implementation. This system can be used to monitor air pollutants in a specific area, analyze air quality, and forecast future air quality. The proposed system will emphasize monitoring air pollutants using a combination of IoT technologies.**

Index Terms **- IoT, air quality, noise pollution, air pollutants.**

I. INTRODUCTION

Pollution is a significant environmental and health concern that affects both developed and developing countries. Traditional pollution monitoring methods often involve manual sampling and laboratory analysis, which can be time-consuming, expensive, and limited in spatial and temporal coverage. The advent of IoT technology has opened up new possibilities for real-time, continuous, and widespread pollution monitoring. IoT devices, equipped with sensors and communication capabilities, can collect and transmit data on various pollutants to a central platform for analysis and visualization. Air pollution is a significant environmental issue affecting public health and the ecosystem. Traditional methods of air quality monitoring are often limited by their high cost and lack of real-time data. The advent of the Internet of Things (IoT) offers a promising solution by enabling the deployment of low-cost, real-time air pollution monitoring systems. This paper explores the development and implementation of an IoT-based air pollution monitoring system, highlighting its components, functionality, and potential applications.

II. LITRATURE REVIEW

Author Himadri Nath Saha et al.[1],addressed the issue of both air and noise pollution by utilizing various sensors capable of detecting air pressure, temperature, ultraviolet radiation, air quality, smoke, nitrogen dioxide, carbon monoxide, and noise levels. These sensors will transmit the collected data to the cloud, where it will be analyzed to generate a report. Based on this report, appropriate actions will be taken to combat pollution.

Authors Temesegan Walelign Ayele and Rutvik Mehta [2] had proposed air pollution monitoring and prediction system, powered by IoT devices, allows us to effectively track air quality. The system employs air sensors to detect pollution levels and transmit this data to a microcontroller. The microcontroller subsequently stores this information on a web server. To predict future pollution trends, we implement a Long Short-Term Memory (LSTM) neural network. LSTM's rapid convergence and reduced training cycles contribute to its high accuracy.

According to Harsh Shah et.al.[3] proposed proposes an IoT-based system to monitor air quality using an Arduino microcontroller. By leveraging IoT technology, we aim to enhance the process of monitoring various environmental aspects, particularly air quality. The system employs MQ135 and MQ6 gas sensors to detect different types of harmful gases. The Arduino microcontroller serves as the central control unit, managing the entire system. A Wi-Fi module connects the system to the internet, enabling remote data access and visualization. Additionally, LEDs provide visual feedback to indicate air quality levels.

Authors Danny M´unera et.al [4] conducted a comprehensive analysis of 55 IoT-based air quality monitoring systems designed for smart cities. To characterize these systems, they employed a four-tier architecture and explored nine research questions. By examining key system components, they aimed to identify technology trends that can inform the design of future systems.

Authors analysis focused on the types of sensors used, hardware components, and network protocols. While authors found patterns in sensor types and hardware, network protocol details were often overlooked in the literature. This lack of information prevented them from identifying trends in this area.

Authors Kinnera Bharath Kumar Sai, Somula Rama Subbareddy, A. Luhach [5] found that project successfully calculates air quality in parts per million (PPM). While the MQ135 sensor is capable of detecting various gases like smoke, carbon monoxide (CO), carbon dioxide (CO2), and ammonia (NH4), it lacks the specificity to distinguish between CO and CO2 levels. To address this limitation, they incorporated an MQ7 sensor specifically designed for CO detection.

III. RESEARCH GAP

3.1 Data Quality and Calibration

Many IoT-based air pollution monitoring systems use low-cost sensors, which can suffer from accuracy and precision issues. Research can focus on developing advanced calibration techniques and algorithms to enhance the data quality from these sensors.

3.2 Integration with Predictive Analytics

While real-time monitoring is common, integrating predictive analytics to forecast air quality trends is less explored. Investigate the use of machine learning models, such as neural networks or random forests, to predict future air quality based on historical data.

3.3 Scalability and Network Optimization

Scaling IoT networks for large urban areas poses challenges in terms of data transmission, storage, and processing.
Research can be directed towards optimizing network architectures and protocols to handle large-scale deployments efficiently.

3.4 Energy Efficiency:

IoT devices often rely on battery power, and frequent data transmission can drain batteries quickly.There is need to explore energy-efficient communication protocols and power management strategies to extend the operational life of IoT devices.

3.5 User Engagement and Accessibility:

There is limited research on how to effectively present air quality data to the public to maximize engagement and understanding.We can develop user-friendly interfaces and applications that make air quality data more accessible and actionable for the general public.

3.6 Interoperability and Standardization:

Lack of standardization in IoT devices and data formats can hinder the integration of different systems.Research can focus on creating standardized protocols and frameworks to ensure interoperability between various IoT-based air quality monitoring systems.

IV. METHODOLOGY

The proposed system consists of several key components:

1. **MQ135 Sensor**: This sensor detects various harmful gases like CO_2, smoke, alcohol, benzene, and NH_3. It measures the air quality in parts per million (PPM) and sends the data to the Arduino Uno.
2. **MQ7 Sensor**: one of the most promising detectors is the MQ-7 carbon monoxide sensor which instantly detects and indicates the presence so the users may save their lives. This is the most popular choice for this purpose because of its low cost, high performance, and instant response.
3. **MQ2 Sensor**: The MQ2 gas sensor is a versatile electronic device designed to detect various gases in the air, including LPG, propane, methane, hydrogen, alcohol, smoke, and carbon monoxide. This type of sensor, also known as a chemiresistor, operates by measuring changes in electrical resistance within its sensing material. When exposed to specific gases, the resistance of the material fluctuates, allowing for accurate gas detection.
4. **Arduino Uno**: The central microcontroller that processes the data received from the MQ135,MQ7,MQ2 sensors. It also controls the other components like the LCD display, buzzer, and Wi-Fi module.
5. **Wi-Fi Module (ESP8266)**: This module connects the Arduino Uno to the internet. It sends the air quality data to a cloud server, such as AWS, for remote monitoring.
6. **LCD Display**: Displays the real-time air quality data in PPM. This allows users to monitor the air quality locally.
7. **Buzzer**: An alert system that activates when the air quality falls below a certain threshold, indicating high levels of pollution.
8. **Cloud Server** : A platform where the air quality data is stored and can be accessed remotely via a web interface. Users can monitor the air quality from anywhere using their computer or mobile device.

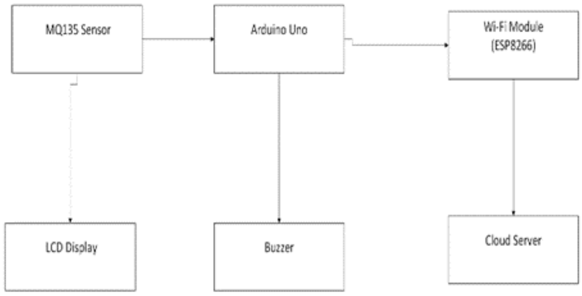

Figure 1.key components and methodology

For this project, we employed an Arduino Uno development board equipped with the ATMega328P microcontroller. To enable wireless connectivity, we integrated a cost-effective ESP-8266 Wi-Fi module, facilitating a seamless connection to the AWS platform. Figure 1 illustrates the interconnections between the components: Arduino Uno, MQ135, MQ2 and MQ7 gas sensors, ESP-8266 Wi-Fi module, a 9-volt battery, and an LM7805 voltage regulator.
The ESP-8266 module was powered by the 3.3-volt output of the Arduino Uno, while the MQ135 sensor operated on the 5-volt supply. To ensure adequate power for the MQ2, MQ7 sensor, we connected it directly to the 9-volt battery, regulating the voltage to 5 volts using the LM7805 regulator. The ESP-8266 module was configured to connect to a local Wi-Fi network by providing the corresponding SSID and password.
A crucial step in this project was calibrating the gas sensors in clean air. This process involved establishing a mathematical equation that converted the sensor's output voltage into the desired units, parts per million (PPM)[6]

TABLE I
AIR QUALITY INDEX

Range(PPM)	Status
0-50	Good
51-100	Moderate
100-150	Unhealthy for sensitive groups
151-200	Unhealthy
201-300	Very Unhealthy
301-500	Hazardous

V. RSULTS

Once the ESP-01 module successfully connected to the Wi-Fi hotspot, it established a connection with the AWS platform. The unique API key associated with your AWS account was integrated into the Arduino code, ensuring that data was exclusively saved to your designated account. AWS requires a refresh interval of 5 seconds to push data to the platform. Table 2 illustrates the field charts of MQ135 and MQ7 sensor values, representing the gas concentrations in parts per million (PPM) measured at the experiment's location.
Based on the data in Table 1, the air quality readings were within a safe range of 39 to 40 PPM. While the CO levels were slightly elevated at around 9 PPM, they were still below the threshold for causing significant health issues. Additionally, the temperature remained comfortable between 30 and 32 degrees Celsius, and the humidity was around 60%.

TABLE 2
MQ135,MQ7 DATASET

ID	Date and Time	Humidity	Temprature	Air Quality	CO
101	8/8/2024 03-07-54	64	32	41	9
102	8/8/2024 03-07-59	63	30	42	8
103	8/8/2024 03-08-04	64	31	41	9
104	8/8/2024 03-08-09	63	31	41	9
105	8/8/2024 03-08-14	64	32	42	9
106	8/8/2024 03-08-19	63	30	41	8
107	8/10/2024 05-14-03	58	31	40	9
108	8/10/2024 05-14-08	59	31	40	9
109	8/10/2024 05-14-13	59	30	41	9
110	8/10/2024 05-14-18	59	31	40	8
111	8/10/2024 05-14-23	58	31	41	8
112	8/10/2024 05-14-28	59	30	41	9

The area plot in Figure 2 visually represents the data as the area under a curve for each data point over time. This visualization provides a clear understanding of how the data evolves over time and facilitates data analysis. Although the area plot generally presents the same information as a line plot, it can offer a more intuitive understanding of trends and patterns.

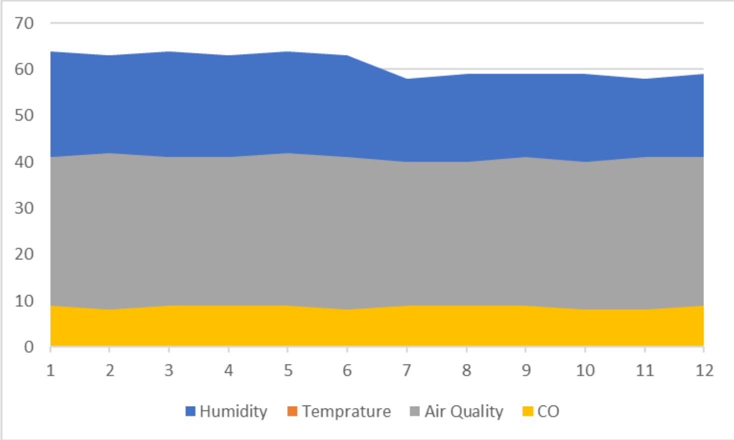

FIGURE 2 AREA PLOT OF THE DATA

VI. CONCLUSION

IoT technology offers a promising solution for addressing the challenges of pollution monitoring. By leveraging a network of interconnected sensors, IoT devices can provide real-time, accurate, and widespread data on various pollutants. This information can be used to inform policy decisions, improve environmental management, and protect public health. While there are still challenges to overcome, such as sensor reliability, data security, and network connectivity, the potential benefits of IoT-based pollution monitoring make it a worthwhile investment for governments and organizations.

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