International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 07 | July - 2023 SJIF Rating: 8.176 ISSN: 2582-3930

Air Quality Monitoring Using IoT and Machine Learning

Surendra H H,Nikita, Mamathshree, Ajay lokesh,Manjunath PJ
BMS College of Engineering

***Abstract*— Air pollution is a significant environmental concern that affects human health and well- being. To address this issue, an air quality monitoring system using IoT (Internet of Things) and ML (Machine Learning) techniques is proposed. The system aims to continuously monitor and analyze air pollutant levels in real- time, providing valuable insights for environmental management and public health.The system consists of air quality sensors deployed in various locations, collecting data on pollutants such as particulate matter, Gas/Smoke, carbon monoxide, metal oxide Benzene, and more. These sensors are connected to a central hub through wireless communication protocols, enabling data transmission to a cloud-based platform. The cloud platform serves as a repository for storing and processing the collected data.ML algorithms are employed to analyze the air quality data and develop predictive models.**

***Keywords*— IoT, air quality monitoring, machine learning, pollution assessment, Arduino,**

I. INTRODUCTION

Air pollution is a pressing environmental issue that poses significant threats to public health and the overall well-being of communities worldwide. The rapid industrialization, urbanization, and increased vehicular emissions have resulted in a decline in air quality, leading to adverse health effects and environmental degradation. To address this challenge, there is a growing need for robust and efficient air quality monitoring systems that can provide real-time data for pollution assessment and enable informed decision-making.

In this context, the integration of Internet of Things (IoT) technology and machine learning techniques offers a promising solution. IoT allows for the seamless connectivity and communication of various devices and sensors, enabling the collection and transmission of data from multiple locations. Machine learning algorithms, on the other hand, empower systems to process and analyze large datasets, extract meaningful insights, and make accurate predictions.

This paper presents an innovative IoT-based air quality monitoring system that leverages machine learning to assess and monitor pollution levels. The system combines an Arduino microcontroller, air sensors, and a reliable power source to measure various pollutants in the air. carbon monoxide (CO), and nitrogen dioxide (NO2) sensors are strategically placed to capture real-time data from different locations.

The Arduino microcontroller serves as the central control unit, responsible for data acquisition, preprocessing, and communication with the cloud. The collected data is then transferred to a cloud-based platform, where advanced machine learning algorithms are employed for data analysis. Neural networks and decision trees are trained on diverse datasets to establish accurate models for air quality prediction and pollution classification.

The objectives of this research are twofold: firstly, to develop a practical IoT-based system for real-time air quality monitoring, and secondly, to investigate the efficacy of machine learning algorithms in predicting pollution levels and identifying pollution sources. By achieving these objectives, the system aims to provide valuable insights into the dynamics of air pollution and facilitate timely interventions to mitigate its harmful effects.

The findings of this study have significant implications for public health and environmental management. By accurately assessing air quality and identifying pollutant sources, policymakers and relevant stakeholders can make informed decisions to improve air quality and reduce pollution levels. Additionally, the integration of IoT and machine learning technologies offers a scalable and cost-effective approach to environmental monitoring, paving the way for sustainable practices and healthier living environments.

The subsequent sections of this paper will detail the system architecture, the data collection and analysis methodologies, the evaluation of machine learning algorithms, and the discussion of the obtained results. Overall, this research contributes to the emerging field of IoT and machine learning applications for environmental monitoring and lays the foundation for future advancements in air quality assessment and pollution control.

.

II. PROPOSED SOLUTION

A. Hardware

The system utilizes an Arduino microcontroller as the central control unit, which is programmed in Python. The Arduino is responsible for coordinating the functioning of the various air sensors, including PM, CO, and NO2 sensors, strategically placed in different locations to capture comprehensive air quality data. A reliable power source ensures uninterrupted operation of the system.

B. Data Acquisition and Preprocessing

The Arduino microcontroller collects data from the deployed sensors, which measure pollutant levels and other relevant parameters. The collected data undergoes preprocessing, including filtering, calibration, and normalization, to ensure accurate and reliable measurements. The preprocessed data is then transmitted to a cloud-based platform for further analysis.

C. Cloud-Based Data Analysis

The cloud-based platform serves as the central repository for the collected data. Advanced machine learning algorithms, such as neural networks and decision trees, are employed to analyze the data and derive meaningful insights. These algorithms are trained on diverse datasets to establish accurate models for predicting air quality and classifying pollutants.

D. Air Quality Prediction and Pollution Classification

The trained machine learning models are used to predict air quality levels based on the collected sensor data. Additionally, the models classify pollutants and identify their sources. This information allows for a comprehensive understanding of the pollution dynamics in different areas, aiding in the formulation of targeted mitigation strategies.

E. Real-Time Monitoring and Visualization

The IoT architecture enables real-time monitoring of air quality parameters and pollutant levels. The analyzed data is visualized through intuitive dashboards and graphical representations, providing stakeholders with a clear understanding of the current air quality status. Alerts and notifications can be generated based on predefined thresholds to facilitate prompt actions when pollution levels exceed acceptable limits.

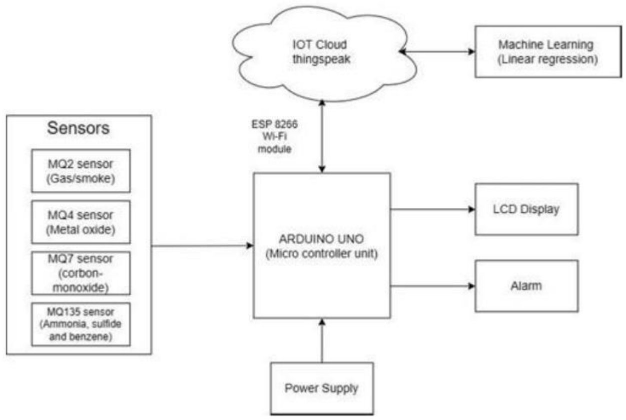
F. Decision Support System

The proposed solution provides decision-makers with valuable insights into air pollution patterns, sources, and trends. This information empowers them to make informed decisions regarding pollution control measures, urban planning, and policy formulation. Timely interventions can be implemented to mitigate pollution sources and reduce the impact on public health and the environment.

The proposed IoT-based air quality monitoring system integrated with machine learning techniques offers a comprehensive and scalable solution to address the challenges posed by air pollution. By providing accurate and real-time data on air quality, identifying pollutant sources, and enabling informed decision-making, this solution has the potential to contribute to the improvement of public health and the implementation of sustainable practices for pollution control.

III. METHODOLOGY

The air quality monitoring system consists of 4 sensors like MQ2,MQ4,MQ7 and MQ135 connnected to Arduino Uno.Hardware components like power supply, alarm ,LCD display are connected to Arduino Uno. Wi-Fi module ,IOT cloud and machine learning are the software mentioned in the below block diagram.
Internet of Things (IoT) mainly deals with connecting smart devices to internet by joining the advantage of OSI layered Architecture. In the context of this work we propose a cluster of Air Quality Monitoring Gas Sensor MQ135, MQ2, MQ4, MQ7 motes, which are used to measure the concentration of Air pollutants in the air. The Gas Sensors MQ135 is interface with a tiny entrenched platform equipped with other. We have mainly used the Arduino UNO which is an open source development boards with ESP8266 12E chips. MQ135, MQ2, MQ4, MQ7 are Gas Sensors used to collect gas concentration measurements.



The successful implementation of the IoT-based air quality monitoring system relies on several key hardware components. The chosen components for this project include the Arduino Uno microcontroller, gas sensors, a Wi-Fi module for

connectivity, a power supply, and an LCD display. These hardware elements work together to ensure reliable data acquisition, processing, and communication within the system.

A. Arduino Uno Microcontroller

The Arduino Uno serves as the central control unit for the air quality monitoring system. It provides the necessary computational power, digital and analog input/output pins, and an integrated development environment (IDE) for programming. The Arduino Uno is compatible with various sensors and modules, making it an ideal choice for this project.

B. Gas Sensors

Gas sensors are crucial for measuring pollutant levels in the air. For this project, a selection of gas sensors, including particulate matter (PM), carbon monoxide (CO), and nitrogen dioxide (NO2) sensors, is utilized. These sensors provide accurate and real-time measurements of specific pollutants, enabling comprehensive air quality assessment.

C. Wi-Fi Module

To enable seamless connectivity and data transfer, a Wi-Fi module is incorporated into the system. The Wi-Fi module allows the Arduino Uno to connect to the internet and transmit data to a cloud-based platform for storage and analysis. This wireless capability ensures flexibility and ease of data retrieval for further processing.

IV. SOFTWARE REQUIREMENTS

The successful implementation of the IoT-based air quality monitoring system involves specific software components and tools. The chosen software requirements for this project include the Arduino IDE for programming the Arduino Uno microcontroller, the IoT cloud platform ThingsSpeak for data storage and visualization, Python with Jupyter Notebook for data analysis and machine learning, and the Linear Regression algorithm for modeling air quality prediction.

1. Arduino IDE (Integrated Development Environment)

The Arduino IDE is the software tool used for programming the Arduino Uno microcontroller. It provides an intuitive and user-friendly interface for writing, compiling, and uploading code to the microcontroller. The programminglanguage used in the Arduino IDE is a variant of embedded C,tailored specifically for Arduino boards. It enables control of the microcontroller's functionality, including data acquisition
from sensors and communication with external devices.

2. IoT Cloud Platform: ThingsSpeak

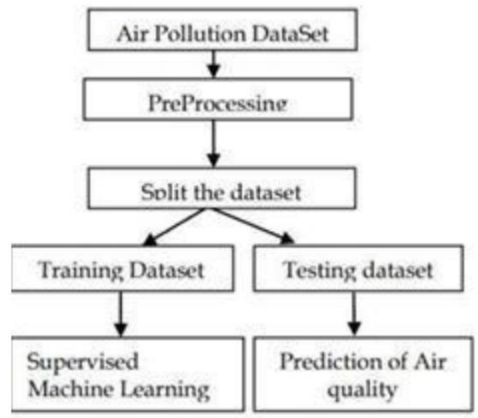
ThingsSpeak is an IoT cloud platform that facilitates the storage, analysis, and visualization of data. It offers a user-friendly interface for managing data streams and generating visualizations in the form of graphs, charts, and dashboards. ThingsSpeak allows for seamless integration with Arduino boards, making it an ideal choice for storing and accessing air quality data in real-time.

3. Python with Jupyter Notebook

Python, a versatile programming language, is utilized in conjunction with Jupyter Notebook for data analysis and machine learning tasks. Jupyter Notebook provides an interactive computing environment that combines code, text, and visualizations. Python's extensive libraries and frameworks, such as NumPy, Pandas, and Scikit-learn, enable efficient data processing, exploratory analysis, and model development.

4. Machine Learning Model: Linear Regression

For air quality prediction, the Linear Regression algorithm is employed as the machine learning model. Linear Regression is a simple yet effective algorithm that establishes a linear relationship between input variables (such as pollutant levels) and output variables (such as air quality index). By fitting a linear equation to the training data, the model can predict air quality based on the measured pollutant levels. Scikit-learn, a popular Python library, provides a convenient implementation of Linear Regression.



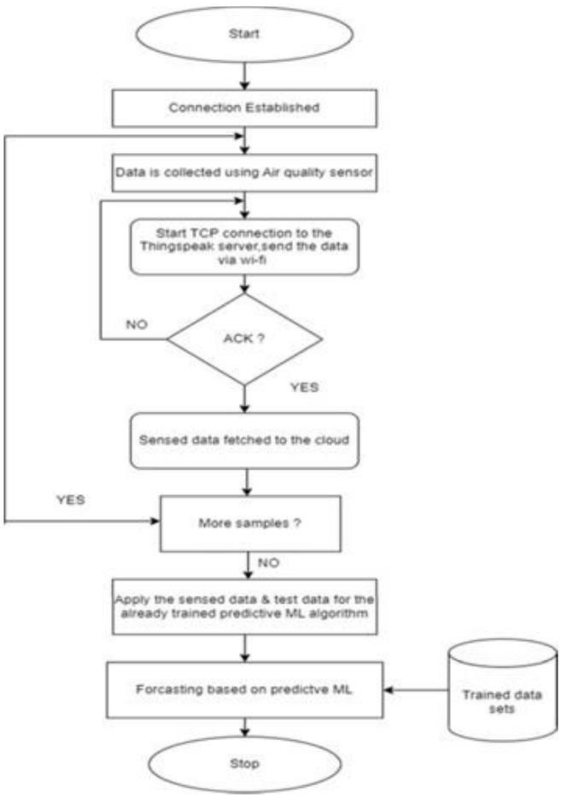
The software requirements described above form the foundation for implementing the IoT-based air quality monitoring system. The Arduino IDE enables programming and control of the microcontroller, while ThingsSpeak serves as the IoT cloud platform for data storage and visualization. Python with Jupyter Notebook facilitates data analysis and machine learning tasks, with the Linear Regression algorithm being used to develop the air quality prediction model.

It is important to ensure compatibility and proper configuration of the software tools throughout the development process. Adequate documentation, online resources, and community support are available for the Arduino IDE, ThingsSpeak, Python, Jupyter Notebook, and the Linear Regression algorithm, enabling a smooth implementation of the air quality monitoring system.

By leveraging these software components, the system can effectively analyze collected data, predict air quality levels, and contribute to the understanding and management of air pollution for the promotion of healthier and sustainable living environments.

V.IMPLIMENTATION

The flowchart for IoT based Air pollution monitoring and forecasting using Predictive Machine Learning model is shown below



Project Outcome When the system starts there will be display of the proposed system name on the LCD display as shown in fig.As soon as the system is turned on it starts detecting the gases or harmful substances present the area. If the air is polluted with the contents like Carbon dioxide , Metal oxide, LPG gas or Benzene it will be displayed on the LCD display as well as in the web application as in fig Arduino UNO alerts the buzzer to trigger. The contents ,range and there effect will be displayed simultaneously.

The air quality will be monitored every second and the state of the contents present will be updated. For this operation the Python application is being used and the data will be analysed continously as shown in the fig 6.5. The data fetched from the Arduino UNO will be transmitted to thingspeak via wifi and in the thingspeak the graphical representation of the system output can be seen.

Fig : hardware model

Fig : machine learning output

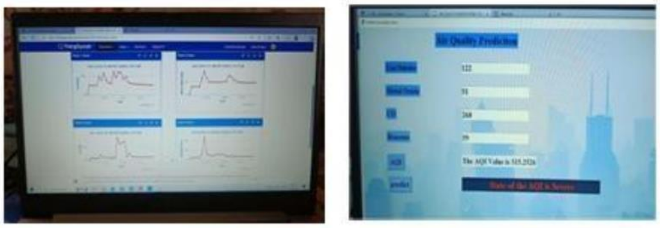


Fig : thingspeak output

VI. RESULT

The hardware connection for an Air Quality Monitoring System utilizing IoT and machine learning involves several components working together as in the below fig 7.1. Sensors capable of measuring various air pollutants, such as particulate matter, carbon dioxide, and volatile organic compounds, are deployed in the target environment. These sensors are connected to a microcontroller or IoT gateway, which collects the data and transmits it to a central server or cloud platform. Machine learning algorithms analyze the collected data to identify patterns, detect anomalies, and predict air quality levels. The results are then visualized and made accessible through a user interface, enabling users to monitor and take appropriate actions based on the air quality information provided.

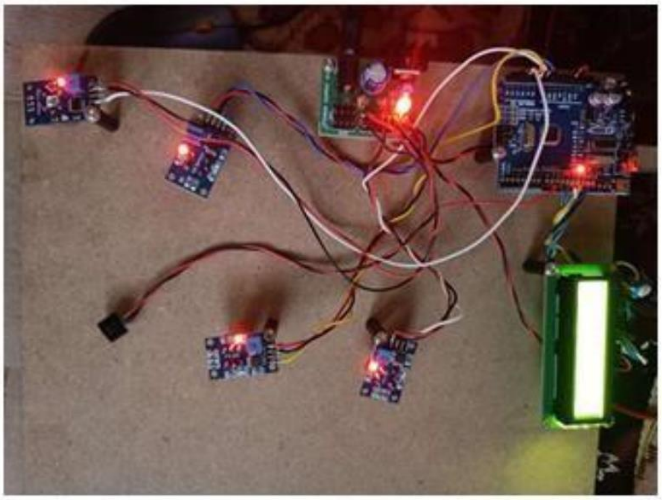


Fig : Hardware connections

VII. CONCLUSION

In this project IoT based on measurement and display of Air Quality Index (AQI), Humidity and Temperature of the atmosphere is monitored. From the information obtained from the project, it is possible to calculate Air Quality in PPM. The advantage of MQ135, MQ2, MQ4, MQ7 is that it is able to detect Gas/smoke, CO, CO2, NH4, etc harmful gases. After performing several experiments, it can be easily concluded that the setup is able to measure the air quality in ppm, the temperature in Celsius and humidity in percentage with considerable accuracy. The results obtained from the experiments are verified through Google data. Moreover, the led indicators help us to detect the air quality level around the setup. However, the project experiences a drawback that is it cannot measure the ppm values of the pollutant components separately. This could have been improved by adding gas sensors for different pollutants. But eventually, it would increase the cost of the setup and not be a necessary provision to monitor the air quality. Since it's an IOT-based project, it will require a stable internet connection for uploading the data to the ThingSpeak cloud. Therefore, it is possible to conclude that the designed prototype can be utilized for air quality, humidity and temperature of the surrounding atmosphere successfully.

VIII. REFRENCES

[1] Aruna Kumari N S , "Prediction of Air Quality in Industrial Area" 2020 ,IEsEE.

[2] Philipp Hahnel, Jakub Marecek, Julien Monteil, Fearghal O'Donncha "Using deep learning to extend the range of air pollution monitoring and forecasting", 2020,IEEE.

[3]T Dineshkumar,V Suresh Babu,Pachaivannan Partheeban, and R Puviarasi, "Air Quality Monitoring System Based on IoT",2020.

[4] Venkat Rao Pasupuleti , Uhasri , Pavan Kalyan , Srikanth , Hari Kiran Reddy, "AirQuality Prediction Of Data Log By Machine Learning" in 2020.

[5] Rohan Kumar Jha, "Air Quality Sensing and Reporting System Using IoT" in 2020.

[6]Rishanti Murugan, "Smart City Air Quality Prediction using Machine Learning",2021,IEEE.

[7]Anand Jayakumar A1, Praviss Yesyandss T, Venkstesh Prashanth K, Ramkumar, "IoT Based Air Pollution Monitoring System",2021.

[8]G.Kalaivani , "Air Quality Prediction and Monitoring using Machine Learning Algorithm based IoT sensor" , 2021-Research Scholar

[9] Rishanti Murugan, "Smart City Air Quality Prediction using Machine Learning"in 2021,IEEE

[10] Xiang Su, Xiaoli Liu, Jacky Cao, Petri Pellikka, Yongchun Liu, Pan Hui "Intelligent and Scalable Air Quality Monitoring With 5G Edge"March/April 2021.

[11] Y. Yang and L. Li, "A smart sensor system for air quality monitoring and massive data collection," in 2015 International Conference on Information and Communication Technology Convergence (ICTC), 2021, pp. 147–152.