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Review on IOT Based Environmental Monitoring and Air Quality Prediction System using Machine Learning

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Abstract -Real-time monitoring is crucial for successful abatement of air pollution since it poses serious threats to human health and the environment. The Internet of Things (IoT)-based air pollution monitoring system described in this research uses sensor networks to gather real-time data on pollutants such PM2.5, CO, and NO_2. The information is sent wirelessly transmission for analysis to a cloud platform. Decision trees and support vector machines are two examples of machine learning techniques that are used to identify anomalies and forecast future pollution patterns. The design of the system is described, emphasizing its scalability and adaptability from sensor deployment to data analytics. The system's capacity to measure pollution levels and produce precise projections is demonstrated by experimental findings from a 30-day urban deployment. The system supports public health and urban planning efforts by providing an affordable, real-time solution for monitoring and forecasting air pollution through the integration of IoT and machine learning.

Key Words: Air Pollution, IOT data, Think speak Web Server, Machine Learning, Data Analytics.

1. INTRODUCTION

Both human health and environmental well-being are significantly impacted by air quality. Unfortunately, a number of factors, including car emissions, industrial processes, energy generation, and natural calamities like wildfires, have contributed to an increase in air pollution. It is crucial to comprehend and evaluate the quality of the air we breathe. Particulate matter and air pollutants including ozone, nitrogen oxides, and sulphar dioxide are measured using Air Quality Monitoring (AQM) systems that are combined with sensors and cutting-edge technologies.

Figure 1. Generic view of IoT air monitoring solution

These systems gather data that is used to monitor pollution reduction initiatives, develop policies, and enable the public to make well-informed decisions about their health and well-being gadgets that sense data in real time. At the moment, the Air Quality Index (AQI) and pollution monitoring are the main uses of AQM stations. However, the growth of AQM networks and the accessibility of air quality data are constrained by the infrastructure needs, operating difficulties, and continuous costs related to these stations. It is essential to create affordable, effective, and real-time data-sensing devices in order to get beyond these restrictions. With recent developments enabling the use of IoT sensors in a variety of sectors, such as smart cities, smart mobiles, smart refrigerators, and smart watches, IoT technology offers a viable answer. By utilizing IoT, sensors (such as temperature, pressure, and noise sensors), Arduino for data processing, and cloud platforms for storage can be used to remotely monitor air quality. Air pollution levels have also been successfully forecasted and predicted by machine learning algorithms as Random Forest, XGBoost, Linear Regression, and ARIMA models. Large-scale air quality monitoring system deployment has been made possible by the availability of reasonably priced sensors and data processing tools. However, keeping these systems accurate is essential since inaccurate data can result in poor policy choices and unsuccessful mitigation initiatives. For air quality monitoring systems to be accurate, regular calibration and validation are crucial.

Several contributions are presented in this paper:

- The creation of an affordable, user-friendly Technology for detecting air pollution.
- The AQM system's real-time data collection Capabilities.
- Using Blynk to visualize data in real time.
- Using the open-source program Thing Speak to Visualize daily pollution.

The significance of air quality and the need for monitoring systems are examined, emphasizing the shortcomings of the existing AQM stations and the requirement for economical and effective IoT-based solutions.

2. LITERATURE REVIEW

Through real-time data gathering, analysis, and forecasting, the Internet of Things (IoT) and machine learning (ML) have greatly improved air quality monitoring capabilities. Current air quality monitoring systems use costly, non-scalable conventional government-run sensor networks. By using inexpensive sensors, cloud computing, and intelligent algorithms to deliver precise and real-time air pollution assessment, IoT-based solutions offer a workable substitute. IoT and ML integration for air quality monitoring has been covered in a number of research publications, leading to creative solutions for mobility, predictive analytics, and real-time data gathering.

IoT-based air quality monitoring systems were comprehensively examined and analyzed by Barot and Kapadia [1], who found problems with data accuracy, sensor calibration, and predictive analysis. The study emphasized how crucial machine learning models are to raising IoT sensor and air quality forecast accuracy.

Additionally, Karnati [2] suggested an IoT-ML hybrid approach that makes accurate pollution level predictions using sensor data analytics. The study showed that ML algorithms like Random Forest and XGBoost greatly improve AQI prediction over baseline statistical methods.

The main elements of IoT-based air quality monitoring systems, such as gas sensors, cloud integration, and mobile applications, were described by Kaur and Sharma [3]. Air quality monitoring technologies are divided into two categories by Kaur and Sharma: fixed station-based monitoring and portable sensor-based monitoring. While portable sensor-based solutions offer scalability and real-time monitoring, fixed stations offer excellent accuracy but limited coverage. Environmental factors continue to be a challenge for portable sensor accuracy.

An Internet of Things (IoT) system for monitoring air quality was created by Kumar, Kumari, and Gupta [4] and integrated with Thing Speak Cloud for data visualization. Their research focused on employing cloud computing to store and retrieve real-time data.

L [5] expanded on that by taking into account how sensor position and calibration affect data accuracy. According to the study, IoT sensors need to be calibrated periodically to ensure that AQI readings are consistent.

A methodical mapping of smart city air quality monitoring systems was carried out by Munera et al. [6]. They discovered that real-time analytics and sensor data fusion are crucial for enhancing pollution detection.

According to the study, edge computing improves real-time decision-making by processing data locally and reducing reliance on the cloud.

Machine learning has been consistently utilized to improve the forecasting accuracy of IoT-based systems and to predict air quality levels. ML-based techniques for analyzing air pollution data were investigated by N, N. H. G., R, N. A., and R, N. N. [7]. They found that Random Forest, XGBoost, and Deep Learning models outperformed the traditional approaches in terms of prediction efficiency. Feature selection was found to be a key factor in improving AQI forecasts.

An IoT-air pollution forecasting system with artificial intelligence capabilities was proposed by Pemula et al. [8]. Through their research, the authors have demonstrated that adaptive pollution warning and forecasting may be achieved by combining machine learning with IoT data.

Similarly, Pendekanti et al. [9] examined recent developments in IoT-air quality monitoring and control and emphasized the need of predictive modeling in preventing pollution exposure. After conducting a thorough analysis of IoT-based indoor air quality monitoring, Tan et al. [10] came to the conclusion that sensor networks, AI-driven analytics, and real-time alerts greatly improve environmental monitoring. They determined that two of the biggest obstacles to IoT adoption are data security and scalability.

3. SYSTEM ARCHITECTURE

The architecture of the Internet of Things-based air pollution monitoring system, which combines hardware components for data gathering with software tools for processing and analytics, is depicted in the block diagram in Figure 2. Real-time data collection, transmission, storage, and analysis are all part of the system's design. The four primary components are explained in more detail below.

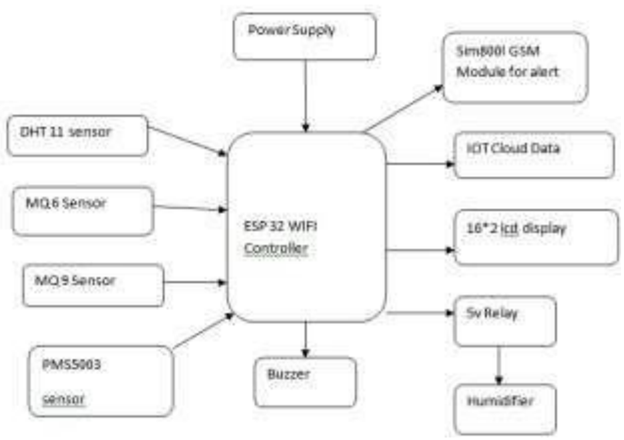

Figure 2 . Block Diagram of IoT air monitoring solution

IoT Sensors: To identify certain environmental contaminants, the system makes use of a range of air quality sensors.

Among them are:

A CO sensor detects the amount of carbon monoxide, a hazardous gas produced during combustion.

Nitrogen dioxide, a major contaminant from automobile emissions and industrial processes, is detected by the NO_2 sensor.PM2.5 and PM10 sensors track airborne particulate matter by size. There are serious dangers to respiratory health from these particles. Temperature and Humidity Sensors: Accurate air quality monitoring depends on environmental factors like temperature and humidity, which influence the dispersion of pollutants.

These sensors give a complete picture of the air quality at any given time by providing real-time data on the concentration of contaminants.

This Internet of Things-based air pollution monitoring system's sensor network is made to be scalable, energy-efficient, and environment-adaptable. The network is made up of several nodes, each of which has a variety of sensors to assess environmental factors including temperature and humidity as well as pollutants like CO, NO_2, PM2.5, and PM10 [4]. With particular precautions in place to account for differences brought on by environmental conditions, these sensors are meticulously calibrated to guarantee the precision and dependability of the data gathered. Important features of the sensor network consist of: Low-cost Sensors: The system makes use of accurate yet reasonably priced sensors to facilitate widespread implementation. Because of their low power consumption, these sensors can run for long periods of time without requiring regular maintenance or battery changes.

In order to provide real-time data collecting, processing, and predictive analytics, the project model for the Internet of Things-based air pollution monitoring system depicted in Figure 2 combines hardware and software components. The system is designed to automate every step of the air quality monitoring process, from collecting sensor data to producing alarms using machine learning models. The project model is outlined in the steps that follow.

A. Data Collection: The sensor network continuously gathers information about environmental conditions and pollutants. To allow for the temporal and spatial mapping of pollution levels, each data point is time stamped and geotagged with the precise location of the sensor.

B. Data Transmission: Using the MQTT protocol, the sensor data is wirelessly sent to a cloud-based server after it has been collected.

C. Preprocessing: Raw data can have inconsistent or missing values and is frequently noisy. To guarantee consistency, noise is eliminated and data normalization is carried out at the preprocessing stage.

D. Machine Learning Models: After the data has been cleaned and preprocessed, it is input into machine learning models for analysis. For classification and prediction, a variety of techniques is employed, including support vector machines (SVM), random forests, and decision trees.

Continuous monitoring, data-driven insights, and proactive actions in controlling air pollution levels are made possible by an end-to-end method, which improves environmental management and safeguards public health.

3. CONCLUSION

An Internet of Things (IoT)-based air pollution monitoring system with machine learning algorithms for real-time data analysis and future trend prediction was reported in this research. Over the course of 30 days, the system effectively demonstrated its capacity to track important air pollutants as PM2.5, PM10, CO, and NO_2, offering precise and useful information. The system provides a scalable and affordable method for monitoring air quality in both urban and rural settings by utilizing inexpensive IoT sensors and cloud-based machine learning models. With an accuracy of 89%, the decision tree algorithm was especially successful in forecasting pollution levels, allowing for prompt actions to lessen negative environmental effects. The system's potential for use in public health programs, environmental management, and smart city development is demonstrated by its integration with IoT and machine learning. All things considered, this approach has the potential to enhance air quality monitoring and assist future proactive pollution control initiatives.

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