ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)

Volume 13, Issue 6, June 2026

VayuSutra: Smart Notification Management System for Pollution Level Detection & Providing Real Time Solutions

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Abstract*— The issue of air pollution is increasingly recognized as a critical environmental challenge, particularly in swiftly growing urban regions. This study introduces VAYUSUTRA, an advanced framework that combines Internet of Things (IoT) devices with machine learning methods for the purpose of monitoring and forecasting pollution levels. The system assesses air quality and alerts users when pollution reaches hazardous thresholds. A variety of sensors are utilized to measure air quality and noise levels in real time. This gathered information is then sent to a backend server for comprehensive processing and analysis. The architecture includes components such as sensors, a server, and a mobile application. The sensors are responsible for measuring the air quality and noise levels, while the server processes this data and notifies users via their mobile devices when air quality becomes unsafe. The mobile application offers users the ability to track air quality and receive notifications, displaying both air quality and noise metrics, along with alerts when conditions deteriorate, such as when the air is deemed unhealthy for breathing. VAYUSUTRA aims to contribute to creating cleaner and healthier urban settings.

Keywords*— IoT, Air Quality Monitoring, Machine Learning, Firebase Notifications, Flask Backend, Environmental Analytics, Smart City Systems, Predictive AQI Modeling.

I. INTRODUCTION

Air pollution in urban areas has emerged as a significant challenge that poses risks to human health. This problem arises from vehicles, industrial processes, and various sources that emit pollutants into the atmosphere. Traditional air quality monitoring methods typically lack real-time data accessibility and extensive geographic coverage. They often do not offer prompt alerts to inform individuals when air quality deteriorates.

This underscores the necessity for a solution such as VAYUSUTRA. The innovative system integrates Internet of Things (IoT) technology with sophisticated algorithms to effectively monitor and forecast pollution levels. VAYUSUTRA aims to contribute to environmental protection. Its framework includes sensor units, a backend processing server, and an interface for mobile applications.

The system is equipped with several key features:

- Sensors that gather information on air quality and noise pollution.
- A processing server that interprets this data and notifies users via their mobile devices.
- A mobile app that displays real-time air quality and noise information.

VAYUSUTRA is designed to assist in creating cleaner and healthier urban spaces.

II. OBJECTIVE

The main goal of this project is to create a scalable and effective solution for overseeing and managing environmental pollution. This system is designed to gather real-time data on air quality and noise levels through the use of IoT sensors, ensuring that the environmental information remains accurate and current. Additionally, it emphasizes the development of a backend server that manages this data and sends alerts to users when pollution levels reach hazardous thresholds, allowing them to take necessary precautions.

Furthermore, the initiative seeks to deliver an intuitive mobile application that enables users to easily access and understand the current conditions of air quality and noise. A significant aim is to integrate advanced analytical techniques to examine the gathered data and forecast future pollution levels, providing early warnings and enhancing decision-making regarding health and safety.

III. LITERATURE SURVEY

In [1], the researchers present a monitoring system for air quality that utilizes an IoT framework leveraging wireless sensor networks. The system incorporates MQ-series sensors to detect pollutant concentrations and transmits this data to cloud platforms for visualization. While it excels in real-time monitoring, it lacks predictive modeling techniques and immediate mobile notifications, limiting its ability to respond proactively.

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In [2], a framework for environmental monitoring in smart cities is proposed, utilizing data processing and classification methods such as TF-IDF vectorization alongside logistic regression. Despite its aim to effectively analyze environmental data, the system may encounter misclassification issues, especially with unstructured and mixed data, and is heavily dependent on the precision of its preprocessing.

In [3], machine learning techniques, specifically Linear Regression and Random Forest, are employed to forecast air quality using historical datasets. Although this approach yields higher accuracy in predictions, it requires substantial data volumes for optimal performance and lacks real-time operational support, making it less effective in rapidly changing environments.

A time-series forecasting system for air pollution using deep learning techniques, particularly LSTM networks, is described in [4]. This model can process time-series data concerning AQI and weather factors, demonstrating high prediction accuracy. However, it is not designed for lightweight or edge computing applications, resulting in significant computational complexity.

In [5], a real-time environmental monitoring system that merges IoT and cloud computing is proposed. This system utilizes REST APIs for seamless data transmission and visualization. Nonetheless, it focuses primarily on monitoring functionalities and does not incorporate predictive analytics or intelligent alert systems.

In [6], sensor networks are employed to establish a system for monitoring noise and air pollution within urban settings. While it offers insights into environmental conditions, the system lacks scalability and integration with real-time alert mechanisms.

A framework based on IoT for real-time monitoring of air and noise pollution is introduced in [7], built with ESP-based sensor nodes and utilizing the MQTT protocol. This system efficiently transmits data to cloud dashboards; however, it is limited to monitoring tasks and does not support machine learning-based predictions or automated notification systems.

In [8], The article introduces an innovative environmental monitoring system that integrates IoT sensors with cloud-based analytics to provide ongoing surveillance of air and noise pollution. While it features effective web visualizations, it lacks support for mobile applications and real-time notifications for early alerts.

In [9], A similar approach is employed in urban pollution management, where sensor networks and cloud computing collaborate to assess environmental conditions. Although this system is thoroughly monitored, it does not incorporate predictive analytics or mobile alert functions, which limits its effectiveness during emergencies.

In [10], Another system for monitoring urban pollution utilizes distributed sensor networks, as described in another study. This system transmits collected data to centralized servers for analysis; however, it faces challenges related to scalability and does not include predictive modeling or a real-time notification feature for users.

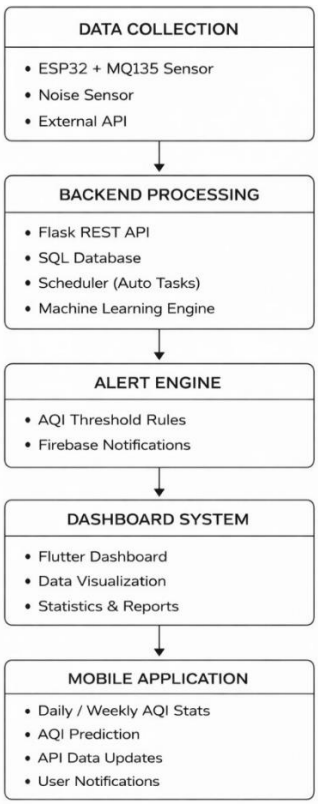
In [11], Additionally, an IoT-driven smart air quality monitoring and alert system is discussed, focusing on parameters like CO2 levels, PM2.5, and temperature through sensor nodes. While this system enables continuous monitoring and dashboard visualization, it lacks machine learning capabilities for predicting air quality indices or integrated mobile alerts.

IV. PROBLEMS WITH CURRENT SYSTEMS

Existing systems for monitoring air pollution encounter a variety of challenges that hinder their efficiency. Key issues comprise:

- Delayed access to real-time data, which hampers the ability to promptly monitor abrupt shifts in air quality.
- The lack of predictive analytics, since many systems only showcase present or historical data.
- Insufficient intelligent forecasting stemming from the absence of machine learning capabilities.
- Frequent inaccuracies and unreliability often arise from inadequate sensor calibration and environmental influences.
- Ineffective data integration, where various data sources are not harmonized properly.
- Ineffective alert systems lead to a lack of user awareness during dangerous conditions.

V. FLOW DIAGRAM OF VAYUSUTRA



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VI. MODULE INFORMATION

The system is composed of several key modules that function collaboratively:

1. IoT Sensor Data Collection Module:

This module is tasked with gathering real-time environmental data through sensors such as the MQ-series and noise detectors. It continuously monitors air contaminants (CO_2, PM2.5) and noise levels.

2. Data Communication & API Integration:

This module is responsible for transferring the gathered data from the IoT device (ESP32) to the backend server, utilizing protocols like HTTP or MQTT. APIs facilitate effective interaction between hardware and software components.

3. Machine Learning Forecasting Module:

This module evaluates historical and current data to forecast future air quality using methods such as Linear Regression or Random Forest.

4. Alert & Notification System:

This module notifies users when pollution levels are deemed unsafe or predicted to rise, enabling them to take appropriate precautions.

5. Data Storage & Management:

This module archives all collected data in a database (such as SQLite) for subsequent analysis and convenient access.

6. Mobile Application:

This module presents real-time air quality and noise information to users while also providing alerts in an intuitive and easy-to-navigate interface.

VII. EXPECTED OUTCOMES

The anticipated results of VAYUSUTRA encompass:

- Real-time air quality monitoring
- Predictive AQI forecasting
- Intelligent alert and notification system

VAYUSUTRA seeks to enhance urban environments by employing IoT and machine learning technologies. The system integrates IoT and machine learning to monitor and predict pollution levels to observe and anticipate pollution levels. It consists of various components, including sensors, a central server, and a mobile app. The sensors gather data regarding air quality and ambient noise. The server processes this information and delivers alerts to users on their smartphones. The mobile application provides users with insights into air quality and noise conditions. VAYUSUTRA is a system intended to aid in environmental conservation. When pollution levels exceed safe thresholds, it promptly alerts users via notifications sent through Firebase Cloud Messaging.

VIII. CONCLUSION

The designed system facilitates continuous observation and prediction of environmental factors, forecasting future conditions effectively. This is achieved through the integration of sensor networks powered by the Internet of Things, cloud computing capabilities, machine learning algorithms, and mobile app interfaces for visualization. In contrast to systems that merely display current pollution metrics, this method offers foresight and immediate notifications regarding anticipated air quality, alerting users through their mobile devices. Such functionality enables both the public and governing bodies to initiate proactive measures before pollution escalates. The system is adaptable, delivers meaningful insights, and features intuitive tools, making it ideal for smart city initiatives and urban environmental management. By enhancing access to pollution data and fostering greater awareness, VAYUSUTRA contributes to the development of healthier urban spaces and sustainable growth. It boosts user engagement and aids in informed decision-making by supplying essential information necessary for implementing changes. The VAYUSUTRA platform empowers individuals to make educated choices about their environmental surroundings, thus facilitating positive change in their communities.

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