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Smart Ai Based Air Pollution Monitoring and Prediction System

[1]Dr. G. Prasuna, [2]Shaik Sameera, [3]Vali Srinagavalli, [4]Vakkalagadda Pushpak, [5]Valeru Rajesh

[1]Associate Professor, Dept of Computer Science and Engineering, St. Ann's College of Engineering and Technology, Chirala-523187, India.

[2,3,4,5]U. G Student, Dept of Computer Science and Engineering, St. Ann's College of Engineering and Technology, Chirala-523187, India.

ABSTRACT- *Air pollution has become a major environmental and public health concern due to rapid urbanization, industrialization, and increasing vehicle emissions. Continuous monitoring and accurate prediction of air quality are essential for minimizing health risks and supporting effective environmental management. This paper presents a Smart AI-Based Air Pollution Monitoring and Prediction System that integrates Internet of Things (IoT) and Artificial Intelligence (AI) technologies for real-time air quality monitoring and forecasting. The system collects environmental data, including CO, CO_2, PM2.5, PM10, temperature, and humidity, using IoT-enabled sensors. The collected data is transmitted to a centralized platform for storage and analysis. Machine learning algorithms process historical and real-time data to predict future Air Quality Index (AQI) values with improved accuracy. A user-friendly dashboard displays current air quality, historical trends, and predicted pollution levels through graphical visualizations. The system also generates alerts when pollution exceeds predefined safety limits, enabling timely preventive actions. By combining IoT-based sensing, cloud data management, and AI-driven predictive analytics, the proposed system provides an efficient, scalable, and intelligent solution for air quality monitoring. It supports proactive environmental management, enhances public awareness.*

KEYWORDS: *Artificial Intelligence (AI), Internet of Things (IoT), Air Pollution Monitoring, Air Quality Index (AQI), Machine Learning, Environmental Monitoring, Predictive*

Analytics, Smart Sensors, Real-Time Monitoring, Pollution Prediction.

INTRODUCTION

Air pollution is one of the most critical environmental and public health challenges worldwide. Rapid industrialization, urbanization, and increasing vehicle emissions have significantly degraded air quality, exposing people to harmful pollutants such as PM2.5, PM10, CO, SO_2, and NOx. Prolonged exposure to these pollutants can cause serious health issues, including respiratory and cardiovascular diseases. Therefore, continuous monitoring and accurate prediction of air quality are essential for effective environmental management and public safety.

LITERATURE SURVEY

Several researchers have developed air pollution monitoring systems using IoT sensors to measure pollutants such as PM2.5, PM10, CO, and CO_2 in real time. Recent studies have combined Artificial Intelligence (AI) and Machine Learning (ML) to predict future Air Quality Index (AQI) values using historical and real-time data. Although existing systems provide effective monitoring, many have limitations in prediction accuracy and real-time alerts. The proposed Smart AI-Based Air Pollution Monitoring and Prediction System overcomes these limitations by integrating IoT, cloud computing, and AI to provide continuous monitoring, accurate AQI prediction, and timely alerts for better environmental management.

RELATED WORK

Several researchers have proposed IoT-based air pollution monitoring systems for collecting real-time environmental data using sensors. Some studies have applied Machine Learning algorithms to predict Air Quality Index (AQI) values from historical data. Other systems use cloud platforms to store and visualize pollution data. However, many existing solutions either focus only on monitoring or only on prediction and do not provide real-time alerts. The proposed Smart AI-Based Air Pollution Monitoring and Prediction System combines IoT, AI, cloud computing, and instant alert mechanisms to provide continuous monitoring, accurate AQI prediction, and timely notifications, making it more effective for smart city applications.

EXISTING SYSTEM

Existing air pollution monitoring systems mainly use fixed monitoring stations and IoT

sensors to measure air quality parameters such as PM2.5, PM10, CO, and CO_2. These systems provide real-time air quality data but often focus only on monitoring. They have limited prediction capabilities, require high installation and maintenance costs, and may not provide instant alerts. As a result, users receive limited support for taking preventive actions against increasing pollution levels.

PROPOSED SYSTEM

The proposed Smart AI-Based Air Pollution Monitoring and Prediction System combines Internet of Things (IoT) and Artificial Intelligence (AI) technologies to monitor and predict air pollution levels. IoT sensors collect real-time data such as PM2.5, PM10, CO, CO_2, temperature, and humidity, and send it to a cloud platform for storage and analysis. Machine Learning algorithms analyse both historical and real-time data to predict future Air Quality Index (AQI) values with improved accuracy. The system displays air quality information through a user-friendly dashboard and generates instant alerts when pollution levels exceed safe limits. This approach provides continuous monitoring, accurate prediction, early warnings, and supports better environmental management and public health.

SYSTEM ARCHITECTURE

The proposed system consists of four main modules: Sensor Module, IoT Communication Module, Cloud & AI Processing Module, and User Interface Module. Environmental sensors continuously measure air quality parameters such as PM2.5, PM10, CO, CO_2, temperature, and humidity. The collected data is transmitted through an IoT device to a cloud server.In the cloud platform, the data is stored and processed using Machine Learning algorithms to predict future Air Quality Index (AQI) values. The processed information is displayed on a dashboard with graphical visualizations. If pollution levels exceed predefined safety limits, the system generates instant alerts and notifications for users and authorities.

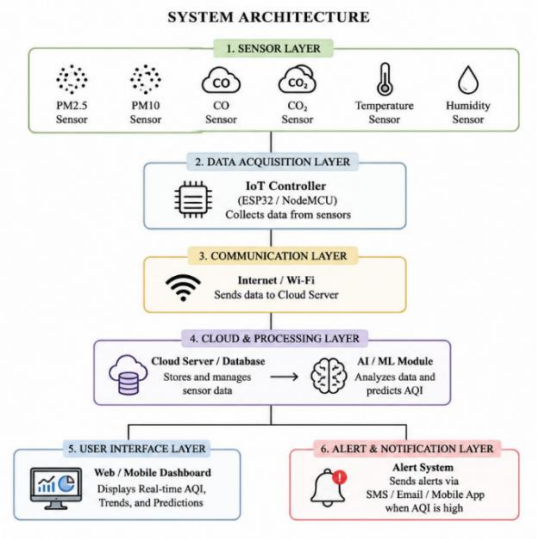

Fig 1: System Architecture

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METHODLOGY DESCRIPTION

The proposed system uses IoT sensors to collect real-time air quality data, including PM2.5, PM10, CO, CO_2, temperature, and humidity. An ESP32/NodeMCU transmits the collected data to a cloud platform for storage and processing. Machine Learning algorithms analyses historical and real-time data to predict future Air Quality Index (AQI) values. The predicted results are displayed on a dashboard with graphical visualizations. If pollution levels exceed predefined safety limits, the system generates instant alerts, enabling users and authorities to take timely preventive actions.

RESULTS AND DISCUSSION

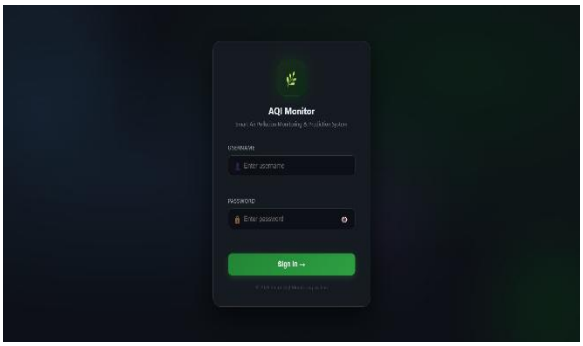

Fig2: Login Page

The login page serves as the secure entry point to the AQI Monitor system. It is designed to be simple and user-friendly, requiring only a valid username and password to authenticate users before granting access to the monitoring dashboard and its features.

Fig 3: Air Quality Dashboard

The Dashboard module acts as the main interface through which users interact with the system. It displays real-time monitoring statistics such as total records, active monitoring stations, average AQI, and model accuracy. It also presents visual summaries including AQI distribution by category, monthly AQI trends, top polluted states, pollutant averages, and a detailed AQI category reference table for quick interpretation of air quality levels.

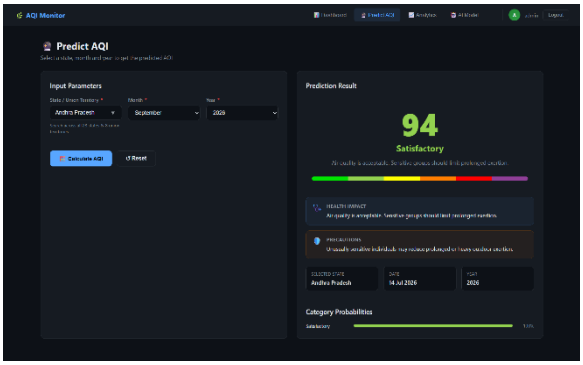

Fig 4: Predict AQI Module

The Predict AQI module allows users to forecast air quality by selecting a state or union territory, month, and year. This module is responsible for processing the selected input parameters and generating a predicted AQI value using the trained machine learning models, enabling proactive planning based on anticipated pollution levels.

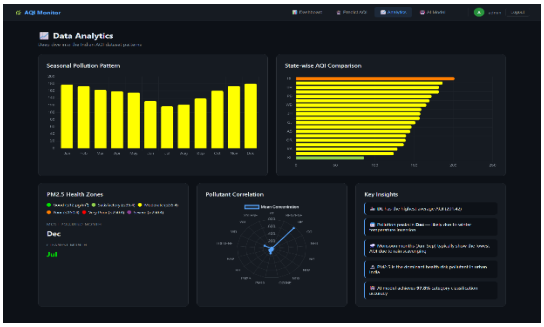

Fig 5: Data Analytics Module

The Data Analytics module provides an in-depth analysis of the Indian AQI dataset. This module is responsible for visualizing seasonal pollution patterns, state-wise AQI comparisons, PM2.5 health zones, pollutant correlations, and key data-driven insights, helping users understand pollution trends across different regions and time periods.

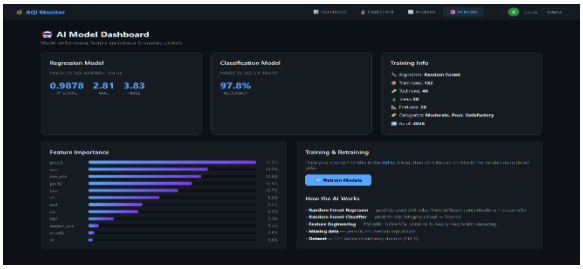

Fig 6: AI Model Dashboard

The AI Model Dashboard module is a core component of the AI-based AQI prediction system, responsible for displaying the performance of the underlying regression and classification models. This module operates by presenting metrics such as R^2 score, MAE, RMSE, and classification accuracy, along with feature importance rankings and training information, and also provides functionality to retrain the models on updated data.

CONCLUSION

The Smart AI-Based Air Pollution Monitoring and Prediction System enhances environmental awareness and public health safety by providing accurate, real-time insights into air pollution levels across Indian states. By leveraging machine learning models for AQI prediction and classification, along with detailed analytics on pollutant trends, the system enables users and authorities to make informed decisions and take timely preventive measures, ensuring a healthier and more sustainable living environment.

FUTURE SCOPE

The proposed Smart AI-Based Air Pollution Monitoring and Prediction System can be further enhanced by integrating advanced deep learning models, such as LSTM or

hybrid neural networks, to improve AQI prediction accuracy over longer time horizons. Real-time data collection can be extended by integrating IoT-based air quality sensors deployed across various locations, enabling live monitoring instead of relying solely on historical datasets. The system can be expanded to support mobile applications for on-the-go access to AQI predictions and alerts. Integration with government and satellite pollution databases can improve dataset coverage and prediction reliability across all regions. Additionally, automated alert systems using SMS or mobile notifications can be implemented to warn users and authorities in real time when AQI levels reach hazardous thresholds, enabling faster preventive action.

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