

Original Article

Artificial Intelligence-Based Air Pollution Prediction Using Machine Learning and Deep Learning Techniques

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Abstract: Air pollution is one of the most critical environmental challenges affecting human health and ecosystems worldwide. Accurate prediction of air quality plays a vital role in environmental monitoring and management. This study presents an Artificial Intelligence (AI)-based approach for predicting air pollution levels using Machine Learning (ML) and Deep Learning (DL) techniques. Random Forest (RF) and Long Short-Term Memory (LSTM) models are used to forecast Air Quality Index (AQI) values based on historical data and meteorological parameters. The performance of the models is evaluated using metrics such as Mean Absolute Error (MAE), Root Mean Square Error (RMSE), and Coefficient of Determination (R^2). The results show that LSTM outperforms traditional models due to its ability to capture temporal dependencies. The proposed system can be used for real-time monitoring and smart city applications.

Keywords: Air Pollution, Artificial Intelligence, Machine Learning, LSTM, Random Forest, AQI.

I. INTRODUCTION

Air pollution has become a major global concern due to rapid industrialization, urbanization, and increased vehicular emissions. Pollutants such as PM_{2.5}, PM₁₀, CO, NO₂, SO₂, and O₃ have significant impacts on human health, leading to respiratory and cardiovascular diseases. Traditional statistical models often fail to accurately predict air pollution due to the complex and nonlinear nature of environmental data.

Artificial Intelligence (AI) techniques, especially Machine Learning and Deep Learning, have shown great potential in handling large datasets and identifying complex patterns. These models can provide accurate predictions and support decision-making for environmental protection.

II. LITERATURE REVIEW

Several researchers have explored AI techniques for air quality prediction. Machine Learning models such as Support Vector Machines (SVM), Decision Trees, and Random Forest have been widely used for regression and classification tasks.

Deep Learning models like Long Short-Term Memory (LSTM) networks are particularly effective for time-series data. Studies show that hybrid models combining Convolutional Neural Networks (CNN) and LSTM provide improved accuracy by capturing both spatial and temporal features.

Despite advancements, challenges such as data availability, model complexity, and real-time implementation remain.

III. METHODOLOGY

The methodology of this study involves the following steps:

A. Data Collection

Air quality data including PM_{2.5}, PM₁₀, CO, NO₂, SO₂, and meteorological parameters (temperature, humidity, wind speed) are collected.

B. Data Preprocessing

- Handling missing values
- Normalization of data
- Feature selection

C. Model Development

Two models are developed:

- **Random Forest (RF):** Used for regression analysis
- **LSTM:** Used for time-series prediction

D. Evaluation Metrics

The models are evaluated using:

- MAE (Mean Absolute Error)
- RMSE (Root Mean Square Error)
- R² Score

IV. RESULTS AND DISCUSSION

The performance of the models is analyzed based on prediction accuracy.

Table 1: Performance Comparison

Model	MAE	RMSE	R ²
Random Forest	5.2	7.8	0.89
LSTM	3.8	5.6	0.93
ARIMA	6.5	8.9	0.85

The results indicate that the LSTM model achieves the lowest error and highest accuracy. This is due to its ability to learn temporal dependencies in air quality data.

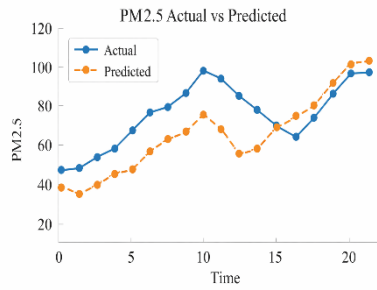


Fig. 1: PM2.5 Actual vs Predicted

Graph 1: PM2.5 Actual vs Predicted

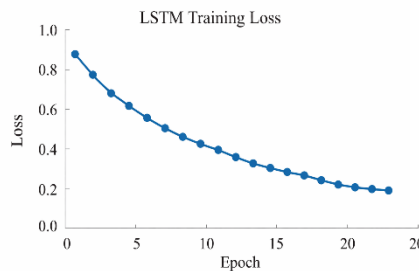


Fig. 2: LSTM Training Loss

Graph 2: LSTM Training Loss

V. APPLICATIONS

The proposed system has several practical applications:

- Smart city air quality monitoring
- Public health advisory systems
- Pollution control strategies
- Environmental impact assessment

VI. CONCLUSION AND FUTURE WORK

This study demonstrates that AI-based models significantly improve air pollution prediction accuracy. The LSTM model performs better than traditional methods due to its ability to capture temporal patterns.

Future work includes:

- Integration with IoT sensors
- Use of real-time data
- Development of hybrid models
- Deployment in smart city systems

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