

AIR QUALITY INDEX FORECASTING VIA GENETIC ALGORITHM BASED IMPROVED EXTREME LEARNING MACHINE

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ABSTRACT.

Air pollution is a major threat to human health and the environment, especially in urban areas. Predicting the Air Quality Index (AQI) in advance helps authorities and the public take necessary actions to reduce its impact.

*This project develops an efficient AQI forecasting system using a combination of **Extreme Learning Machine (ELM)** and **Genetic Algorithm (GA)**. ELM is a fast neural network model that can handle complex relationships between pollution and weather data. However, it has limitations due to random weight selection. To solve this, GA is used to optimize the weights and biases, improving prediction accuracy.*

The system uses historical data such as pollutant levels (PM_{2.5}, PM₁₀, NO₂, SO₂, CO, NH₃, O₃) and weather parameters (temperature, humidity, wind speed, etc.). The data is preprocessed by cleaning, handling missing values, and normalizing using Min-Max scaling.

*The hybrid GA-ELM model is trained and tested using performance metrics like **RMSE** and **MAE**, showing better accuracy, speed, and stability compared to traditional models.*

*Additionally, a **Flask-based web dashboard** is developed to display real-*

time AQI predictions. It provides 1–12 hour forecasts, visual charts, and color indicators for easy understanding.

Overall, this system offers a reliable and scalable solution for short-term air quality prediction, supporting better environmental management and sustainable urban living

Keywords: AQI, Machine Learning, GA-ELM, Genetic Algorithm, Extreme Learning Machine, Air Pollution, Data Preprocessing, Meteorological Data, Real-time Forecasting, Flask Dashboard

INTRODUCTION

Air pollution is a major environmental problem affecting human health, climate, and ecosystems. It is mainly caused by urbanization, industries, and vehicle emissions. The Air Quality Index (AQI) is used to measure and report pollution levels, helping authorities and the public take necessary actions.

Traditional AQI prediction methods use basic statistical techniques, which cannot handle complex relationships between pollutants and weather conditions. Modern machine learning and deep learning approaches improve prediction accuracy

by analyzing these complex patterns effectively

- ✓ The study supports pollution control and sustainable urban development.

OBJECTIVE

- To develop an efficient system for forecasting Air Quality Index (AQI) using machine learning techniques.
- To improve prediction accuracy by combining Extreme Learning Machine (ELM) with Genetic Algorithm (GA).
- To analyze the relationship between air pollutants and meteorological parameters.
- To preprocess and utilize real-time and historical environmental data effectively.
- To provide fast and reliable short-term AQI predictions.
- To design a user-friendly dashboard for real-time AQI visualization and monitoring.
- To support environmental decision-making and promote sustainable urban development.

NEED FOR STUDY

- ✓ Air pollution is increasing rapidly and causing serious health and environmental problems.
- ✓ Accurate AQI forecasting helps in early warning and preventive actions.
- ✓ Traditional prediction methods are not effective for complex and nonlinear data.
- ✓ There is a need for advanced machine learning models to improve prediction accuracy.
- ✓ Combining GA and ELM can provide faster and more reliable results.
- ✓ Real-time monitoring systems are required for better decision-making.

EXISTING SYSTEM

. Traditional air quality forecasting methods mainly used statistical models like ARIMA and Linear Regression. These methods were easy to use but could not handle complex relationships between pollutants and weather conditions, leading to low accuracy in changing environments.

Later, machine learning models such as Random Forest, SVM, and Gradient Boosting improved prediction accuracy by capturing non-linear patterns. However, they required manual feature selection and were computationally expensive, making real-time prediction difficult. Most systems also focused on individual pollutants instead of overall AQI.

Some real-time dashboards were developed for AQI monitoring, but they used static models that did not adapt to changing conditions, reducing prediction accuracy. They also lacked efficiency for real-time data processing and scalability.

Overall, existing systems have issues like lower accuracy, high computation time, and lack of optimization. To overcome these problems, this project uses a hybrid approach combining Extreme Learning Machine (ELM) and Genetic Algorithm (GA) for faster, more accurate, and scalable AQI forecasting.

PROPOSES SYSTEM :

The proposed system is a Hybrid Air Quality Forecasting System that combines Extreme Learning Machine (ELM) and Genetic Algorithm (GA) to provide accurate and fast AQI predictions. ELM handles complex non-linear relationships, while GA optimizes the model by selecting the best weights and biases, improving stability and accuracy.

The system uses historical pollutant data (PM2.5, PM10, NO₂, SO₂, CO, NH₃, O₃) along with weather data like temperature, humidity, and wind speed. Data is preprocessed using cleaning and normalization techniques to ensure better performance. The model is evaluated using RMSE and MAE metrics, showing high accuracy with faster processing.

It also includes a Flask-based web dashboard for real-time AQI monitoring, 1–12 hour predictions, visual charts, and color indicators. An alert system notifies users when pollution levels are high, and API integration ensures continuous real-time data updates.

Overall, the system provides a fast, accurate, and scalable solution for air quality prediction and environmental monitoring.

Functional Requirements

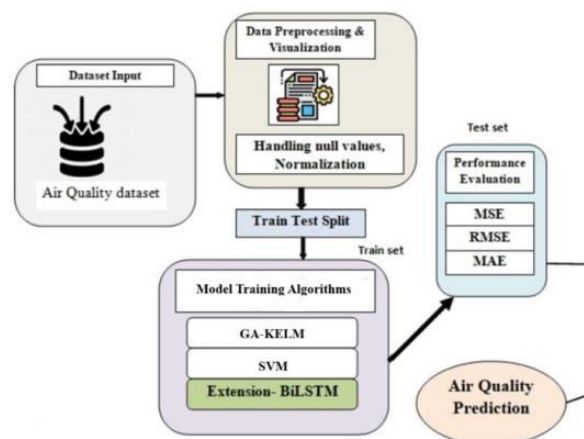
The system is designed to collect and process historical and real-time air quality data. It performs data preprocessing including cleaning, handling missing values, and normalization. A hybrid GA-ELM model is used to train and predict AQI values for short-term forecasting (1–12 hours). The system provides an interactive web dashboard for AQI visualization with charts and color indicators. It also includes an alert mechanism for high pollution levels and

supports API-based real-time data integration.

Non-Functional Requirements

The system ensures high accuracy and reliability in AQI prediction with minimal computational time. It is scalable to handle large and continuous data streams efficiently. The interface is user-friendly and easy to understand. The system maintains data security, ensures continuous availability for real-time monitoring, and supports easy maintenance and future enhancements

SYSTEM ARCHITECTURE



SYSTEM REQUIREMENTS

Software Requirements

Backend: Django

Frontend: HTML,CSS,JavaScript

Data base : SQLite

Editor: VisualStudioCode

HardwareRequirements

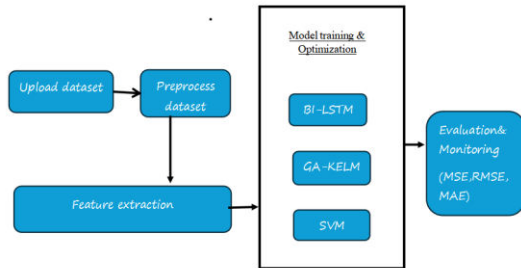
Processor:Anyprocessormoreethani3

RAM:8 GB

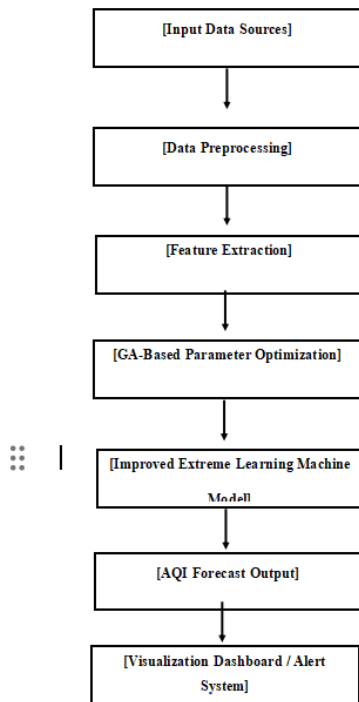
HardDisk:512GB

Web cam:For facial recognition

Technical Architecture



Flow diagram



MODULES

A module is a part of the system that performs a specific task and works with other modules to complete the process.

1. Data Collection Module:

Collects real-time and historical air quality data (PM2.5, PM10, CO, NO₂, SO₂, O₃) and weather data (temperature, humidity, wind speed) from sensors and datasets.

2. Data Preprocessing Module:

Cleans the data by removing noise, handling missing values, and normalizing it for better model performance.

3. Feature Extraction Module:

Selects important features from the data to improve accuracy and reduce complexity.

4. Model Optimization Module (GA):

Uses Genetic Algorithm to optimize model parameters like weights and neurons for better accuracy and faster performance.

5. AQI Forecasting Module (Improved ELM):

Predicts future AQI values using the optimized ELM model with high speed and accuracy.

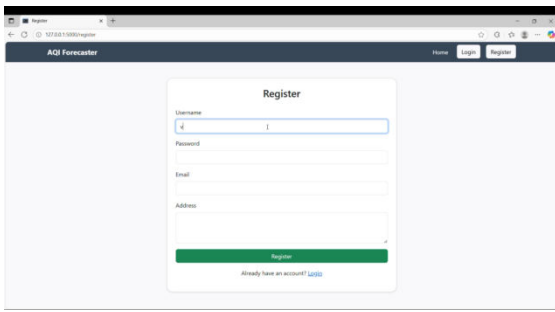
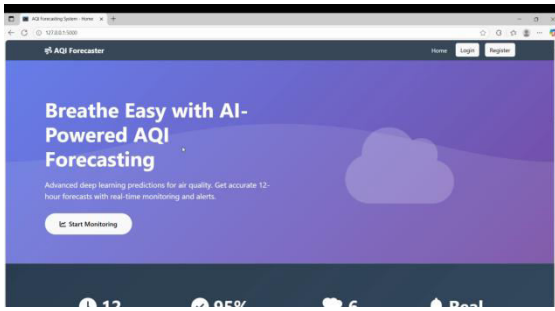
6. Evaluation Module:

Measures model performance using metrics like RMSE, MAE, and compares with other models.

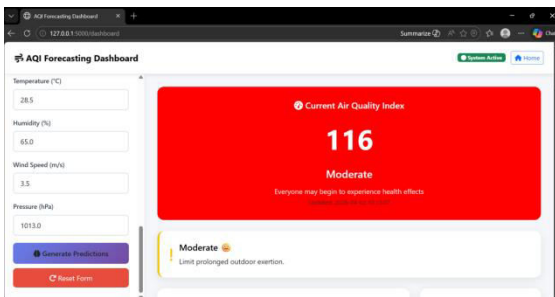
7. Visualization & Reporting Module:

Displays AQI results using charts, graphs, and indicators, helping users understand and make decisions.

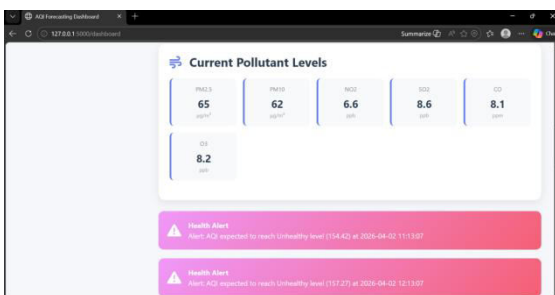
SCREEN SHOTS



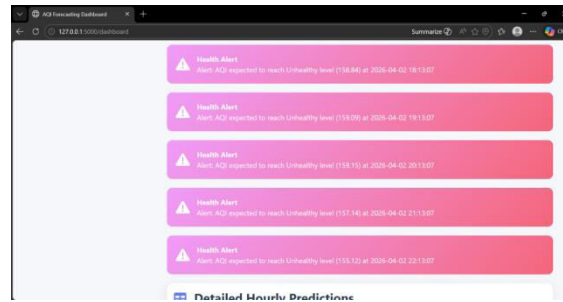
Register Page



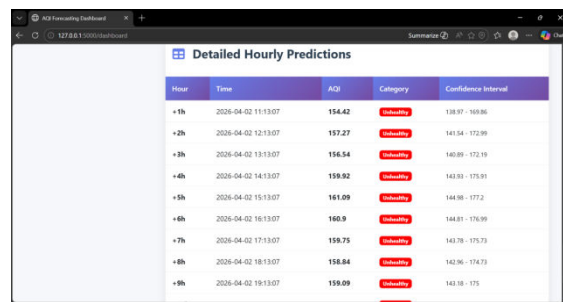
Prediction Page



Pollutant Levels



Alert Levels



Hourly Prediction

Conclusion

The proposed GA-ELM based AQI forecasting system provides an efficient and accurate solution for short-term air quality prediction. By combining fast learning capabilities with evolutionary optimization, the system achieves better performance compared to traditional methods. The integration of real-time monitoring and visualization enhances usability and decision-making. Overall, the system offers a scalable and reliable approach for environmental monitoring and supports sustainable urban development.

FUTURE ENHANCEMENT

Future work can focus on integrating deep learning models such as LSTM for improved temporal prediction. The system can be enhanced with IoT-based real-time sensors for better data accuracy. Incorporating advanced feature selection techniques and hybrid models can further improve performance. Deployment on cloud platforms can enhance scalability and accessibility. Mobile application support and advanced alert systems can also be added for better user interaction.

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