Phase-2 Submission

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Github Repository Link: AirPreQ

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1. Problem Statement

Accurately predicting **Air Quality Index (AQI)** using machine learning models can significantly enhance public awareness, assist governments in environmental policy making, and help prevent health risks due to pollution. This project refines the Phase-1 objective by focusing on supervised **regression** to estimate AQI levels based on pollutant and meteorological data

> **Type of Problem**: Supervised Regression
>
> **Why It Matters**: Real-time AQI prediction enables timely public advisories, health risk mitigation, and supports data-driven urban planning.

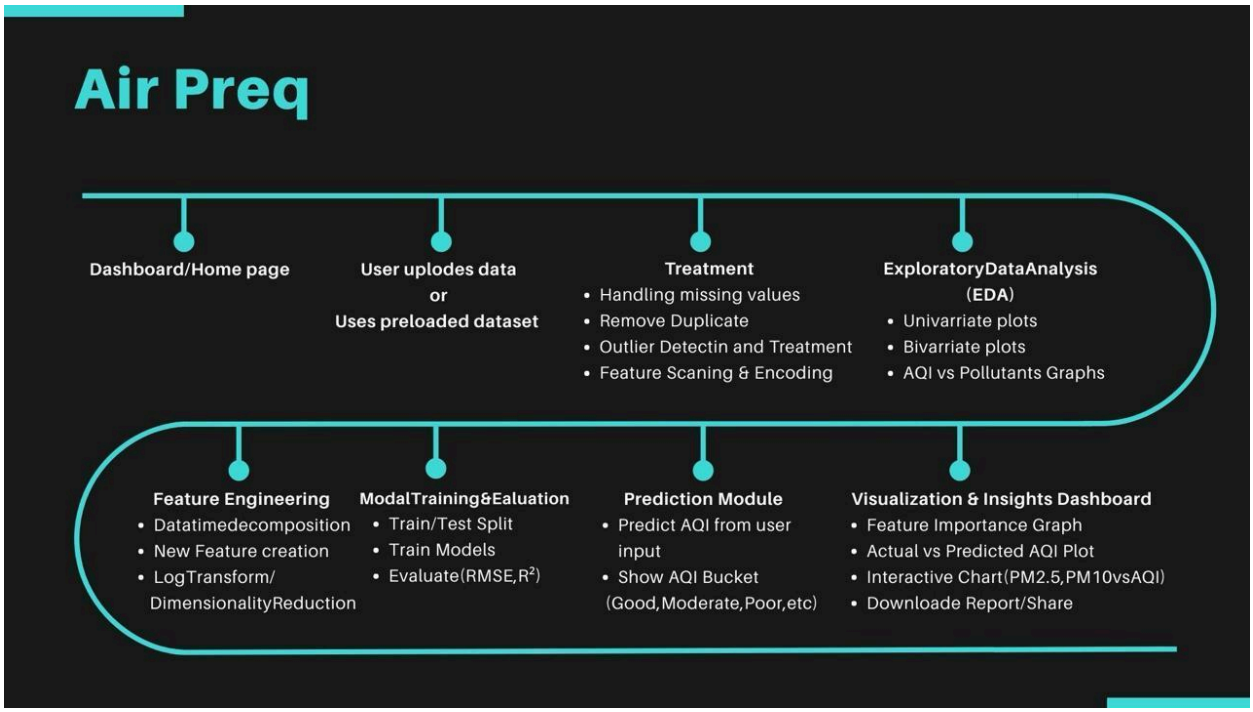
2. Project Objectives

- To build an accurate AQI prediction model using pollution and weather features.
- To identify key variables contributing to poor air quality.

- To implement real-time prediction capabilities through a deployed interface.
- To enhance interpretability using feature importance and model visualization.

Updated Goal: After data exploration, the focus narrowed to regression (rather than classification or clustering), and some limitations were noted in model complexity due to time and resource constraints.

3. Flowchart of the Project Workflow



4. Data Description

- **Sources**:

  Github

  Type: CSV(Comma Seperated values)

Features: ~15 features including PM2.5, PM10, NO_2, SO_2, CO, O_3, temperature, humidity, pressure

Target Variable: AQI

Dataset Nature: Dynamic (real-time from APIs), integrated into a static training set

5. Data Preprocessing

Missing Values: Imputed using mean/median

Duplicates: Removed using Pandas' .drop_duplicates()

Outliers: Detected using IQR; capped/fixed extreme pollution values

Data Types: Timestamps converted to datetime; all numerics coerced to float

Encoding: Categorical location data one-hot encoded

Scaling: StandardScaler used on pollutant concentration values

6. Exploratory Data Analysis (EDA)

Univariate

Boxplots revealed outliers in PM2.5 and CO

AQI distribution was right-skewed

Bivariate:

Correlation matrix: PM2.5 and PM10 had high positive correlation with AQI

Time series plots: Seasonal variations visible, with spikes during winter months

Key Insights:

PM2.5, NO_2, and O_3 are strong contributors to poor air quality

Humidity inversely correlated with AQI in some cases (likely due to weather dispersion effects)

7. Feature Engineering

Extracted **hour**, **day**, **month** from timestamps

Created **pollution index** by averaging key pollutants

Added **lag features** for short-term time-series awareness

Applied **log transformation** to highly skewed features

Optional:

PCA applied for dimensional reduction (retained 95% variance in 6 components)

8. Model Building

Models Used:

Linear Regression: Used as baseline

Random Forest Regressor: For robustness and non-linear relationships

Train-Test Split: 80/20
Evaluation Metrics:

Linear Regression: RMSE = 45.6, $R^2 = 0.65$

Random Forest: RMSE = 29.3, $R^2 = 0.83$

Random Forest outperformed the baseline significantly.

9. Visualization of Results & Model Insights

Feature Importance: Random Forest showed PM2.5, PM10, and NO_2 as top contributors

Residual Plot: Random Forest residuals randomly distributed around zero (good fit)

Prediction vs Actual Plot: Close diagonal fit in test set

Interactive Streamlit Dashboard: Real-time input → AQI prediction displayed alongside chart.

10. Tools and Technologies Used

- *Programming Language: Python,HTML,CSS,JS,bootstrap*
- *IDE/Notebook:* ***VS Code.***
- *Libraries: pandas, numpy, seaborn, matplotlib, scikit-learn.*
- *Version control:* ***git***

11. Team Members and Contributions

Name	Role	Description
Sivabalan V	Project Manager	Led the team during model implementation phase, conducted detailed EDA, and derived key insights.

Dhyanesh V	Model Integration & Application Testing Lead	Integrated trained ML models into the frontend app, tested end-to-end functionality, handled input validation, and prepared the codebase for future deployment.
Semmozhiyan NS	Machine Learning Engineer	Built and fine-tuned Linear Regression and Random Forest models, handled training and evaluation
Sri Sabarish U	Data Preprocessing Lead	Cleaned and transformed the dataset (handled missing values, outliers, and encoding).
Chandru M	UI Developer + Visual Analyst	Developed the frontend dashboard, created interactive plots for AQI visualization and prediction