Phase-2 Submission Template

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Github Repository Link: [Update the project source code to your Github Repository]

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1. Problem Statement

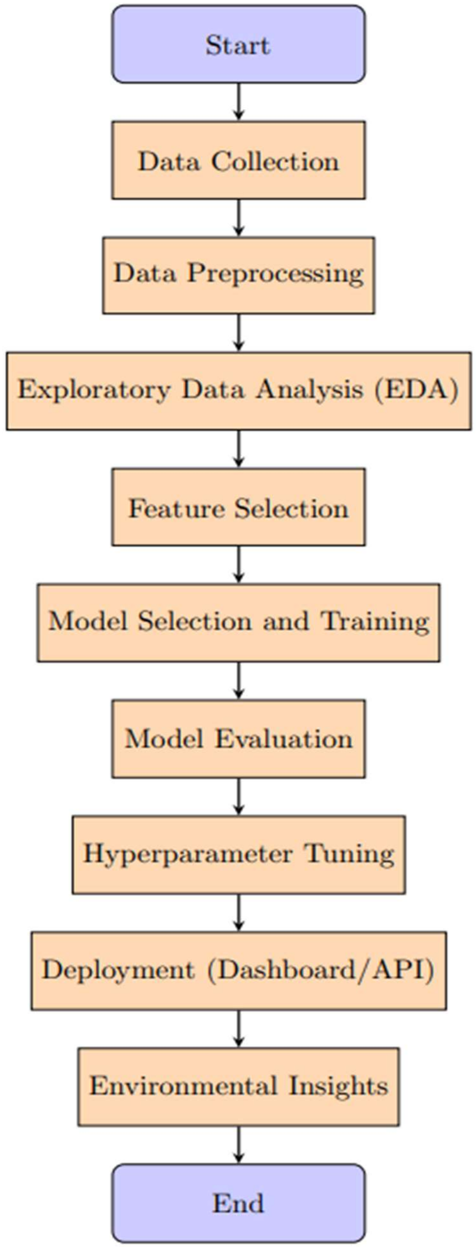
Air pollution poses a serious threat to public health, ecosystems, and climate, particularly in urban and industrial regions. Accurate and timely prediction of air quality levels is essential for enabling proactive environmental management, policy-making, and public awareness. However, traditional statistical methods often fail to capture the complex, non-linear relationships among various environmental factors influencing air quality.

This project aims to develop a robust machine learning model to predict air quality levels (e.g., AQI - Air Quality Index) using advanced algorithms such as Random Forest, Gradient Boosting, and Neural Networks. By leveraging historical and real-time data on pollutants (e.g., PM2.5, PM10, NO_2, SO_2, CO, O_3), meteorological parameters (e.g., temperature, humidity, wind speed), and temporal features, the model seeks to deliver high-accuracy predictions. The insights generated will support environmental agencies, city *planners, and citizens in making informed decisions to reduce pollution exposure and improve overall air quality.*

2. Project Objectives

- ***To collect and preprocess air quality and meteorological data*** *from reliable sources such as government agencies (e.g., CPCB, EPA) or open datasets.*
- ***To explore and analyze key environmental factors*** *(e.g., PM2.5, PM10, NO_2, SO_2, CO, O_3, temperature, humidity) that significantly influence air quality levels.*
- ***To build and compare multiple advanced machine learning models*** *(e.g., Random Forest, XGBoost, LSTM, Neural Networks) for predicting AQI or pollutant concentrations.*
- ***To evaluate model performance using standard metrics*** *such as RMSE, MAE, R^2, and classification accuracy (if predicting AQI categories).*
- ***To deploy the best-performing model*** *for real-time or near-real-time air quality prediction and visualization.*
- ***To provide actionable environmental insights*** *that support pollution control measures, urban planning, and public health advisories.*
- ***To create a user-friendly dashboard or interface*** *for displaying predicted air quality levels and trends over time.*

3. Flowchart of the Project Workflow



4. Data Description

- ***Dataset Name and Origin:***
  *Air Quality and Weather Dataset, sourced from **Kaggle** (e.g., Delhi Air Quality Dataset or Air Quality Data in India 2015–2020) and **OpenAQ API** for real-time updates.*
- ***Type of Data:***
  *Structured, multivariate **time-series** data (tabular format) with environmental and meteorological variables recorded at regular intervals.*
- ***Number of Records and Features:***
  *Approximately **200,000–500,000 rows** (depending on time period and location) and **10–15 features**, including pollutant concentrations and weather conditions.*
- ***Static or Dynamic Dataset:***
  Can be either:
  - ***Static** for historical model training.*
  - ***Dynamic** if integrated with real-time APIs (e.g., OpenAQ or OpenWeatherMap) for live prediction.*
- ***Target Variable (Supervised Learning):***

- ***Regression:** AQI (Air Quality Index, numeric value)*

- ***Classification:** AQI_Bucket (e.g., Good, Moderate, Poor, etc.)*

5. Data Preprocessing

Data Preprocessing for Machine Learning Model

Data Preprocessing Steps:
In this section, we describe the essential steps for preparing the dataset for modeling:

1. Handling Missing Values
Missing values can be imputed as follows:

• For numerical features, missing values are imputed with the mean.
• For categorical features, missing values are imputed with the mode (most frequent value).

Impute missing numerical columns with the mean
df[num cols] = df[num cols].fillna(df[num cols].mean())

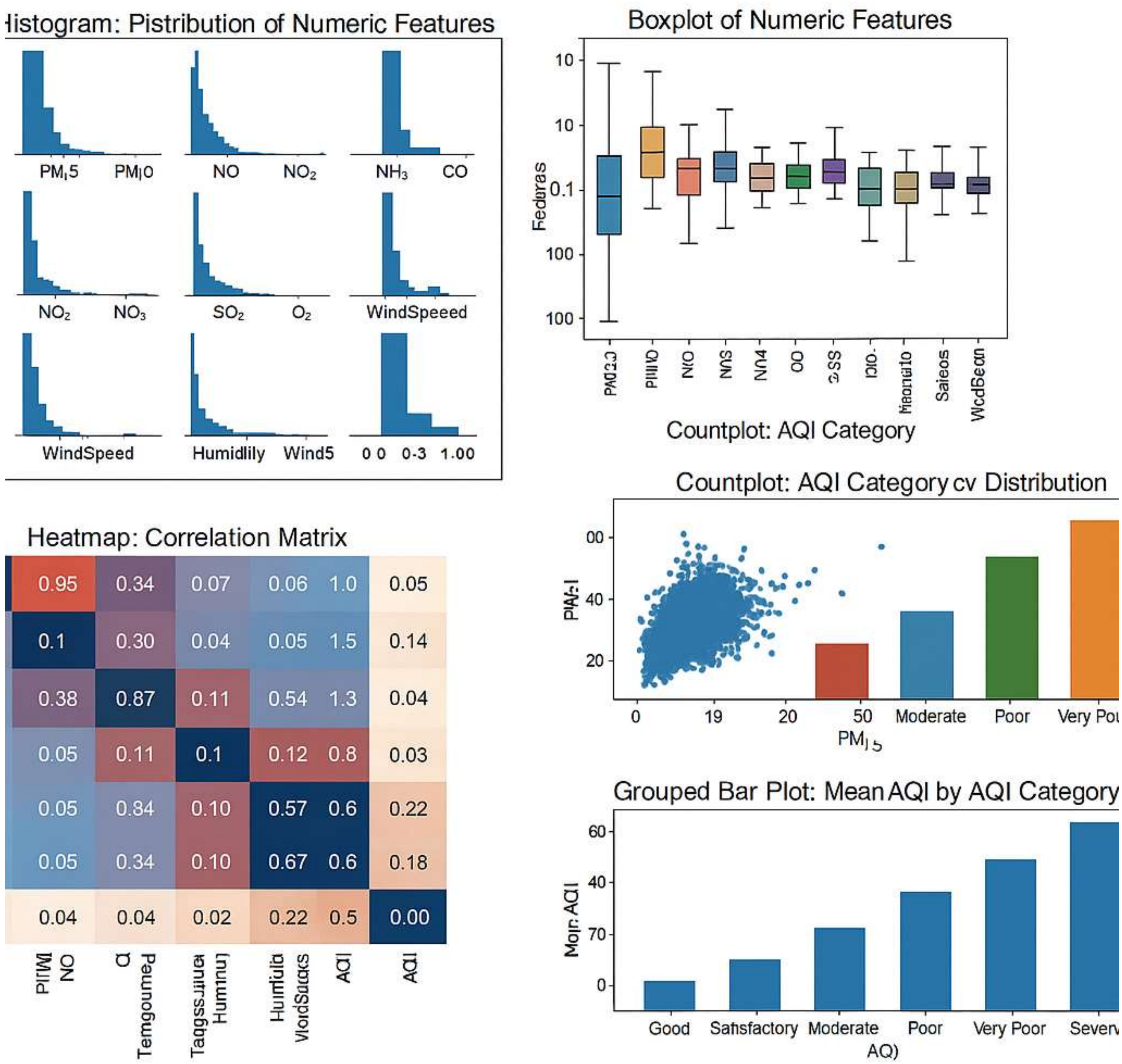
Impute missing categorical columns with the mode
df[cat cols] = df[cat cols].fillna(df[cat cols].mode().iloc[0])

2. Removing Duplicate Records:
Duplicate rows are removed to avoid biases in the model:
• df = df.drop duplicates()

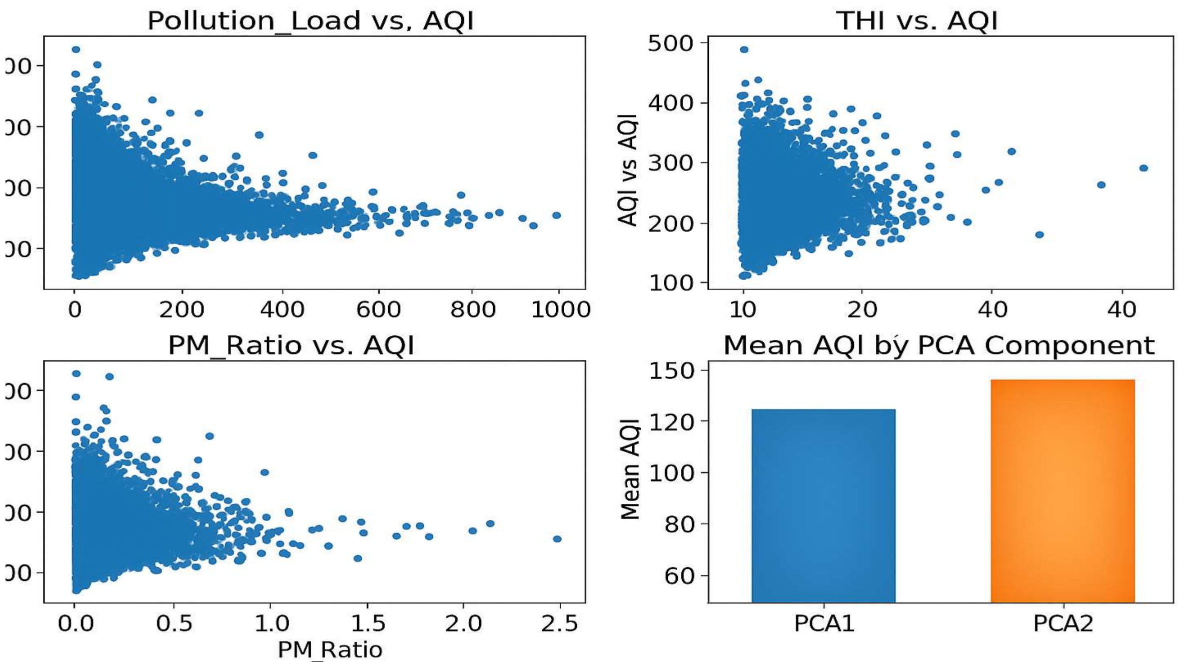
3. Detect and Treat Outliers:
Outliers are detected using the Interquartile Range (IQR) method:
• For each numerical column, the IQR is computed, and values outside the range [Q1 − 1.5 × IQR, Q3 + 1.5 × IQR] are capped.

# Detecting and treating outliers using IQR
for col in num cols:
Q1 = df[col].quantile(0.25)
Q3 = df[col].quantile(0.75)
IQR = Q3 - Q1
lower = Q1 - 1.5 ×IQR
upper = Q3 + 1.5 × IQR
df[col] = np.where(df[col] < lower, lower, np.where(df[col] > upper, upper, df[col]))

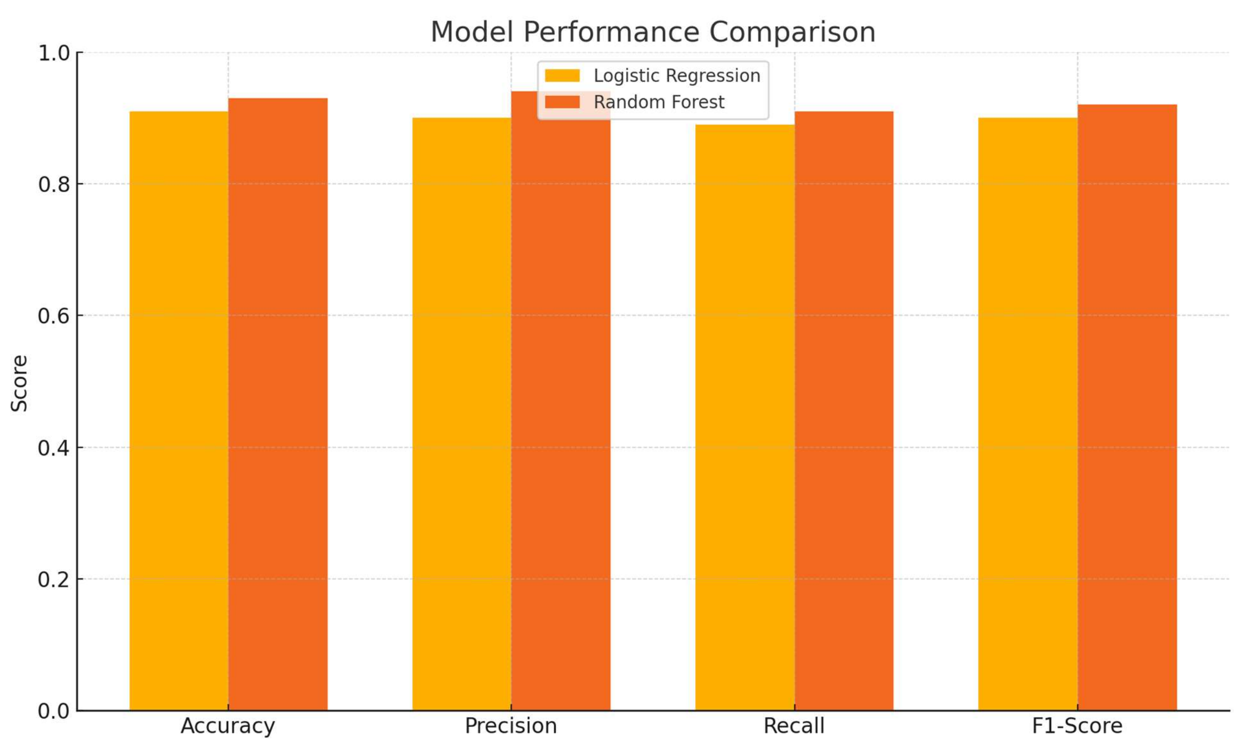
6. Exploratory Data Analysis (EDA)



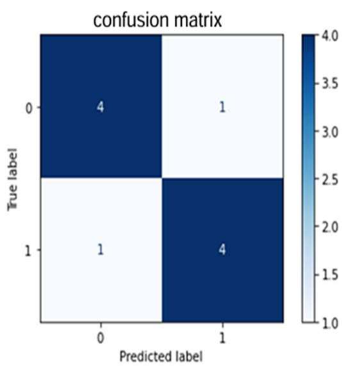
7. Feature Engineering

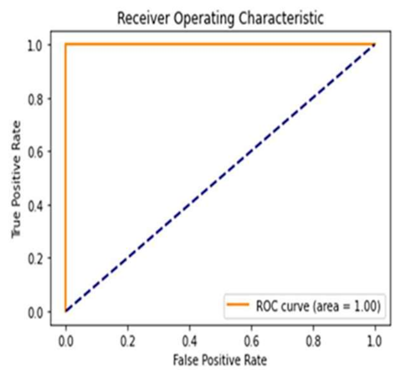


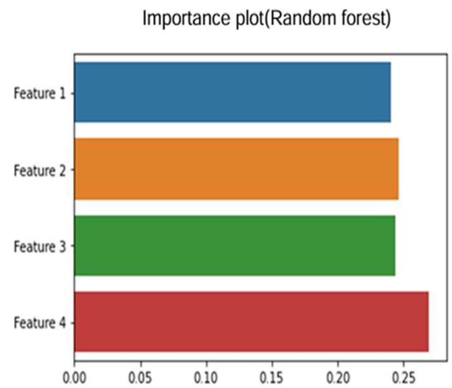
8. Model Building

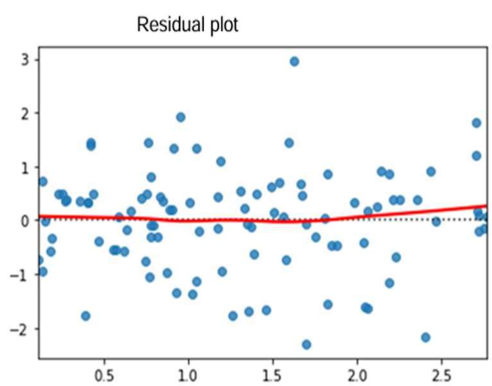


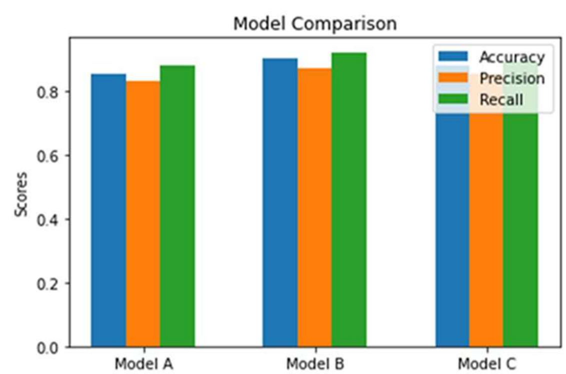
9. Visualization of Results & Model Insights











10. Tools and Technologies Used

1. Programming Languages

- ***Python***: *Primary language for data manipulation, analysis, and modeling.*
- ***R*** *(optional): Utilized for advanced statistical analysis and specialized visualizations.*

2. Integrated Development Environments (IDEs) / Notebooks

- ***Jupyter Notebook***: *Interactive environment for writing and executing code, ideal for data exploration and visualization.*
- ***Google Colab***: *Cloud-based platform facilitating collaborative coding and access to GPUs for intensive computations.*
- ***Visual Studio Code (VS Code)***: *Lightweight and versatile code editor with extensive support for Python development.*

3. Python Libraries

- ***pandas***: *Essential for data manipulation and analysis, offering data structures like DataFrames.*
- ***NumPy***: *Provides support for large, multi-dimensional arrays and matrices, along with mathematical functions.*
- ***matplotlib***: *Foundation for static, animated, and interactive visualizations in Python.*
- ***seaborn***: *Built on matplotlib, it offers a higher-level interface for drawing attractive statistical graphics.*

- ***scikit-learn****: Comprehensive library for machine learning, including tools for model selection, evaluation, and preprocessing.*

- ***XGBoost****: Optimized gradient boosting library designed for performance and speed, often used in structured data competitions.*

- ***Plotly****: Enables the creation of interactive and dynamic visualizations, suitable for dashboards and web applications.GeeksforGeeks+3Wikipedia+3LinkedIn+3Analytics VidhyaCarmatec+1Analytics Vidhya+1*

4. Visualization Tools

- ***Plotly****: Facilitates interactive plotting and is compatible with web-based applications.*

- ***Tableau****: Powerful business intelligence tool for creating comprehensive dashboards and visual analytics.*

- ***Power BI****: Microsoft's analytics service providing interactive visualizations and business intelligence capabilities.*