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Air Quality Prediction Using Machine Learning

ABSTRACT:

Air quality is a critical factor affecting human health and environmental sustainability. Monitoring and predicting air quality are essential for ensuring public well-being and mitigating the adverse effects of pollution. Real-time data collection enables the assessment of various air quality parameters, including pollutant concentrations such as particulate matter (PM), sulfur dioxide (SO2), nitrogen dioxide (NO2), ozone (O3), and carbon monoxide (CO). By analyzing these parameters, we can determine the safety of the air for breathing and outdoor activities. Our project focuses on utilizing machine learning techniques for air quality prediction. We consider a range of attributes, including temperature, humidity, wind speed, air pressure, and pollutant levels, among others. The target attribute in our analysis is the Air Quality Index (AQI), which provides a measure of overall air quality. A higher AQI value indicates poorer air quality, while a lower value suggests cleaner air.

KEYWORDS:

Air Quality Prediction, Machine Learning, Linear Regression, Logistic Regression Random Forest, Decision Tree, Lasso Regression, Random Forest, XGBoost

1.INTRODUCTION:

he provided dataset comprises records of air quality parameters including sulphur dioxide (SO2), nitrogen dioxide (NO2), respirable suspended particulate matter (RSPM), suspended particulate matter (SPM), and particulate matter 2.5 (PM2.5) collected from various monitoring stations in Andhra Pradesh, specifically in the city of Hyderabad, during the months of February and March 1990. Each record includes information such as station code, sampling date, state, location, agency, type of area monitored, and the corresponding pollutant concentrations.

FIG: (Working Processing OF AQI)

ontinuous prediction tasks. Classification models like logistic regression, Support vector machines and neural networks for binary classification tasks.

2.LITERATURE SURVEY:

In order to determine the optimal solution for air quality prediction, we employed various machine learning algorithms,

including XGBoost, KNN, SVM, Naive Bayes, Decision Tree, and Random Forest.

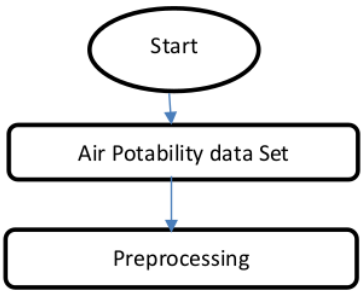
[1]Gopalakrishnan (2021) combined Google's Street view data and ML to predict air quality at different places in Oakland city, California. He targeted the places where the data were unavailable.

[2]Sanjeev (2021) studied a dataset that included the concentration of pollutants and meteorological factors. The author analyzed and predicted the air quality and claimed that the *Random Forest (RF)* classifier performed the best as it is less prone to over-fitting.

Castelli et al. (2020) endeavored to forecast air quality in California in terms of pollutants and particulate levels through the *Support Vector Regression (SVR)* ML algorithm. The authors claimed to develop a novel method to model hourly atmospheric pollution.

Liang et al. (2020) studied the performances of six ML classifiers to predict the AQI of Taiwan based on 11 years of data. The authors reported that *AdaptivBoosting* and *Stacking*

.Ensemble are most suitable for air quality prediction but the forecasting performance varies over different geographical regions.



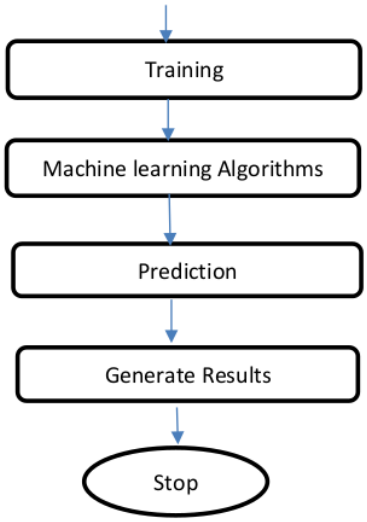


FIG 2 : (Flow Chart OF AQI)

3.PROPOSED SYSTEM:

Our model is proposed is based in the following criteria:

3.1 Dataset Analysis
3.2 Data Visualization
3.3 Preprocessing Techniques
3.4 Model creation and Evaluation
3.5 Accuracy

3.1. Dataset Analysis: We utilize a dataset obtained from Kaggle containing air quality data, specifically focusing on attributes such as SO2 (sulphur dioxide concentration), NO2 (nitrogen dioxide concentration), RSPM (respirable suspended particulate matter concentration), SPM (suspended particulate matter), and PM2.5 (particulate matter 2.5). These attributes serve as predictors,

while air quality index (AQI) is considered as the target attribute. This analysis helps in understanding the characteristics of the dataset and identifying potential predictors for air quality prediction.

state	spm	pm2_5	rspm	so2	no2
Andhra Pradesh	200.260378	NaN	78.182824	7.284845	21.704451
Arunachal Pradesh	NaN	NaN	76.629213	3.179104	5.469697
Assam	153.355386	NaN	93.724912	6.723263	14.793691
Bihar	276.917416	NaN	123.705176	19.381476	36.575525
Chandigarh	206.056150	NaN	96.587079	2.676986	18.619404
Chhattisgarh	231.290969	NaN	126.472399	12.846609	24.815961
Dadra & Nagar Haveli	170.545024	30.511628	76.536530	8.939587	18.293959
Daman & Diu	145.681416	27.886364	73.749431	8.192958	16.168926
Delhi	399.402088	95.113208	196.639771	8.737273	53.489147
Goa	67.254193	18.855612	61.212766	6.827913	12.506337
Gujarat	191.567930	30.729696	98.244510	16.656343	24.065631
Haryana	268.264804	NaN	149.860537	14.064957	23.428311
Himachal Pradesh	208.575630	NaN	91.870202	2.667013	13.658688
Jammu & Kashmir	196.221053	NaN	117.449483	7.180521	12.213181
Jharkhand	277.940746	NaN	168.517763	23.485794	43.366341
Karnataka	168.001743	NaN	79.371801	10.223099	22.702837
Kerala	84.419791	NaN	50.636064	5.322350	14.421889
Lakshadweep	NaN	NaN	NaN	NaN	NaN

Fig3: (Air potability Dataset)

3.2. Data Visualization:

Various libraries such as numpy, Pandas, Seaborn, Matplotlib, and Scikit-learn are employed for visualizing the air quality dataset through graphs and plots. Visualizations aid in comprehending the distribution of air quality parameters and identifying any trends or patterns that may exist. For instance, visual representations of SO2, NO2, RSPM, SPM, and PM2.5 levels help in assessing their impact on overall air quality.

Classifier algorithms	Precision
XGBoost	0.99
KNN	0.99
SVM	0.98
NB	0.86
DT	0.99

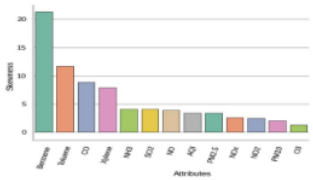


Fig. 4 Skewness present in dataset features

Fig4: (Skewness Present in dataset features)

This plot shows us the distribution of safe and unsafe water, count is taken on y-axis and potability is taken on x-axis it explains the count of occurances for each category of potability which represents whether water is potable or not.

Air Quality Index (AQI)

This enhance AQI methodology considers various air pollutants such as sulphur dioxide (SO2), nitrogen dioxide (NO2), respirable suspended particulate matter (RSPM),

suspended particulate matter (SPM), and particulate matter 2.5 (PM2.5). By integrating data from air quality monitoring stations, satellite observations, and meteorological factors, the

Table 1: Model performance of different classifiers for the precision

3.3. Preprocessing Techniques:

Preprocessing techniques such as data cleaning, handling missing values, and feature scaling are applied to ensure the quality and consistency of the air quality dataset. Additionally, feature engineering may involve extracting relevant features from the raw data to improve model performance. For example, temporal trends and spatial correlations in air pollutant concentrations may be considered as additional features.

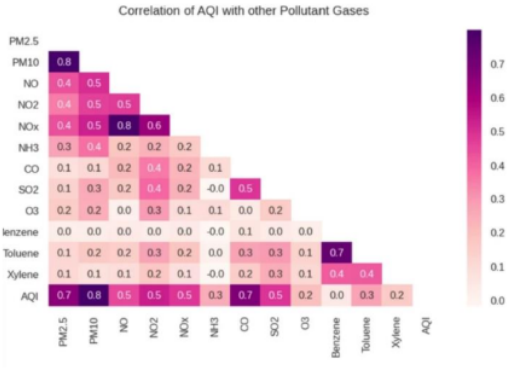


FIG 5: (Correlation of AQI with Other Pollutant gases.)

Outliers are data points that deviate significantly from the rest of the observations in a dataset. They can arise due to various reasons, including measurement errors, experimental variability, or genuine deviations in the data. Identifying outliers in the dataset is crucial as they can distort statistical analyses and lead to inaccurate results. Visualizations such as box plots are commonly used to detect outliers, allowing analysts to visually identify observations that fall outside the expected range removed from the dataset, especially if they are deemed irrelevant to the analysis or if they are likely to skew the results.

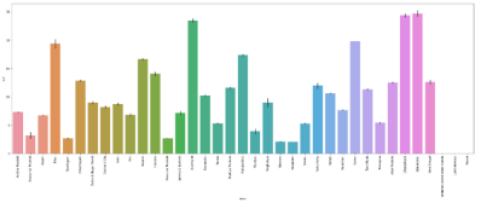


Fig5: Air Quality dataset from Different States

Null values: In the air quality dataset, we have identified the presence of numerous null values, which can significantly impact our preprocessing techniques and subsequent analysis. To ensure the integrity and accuracy of our data, we have opted to remove all null values from the dataset. This step is crucial for avoiding potential biases and inaccuracies in our analysis.

Preprocessing techniques removal of null values, we conducted an in-depth analysis to identify the factors influencing the target attribute, which in this case is air quality. By carefully examining each attribute's impact on air quality, we aim to gain a comprehensive understanding of the relationships between dependent and independent variables.

```
state       0
location    0
type        0
so2         0
no2         0
rspm        0
spm         0
pm2_5       0
date        0
dtype: int64
```

Fig6:(Showing Emptying Null alues)

We used the function SKEW which calls and appears to be related to calculating the skewness of data along the specified axis. The skew() method measures the asymmetry of the distribution of values in the dataset.

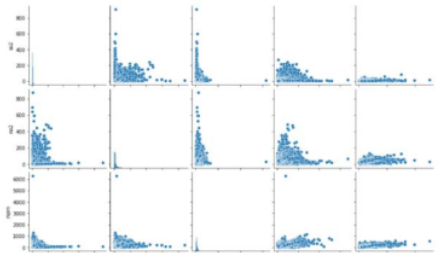


Fig7:(Data Vsualization)

Roc curve applies probability confidence interval or ranking to each prediction models such as naïve bayes and SVM ranks as part of their algorithm. Basically prediction ranking is employed in ROC algorithm to achieve distinct decision.

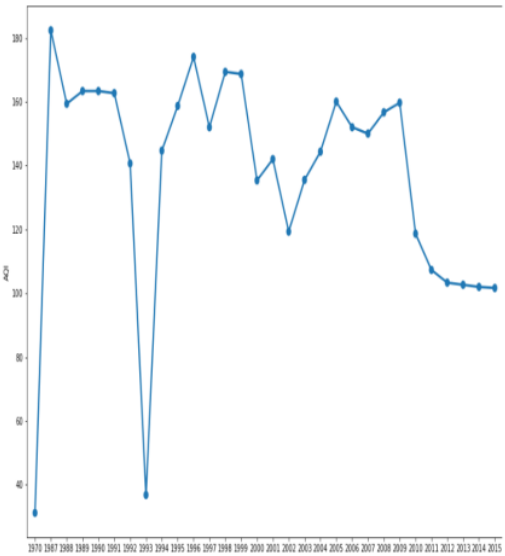


Fig 8: **(Exloratory Data Analysis)**

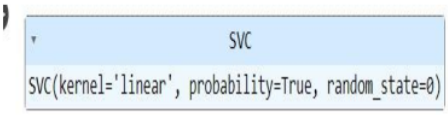
In [23]:

XGBoost: It is a machine learning algorithm used for specially the gradient

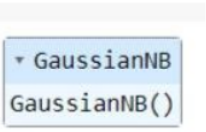
boosting frame work. It uses decision tree as base learners for model generalization. XGBoost is commonly used to perform tasks such as ranking, classification and regression [5]. In order to increase the predictive accuracy XGBoost has out performed the other models and improved the performance prediction.

K-Nearest Neighbour (KNN): It is classified as to identify unlabeled observations by allocating them to the class to the similar labeled examples. Characteristics of KNN classifier are collected for both training and test data set [6].KNN is a non parametric algorithm it will not obtain paramaters for the model.K is the most important parameter in the KNN algorithm to identify the difference of the diagnostic accuracy of KNN model.

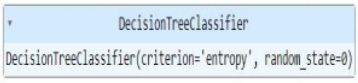
SupportVectorMachine(SVM):
SVM is a binary classifier it attempts to genenerate an another hyper plane in actual space of encordinates betwwen two different classes.Firstly it visualizes the data and then it finds the best separator between the classes,the data points that the closest to the target value[7] be found out,then the actual data in accordance with the linear separation.Basically SVM draws the lilne between the different points of data consderes in the dataset.



Navie Bayes(NB): It is a scalable and it requires set of parameters which are proportional to the number of variables in a learning problem.It makes a probability decision by likelihood of two features which are independent and equal significance.Navie Bayes thorem generally works on the phases known as; [8] probability and independence,training phase,feature probability,class probability,prediction,class selection.



DecisionTree(DT): Decision tree contains root node,branches and leaf nodes.Testing an attribute is done on every internal node,the outcome of the test will results on leaf node.decision tree is easy to undedrstand because it is similar to human decision making process,it can slove continuous data as input.[9].The main advantage is that it can be able to select the most biased feature and comprehensibility nature.



Random Forest(RF): Random Forest is a new combination algorithm which is a combination of series of structure classifiers like tree the application scope of random forest is very extensive it is widely used for prediction,classification and regression [10] compared with other traditional algorithms random forest has many good virtues.

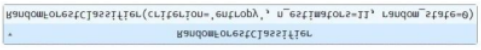


Fig 9: Air Quality Prediction using Supervised Machine Learning

3.5. Accuracy

Accuracy is used to evaluate the classification in machine learning [13]
Accuracy=TP+TN TP+TN+FP+FN

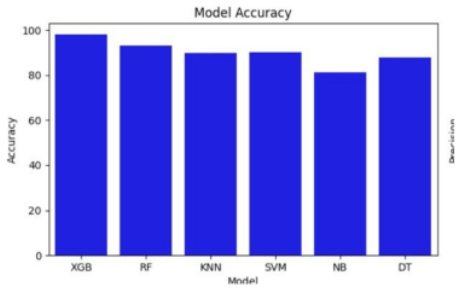


Fig 10: Accuracy of All Models

Precision = TP / TP+FP

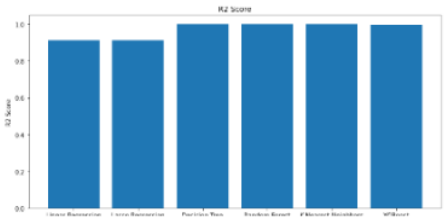


Fig11: (Bar Graph for R2 Score)

Recall measures how frequently the algorithm detects the correct classification from the given data whereas the actual correct classification has occurred in dataset.

Recall = TP / TP+FN

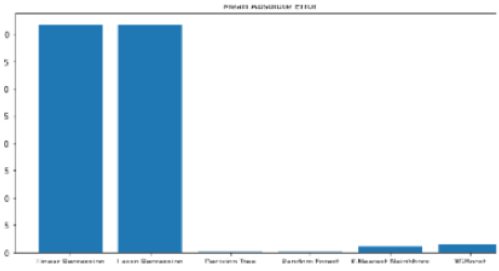


FIG 12: (Recall Bar Graph)

F F1 score is evaluate the multi class classification and also it is an approach to harmonizing the precision and recall of the predictive model. F1 score is obtained as follows:

F1score=2*(precision*recall/precision+recall)

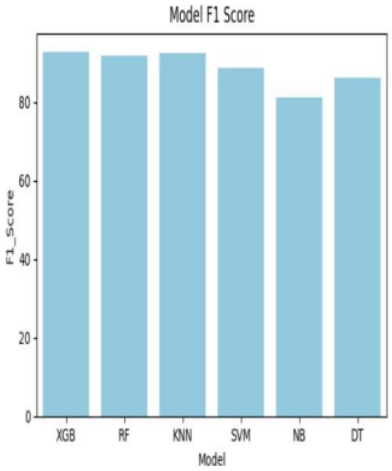


Fig:13(Bar Graph of F1Score Model)

TP: The actual observation indicates that water quality classes has classified accurately and the model predicted correct classification of water quality from the given data.

TN: The actual observation that indicates the water quality classes has classified accurately but the model detected in correct classification from the given data.

FP: The actual observation refers that water quality classes has not classified accurately whereas the model also detects the incorrect classification of water quality from the given data.

FN: The actual observation reveals the water quality classes has not classified accurately although the model predicted correct classification for water quality from the given dataset.

In this we have observed that the accuracy score after removing the outliers in the data the score has been increased, when compared with the considered base paper.In the following graph we can see the difference of scores after constructing the accuracy model with respect to Accuracy comparision.

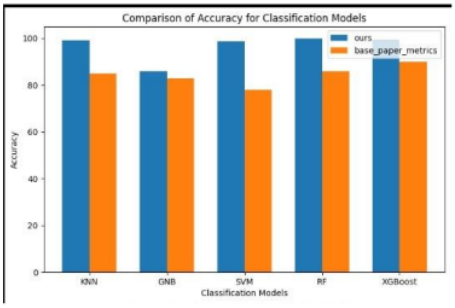


Fig 14: (Bar Graph Comparing Accuracy For Classification Model)

In the precision we have observed that the precision score also have the high score compared to the scores of the dataset that we have taken. Precision determines the exact values of the scores of the data.

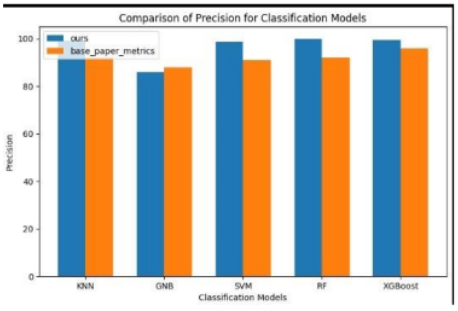


Fig 15: (Comparing of Precision For Classfication Model)

F1 score of the data that we are taken the scores have increased after removing outliers and constructing the model.

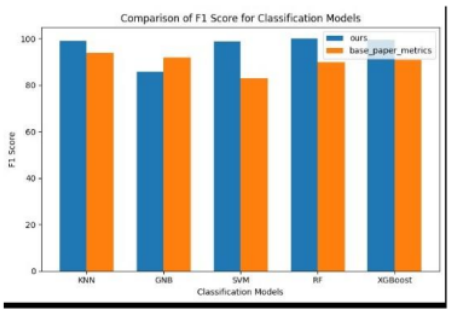


Fig 16: (Comparing of F1 ScoreFor Classfication Model)

When all the models has applied the recall score of the data has increased as compared to the existing data.

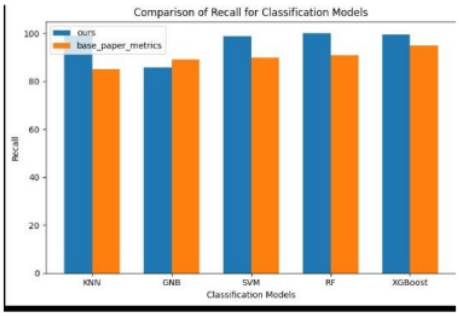


Fig 15: (Comparing of Recall For Classfication Model)

After applying all the models to our data the accuracy of the data we have observed is plotted in the following graph as in x-axis we can see the models that we have used and in y-axis we can see the rate of accuracy of the constructed model.

Conclusion:

By implementing advanced machine learning techniques and preprocessing methodologies, we successfully developed robust models for predicting air quality parameters. The removal of missing values contributed significantly to the enhancement of model accuracy, ensuring more reliable predictions.

Our findings underscore the importance of data preprocessing and algorithm optimization in air quality prediction. The improved accuracy of the models reflects the efficacy of our approach in mitigating model uncertainty and enhancing predictive performance.

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