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PREDICTIVE ANALYSIS OF WIND POWER GENERATIONUSING MACHINE LEARNING

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Abstract — **The proposed aim of project predictive analysis of wind power generation using** Machine learning **is to reduce the cost, provide cleaner and eco friendly source of energy and increase the efficiency of existing systems to greater extent by calculative analysis [1]. As the world is progressing towards renewable and clean energy it is an interdisciplinary research model that is designed to find an optimal way of harnessing wind energy via machine learning models. It is a viable option for Governments and Companies around the world which will help them to set up Wind Energy Plants at appropriate locations for maximizing the output power generation by prediction from the Machine Learning model.**

The experience obtained while working in the simulation of predictive analysis of wind power generation using machine learning based wind conversion can be successfully implemented in real life scenario helping in increasing renewable energy production.

The main objective is to maximize the performance and efficiency of Wind Mills. This project will help in automation-. The control strategy used in this project is for maximizing the performance and efficiency of a Wind Mills.

I. INTRODUCTION

An impending energy catastrophe is coming speeding towards us and our future generations. It is a well known fact that we are exhausting the nearly exhausted non renewable energy sources like coal, natural gas, petroleum etc. on an unprecedented scale. So it becomes a compulsion for mankind to find ways of efficient extraction and distribution of renewable energy sources like tidal power, geothermal energy, wind energy and others. Amongst these the extraction of wind energy is a viable option as the world has a lot of wind power potential in countries like China, US, European states like Germany, Spain and France.

In the context of our country, nine states have humongous wind power potential like Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan and Tamil Nadu. The production and distribution costs to be incurred in wind power production and transmission are becoming more and more affordable by the passing day and the present regime is striding towards the goal of achieving 140 GW of wind energyby 2030. [2]

Machine learning has been employed to study and develop a new method to predict the behavior of a dataset, model input features with respect to the expected output and predict expected outputs with respect to its historical records. To promote the widespread adoption of wind energy which would not only help be less dependent on fossil fuels but would also be the flag bearer for clean energy [3].

For harnessing maximum wind energy, collecting and analyzing past data would help drive our technology based decisions such as design and placement of wind turbines.

II. LITERATURE REVIEW

Due to increase in population and economic activities more and more energy is required to meet daily needs. In this drastically changing circumstances forecasting of power is becoming most necessary in managing the power systems. Forecasting helps in operation planning, scheduling and real time balancing of power systems.

Renewable energy source is an alternative to fossil fuels. Wind power industry has witnessed tremendous growth. Wind power depends on factors such as wind speed, wind direction etc. Hence there are a lot of uncertainties associated with the calculation of wind power, so it demands efficient forecasting methods [4]. More is forecast reliability less will be the reserve maintenance cost of the system, which results in technical and commercial implications for proper management and working of power systems. [5]

With the help of wind power forecasting we can predict how much wind power is needed after some time.

III. RESEARCH METHODOLOGY

ABOUT THE DATASET

The dataset is from a wind farm and was collected by sensors on a meteorological mast, while the power output was measured at a wind turbine. The data is recorded as a ten-minute average and the training data has data records from the year 2018 to 2020.

Active power, average wind speed (m/s), reactive power, average wind direction (degrees) and ambient temperature (℃) are some of the attributes in the dataset. Wind power (normalized) is the output which is expressed in a value between 0 to 1.

DATA PREPROCESSING

Data generally contains noises, missing values, and maybe in an unusable format which cannot be directly used for machine learning models.

Data preprocessing is required for cleaning the data and making it suitable for a machine learning model which also increases the accuracy and efficiency of a machine learning model.

CORRELATION BETWEEN ATTRIBUTES

After selection of the Dataset it is important to develop a correlation between different attributes so we can use these attributes for correct prediction of wind energy production.

We can intuitively get an image of the attributes that are highly related to the output and those that are not. Also, highly correlated attributes do not provide any additional valuable information for prediction. For this purpose, we have plotted the correlation matrix using the seaborn. heat map tool.

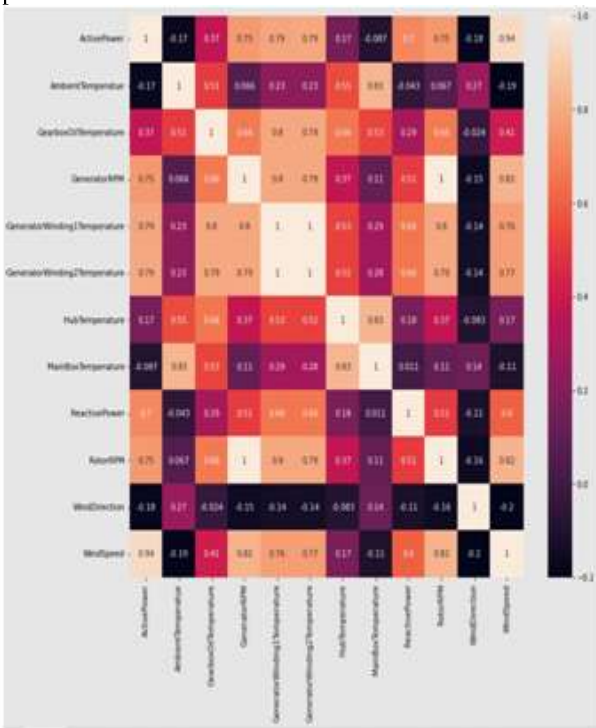

Fig1 (Correlation Matrix)

By the above correlation matrix we can clearly get an idea of attributes which have a relation with active power and can be used for wind power prediction.

Attributes having a relation value of more than 0.7 can be used for prediction in machine learning models [6].

Thereafter, To illustrate the effect of correlation further, we have plotted the scatter plots between the pairs of attributes and power output having relation greater than 0.7 in correlation matrix, using the seaborn. Pair Grid tool.

IV. METHODOLOGY

We applied different Machine Learning Algorithms like Linear Regression, XGBoost and Random Forest to make our prediction model and reduce Root Mean Square Error to maximum extent.

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The data is divided into training data and testing data for training the model and testing the model. 70 % of space is given to training data and 30% for testing purposes.

We applied two classification and one regression technique on ourmodel to determine which particular method provides better accuracy and prediction for our model.

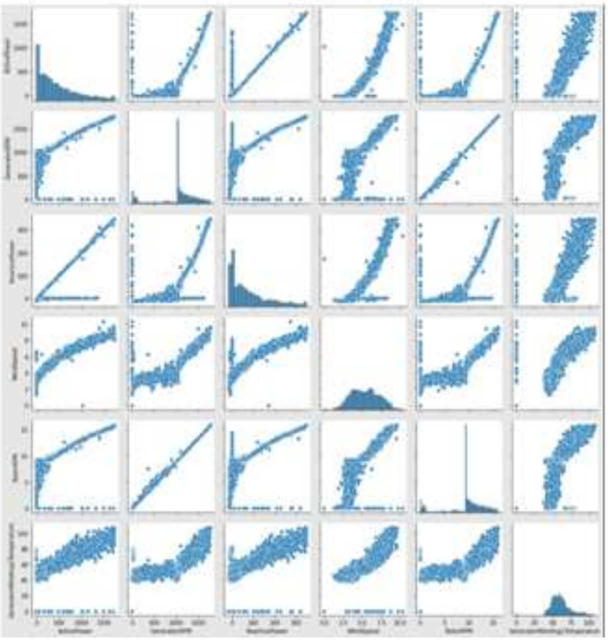

Fig 2 (Scatterplots)

DIFFERENT MACHINE LEARNING ALGORITHMS USED

1) **Linear Regression**- It is a machine learning approach in which relation between two variables is established on a graph and shown by a line. For a good linear regression model perpendicular distance of scatter points must be minimum from the line plotted [7].

2) **Random Forest**- The random forest classifier is a supervised learning algorithm. It consists of multiple decision trees just as a forest has many trees. It uses randomness to enhance its accuracy and combat over fitting. These algorithms make decision trees based on a random selection of data samples and get predictions from every tree, after that, they select the best viable solution through votes. A tree has several nodes and the model searches for the best solution by going through all nodes [8].

3) **XG Boost**- It is an implementation of gradient boosted decision trees. In this algorithm decision trees are created in sequential form [9]. Weights play an important role in XGBoost. Weights are assigned to all the independent variables which are then fed into a decision tree which predicts results [10].

Error Metrics

i).R2 Score: It is the amount of variation in output dependent attribute which is predictable from input independent variables [11].

$$1 - \frac{\sum_{t=1}^{N}(y_t-\hat{y}_t)^2}{\sum_{t=1}^{N}(y_t-\hat{y}_t)^2}$$

ii) MAE: Mean absolute error is calculated as the sum of absolute errors divided by the sample size.

$$\frac{\sum_{i=1}^{n}|y_i-x_i|}{n}$$

iii) RMSE: Root mean square error is the square root of the difference between the values predicted by the model and the values observed [12].

$$\sqrt{\frac{1\sum_{t=1}^{N}(y_t-\hat{y}_t)^2}{N}}$$

V. MODEL RESULTS

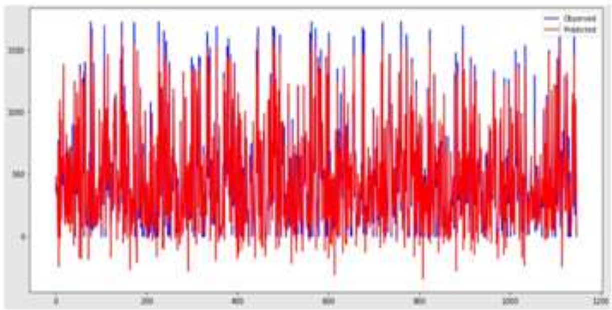

Fig 3 (Linear Regression)

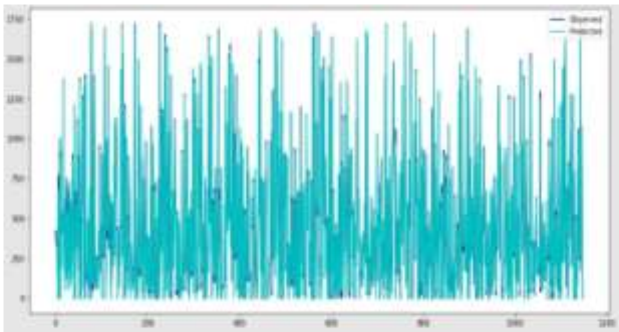

Fig 4 (XG Boost)

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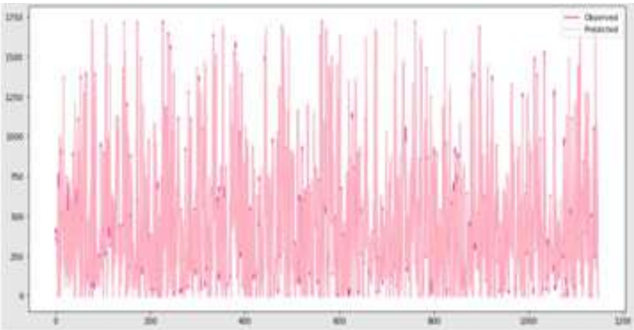

Fig 5 (Random Forest)

Model Name	R2 Score	MAE	RMSE
Linear Regression	**0.96**	**64.86**	**85.62**
XG Boost	**0.99**	**15.58**	**23.99**
Random Forest	**0.99**	**8.55**	**16.39**

Table 1: Performance Score

VI. CONCLUSION

We have taken 3 different types of error metric for comparing our model performance on the dataset.

From the table we see that linear regression models have highest mean absolute error and root mean square error whereas random forest have least mean absolute error and root mean square error . So for this data set random forest outperform other model.

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