IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

DEEP LEARNING APPROACH TO IMPROVE THE EFFICIENCY OF SHORT-TERM WIND POWER FORECASTING

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***Abstract*:** Deep learning is one of the Artificial Intelligence methods that work like a human brain to store record and process the data. Machine learning (ML) algorithms have capacity to learn things that are required for particular application. Hence. They have the ability to learn. Investigate and assess the potential of a novel mechanism to boost the effectiveness of intermittent wind energy. It includes the preprocessing of the dataset to eliminate the null values, increase the Wind Power Forecasting (WPF) effectiveness by using Artificial Neural Network (ANN) algorithm. Graph utilize the ANN algorithm that shows the accuracy, Mean Absolute Error (MAE), Root Mean Square Error (RMSE) percentages. The proposed system improves the efficiency of short-term WPF. According to experimental results the proposed ANN algorithm has less MAE and RMSE percentage that is 70.01% and 77% less than existing system of short-term WPF. Also, ANN is 70% faster than Support Vector Machine (SVM) and accuracy of ANN is improved by 14% than existing system (SVM), from the experimental evaluations the proposed algorithm performs better in terms of improved accuracy of 14% compared to the existing system, MAE of 70.01% and RMSE of 77%.

***Index Terms* - Machine Learning, Wind Power Forecasting, Support Vector Machine, Artificial Neural Network.**

I. INTRODUCTION

Renewable energy is generally wind energy, above all are growing within the last decade, the event and use of renewable energy is most popular, alternative energy produced is increasing in a huge business. A catalyst for such growth has been growing energy demand, coiling fuel costs. In recent years, wind speed and alternative energy prediction approaches area unit in the main classified with relevance the time horizon of the applying, from the present perspective all the factors that junction rectifies to the expansion of wind energy within the last decades can continue advancing it within the future. world energy demand is predicted to stay growing, even beneath the declared intentions to extend energy potency (use energy wiser). Data mining is the process of analyzing data from a variety of angles and producing useful information that can be utilized to boost profits, save costs, or do both (also known as data or knowledge discovery). One of the analytical techniques for analyzing data is data mining software. Users are able to classify the data, summaries the relationships found, and evaluate it from a variety of various dimensions or angles. In big relational databases, data mining technically refers to the act of identifying correlations or patterns among numerous fields. Due to its cleanliness and widespread availability, wind power generation(WPG) is quickly becoming a significant sector. However, it has been noted that this type of energy is erratic and unpredictable. Unfortunately, it can be challenging to guarantee stability and security while utilizing the energy grid, particularly for large-scale applications. Power quality and dependability management, as well as lowering the cost of supplying spinning reserve, depend on an accurate and trustworthy WPF approach. The amount of physical information has a significant impact on how accurate this method is. The statistical technique seeks to find the link between wind power and the set of elements by using historical data as well as data that may be seen online, such as wind speed and wind direction.
Fuel costs area unit expected (under a comparatively optimistic scenario) to remain a minimum of as high within the future. heating continues business for vital reductions in carbonic acid gas emissions. additionally, the recent Fukushima disaster has junction rectifier to a replacement wave of great dialogue on the protection of energy, creating it somewhat undesirable within the progressive policies. All this makes wind energy a awfully engaging different, that is predicted to stay growing considerably within the years to come back.

These strategies area unit in the main divided into 3 category:

1. Short-term wind forecasts assess the wind data for many minutes to hours in the future. assessing the benefits of electricity in this way.
2. The number of hours per week in the medium-term statement varies. These kinds of projections were used to establish choices for reserve allocation and unit commitment.
3. Wind speed is introduced in the long-term forecasting statement for the time period of one week to one year. This duty is fascinated with expansion planning as well as the feasibility analysis of the wind farm planning.

II. PROBLEM DEFINATION

Explore and evaluate the possibility of a new mechanism to improve the efficiency of short-term wind power. The given problem is divided into following sub-problems:

1. Preprocessing the dataset.
2. Improve the efficiency of WPF using ANN algorithm.
3. Graphs displaying the percentage of accuracy, MAE and RMSE using the ANN algorithm.

III. OBJECTIVES

The goals of project are:

- To achieve the good forecasting results.
- To achieve scalability.
- To find wind power Production area.
- To Achieve maximum Forecasting accuracy.

IV. LITERATURE SURVEY

[1] proposed the fundamental and crucial role in running a wind power facility is WPF. One of the viable power sources that is rapidly expanding is wind power, which will be seen as an additional replacement for conservative power provided by non-sustainable power sources. With the aid of wind power forecasts, less electricity will be generated from conventional sources (WPF). The wind's erratic behavior will make it challenging to gather accurate original data, and it will have a significant impact on predicting precision. Over the past few years, a lot of researchers have used various data mining techniques in various prediction systems, producing good forecasting accuracy. To improve prediction accuracy and reduce computational complexity, a hybrid strategy combining fuzzy k-means clustering and a bagging neural network is given (BNN).There are many similarities between historical days, and fuzzy k-means clustering is utilized to group the comparable days together. This method includes precise information on historical data and meteorological conditions. Backpropagation neural networks should integrate a bagging algorithm to prevent the overfitting issue. The suggested hybrid method, which is predicted to offer greater forecasting accuracy and also to minimize computational complexity when compared to other existing WPF approaches, will be tested in a real wind farm to demonstrate its efficiency.

[2] proposed the advancement of wind power on a global scale has been notable. However, due to the unpredictability of the wind, incorporating it into electrical systems poses a variety of difficulties. Consequently, it is essential to accurately predict wind generation in order to offer a consistent and reasonable supply of electricity. To finish this work, you can use the Wind Power Prediction Tool and the power curve connected to a wind farm (WPPT). Recurrent neural networks (RNNs) enable the modelling of complex non-linear interactions without the need for explicit mathematical equations to link the various variables. Long Short-Term Memory (LSTM) and Echo State Network are two specific RNN variations that have demonstrated successful time series forecasting (ESN). We present an LSTM+ESN design in this study that combines the benefits of the two networks. It is suggested to employ LSTM blocks as units in the hidden layer of an ESN-like design. The hidden layer is learned online using a descending gradient technique while one epoch is used to update the output layer during the network's training phase. In one case, Step I uses the input signal as a target to automatically extract characteristics using the autoencoder method, and Step (ii) uses a quantile regression to generate a reliable estimate of the expected target. According to the experimental findings, the LSTM+ESN model beats the WPPT model in all of the applied global measures when employing the autoencoder and quantile regression.

[3] Using wind power forecasts to lessen the strain of peak load and frequency management on the power system and ensure that it operates steadily is considered as the essential challenge that results from the gradual increase in wind power generation. As a result of the continual development of the artificial intelligence industry, neural networks have shown a good predictive effect in time series data forecasting. Long-term short-term memory is a sort of time recursive neural network that is well suited for processing and predicting events in time series with comparatively large intervals and delays. This research proposes an improved LSTM-EFG (Long Short-Term Memory-enhanced Forget-Gate Network) model for WPF. The feature data of turbine groups within a certain distance are filtered based on correlation in order to further maximise the forecasting influence on wind power via clustering. The Spectral Clustering approach has a higher accuracy than the other forecasting models, up 18.3 percent, and also speeds up the convergence process, according to the data.

[4] Since WPF provided efficiently direct grid dispatching and wind farm production planning, it is essential. Because of the intermittent and irregular character of the wind, the training samples' diversity has a significant impact on how accurate the forecasts are. A data mining method for short-term WPF based on K-means clustering and bagging neural networks is proposed to deal with the dynamics of the training samples and increase predicting accuracy. Using K-means clustering, the samples are split into groups that each contain weather and historical power data and that each correspond to past days with shared characteristics. A bagging-based ensemble algorithm is incorporated into the back propagation neural network to address the over fitting and instability problems of traditional networks. The proposed data mining method is assessed to check its efficacy on actual wind generating data traces. The results of the simulation demonstrate that it can generate forecasts that are more precise than other short-term WPF baseline and existing approaches.

[5] An accurate short-term wind power forecast is essential for the reliable and efficient operation of power networks with significant wind power penetration. Numerous traditional and artificial intelligence strategies have been developed to create accurate wind power forecasts. It is well known that time-series-based algorithms are simple, trustworthy, and have been applied to forecasting in the past with varied degrees of success. Artificial intelligence-based forecasting techniques like ANN, Fuzzy Logic, and others have lately received support from a number of researchers due to their adaptability. In this study, two artificial intelligence systems are compared to traditional forecasting techniques for wind energy. One of the most dependable and simple time-series techniques, Autoregressive Moving Average (ARMA), is used in the conventional method discussed in this study. Artificial intelligence methods include Adaptive Neuro-fuzzy Inference Systems (ANN) and neural networks (ANFIS). ARMA is suitable for very-short-term wind speed and power forecasting (10 minutes ahead), while ANNs and ANFIS are suitable for short-term wind speed and power forecasting, according to simulation results for both very-short-term and short-term forecasting (1 hour ahead).

[6] proposed the recent and new advancements in wind forecasting is provided, with an emphasis on fundamental ideas and real-world applications. Because wind power generation is unpredictable and variable, power system operators face a variety of challenges as a result of the significant penetration of wind power in the electrical grid. The power system operators can reduce the risk of an unpredictable electricity supply even when wind energy might not be distributed by utilising an accurate wind speed and power generation forecasting approach. This essay provides a review of the research on the different types and primary approaches to wind forecasting. The direction for future development of wind forecasting is suggested based on the evaluation of wind speed and power forecasting techniques.

[7] proposed the main energy sources used to meet the world's rising energy demand, wind power has attracted the attention of energy authorities in many nations. However, due to climate change, careful consideration is required when determining the wind power potential in a certain place. Forecasting wind power potential as well as wind power generation is crucial in this regard. In this study, ANN models are created to forecast the production of wind energy at Sri Lanka's a working wind farm. The wind speed, wind direction, and regional ambient temperature were utilised as the independent variable matrices while the generated wind power was used as the dependent variable in the ANN models that were built. The models were evaluated using three training algorithms: Levenberg-Marquardt (LM), Scaled Conjugate Gradient (SCG), and Bayesian Regularization (BR). The model was calibrated for five validation percentages (5 percent to 25 percent in 5 percent intervals) for each approach in order to select the best training algorithm with the most appropriate training and validation percentages. The following metrics were used to evaluate the performance of the developed ANN models: Nash number, mean squared error, coefficient of correlation, and RMSE ratio. With R > 0.91, MSE 0.22, and BIAS 1, the results demonstrated that all three training methods provide estimates for the wind farm's power generation that are reasonable. The best forecasting results are obtained while using the LM training approach with a 70% training and 5% validation percentage. The forecast for wind farms can be successfully applied using the suggested models.

V. EXISTING AND PROPOSED SYSTEM

- The physical technique can produce a specific WPF model for a wind farm without much previous data.
- This method in particular needs specific physical characteristics of wind turbines and wind farms in order to develop an accurate model.
- The SVM algorithm is employed.
- The model's lack of adaptability is also a result of the particular geographic conditions and the operational status of the wind turbines, which are difficult to collect in a short length of time. In order to develop the forecasting model, the statistical approach needs a lot more historical data collection than the physical approach does.
- The time series model is typically used in conventional statistical methods to forecast wind power, depending on the continuity principle.
- There has been a lot of use of data mining techniques for categorization and prediction issues. The suggested method relies on data mining and the k-means clustering and bagging neural network.
- A wind energy forecasting system. In order to remove inaccurate data, standardise the training samples, and select the most relevant variables as the neural network's inputs, data preprocessing is first performed on the vector space.
- After preprocessing, data are clustered using the ANN algorithm, and then the training set that most closely reflects the forecasting day is selected.

VI. PROPOSED SYSTEM ARCHITECTURE

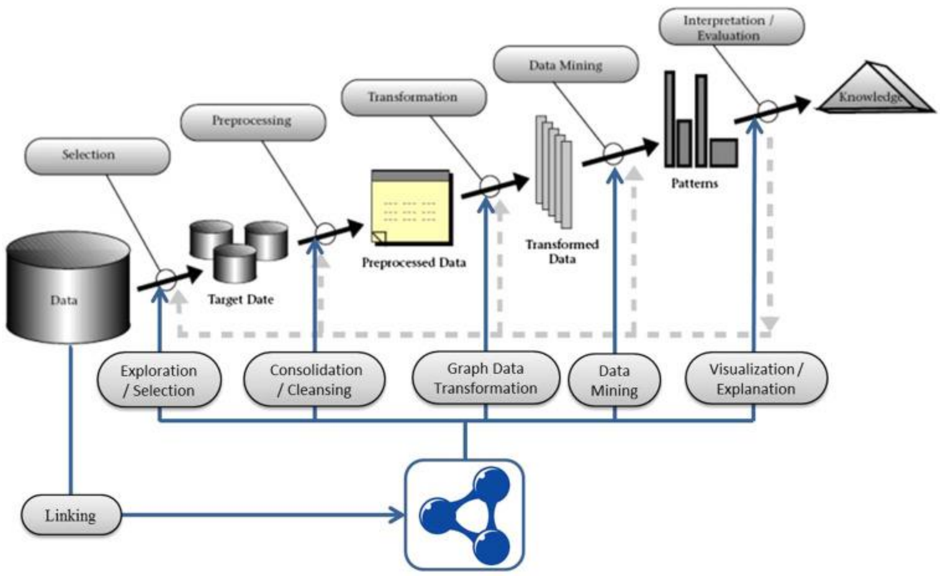

Figure : The above figure shows the architecture of proposed system.

Description: The data undergoes various processes such as **selection** where the data is selected as per to the requirements, **preprocessing** where the null values are eliminated that can cause the error in upcoming process, **transformation** where the data is processed, converting raw data into a format or structure that is more suitable for model development and data discovery in general. **Data Mining** is one of the more commonly used terms in the subject of machine learning. It is the process of obtaining meaningful information from a large number of datasets and applying it to assist in decision-making. Both corporations and academic institutions regularly use it as a way for identifying trends in a pre-existing database, and finally one of the most common charts for easy data view in machine learning and data science is **Visualization**.

VII. FLOW DIAGRAM

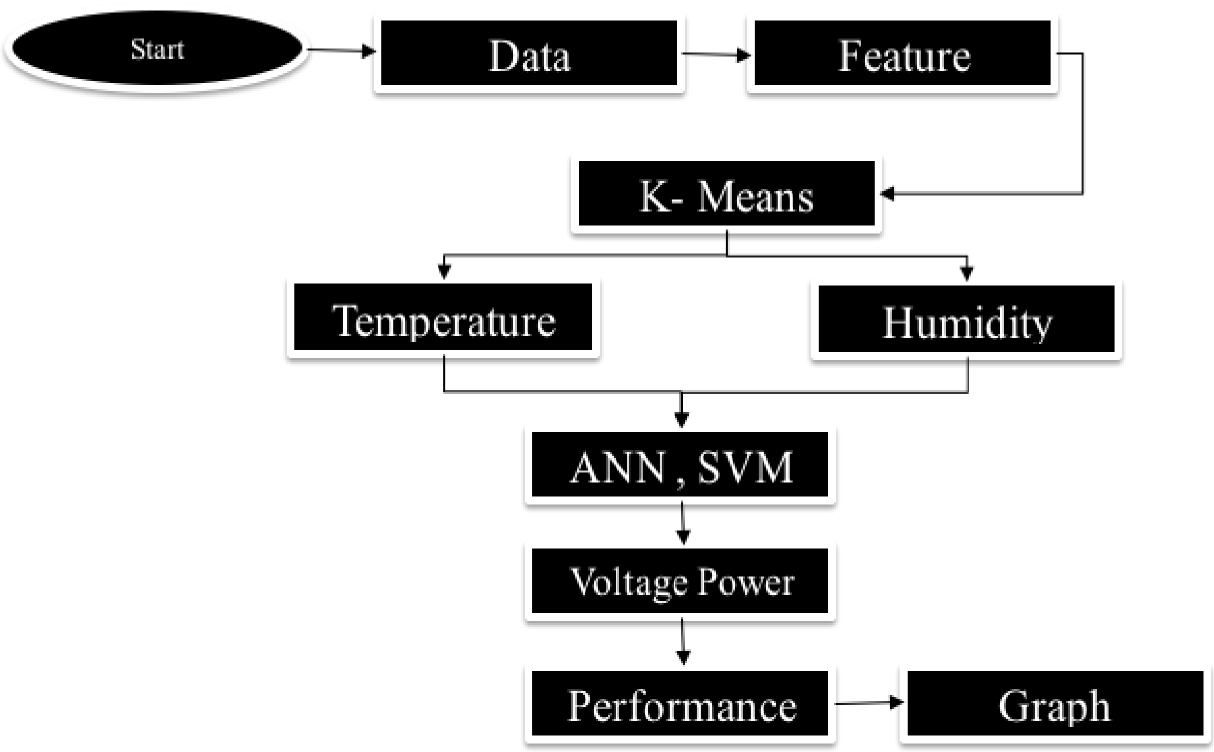

Figure : Figure shows the flow diagram.

Description: Flow diagram shows the steps involved in the project where dataset is first collected, then the Features are selected accordingly, k-means algorithm is applied to the extracted feature that is Temperature and Humidity, then the ANN and SVM Algorithm is applied to both of the selected features, voltage power is predicted and it's performance, finally the visualization of data is done.

VIII. OUTLINE OF ADVANCES

SVM

Classification and regression issues are resolved using SVM, one of the most used supervised learning algorithms. It is mostly used, nevertheless, in Machine Learning Classification problems.

The extreme vectors and points that help create the hyperplane are chosen via SVM. The SVM approach is based on support vectors, which are utilized to represent these extreme situations. Take a look at the diagram below, which uses a decision boundary or hyperplane to separate two different categories:

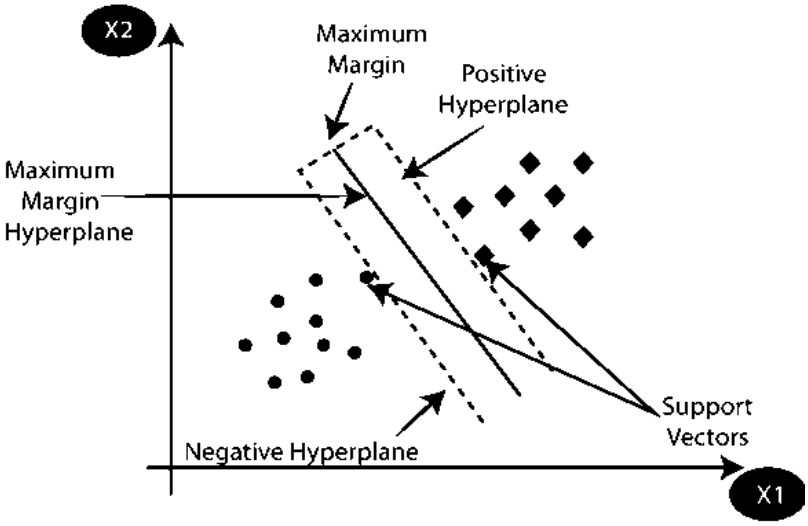

Figure : The above figure shows a decision boundary or hyperplane is used to categorize.

Different SVMs

SVM comes in two varieties:

Linear SVM: Data that can be separated into two classes by a single straight line are used for linear SVM. The classifier used is referred to as a Linear SVM classifier, and this type of data is known as linearly separable data.

Non-linear SVM: For non-linearly separated data, Non-Linear SVM is utilized. A dataset is deemed non-linear if it cannot be categorized along a straight line, and the classifier used is referred to as a Non-linear SVM classifier.

ANN

An area of AI known as ANN was developed after the brain and is influenced by biology. An ANN is a term used to describe a computational network that is based on biological neural networks, which are responsible for the structure of the human brain. Similar to neurons in a biological brain, ANN neurons are connected to one another in various layers of the networks. These neurons are referred to as nodes.

An ANN's structure:

To understand the concept of the architecture of an ANN, one must first understand the elements of a neural network. A neural network is made up of a huge number of artificial neurons, sometimes referred to as units, that are arranged in a hierarchy of layers. Let's look at the many levels that an ANN can contain.

Generally speaking, an ANN has three layers:

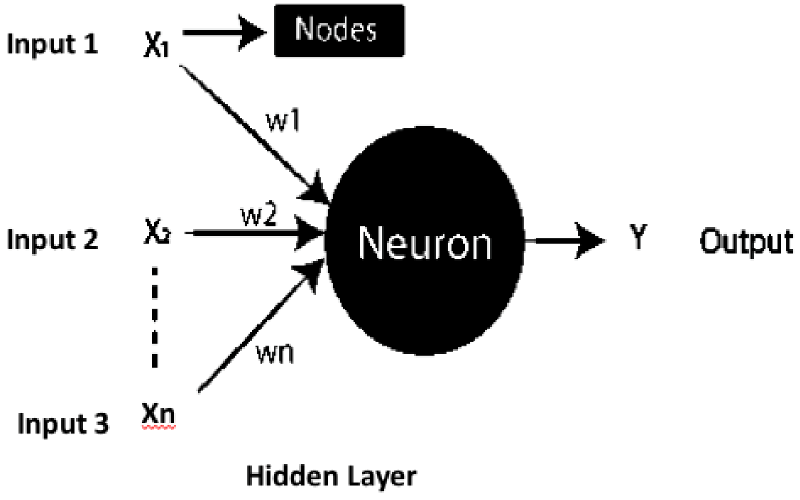

Figure : The above shown figure shows the 3 layers of ANN.

Input Layer :

It accepts input in a number of programming-provided forms, as the name suggests.

Hidden Layer :

The hidden layer lies between the input and output layers. It does all the calculations required to find hidden patterns and features.

Output Layer :

The input is changed by the hidden layer into a number of different outputs, which are subsequently sent through this layer.

The ANN computes the weighted sum of the inputs when provided input and includes a bias. This algorithm is visualized using a transfer function.

$$\sum_{i=1}^{n} Wi * Xi + b$$

Where, Wi is the total computed weight

Xi is the input value

B is the bias

In order to produce the output, it passes the weighted total as an input to an activation function. A node's activation functions determine whether or not it should fire. The output layer is only accessible to individuals who are fired. Depending on the type of task we are completing, there are many activation functions that can be used.

How do ANN function?

It feeds the weighted total as an input to an activation function, which outputs the result. The activation functions of a node control whether it should fire or not. Only those who are fired have access to the output layer. There are numerous activation functions that can be used, depending on the sort of task we are accomplishing.

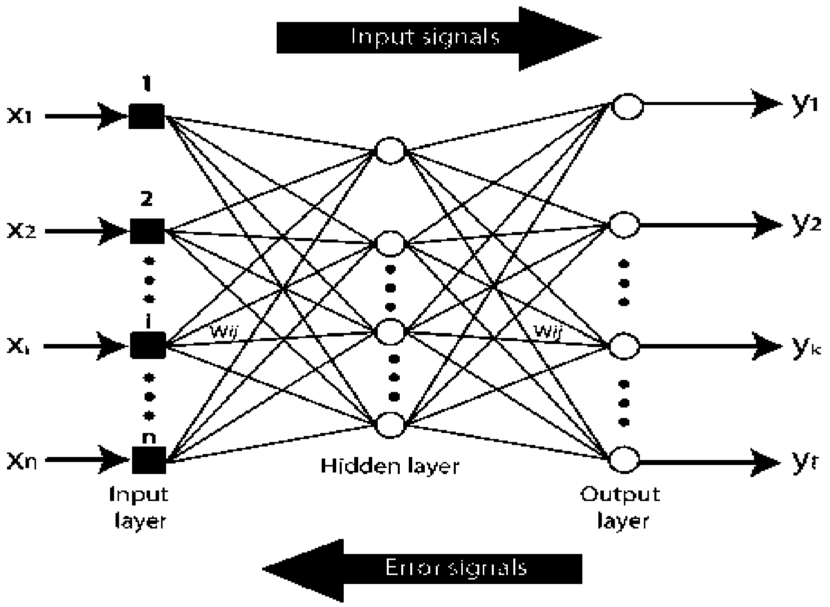

Figure : The given figure represents the visualization of the ANN function.

The associated weights are then multiplied by each input (these weights are the details utilized by the ANN to solve a specific problem). These weights in the ANN frequently represent how interconnected the neurons are. Each weighted input is summarized inside the computer unit.

IX. RESULTS AND DISCUSSION

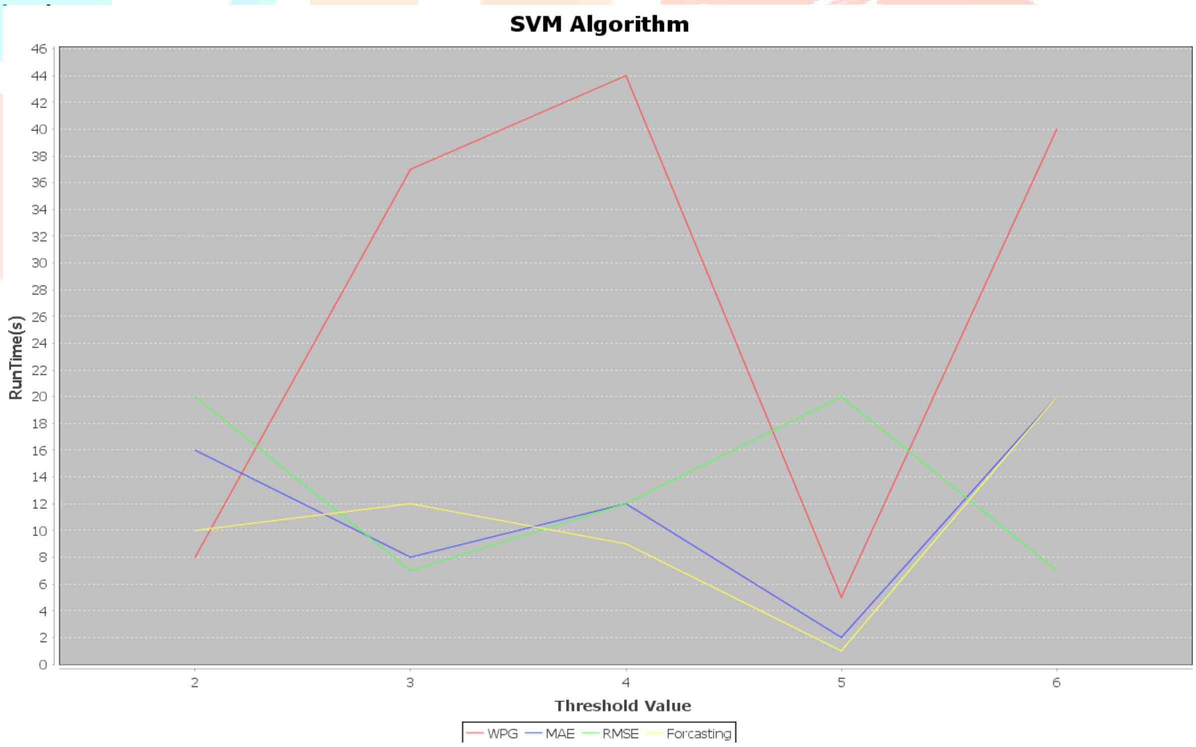

Figure : The above figure shows the SVM Result.

Description: Graphical representation of the SVM, where the red line indicated the WPG, blue represents the MAE, green represents the RMSE and yellow is represented by the forecasting result.

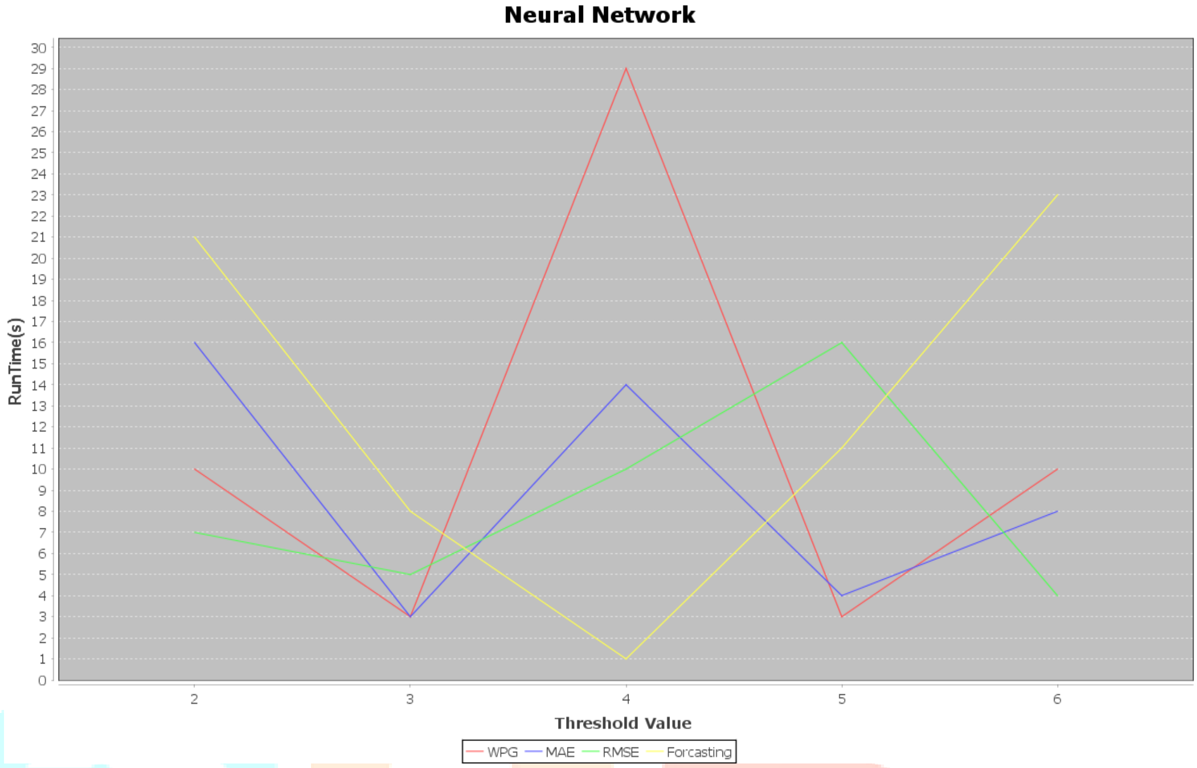

Figure : The above figure shows the ANN result.

Description: Graphical representation of the proposed ANN, where the red line indicated the WPG, blue represents the MAE, green represents the RMSE and yellow is represented by the forecasting result.

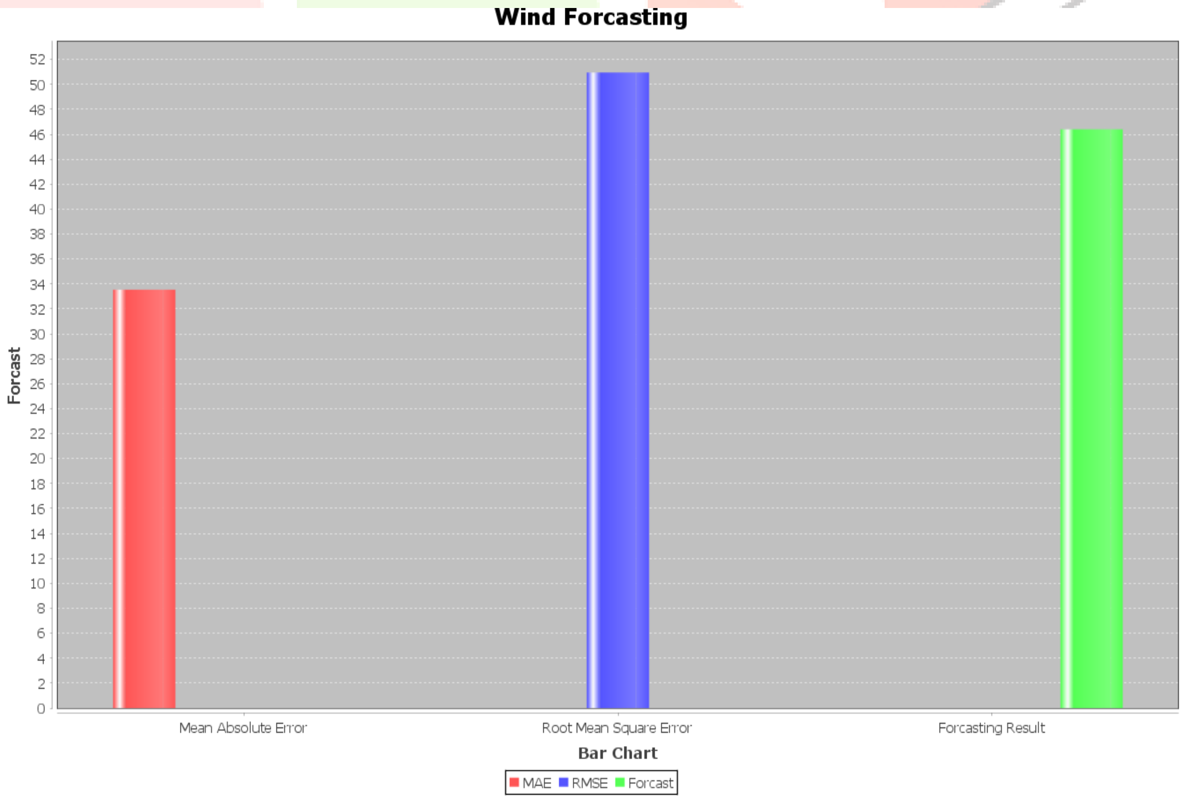

Figure : The above snapshot shows the bar graph.

Description: Above shown bar graph is the representation of MAE, RMSE and forecasting result.

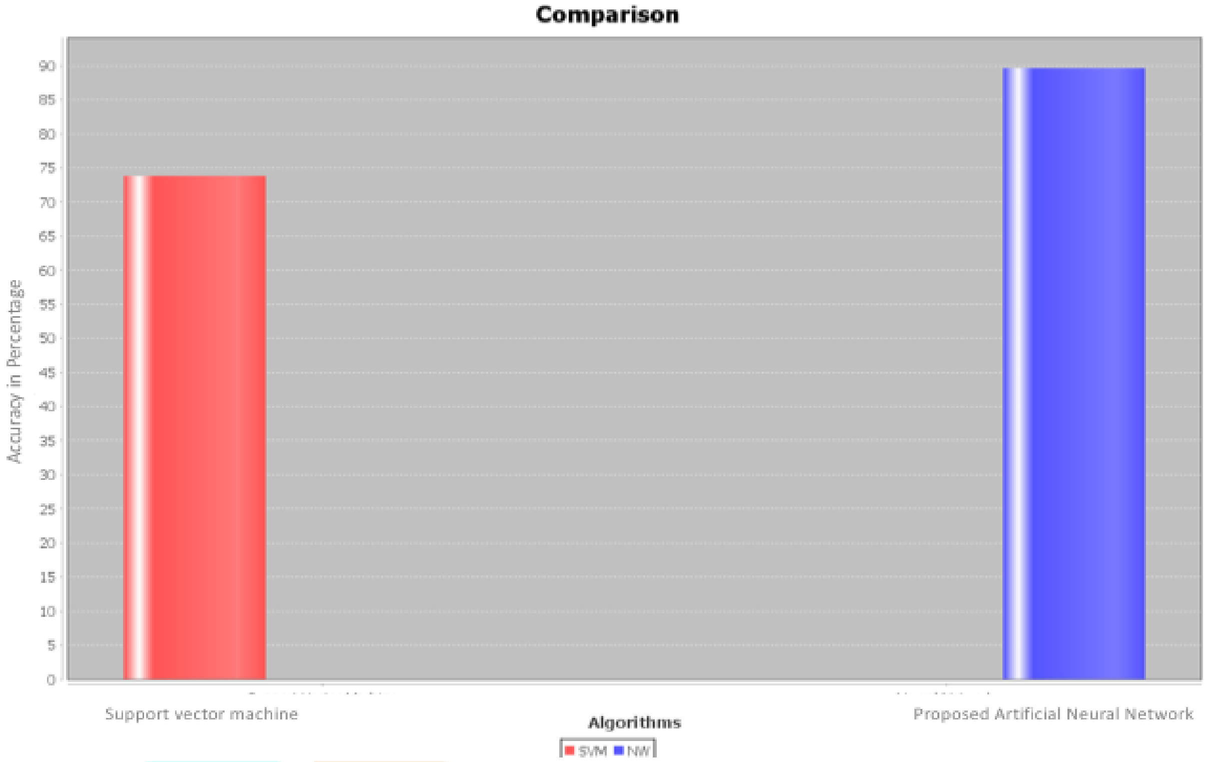

Figure : The above snapshot shows the comparison on SVM and ANN

Description: Comparison of SVM and proposed ANN algorithm is shown above, where the y axis represents the accuracy in percentage and x axis represents the algorithm.

X. CONCLUSION AND FUTURE SCOPE

Wind energy is an important source of renewable energy. Only a small fraction of what the wind produces is power. In contrast to coal, wind turbines don't emit greenhouse gases and are an entirely renewable source of energy. A key area of AI based ML is deep learning. The primary goal was to increase short-term wind power's effectiveness. ANN is the proposed system. The proposed ANN algorithm performs better in terms of improved accuracy of 14% as compared to the existing system, less percentage of MAE and RMSE of 70.01 and 77%, respectively, as compared to the existing algorithm, and increases the efficiency of short-term wind power, according to experimental results (SVM).

This can be done in the future with the help of temperature and humidity sensors, which measure the temperatures and humidity in their immediate environment and convert the input data into electronic data for monitoring, recording, signal, temperature and humidity sensors can calculate the amount of water vapor in the air.

REFERENCES

[1] Jung and R. P. Broadwater, "*Current status and future advances for wind speed and power forecasting*," Renew. Sustain. Energy Rev., vol. 31, no. 2, pp. 762-777, Mar.2019.

[2] Carvalho, A. Rocha, M. Gómez-Gesteira, and C. Santos, "*A sensitivity study of the WRF model in wind simulation for an areaof high wind energy*," Environ. Model. Softw., vol. 33, no. 7, pp. 23-34, Jul. 2019

[3] Foley, P. G. Leahy, A. Marvuglia, and E. J. McKeogh, "*Current methods and advances in forecasting of wind power generation*" Renew. Energy, vol. 37, no. 1, pp. 1-8, Jan.2017

[4] Xu et al., "*A short-term wind power forecasting approach with adjustment of numerical weather prediction input by data mining*," IEEE Trans. Sustain. Energy, vol. 6, no. 4, pp. 1283-1291, Oct.2018.

[5] Colak, S. Sagiroglu, M. Yesibudak, E. Kabalci, and H. I. Bulbul, "*Multi-time series and-time scale modeling for wind speed and wind power forecasting-Part I: Statistical methods, very short-term and short-term applications*," in Proc. IEEE ICRERA, Palermo, Italy, Nov. 2018, pp.209-214.

[6] Yuan-Kang,Po-En-Su,"Strati?cation-Based Wind Power Forecasting in a High-Penetration Wind Power System Using a Hybrid Model",IEEE,June-2016, Vol.53, N0. 3.

[7] K. Bhaskar and S. N. Singh, "*AWNN-assisted wind power forecasting using feed-forward neural network*," IEEE Trans. Sustain. Energy, vol. 3, no. 2, pp. 306-315, Apr.2012

[8] S. Li, P. Wang, and L. Goel, "*Wind power forecasting using neural network ensembles with feature selection*," IEEE Trans. Sustain. Energy, vol. 6, no. 4, pp. 1447-1456, Oct.2015.

[9] X. Zhang, R. Wang, T. Liao, T. Zhang, and Y. Zha, "*Short-term forecasting of wind power generation based on the similar day and Elman neural network*," in Proc. IEEE SSCI, Cape Town, South Africa, Dec. 2015, pp.647-650.

[10] M. Peng, S. Yan, K. Zhang, and C. Wang, *"Fog computing based radio access networks: Issues and challenges," IEEE Network*, vol. 30, no. 4, pp. 46–53, Aug. 2016.

[11] A. Kusiak, H. Zheng, and Z. Song, "*Short-term prediction of wind farm power: A data mining approach," IEEE Trans. Energ. Conver.*, vol. 24, no. 1, pp. 125-136, Mar. 2009.

[12] I. Colak, S. Sagiroglu, M. Yesibudak, E. Kabalci and H. I. Bulbul, "*Multi-time series and -time scale modeling for wind speed and wind power forecasting part I: Statistical methods, very short-term and short- term applications," in Proc. IEEE ICRERA*, Paris, France, Nov. 2015, pp. 209-214.