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A VERY SHORT TERM WIND POWER FORECASTING USING BACK-PROPAGATION ALGORITHM IN NEURAL NETWORKS

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ABSTRACT

This paper presents an application of Artificial Neural Networks-Back Propagation (ANN-BP) for wind power forecasting. The need for accurate forecasting keeps on increasing as power demands and power markets are becoming more competitive and complex structure in integrating wind power into the grid power system. This paper presents a model for wind power forecasting for the very short term scheduling.

Keywords: wind power forecasting, ANN, back propagation algorithm.

INTRODUCTION

The inaccessibility of adequate energy sources is a major challenge in the present trend for developed and developing countries. The limited availability of commercial energy sources makes renewable energy sources in all its forms keeping future purposes in view. Wind and solar energy is considered as the best alternate source for fossil fuels. Many developing nations such as India, USA, China has launched upon many wind power projects all over the country to meet the power demand. The operation of a wind power system is generally divided into four different categories: long term, medium term, short term and real-time. Long-term power forecasting is primarily associated with maintenance and scheduling of generator throughout the year. It considers previous data and predicts power well over a year in advance. Medium-term scheduling is used primarily for fuel planning and operations between maintenance checks and upgrades. It generally considers time frames from a week to a year ahead. Short-term scheduling is the operation of a power system from anywhere between five minute load schedules to week-ahead planning.

This paper investigates short-term forecasting for wind power system. Since power scheduling is the major problem in integrating wind power into the grid power system. However it follows a sub -class referred to as very short-term forecasting. Very-short-term forecasting is predominantly focused on predicting the value of the next period for a week to year depending on applicable data set. In this instance, that period of a year data is used based on operating cycle of a suzlon machine.

NEED FOR FORECASTING

Very-Short-Term scheduling is widely recognized as an essential element of scheduling the grid connected power system operation. Due to high production costs, small increases in efficiency also lead to large savings. This means that utilities are always in need of a more efficient means of short term operation. When considering short term scheduling and economic dispatch, accurate demand forecasts are essential. The forecasts are used to reduce the difference between the power available and the power consumed by the utility. The use of forecasting techniques for load forecasting is a topic widely discussed in power engineering all over the world. In this paper wind power forecasting is described for a Very-Short-term by developing an ANN model.

FORECASTING PARAMETERS

For efficient operation of a power system, it is important to have good predictions to determine the system's operation. For example, if the wind speed is not accurately forecasted, it becomes very difficult to properly schedule wind resources. power forecasting can be scheduled in several ways, including weather dependent, weather independent and a combination of the two.

While, comparing the success of three, the weather independent models have main advantage. This is because of its greater accuracy in prediction. However, some power stations are dependent on the weather predictions for operation and thus the accuracy is more important as the weather predictions are already an integral part of the system. Load forecasting is highly important and has been researched quite extensively using various traditional methods and in recent years, artificial intelligence techniques have also been applied to this field. In this paper wind power is forecasted using ANN by training the model with the collected weather data.

FORECASTING PATTERN

Collected weather observations are set the initial conditions, but there is never enough data as the wind speed, temperature, and humidity data dwindle quite very fast. Numerical Weather Prediction (NWP) modes forecast evolution of weather systems Figure-1. Statistical models convert wind to power output and the system is corrected based on the error patterns.

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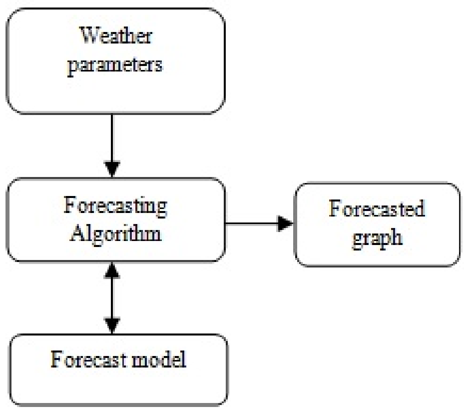

Figure-1. Forecasting pattern.

BACK PROPAGATION NEURAL NETWORK

Neural Networks (NNs) are networks of neurons, for example, as found in real (i.e. biological) brains. Artificial Neurons are crude approximations of the neurons found in brains. They may be physical devices, or purely mathematical constructs. They may be physical devices, or simulated on conventional computers. From a practical point of view, an ANN is just a parallel computational system consisting of many simple processing elements connected together in a specific way in order to perform a particular task.

This paper proposes models using ANN because they are extremely power computational devices. Massive parallelism makes them very efficient. They can learn and generalize from training data- so there is no need for enormous feast of programming. They are particularly fault tolerant- this equivalent to the “graceful degradation” found in biological systems. They are very noise tolerant- so they can cope with situations where normal symbolic systems would have very difficult.

A. Network topology

The ANN follows two distinctive patterns Feed-forward networks and recurrent networks. Feed-forward networks, where the data flow from input to output units is strictly feed forward . The data processing can extend over multiple units, but no feedback connections are present, that is, connections extending from outputs of units to units in same layer or previous layers.

Recurrent networks also contain feedback connections. In some cases, the activation values of the units undergo a relaxation process and hence change the activation value of the output neurons. Most commonly feed-forward back propagation algorithm is used.

B. ANN model

The feed-forward multi layer back propagation topology, is most commonly used in power electronics and motor drives. The name “back propagation” comes from the method of supervised training used for NNW. The network is normally called Multilayer Perceptron (MLP). The network shown has three layers: (a) input layer, (b) hidden layer and (c) output layer.

With six neurons in the hidden layer it is normally indicated as 3-6-1 network Figure-2. The input layer is nothing but the nodes that distribute the signals to the middle layer. Therefore, the topology is often defined as two-layer network. In this paper ANN model Figure-2. is developed due it its greater flexibility, and capable of handling rapidly fluctuating data patterns.

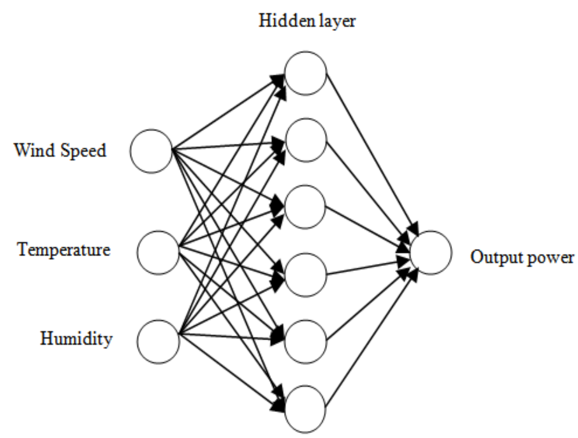

Figure-2. General ANN model.

WEATHER PARAMETER GRAPH

The wind speed, temperature, humidity data are collected from the site in Tamil Nadu. The machine considered for study is S-64/1.5MW. It is a three blade, up wind, horizontal type rotor producing 1.5MW power. The wind speed, temperature, humidity data are collected regularly and their respective maximum power generated is recorded along with their operating hours per day.

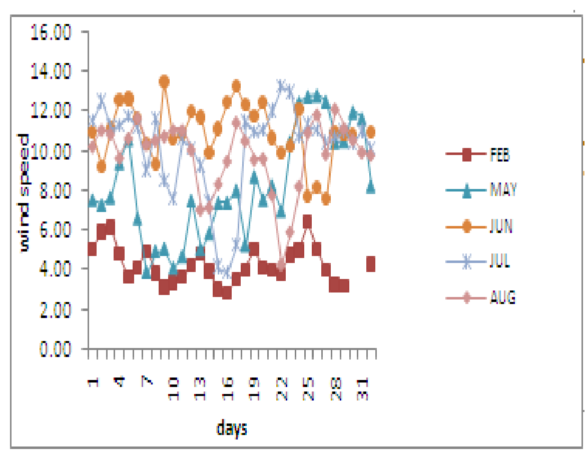

Figure-3. Average speed graph.

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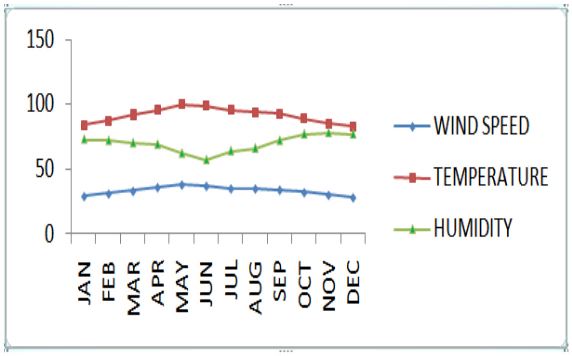

Figure-4. Average monthly weather graph.

The Figure-3., Figure-4. shows high wind speed producing months and the average monthly weather condition in a year, respectively.

DEVELOPED NETWORK

The network is developed using cascaded Back Propagation Algorithm. The developed network is then trained using the collected data. Wind speed, temperature and humidity are given as the input data and the generated wind power is given as the target data to train the developed network.

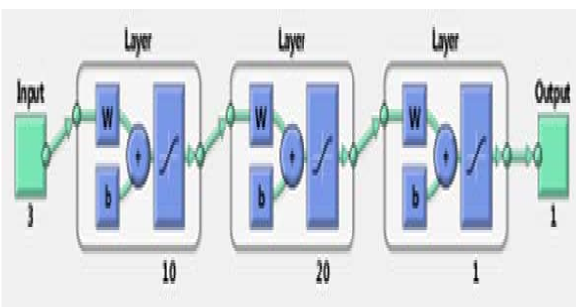

Figure-5. Developed network.

The network is developed using the MATLAB 11. In Figure-5 network the input is wind speed, temperature, humudity and generated power is the target data. The network type is feed forward backdrop. This model is developed to study the performance function of the network by determining the Mean Square Error (MSE) of the developed network. The transfer function used in the network is TANSIG that is hyperbolic tangent sigmoidal transfer function. This is used due to its high convergence in the result .

A. Performance graph

By training the developed network with the collected data Figure-6 is obtained.

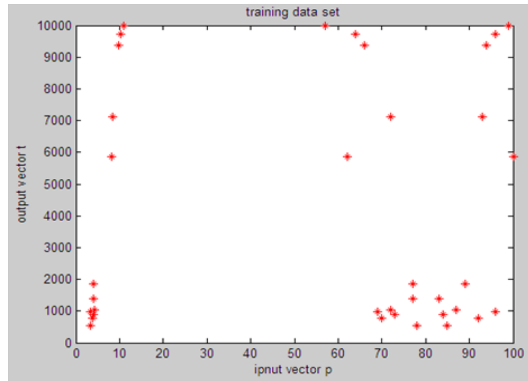

Figure-6. Training data graph.

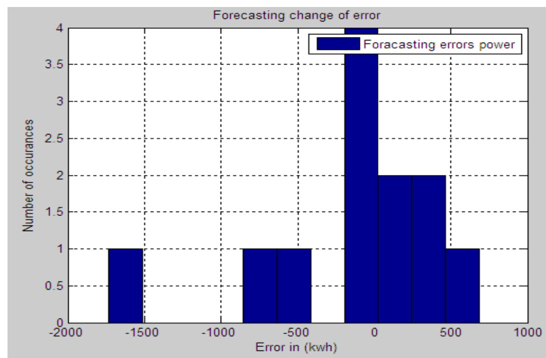

Figure-7. Forecast error graph.

From the developed error graph pattern Figure-7. the developed network is corrected for reducing the developed error. The graph shows the maximum error in kwh and the number of occurrences. The purpose of this graph is to reduce the error occurrences.

The Figure-8.shows the training graph of the developed neural network. The respective performance graph are shown below.

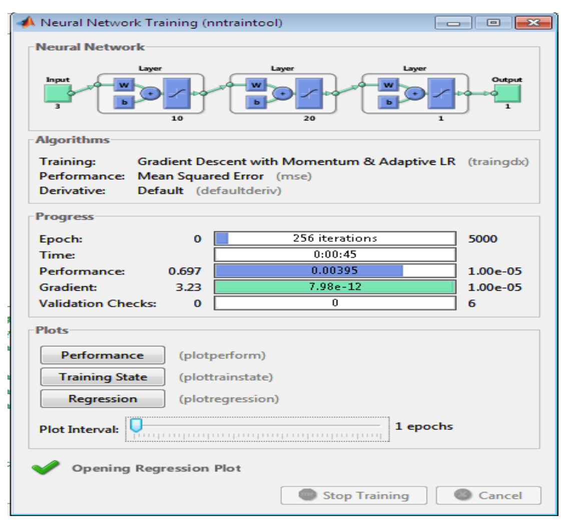

Figure-8. Neural network training graph.

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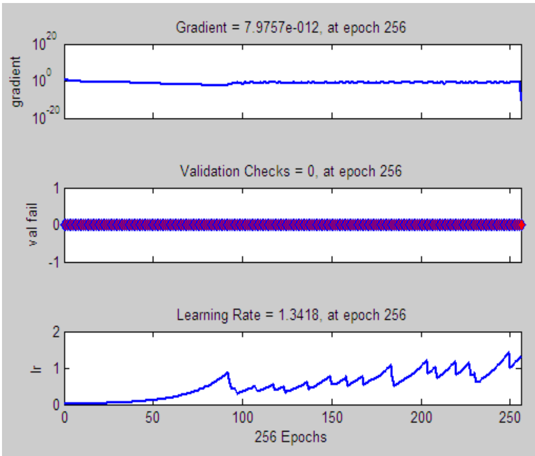

Figure-9. Training state.

Figure-9 represents the training sate of the developed neural network model, it represents the learning rate graph and the validation graph.

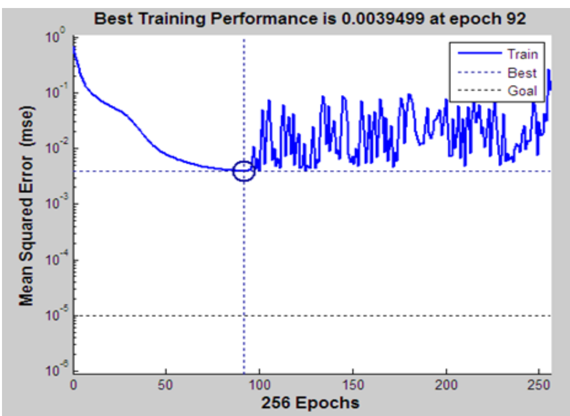

Figure-10. Mean square error graph.

From Figure-10 it is evident that the Mean Square Error (MSE) of the develop network is 0.0039499 at 92 epoches. The network produces the least mean square error with the greater accuracy in wind power forecasting. Now for the developed network a MATLAB program is developed for power forecasting.

FORECASTED WIND POWER

By training the developed Neural Network with the collected wind speed, temperature, humidity data as input and generated power data as target data the wind power is forecasted by developing the MATLAB program.

From Figure-11 it is observed that the average monthly wind power is forecasted from the developed program. It is evident that the obtained MSE is minimal and hence the developed network is efficient for the forecasting.

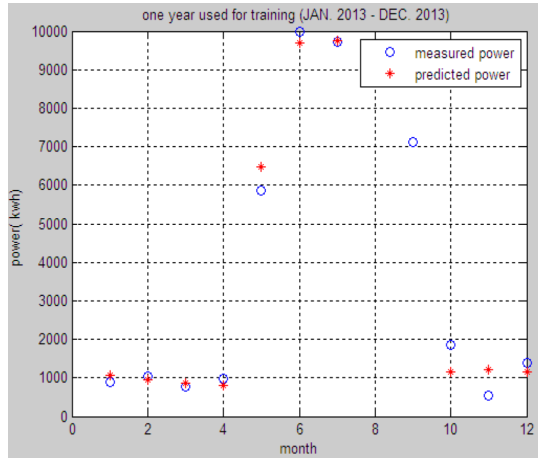

Figure-11. Forecasted graph.

CONCLUSIONS

The developed network shows that the Mean Square Error (MSE) obtained is 0.0039499 which is very minimal and hence the accuracy in forecasting increases. This network forecast the average monthly wind power by training the network using the collected wind speed, temperature and humidity data. The study shows that ANN is an excellent technique for power forecasting and is likely to work very well for other forecasting applications as well. This is due to its higher degree of accuracy, reduced complexity.

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