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MODELING OF WIND POWER PLANT USING ARTIFICIAL NEURAL NETWORK

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Abstract: The Wind Power Generation in the Power System Increases Rapidly in present and in the later trifling years. The fluctuation of electric power produced by wind power plants, will build, prompting greater expenses associated with the balance of generation and demand. This paper presents an application of artificial neural network for Modelling of Wind Power plant. The proposed algorithm is based on three parameter i.e. blade diameter, wind speed, and the blade pitch angle. The yield will be the power flow. The algorithm has been skilled with the collected data and then we are able to establish a model of wind Power plant. The proposed scheme is capable of modeling the parameters of wind power plant. The appearance of tested outcome is that the neural net trained data give more accurate result.
Keywords: Artificial neural network, Blade Diameter, Blade Pitch angle, Wind Speed

INTRODUCTION

Energy is avenue for human well-being, growth, development. To certify everybody has adequate access to power is challenge for worldwide development. The source for the blossoming of energy are coal, wind, solar, water etc. Production of energy affects the climate. Authentic and modern way of energy generation are influenced by fossil fuel (coal, gas, and oil) which produce harmful substances like carbon dioxide, greenhouse gases. These substances are the heart for global warming. The Environment is on fatal line. To redeem the aura, the world needs to transit the energy sources. Taking a deviation from non-renewable energy source to sustainable energy source for generation of energy will be a huge contribution to save the environment [18,19]. Wind power has been utilized for a sustained time for processing grains, siphoning water, and cruising the oceans. In the evolution of recent decades, an assortment of wind control advancements have been created, which have improved the change effectiveness of and diminished the expenses for wind power generation. But the progress of large capacity power plants (wind, solar etc.) requires new approaches to analyze plant dynamics for control purposes. It is a challenge to design a new model without specification of components. In order to design a control system for a power plant, it is necessary to develop a model in advance [1]. In the ancient time the technique which has been used in the electrical power industry is the mathematical optimization for many power systems operations, planning, and control problems. Mathematical formulations of real-world problems are derived under certain presumption and even with these presumptions; the result of modern power systems is not simple. Then again, there are numerous vulnerabilities in control framework issues due to their huge, complex, and topographically broadly dispersed nature. Simple model are easy to manage with mathematical modeling but if we see complex structure (solar, wind, thermal power plants etc) mathematical modeling is not a solution. Mathematical model is the simplification of the real problems and does not include all aspect of the problems. The mathematical model may work only in certain situation and with specified range. These facts make it complicated to deal effectively with many problems in this area through strict mathematical formulation alone [2]. In this manner, artificial intelligence techniques which ensure a worldwide ideal or about along these lines, for example, master frameworks, genetic algorithm, fuzzy logic, and Artificial neural network have risen as of late as a supplement apparatus to regular numerical procedures [3].

The paper is split into different sections as follow. In SECTION II, the detail of artificial neural network has been provided. In SECTION III the methodology which has been used is explained in detail. Further the SECTION IV and SECTION V justify the result and conclusion obtains with future scope.

OUTLINE OF ARTIFICIAL NEURAL NETWORKS

The investigation of Artificial neural systems (ANN) is roused by their closeness to effectively working biological system, which in contrast with the general system comprise of extremely basic however various nerve cells that work enormously in resemble and have the skills to grasp from training samples .One outcome from this learning strategy is the capacity of neural systems to sum up and partner information. After fruitful preparing a neural system we can find sensible answers for comparative issues of a analogous class that were not especially trained. This thusly brings about a high level of adaptation to internal failure against input data. The cerebrum is

tolerant against interior blunders and furthermore against outer mistakes. Our modernized society, in any case, isn't consequently shortcoming tolerant. Hence artificial neural network is used. Artificial Neural Network is nonlinear information driven self-versatile methodology instead of traditional model based technique. They are amazing asset for demonstrating particularly when the basic information relationship is unknown. ANN can recognize learn connect design between input informational index and target information. In the wake of preparing the ANN can be utilized to visualize the new free data. ANN copies the learning procedure of the human cerebrum and can process the issues including non-straight and complex information if the information are uncertain and loud. The wording of artificial neural system has created from organic model of the mind. The human cerebrum gives proof of the presence of huge neural systems that can prevail at those psychological, perceptual, and control assignments in which people are fruitful. The cerebrum can do computationally mentioning perceptual acts and control exercises. Treelike systems of nerve fibers called dendrites are associated with the cell body or soma, where the cell core is found. Reaching out from the cell body is a solitary long fibers called the axon, which inevitably branches into strands and sub strands, and are associated with different neurons through synaptic terminals or neurotransmitters [4]. With the help of Table 1 we can easily correlate the terminology of biological and artificial neural network.

Table 1-Terminologies of biological and artificial neural network

Biological Neural Network	Artificial Neural Network
Cell Body	Neurons
Dendrite	Weights
Soma	Net input
Axon	Output

The architecture of artificial neural network is described in Fig-1. There are three different layers, the input layer in which the input parameters are provided which are denoted by $x_1, x_2 \ldots x_n$, the output layer from which we get the desired output as y and the hidden layer. The purpose of hidden layer is to apply weights so that the desired output is obtained. The improvement of ANN includes two stages: preparing or learning stage and testing stage. During preparing, the synaptic loads get altered to show the given issue. As soon as the system has taken in the issue it might be tried with new obscure examples and its effectiveness can be checked. Most utilizations of ANN show that the back-propagation system is an incredible asset for developing nonlinear functions among several esteemed sources of info and at least one continuous esteemed output. Due to their capability to map complicated and nonlinear relationships of input-output patterns, ANN has become a powerful computing technique, and has thus inspired many people to apply them to various system problems.

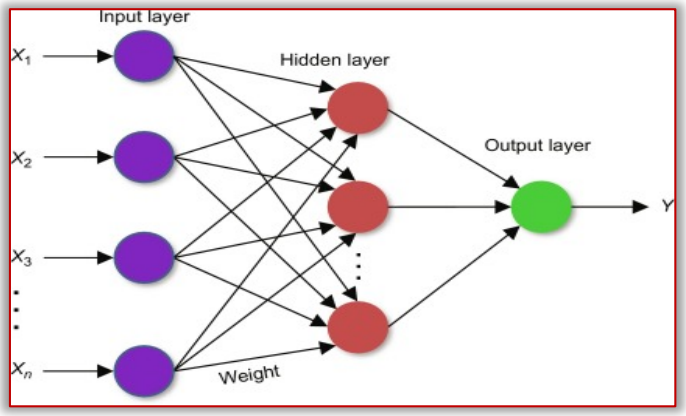

Figure 1-Architecture of Artificial Neural Network

Learning can be characterized as the capacity to perform better at a given assignment with experience. The learning procedure of the mind includes modifying organic neural structure, evolving the quality of associations relying upon activity. This learning procedure can be demonstrated by changing the loads of the associations between nodes in the structure. Learning calculations are incredibly valuable when it comes to complex perceptual issues which are hard to be composed by a developer [6]. Depend upon the training Imparted, ANN can be classified as supervised ANN, unsupervised ANN and Re-enforcement ANN.

A. Supervised ANN:

The managed ANN requires the arrangements of information sources and the output for its preparation. During the preparation, the output from the ANN is analysed and the ideal yield (target) and the error (mistake) is diminished by utilizing some method. This preparation is rehashed till the real yield secures a satisfactory level. Supervised ANN might be a forward or non-recurrent system.

B. Unsupervised ANN:

The artificial neural system which doesn't require a predominant or instructor for preparing is known as unsupervised ANN. In aggressive or unsupervised learning units of the output layer seek the opportunity to react to a given info design.

C. Re-enforcement ANN:

In this learning system, the learning of a data yield mapping is performed through continued with nature in order to constrain a scalar record of performance. The expert changes over a primary re-source signal got from the environment into a higher re-witness signal called the heuristic re-source signal, the two of which are scalar data sources [3].

ANNs are utilized in fields because of their various points of interest, for example medication, science,

mechanical technology, geospatial investigation, and so forth. ANNs can be utilized to produce capacities to clarify a specific marvel when the information doesn't enable such capacities to be made by hand. The primary favourable circumstances are:

- Adaptive learning: They can figure out how to perform undertakings through a preparation procedure.
- Self-association: ANNs can make their very own structure to speak to the data through a preparation procedure
- Fault resilience: The ANN can in any case work when its structure is harmed (resistance to debasement), and twisted or deficient when the information are loud (resistance to information).
- On-line activity: They can be executed in parallel and work quickly. Subsequently, they are uniquely modified to complete on-line forms.
- Easy usage into the frameworks: There are particular chips that can encourage the incorporation of ANNs into the framework

The NNs are helpful for taking care of a wide scope of issues from seven classes:

- Pattern order: The ANNs can recognize designs in a dataset through administered learning.
- Clustering: The information similitude, or dissimilarities, is distinguished through unaided learning. The system will dole out comparative information to a similar gathering (or group).
- Function estimation: ANNs can be applied to issues where a hypothetical model can't be applied. They can rough the info information to a capacity with a specific level of detail.
- Forecasting: A NN can be prepared by time arrangement to get an expectation of things to come conduct.
- Optimization: An answer that amplifies, or limits, a capacity subject to various requirements can be found.
- Association: A cooperative system can be utilized to remake adulterated information by building up an affiliated example.
- Control: It is conceivable to decide the sources of info that will cause an ideal framework conduct. This exploration work thinks about the accompanying order, concentrating on the investigation of the most compelling and considered issues.[5]

DATA PREPARATION

The data preparation plays a crucial role in modeling of plant as the quality and quantity both has the impact on modeling. Modeling of wind power plant has been done on the basis of three parameters, Rotor Diameter, Wind Speed, and Blade Pitch Angle. The data is collected from different sites and trained using MATLAB Neural network toolbox. Levenberg-marquadt (trainlm) is the training algorithm, used; it is the back propagation technique. Back propagation is a supervised training technique for artificial neural systems. It assesses the error commitment of every neuron after a lot of information is handled. The objective of back propagation is to alter the loads in order to prepare the neural system to accurately map arbitrary inputs to yields [6]. The transfer function used is sigmoid symmetric (transig) and the simulink model is prepared with the help of gensim. After training the performance graph is plotted. The y axis shows the mean square error and the x axis shows the epochs. From the total readings taken of all the three parameters, 25% will be used for testing and 25% will be used for validation and remaining will be used in training.

- ≡ Training - In training, network is arrange and adjusted according to the error.
- ≡ Validation - They are used to measure the system speculation and to end preparing when speculation quits improving.
- ≡ Testing - Testing has no effect on training and so provide an independent measure of network performance during and after training.

A.ROTOR DIAMETER

Rotor blade radius maximizes the power output. Larger blade allows the wind turbine to acquire more kinetic energy but required more space. Modernized wind turbine have diameter of 40m to 90m and are rated between 500 KW to 2MW. In 2019 the average size of the rotor diameter is 129 m. Turbine are zoned out of four times the rotor diameter. In the event that you double the rotor diameter you get a cleared region which is four times as well as the four times power output from the rotor.

The rotor diameter data is collected from site [20]. In the collected data there were 21 readings of rotor diameter out of which 3,3 samples are used for testing and validation respectively and 15 are used for training purpose. To train the neural network only 10 sec has been taken. After this we can determine the neural net calculated data.

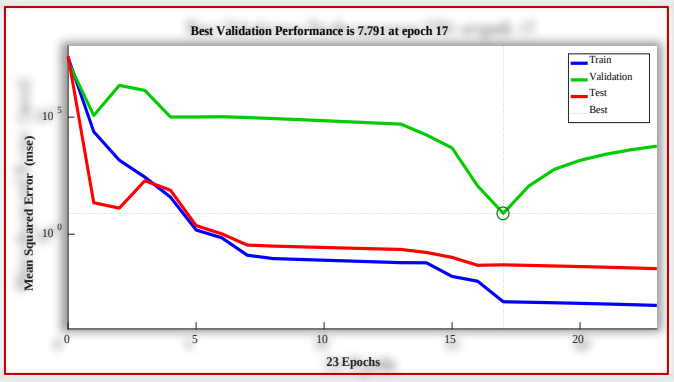

Figure 2- Rotor Diameter Performance graph

Fig-2 shows a plot of the training errors (Blue line), validation errors (Green line), and test errors (Red line) and the Best is denoted by dotted line with the circle in the graph. 23 epoch means it took 23 cycles to give the best result. The best performance is obtained with 15 number of hidden layer having Mean Square Error (MSE) and number of epoch of 7.791 and 17 respectively. The ANN trained structure has error of 0.01677.If the training plot (blue line) reached to zero than it depicts that the error is zero.

B.WIND SPEED

Wind speed to a great extent decides the measure of power produce by a turbine. Higher wind speeds cultivate more power because durable wind permits the blade to turn quicker. Turbines are designed in such a fashion so that it works inside a particular dimension of wind speed. The limit of range are known as cut in speed and cut out speed. The cut in speed is where the wind turbine can create control. Between the cut in speed and the evaluated speed where the most extreme output is arrived at the power yield will increment cubically. Cut out speed is where the turbine must be closed down to stay away from harm to the equipment. The wind speed of 2 m/s is required for small wind turbine and at speed of 25 m/s the turbine stops or braked must be applied. The anemometer is one of the tools used to measure wind speed. The wind speed data is collected from the site [21]. In the collected data there were also 21 readings of wind speed out of which 3,3 samples are used for testing and validation respectively and 15 are used for training purpose. To train the neural network only 0 sec has been taken and hence neural net calculated data is determined.

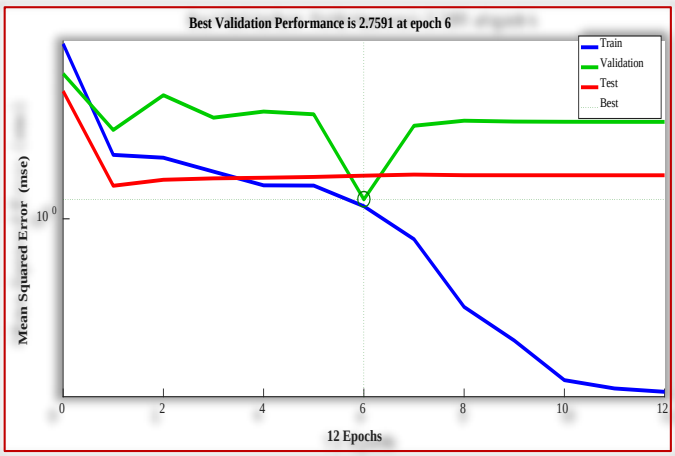

Figure 3- Wind Speed Performance graph

In wind speed performance graph 12epoch means it took 12 cycles to give the best result. The best performance is obtained with 10 number of hidden layer having MSE and number of epoch of 2.7591 and 6 respectively. The ANN trained structure has error of 0.001375. If the training plot (blue line) reached to zero than it depicts that the error is zero.

C.BLADE PITCH ANGLE

Blade pitch refers to spinning the angle of attack of the blade of the propeller. Wind turbine utilizes this to alter the revolution speed and the created power. While working a wind turbine control framework modify the sharp blade pitch to keep the rotor speed inside working cut-off points as the wind speed changes. Blade pitch control is favoured over rotor brake as brake is dependent upon failure or over-burden by the wind power on the turbine.

Pitch control does not need to be active. Passive wind turbine depends on the way that approach speeds up. This is a piece of the explanations behind twisted blades-the twist allow to take into consideration a steady slow down as each part of the blade has an alternate approach and will stop at an alternate time. The data of blade pitch angle is collected from the reference paper [7] In the collected data there were 17 readings of rotor diameter out of which 3, 3 samples are used for testing and validation respectively and 11 are used for training purpose. To train the neural network only 0 sec has been taken. With this we can determine the neural net calculated data.

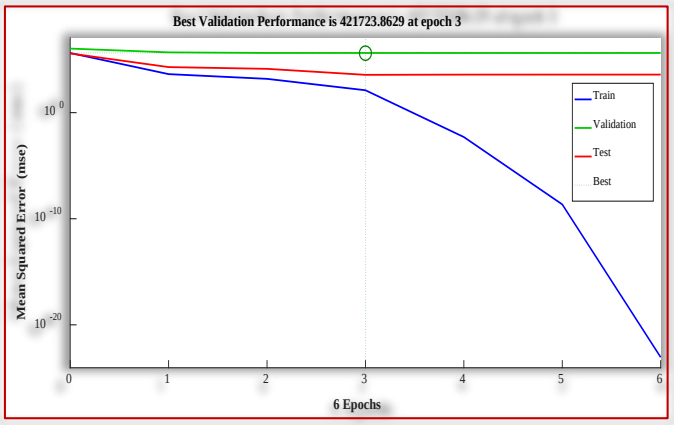

Figure 4-Pitch Angle Performance graph

In blade pitch performance graphs 6 epoch means it took 6 cycles to give the best result. The best performance is obtained with 18 number of hidden layer having MSE and number of epoch of 42123.8629 and 3 respectively. The ANN trained structure has error of 0.2752. If the training plot (blue line) reached to zero than it depicts that the error is zero.

RESULTS

The collected data from different papers and sites are trained and neural net data is calculated from simulink diagram. The plot has been drawn between collected data and neural net data of all the parameters. The x axis represents the parameters and the y axis represents the power output.

The blue line denotes the collected output from the different sites and the pink dots depicts the output which we have obtained after training the artificial neural network.

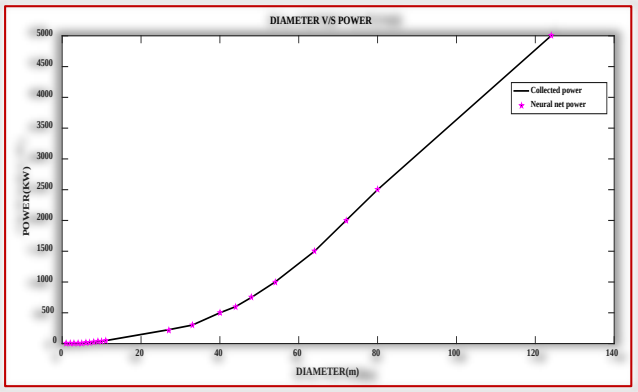

Figure 5-Plot between diameter and power

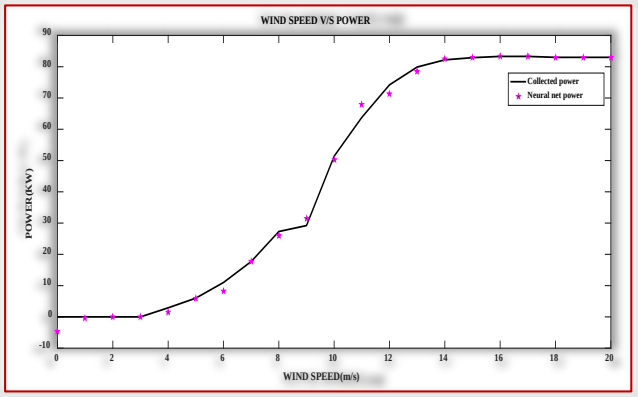

Figure 6-Plot between wind speed and power

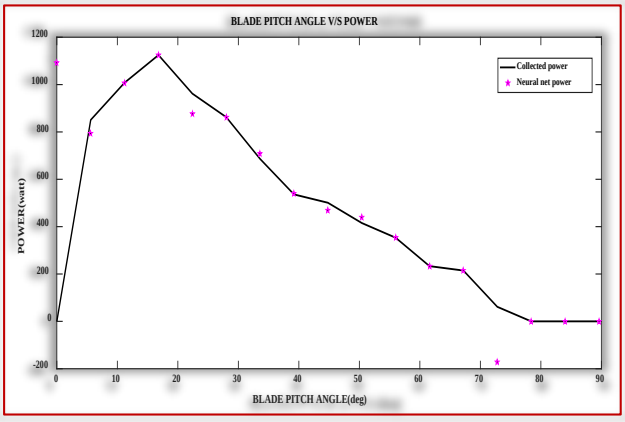

Figure7-Plot between blade pitch angle and power

CONCLUSIONS

In this paper we have collected the data and trained it using neural network. After training a data we are able to establish a nonlinear relationship between input and output. The established relationship is a model based relationship and not a mathematical relationship. Collection of data also plays a very important role as by collecting the more number of data we can minimize the difference between the collected data and the neural net data. In the above figs the graph is plotted to compare collected data and the neural net data. After comparison it is found that the collected data and the neural net trained data are almost same. Hence we can conclude that neural net trained data give more accurate result. The future scope of this project is in different field. They are as follows-

Forecasting and predictions Neural systems are end up being increasingly proficient for momentary wind speed forecast, and the cross breed ANN based strategy gives better outcomes to transient expectations than other convectional techniques.

Fault detection and diagnosis: The main ANN based techniques to detect faults and perform diagnostics of wind turbine. Most of the ANN based methods are created to detect breaks down in gearbox and bearings. The fault detection does not desire a fast computation process and, therefore, the main factor is the accuracy of the method. Control optimization: The most influential and recent ANN based methods for controllers. The controllers require low computational costs because immediate responses to sudden changes of the system condition are needed. For this purpose, neuro-fuzzy inference systems and radial basis function neural networks are the most employed methods.

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