Effective P - Hit Methodologies For Generation Monitoring System

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Abstract - Wind turbine acts as an important role in producing wind power from renewable resources. The wind power is the conversion of wind energy into electricity. Each degree of pitch angle misalignment with the approaching wind would actually rates a wind turbine in some percentage of operating efficiency. In my research a new methodology of wind turbine sensor modeling system helps to predict wind speed and positioning the degree of alignment and improve the co-efficiency of power by Neural network based Genetic algorithm controller (NNGAC) and evaluate a P-Hit value from wind power generation and minimizing an error level by MLP NN algorithm.
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Index Terms - Aerodynamic, Genetic algorithm controller, P-Hit value, pitch angle regulation.

I. INTRODUCTION

Moving air is one of the most powerful energy sources that permeates all over this world. In day-to-day life wind, available source of energy, plays an effective role in commercialization of technological means. Utilization of wind to generate power is widely practiced all over the world [1]. In general, the nature of wind changes periodically in accordance with varying location. So prediction of the power of wind is not possible because, the velocity of the wind can be differed from time to time and from place to place [2].

If the rotational speed is higher than the operating speed of a wind turbine, the internal parts of a wind turbine will get damaged. In order to safeguard the wind turbine from damage, we install a power controller technique in wind turbines. Basically there are three types of power controllers namely stall control, pitch angle control and active stall control. In this paper we focus on the pitch angle control. Horizontal axis wind turbine has a sensor for predicting wind direction, speed and the power of controlling the tip speed by using neural networks based Genetic algorithm controller(NNGAC). By regulating the pitch angle of the wind mill we can maintain constant rotational speed of the blades, even at the time of high wind speed [3]. Pressure sensor based prediction can enable us to effectively optimize the pitch angles and it also enables us to gain maximum power output. By this description it is understood that wind power can be observed in two ways, 1. Predicted wind power 2. Observed wind power. When the observed output value of the wind power is equal to the predicted output value of the wind power, it is described as P-hit (Predicted Hit), which is measured by multilayer perceptron neural network (MLP-NN) algorithm. This algorithm helps to reduce the error level and helps us obtain more perfect results. The variation between these two is noted as P-miss.

The rest of this paper is organized as follows: In Section II the workflow of wind turbine modeling is briefly discussed. Section III describes the sensor based pitch angle control using (NN-GA) Controller. In Section IV, estimation of the P-hit and P-miss value using MLP algorithm is elaborated whereas, Section V displays the experiments and their results. Finally in Section VI, conclusion and future work are described.

II. AERODYNAMICS OF WIND TURBINE

The amount of power produced from a wind turbine depends on the length of the blades and the speed of the wind [4]. The usable power extracted from the wind can be expressed as

$$P(U) = (S.\rho.V_{aw}^{3}.C_p(TS_r, dlog(V_{out})/dlog(V_{in}))/2 \quad \rightarrow \mathbf{(1)}$$

Here V_{aw} is the wind velocity, ρ is density of air, S is the swept area and it can be calculated as $S=\Pi r^2$ (r is the rotor blade) and $C_p(TS_r , dlog(V_{out})/dlog(V_{in})$ is the power co-efficient that is dependent upon the tip speed ratio and the pitch angle. The power co-efficient $C_p(TS_r,dlog(V_{out})/dlog(V_{in})$ is a non-linear function of TS_{ri} and $dlog(V_{out})/dlog(V_{in})$ given as

$$C_P(TS_r,dlog(V_{out})/dlog(V_{in})=Y_1(Y_2/TS_{ri}-Y_3(dlog(V_{out})/dlog(V_{in}))-Y_4)e^{-Y5(1/TS_{ri})}+Y_6\,TS_r \quad \rightarrow \mathbf{(2)}$$

Here Y_1, Y_2, Y_3, Y_4, Y_5, Y_6 are co-efficients that wind turbine manufacturer should provide. Note that the maximum power co-efficient that you can achieve with any turbine is .59, or the betz limit. Where,

$$1/TS_{ri}=1/(TS_r+0.08*dlog(V_{out})/dlog(V_{in}))-0.035/((dlog(V_{out})/dlog(V_{in}))^3+1) \rightarrow (3)$$

The stability between rotational speed and wind velocity is referred to as the tip speed ratio, which is calculated as

$$TS_r, \quad = 2\Pi fR/ V_{aw} \qquad \rightarrow (4)$$

where f is the frequency of the rotation (Hz) of blades. R is radius of the blade (m).

In Table 1 shown correlation of rotational speed measurement with various pitch angle and the illustrated graph is shown in Figure 2, in horizontal axis wind turbine, the major component to produce electricity is rotor and generator; hub and blades are incorporated within the area of rotor. As wind strikes the turbines, the hub rotates due to aerodynamic force. Each degree of disorder with the approaching wind would actually rates a wind turbine in some percentage of operating efficiency.

To overcome the disorders, we prefer fiber optic laser sensor. This sensor would help to predict the wind before 1 km and measure the wind velocity and positioning the degree of alignment and improve the co-efficiency of power by neural network based genetic algorithm controller (NNGAC). In this NNAG controller approach, we provide a dataset as an input and reduce the hidden layer iteration and predict the efficient power output. Wireless sensor networks are used for condition monitoring [5]. Wireless sensor networks can be used to measure noise, vibrations, pressure and temperature within the turbine equipment to determine the prospect of failure and prevent unnecessary revenue.

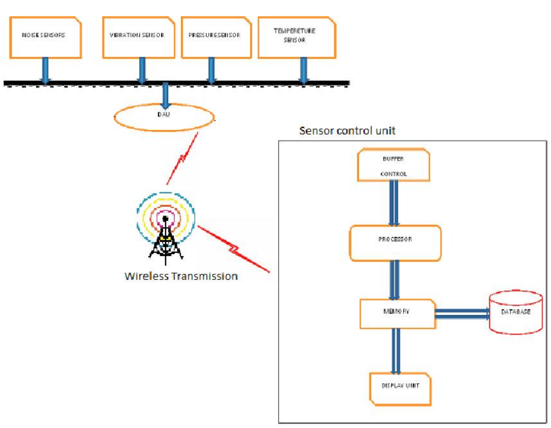

Figure 1 Wind Forecasting Using Sensor Wireless Transmission

In Figure 2, wind forecasting using sensor wireless transmission describes each sensor will transmit signals to the data acquisition units (DAU). Each of which provides 16 analogue inputs are converted into 16-bit quantities and assembled in a binary[6],which is transmitted to the pc over a RS232 serial channel. The sampling rate at the DAUs is set to 40Hz, so new frequency lines are created and sent 40 times per channel. The data streams received on the serial channels from DAU are transmitted and stored at the buffer controller. In specific time interval buffer data are posted to the DSP processor. Now the data streams are calculated using neural network based genetic algorithm controller (NNGAC). By using this algorithm expected result could be achieved and efficient output is possible. The Output data from the processor are transmitted to the memory unit, and the data are stored on the database and simultaneously transmitted to the display unit in every second.

Table 1: Correlation of rotational speed

	Wind Speed			
Pitch angle(deg)	3m/s	4m/s	5m/s	6m/s
2	2	2	2	2
8	2	94	144	204
13	2	126	184	254
19	22	137	204	284
24	2	119	164	220
30	2	108	148	197
36	2	98	119	147
41	2	83	101	125
47	2	47	80	119
52	2	40	65	95

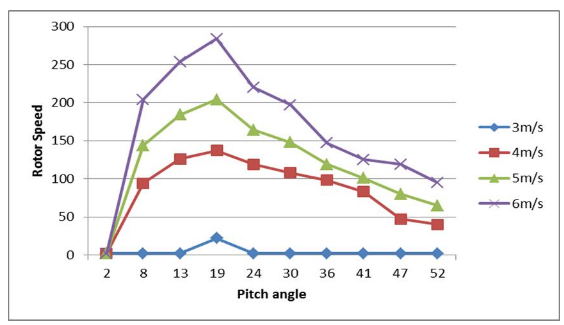

Figure 2 Rotor speed and pitch angle for various wind speed

III. SENSOR BASED PITCH ANGLE, CONTROLLED USING NNGA CONTROLLER

In the wind turbine there are different control methods either to optimize or limit power output. Generator speed, blade angle and turbine rotation determine the output power of the wind turbine. Pitch angle adjustment and turbine rotation are also known as pitch and yaw control respectively.

a. Yaw Control

The regular variation of the entire wind turbine in the horizontal axis is said to be Yaw it is shown in Figure 3. The complete control of Yaw ensures that the turbine is frequently opposite into the wind, (i.e) in order to make the most of the successful rotor locale. In our research, the airstream is captured before 1000m using LIDAR (Light detecting and ranging) system [8], so that it can be mounted on wind turbines. This is used to measure wind speed in time and make adjustments to the turbine with respect to the signals from the optical fiber sensor and transmitting signals to the control unit based on the wind velocity and wind density. Now the control unit provides the signals to fiddle with the yaw drive.

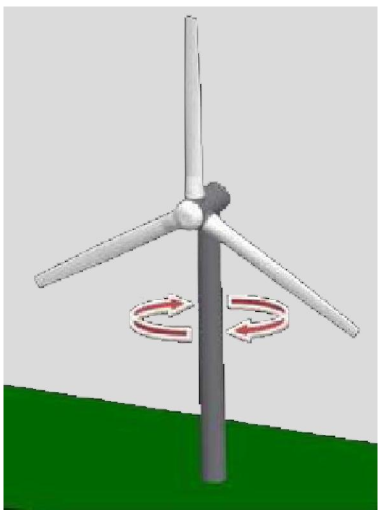

Figure 3 Turbine rotation using Yaw drive

b. Pitch Control

A schematic diagram of the pitch angle adjustment is shown in Figure 4. In the optimum blade angle is maintained by the pitch angle. An accurate angle is measured to realize confident rotor rapidity or to find the power productivity. The adjustment made in the pitch angle is the most valuable approach which is used to border productivity power by altering an aerodynamic force on the blade at lofty airstream speeds.

Figure 4 Pitch angle adjustment in wind turbine

c. Aerodynamics on Blade

The swiftness of the wind at the cross section of the blade has a mechanism which comprises wind speed; the revolving alacrity of the rotor and the flow factors are the two things which help to establish the angle of harass. By insolent the angle of attack, speed and the energy on a blade element gets evaluated by means of pitch angle control mechanism. In Figure 5 shown that AE Sensor system for blade adjustment control technique.

The inflow wind velocity which is at a 90 degree angle to the rotor plane is $\mathbf{V_{in}}$. The vigor of the wind gets concentrated when it strikes the rotor plane and this is strong-minded by the amount of $\mathbf{bV_{in}}$, due to axial dimension. The complete angular velocity of the blade is $\mathbf{\Omega}$ and the distance of the blade element from the rotor axis is **r**, which in terms of the moving speed is calculated by the combination as $\mathbf{\Omega r}$ in the rotor. when the wind passes all the way through the rotor plane and gets interacts with moving rotor, a tangential velocity of

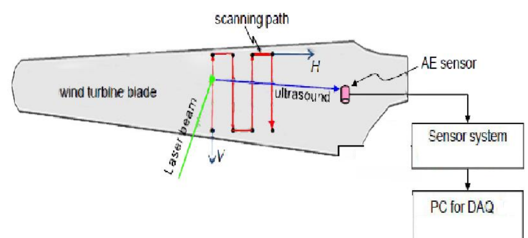

Figure 5 Wind turbine blade with AE sensor

the $\mathbf{b'\Omega r}$ is found. The Net tangential rapidity is $\mathbf{1+b'\Omega r}$. The ensuing relative velocity of the blade is

$$\mathbf{V(B) = \sqrt{V_{in}^2 - b^2 V_{in}^2 + \Omega^2 r^2 (1 + b'^2 + 2b')}} \rightarrow (5)$$

Where **V(B)** is the consequential comparative rapidity of the blade, b and b' are the flow factors, **r** is the distance of blade constituent from the rotor alliance.The secondary comparative rapidity gives rise to the aerodynamic force on the blade, therefore a lift force is defined as

$$\mathbf{F(L) = \frac{1}{2}(\rho c V^2 C_{LF})} \rightarrow (6)$$

and drag force is defined as

$$\mathbf{F(D) = \frac{1}{2}(\rho c V^2 C_{DF})} \rightarrow (7)$$

Where ρ is the density in kg/m^3, c is chord length $\mathbf{C_{LF}}$ is the lift force co-efficient; $\mathbf{C_{DF}}$ **is** the drag force co-efficient**.** Based on the estimation, we can decide the input to the NNAGA manager and this will make a successful judgment to put the blade into the obligatory position and this also helps to harness the wind energy successfully.

d. Design of Neural Network based Genetic Algorithm Controller

The basis of neurons is of three types. They are as follows: a) input neurons, b) hidden processing element and c) output neuron. This neuro model adds on an outwardly supplied charge which is denoted by V_k, which has the upshot of altering the net input value n_k for the task of activation scientifically we describe a neuron k by

$$\mathbf{u_k = W_{kj} X_j}$$
$$\mathbf{o_k = \psi(u_k + v_k)}$$

Where 'a' is the slope structure of the sigmoid task.Here the genetic algorithm (GA) worn is used for minimizing a iterative task which is declared as the NNGA function. The NNGA task has to be distinct to resolve the network obstruction. The heaviness in the network has to be adjusted to get utmost performance and also used to minimize the errors. The Root Mean Square inaccuracy (RMSE) helps to settle the robustness value function. The RMSE is also analyzed to study all its utmost values and also the smallest value of the RMSE mistake. All intended information (or) chromosomes are agreed in ascending order of the RMSE. The minimum RMSE is determined specifically and if the RMSE is not minimum then all the old chromosomes will get updated. The concluding productivity is transferred to the control unit, then pitch is adjusted successfully.

$$\Psi(n) = 1/(1+\exp(-an) \quad \rightarrow (8)$$

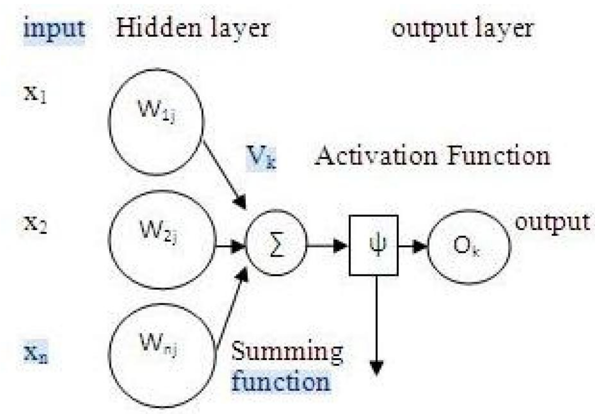

Figure 6 NNGA Based Controller

e. Proposed Architecture of the Network

Here we are given an input W_B, F_L and F_D to the input layer based on the input we will get on efficient pitch angle control output. Then pitch adjustment can be made effectively.

The step used in NNGA can be summarized as follows:

Step 1: Determine Input variables from training and testing data.

Step 2: Determine initial information for constructing the NNGA structure.

Step 3: Apply Genetic algorithms for determining

Representation
Fitness Value evaluation
Selection
Cross & Mutation
Elitism

Step 4: Estimate the co efficient of the corresponding selected node.

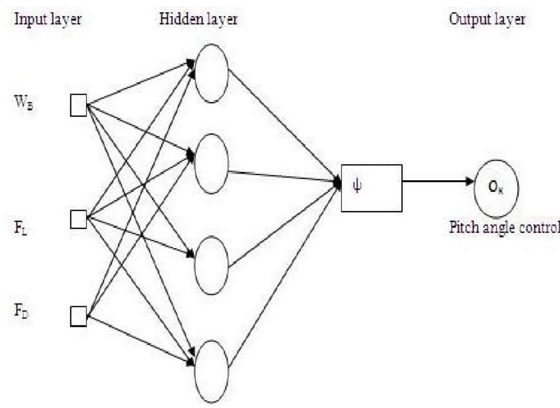

Figure 7 Network Architecture

Step 5: Select nodes with the best predictive capability, and construct their corresponding layer.

Step 6: Check the termination criterion

Step 7: Determine new input variable for the next layer. The NNGA algorithm is carried out by repeating the steps 3-7 consecutively.

IV. DIRECT PREDICATION HIT EVALUATION--(P-HIT)

Artificial neural network based wind power prediction has been proposed in some papers [8-11]. Refs[8-10]. Proposed an artificial neural network model for spatially distributed prediction of wind gusts and refs [11] proposed a model for wind prediction using MLP neural network. In this paper, NNGA controller based prediction that provides minimum errors using MLP algorithm is proposed to maximize the power output.

In this part, we are focusing on NNGA controller for the prediction of methodological parameters. NNGA predictor will predict wind speed and power co-efficient by adjusting the pitch angle. The meteorological data that is captured with different sensors has been implemented on FPGA (Field programmable gate array).[13].

The NNGA controller that has been invented based on neural genetic and evaluation. The NNGA uses polynomial neural network to represent the model. Each layer of the polynomial neural network is regarded as a separate optimization problem [14]. The NNGA controller based prediction model is used to predict wind farm based on the wind forecasting data. MLP algorithm in NNGA is used to model complex relationship between input and output which provides best output compared to other existing models.

Now the predicted values are analyzed with the observed value.

In Table 2 the actual values are mostly related to predicted values that is P-Hit. With the help of NNGA controller the power forecasting can be determine effectively and also get the very lowest error. In order to evaluate the performance of MLP algorithm, the MAE is calculated comparing the outputs of the improved wind power forecast with the actual wind power forecast.

$$MAE = \frac{1}{N}\sum_{i=1}^{N} |er|$$

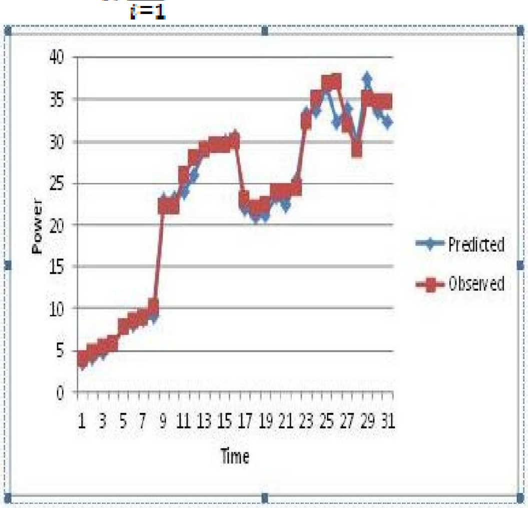

Figure 8 Predicted vs Observed output power

Table 2: P-Hit values

Observed	Predicted	P-Err
19	19	0
24	24	0
28	28	0
31.75	32	0.25
37	36	1
41	41	0
45	45	0
48.5	49	0.5
54	55	1
57	57	0
59	59	0
63	63	0
66	66	0

Average error- 0.211

$$e_r = \left(\frac{P_f - P_a}{P_i}\right) \cdot 100\%$$

where $e_r$is the wind power prediction error, $P_f$is the forecasted wind power provided by the NNGA, P_a is the actual wind power, P_i is the total installed wind power capacity and N is the number of hours studied.

V. CONCLUSION

In this, Introduce neural network based genetic algorithm controller by which system analysis the input from the sensor based on the concepts where as the input set of data's are taken for an iteration.

REFERENCES

[1] L. Ma, S. Luan, C. Jiang, H. Liu, and Y. Zhang, "Areviewon the forecasting of wind speed and generated power," Renewable and Sustainable Energy Reviews, vol. 13, no. 4, pp. 915–920, 2009.

[2] Burton T, Sharpe D, Jenkins N, Bossanyi E. Wind energy handbook. Chichester: John Wiley and Sons; 2001.

[3] Pitch Angle Control for Variable Speed Wind Turbines Jianzhong Zhang, Ming Cheng, Zhe Chen, Xiaofan Fu, 978-7-900714-13-8/08/ ©2008 DRPT.

[4] Danish Wind Industry Association" http://www.talentfactory.dk/

[5] Van der Hoek M.J. Wind turbine blade condition monitoring. Part 2: Fibre Bragg Grating Read-Out Units. VanderhoekPhotonics, January 2007.

[6] Presented at EWEC 2006, Athens 27 February – 2 March 2006Online wind turbine measurement laboratory.Kurt S. Hansen, Knud Ole Helgesen Pedersen 2 & Uwe Schmidt Paulsen.

[7] The MEXICO project (Model Experiments in Controlled Conditions): The database and first results of data processing and interpretation, H Snel, J G Schepers and B Montgomerie, 2007.

[8] Neural networks based prediction of wind gusts Vedrana Spudi´ c, Matej Mari´ c, Nedjeljko Peri ´c University of Zagreb Faculty of Electrical Engineering and Computing Unska 3, 10000 Zagreb, Croatia E-mail: vedrana.spudic@fer.hr, matej.maric@itgcentar.hr, nedjeljko.peric@fer.hr.

[9] Improved Wind Power Forecasting Using a Combined Neuro-fuzzy and Artificial Neural Network Model Yiannis A. Katsigiannis1,

Antonis G. Tsikalakis2, Pavlos S. Georgilakis1, and Nikos D. Hatziargyriou2 1 Department of Production Engineering and Management, Technical University of Crete, University Campus, Kounoupidiana, Chania, Greece.

[10] wind farm power prediction:a data-mining approach, Andrew Kusiak*, Haiyang Zheng and Zhe Song, Department of Mechanical and Industrial Engineering, 3131 Seamans Center, The University of Iowa, Iowa City, IA 52242–1527, USA.

[11] Wind Power Plant Prediction by Using Neural Networks Z. Liu and W. Gao University of Denver Y.-H. Wan and E. Muljadi National Renewable Energy Laboratory To be presented at the IEEE Energy Conversion Conference and Exposition Raleigh, North Carolina September 15–20, 2012.

[12] APPLICATION OF GENETIC ALGORITHM TO NEURAL NETWORK MODEL FOR ESTIMATION OF WIND POWER POTENTIAL M.K. Deshmukh*, C. Balakrishna Moorthy** Recieved Aug. 30, 2010, Revised Sept. 06, 2010 ; Accepted Oct. 07, 2010.

[13] A. Mellit, S. Shaari, H. Mekki and N. Khorissi, 'FPGA-Based Artificial Neural Network or Prediction of Solar Radiation Data from Sunshine Duration and Air Temperature', IEEE International Conference on Computational Technologies in Electrical and Electronics Engineering, Sibircon-2008, pp. 118-123, Novosibirsk, Russia, 21-25 July, 2008.

[14] A. Foka, 'Time Series Prediction Using Evolving Polynomial Neural Networks', MSc dissertation, Dept. of Elec. Eng. & Elec., Univ. of Manchester, Institute of Science and Technology, 1999.

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