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Improve the Prediction of Wind Speed using Hyperbolic Tangent Function with Artificial Neural Network

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ABSTRACT

India is truculent to meet the electric power demands of a fast-expanding economy. Restructuring of the power industry has only increased several challenges for the power system engineers. The two largest challenges facing the Indian power sector are:

Fuel supply uncertainty and deteriorating distribution companies (discoms) finances. Considering dominance of coal in India's fuel mix, coal shortages can severely impede investments in the generation segment. India is aiming to attain 175 GW of renewable energy which would consist of 100 GW from solar energy, 10 GW from bio-power, 60 GW from wind power, and 5 GW from small hydropower plants by the year 2020. Investors have promised to achieve more than 270 GW, which is significantly above the ambitious targets.

Wind energy generation, at present facing many problems like wind speed prediction. In this paper to improve the wind speed prediction by using hyperbolic tangent function with artificial neural network. Hyperbolic tangent with artificial neural network, we know that ANN work like a human brain to perform computations on real time or hyperbolic tangent function lies between 1 to -1 would be near the zero.

1. Introduction

Electricity demand day by day increasing, global demand of electricity is set to drop by 5% in 2020, oil demand 8% & 7% coal demand. India is third largest electricity producer & consumer. India electricity consumption in 2019-2020 was 1208 kWh per capita. WIND POWER is one of the fastest growing renewable energy technologies. India has the 4th largest installed capacity in wind power after China, U.S and Germany.

Wind speed prediction models are important in control engineering as they are used in data driven control and also in building linear/nonlinear model predictive controls (MPC), for optimization of wind energy generation. Information obtained from this thesis (Madhiarasan Protection and Control of Modern Power Systems 2020).

Wind turbine extracts energy from a moving mass of air (wind) and converts its kinetic energy into mechanical energy from which the generator/alternator transforms it into the electrical energy we know. On the other hand, in order for the wind turbine to rotate and generate the mechanical energy, there must be a pressure drop between the windward and leeward side of the wind turbine blades. Putting the above descriptions together, it can then be interpreted that wind power generation is an optimization problem in which the objective is to compromise between the two among other constraints; the air mass flow allowed to pass through to the leeward side of the wind turbine blades and the amount converted into mechanical energy. The theoretical energy carried by the wind just before coming in contact with the wind turbine blades is the kinetic energy expressed as,

$$Pa = \frac{1}{2}\pi_p R^2 V_s^2 C_p \qquad (1)$$

Where, Cp is the power coefficient, Pa actual mechanical power captured by the wind, R is radius of turbine, Vs wind speed.

In this study wind speed prediction feasibility reference from (Energy Education Scienc1e and Technology Part A: Energy Science and Research 2012 Volume (issues) 30(1): 45-54) & (Madhiarasan Protection and Control of Modern Power Systems 2020). Wind energy depends on the wind speed. Wind speed is main parameter of wind energy potential. Wind speed prediction is very important impact of wind speed on wind potential. There are many methods are used for wind speed prediction like fuzzy logic method, ANN multilayer feedback network method, ANN radial biased network method. But in this paper to improve wind speed prediction through hyperbolic tangent function with artificial neural network method.

Fuzzy logic method like a human decision, it is reasoning type method. ANN multilayer feedback network method is very complex because to needs more data like width, depth, height. Because of complexity output is insufficient. ANN radial biased network method provides output use in radial network. There are many activations function but mainly two activation function use:

- Sigmoid Function
- Hyperbolic tangent Function (Tanh)

Both functions are use on non-linear AF (activation function). Both graph shapes are 'S'. Sigmoid function varying the range 0 to 1, because of non-zero centre output the gradient saturation to proposed the irregular direction. Hyperbolic tangent function varying the range 1 to -1, because of zero centre output it helped the backpropagation process. This is easy method because sine and cosine function mean ratio between two exponential half difference and half sum, resultant get better for the next layer. Wind speed prediction optimised the energy generation as well as reliability system. If our system is reliable then control the wind energy generation.

Wind turbines extract the kinetic energy from air, Pm is mechanical power. Therefore, we can write:

$$Pm = \frac{1}{2}\pi\rho R^2 Vs^3 \qquad (2)$$

Where Vs is wind speed, turbine has electrical losses or overall efficiency is referred to power coefficient C_p, P has air density, R for radius of turbine and Pa actual mechanical power captured by the blades.

$$Pa = \frac{1}{2}\pi\rho\ leR^2 Vs^3 Cp \qquad (3)$$

Where, le is electrical loss varied between 0.9 to 0.95.

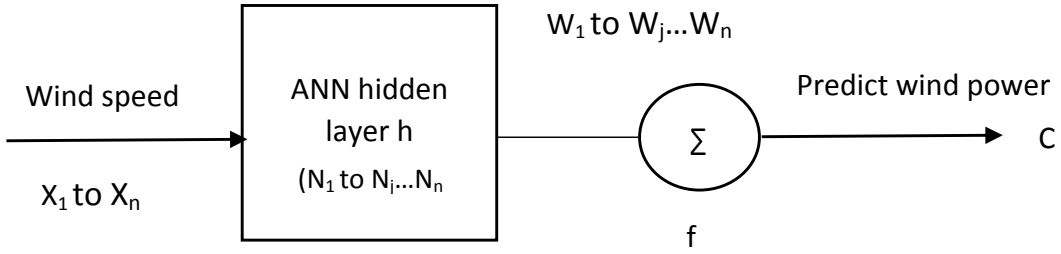
2. Method

ANN to improve the control techniques, optimization, prediction, reliable system. Neural network is a system that is based on the biological neurons of a human brain to perform computations.

To solve the real time non-linear system. Gaussian activation function can be expressed as,

$$F(C) = e^{(-c2)} \qquad (4)$$

Where, C is the output value of ANN with hyperbolic tangent function.



$$C = f \sum_{i=1}^{h} (X - Nj) W_j \qquad (5)$$

Weight vectors is between the hidden to output layer are

$$W = W_1 \text{ to } W_j \ldots W_n \qquad (6)$$

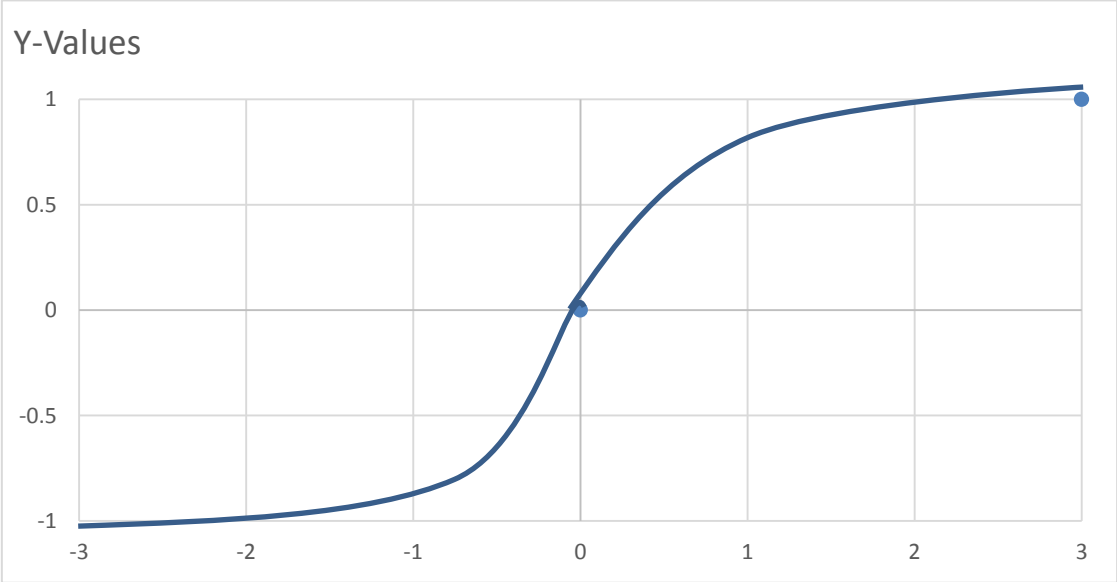
Where, input is wind speed (X_1 to $X_{n)}$, weight is W_n , N_j is the centre of the hidden layer, (X-Nj) is the distance between input to hidden layer, thresold activation function 'f ', W_iC is the weight between the hidden to output preduct layer and h is the no of hidden neorons.

These functions either non-linear or linear mathematically expression of hyperbolic tangent functions lie between 1 to -1 to reach the result in ANN and sigmoid functions lie between 0 to 1 to reach the result in ANN.

Hyperbolic tangent function

$$F(\sum) = e^{\Sigma} + e^{-\Sigma} / e^{\Sigma} - e^{-\Sigma} \qquad (7)$$

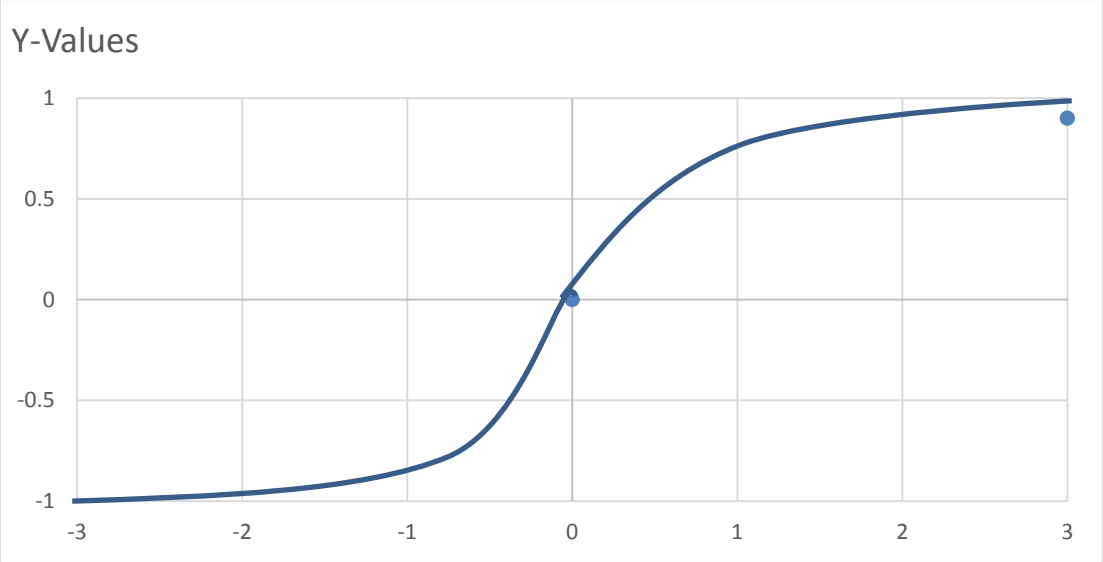
Hyperbolic tangent functions lie between 1 to -1 to reach the result in ANN.



Sigmoid function

$$F = 1/1+e^{-\Sigma} \qquad (8)$$

Sigmoid functions lie between 0 to 1 to reach the result in ANN.



3. Evaluate Algorithm

To improve accuracy level of the wind speed prediction model observed by the statistical error method like Mean square error (MSE), Root Mean Square Error (RMSE), Mean Absolute Error (MAE), Mean Relative Error (MRE) and Mean Absolute Percentage Error (MAPE) are given, this method feasible on Microsoft excel.

Take C_i' for actual sales & C_i for predict,

$$\text{Error} = C_i' - C_i \qquad (9)$$

Where, C_i' is the observed actual output and C_i is the predict output and $\overline{C_i}$ average actual output, N_t is number of samples with time.

$$\text{MSE} = 1/N_t \sum_{i=1}^{Nt} (Ci' - Ci)^2 \qquad (10)$$

$$\text{RMSE} = \sqrt{1/N_t} \sum_{i=1}^{Nt} (Ci' - Ci)^2 \qquad (11)$$

$$\text{MAE} = 1/N_t \sum_{i=1}^{Nt} (Ci' - Ci) \qquad (12)$$

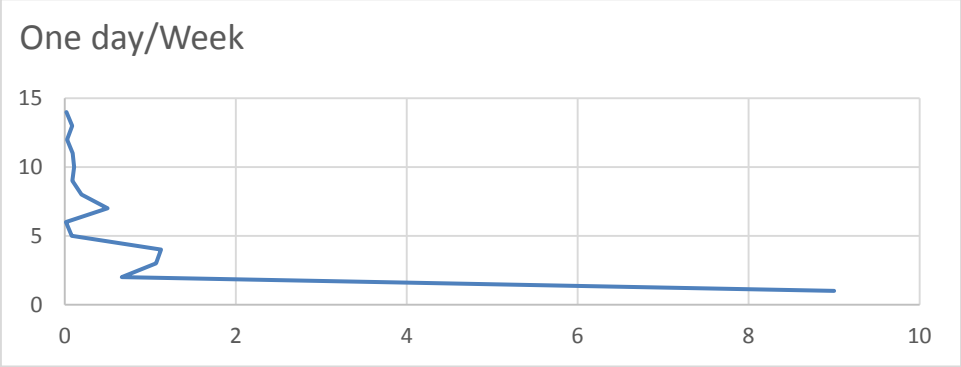
$$\text{MAPE} = 100/N_t \sum_{i=1}^{Nt} | (Ci' - Ci) / \overline{C_i} | \qquad (13)$$

In table, statistical performance model with hidden layer short term prediction.

S. No.	Hidden neurons	MSE	RMSE	MAE	MAPE
1	1	9	12.726	-3	-7.5
2	3	0.666666667	0.942666667	0.333333333	1.041666667
3	5	**1.066666667**	**1.508266667**	**0.266666667**	**0.833333333**
4	8	1.125	1.59075	-0.1875	-0.426136364
5	10	0.08	0.11312	-0.04	-0.095238095

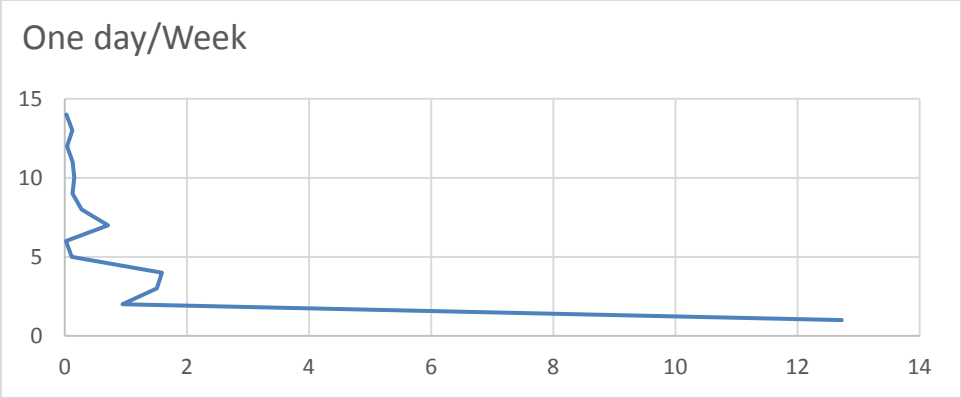
6	12	0.013888889	0.019638889	0.013888889	0.033875339
7	14	0.5	0.707	-0.071428571	-0.204081633
8	16	0.1953125	0.276171875	-0.0390625	-0.114889706
9	20	0.088888889	0.125688889	-0.022222222	-0.046296296
10	23	0.108695652	0.153695652	-0.02173913	-0.060386473
11	25	0.090909091	0.128545455	-0.018181818	-0.053475936
12	28	0.026785714	0.037875	-0.008928571	-0.030788177
13	32	0.086538462	0.122365385	-0.014423077	-0.043706294
14	34	0.018907563	0.026735294	-0.006302521	-0.015006002

For this above table actual sales and predict sales data put on the formulas are Mean square error (MSE), Root Mean Square Error (RMSE), Mean Absolute Error (MAE), Mean Relative Error (MRE) and Mean Absolute Percentage Error (MAPE) at Microsoft excel the comes out the statistical error, samples with time. On the basis of table given below graphs comes out.



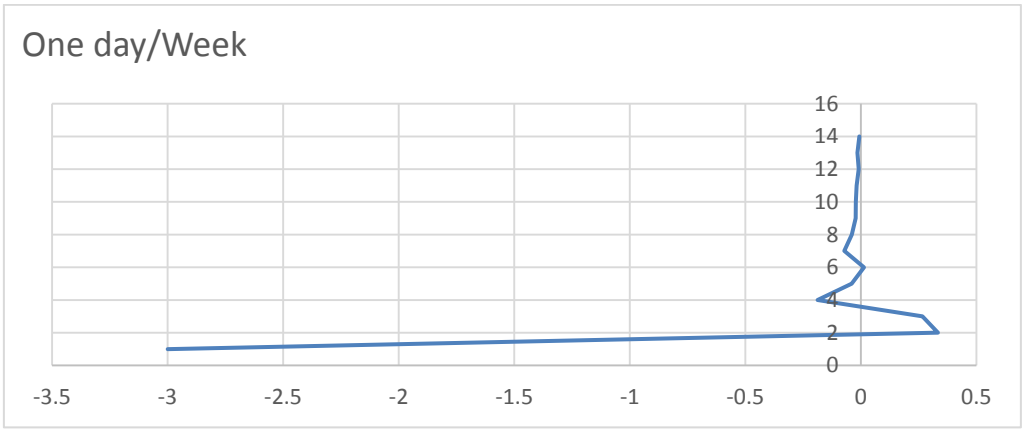
MSE Prediction - Graph 1

In the above MSE graph, hidden neuron 5 & 8 gives the minimum statistical error.



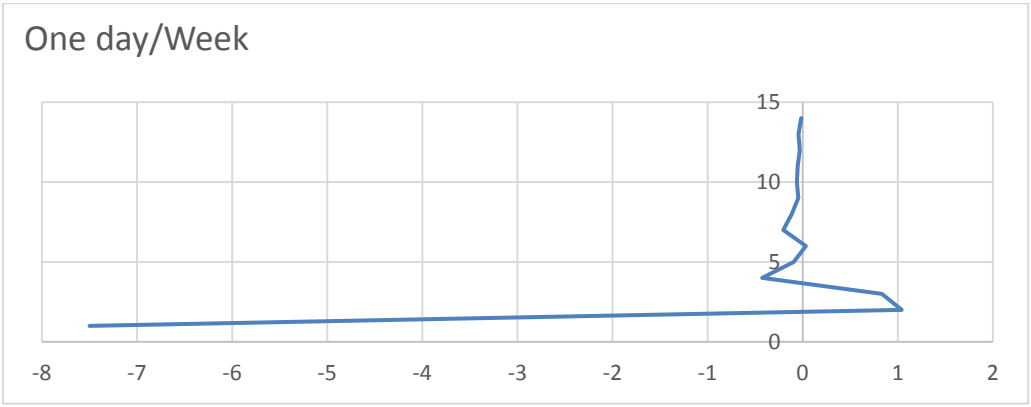
RMSE Prediction - Graph 2

In the above RMSE graph, hidden neuron 5 & 8 gives the minimum statistical error.



MAE Prediction - Graph 3

In the above MAE graph, hidden neuron 5 gives to the approximately near the 1, minimum statistical error.



MAPE Prediction - Graph 4

In the above MAPE graph, hidden neuron 5 gives to the approximately near the 1, minimum statistical error.

4. Conclusion

Results show above the table wind speed prediction change in every hidden neuron. We observed the minimum statistical error in hidden neuron 5. If control the wind speed then automatically control the wind power & protection. We know that renewable energy is the substitute of the conventional energy or wind energy is very reliable energy for the future. Wind speed prediction not only control the power system it provides reliable planning as well as integration of the system. In above study wind speed prediction depend on weight on hyperbolic tangent function and statistical error method. It would be observed that study, short term prediction depends on time means less time better prediction and long-term prediction may be depend on sampling of neurons means increase the sampling hidden neurons with time its gives minimum error. Short term wind speed prediction provides very competitive result as compared to the other neural network methodology.

Declarations

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Competing Interests Statement

The authors declare no competing financial, professional and personal interests.

Consent for publication

Authors declare that they consented for the publication of this research work.

Availability of data and material

Authors are willing to share data and material according to the relevant needs.

References

[1] Madhiarasan Protection and Control of Modern Power Systems (2020).

[2] Hyperbolic Tangent Basis Function Neural Networks Training by Hybrid Evolutionary Programming for Accurate Short-Term Wind Speed Prediction, Ninth International Conference on Intelligent Systems Design and Applications, 2009.

[3] Wind speed estimation for missing wind data with three different backpropagation algorithms, Energy Education Scienc and Technology Part A: Energy Science and Research,Volume (issues), 30(1): 45-54, 2012.

[4] Forecasting of Wind Speeds and Directions with Artificial Neural Networks, Lappeenranta University of Technology, Faculty of Technology Environmental Energy Technology.

[5] Sliding Mode Control for Variable-Speed Wind Turbine Generation Systems using Artificial Neural Network, The 6th International Conference on Applied Energy – ICAE 2014.

[6] Comparison of Machine Learning Alg. for Wind Speed Prediction, Proceedings of the 5th NA International Conference on Industrial Engineering and Operations Management Detroit, Michigan, USA, August 10 - 14, 2020.

[7] Yi Wang, Jianhui Meng, Xiangyu Zhang, and Lie Xu, Control of PMSG-based Wind Turbines for System Inertial Response and Power Oscillation Damping, IEEE.

[8] PMSG Based Wind Turbines Control for System Inertial Response and Power Oscillation Damping by Fuzzy, International Journal of Electrical Engineering, Volume 9, Number 1 (2016).

[9] Wind Generation Forecasting Methods and Proliferation of Artificial Neural Network: A Review of Five Years Research Trend, Sustainability, 2020, 12, 3778.

[10] A general method to estimate wind farm power using artificial neural network, College of Earth, Ocean, and Environment, University of Delaware, Newark, Delaware 19716, USA .

[11] Wind power forecast using neural networks: Tuning with optimization techniques and error analysis: IST—Instituto Superior Técnico, University of Lisbon, Lisbon, Portugal.

[12] Sumit Saroha, Sanjeev Kumar Aggarwal and Preeti Rana, Wind Power Forecasting.

[13] Hyperbolic Tangent as Neural Network Activation Function, Machine Learning, Math., January 29, 2017.

[14] Soteris A. Kalogirou, Neural Network Modeling of Energy Systems, in Encyclopedia of Energy, 2004.