



USING ARTIFICIAL NEURAL NETWORKS FOR FORECASTING WIND SPEED CHANGES IN THE CITY OF KERMAN

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Received: 29.04.2015; Accepted: 09.07.2015

Abstract. Nowadays, taking advantage of renewable energies has increased in order to produce electric energy. Wind energy is one of renewable energies which has been the center of attention in industrial communities. Correct wind –speed forecast has a considerable number of applications in military and civilian affairs for air traffic control, missile , and ship navigation .Furthermore, forecasting wind-speed changes has also become important due to controlling appropriate reactions in wind turbines in order to prevent sudden shocks and take advantage of maximum capacity of wind turbines .According to inevitable role of wind energy in the future, the capability to predict this energy can play a noticeable role on related predictions of production or electricity energy buying and selling as a result of substantial effect on energy final price .In this study , considering one-year collected data of wind speed and temperature in one meteorology station in Kerman, one applied model has been recommended for forecasting wind speed using artificial neural network.

Keywords: Wind-speed forecast, wind power station, artificial neural network

1. INTRODUCTION

In the world of today, taking advantage of new energies is inevitable because of reduced fossil fuel resources, environmental pollution, growing demand of societies, and continuity of economic development of countries. Wind energy is one of renewable energies which has received a special attention in industrial communities. Correct wind-speed forecast for controlling appropriate reactions in wind turbines in order to prevent sudden shocks and take advantage of maximum capacity of wind turbines has led to great importance of wind-speed forecasting algorithms .[1].So far , a considerable number of researchers have been conducted concerning wind-speed forecast . Using mixed approach of Markov chain and Hybrid algorithm ,GA-SA,[1] ; constant time series such as Auto Regression , AR,[2]; wavelet decomposition model [1]; mixed model of Auto Regression , AR, and wavelet [3] ; Auto Regression Integrated Moving Average , ARIMA [5]; mixed model of ARIMA and wavelet [4] ; non-constant time series model such as Generalized Auto Regressive Conditional Heteroskedastic ,GARCH[6]; and Neural Network Systems ,NNS[7] have been proposed for forecasting wind speed .In this article, a model for wind-speed forecasting was proposed using one-hour collected data during one year in one meteorology station in the city of Kerman and artificial neural network .Inputs include temperature and weekly wind speed .The obtained results indicate that this method enjoys great ability for forecasting wind speed .

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2. FORECASTING BY NEURAL NETWORKS

Artificial Neural Networks are patterns for information processing which have been made by imitating biological neural networks of human brain. Key element in this pattern is new structure of information-processing system. This system is made up of many elements (neurons) with strong internal communications used for solving the questions. Similar to people, ANN receives training by providing examples like a child who is able to distinguish animals by seeing various kinds of one certain animal. To sum up, it can be stated that neural networks are made up of simple processing elements working in parallel form. These units have been inspired by neurons. Neurons are in touch by a substantial number of nerve fibers called Synapse with certain weight. [9] To train one neural network, calculating optimum weights and bias is sufficient. Generally, the aim of training is the fact that the network creates pleasant output by a certain input. In mathematical modelling, neurons receive information through a collection of input nodes. These inputs are multiplied by weight matrix, W : They are weighed. Total sum of these multiplications enter network performance function which might have one linear threshold and function output is network output. Neural structure is shown in figure (1).

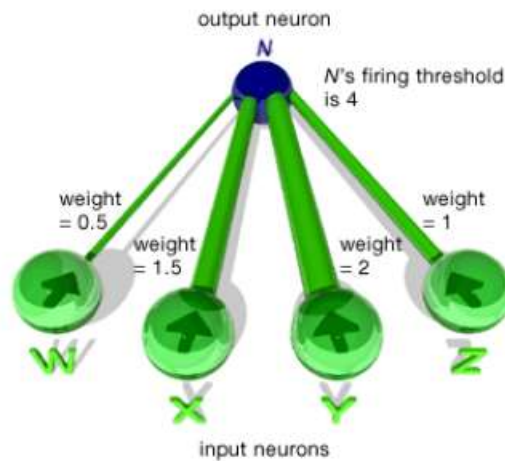


Figure 1. Neuron mathematical model.

2.1. RBF neural networks

RBF is one of different kinds of neural networks. The theory which lies behind these networks is on the fact that any given non-linear function can be modelled in to mixture of some non-linear basis function. [10]. In fact, in comparison with Multi-Layer Perceptron neural networks, MLP, inspired by living creatures, RBF enjoys mathematical nature and their efficiency is mathematically provable. Due to extra similarities between RBFs and MLPs as well as their network structures, RBFs are considered as subsection of neural networks. Figure (2) shows schematic structure of these types of networks.

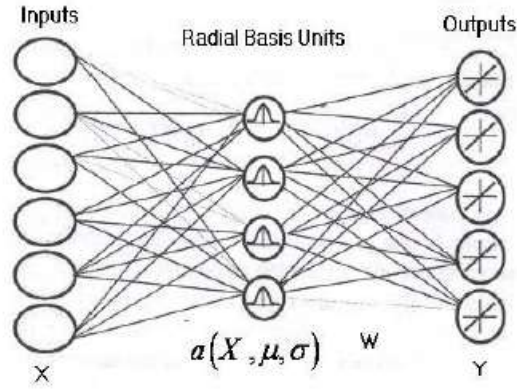


Figure 2. RBF network structure with Gaussian functions.

In this figure, X is the input matrix made up of K N-dimensional vector and Y is the output made up of K M-dimensional vector .Intermediate layer is actually hidden neurons of neural networks with Gaussian function .Despite MLPs, inputs enter intermediate layer directly in these networks .In fact, all first layer weights equal one .Intermediate layer is made up of H Gaussian basis functions, creating a vector as output after implementing on input vectors. a vector enters output layer as a result of W ,weight matrix, and finally , it produces linear mixture of inputs of last vector layer .The following figure shows used neural network in this article.

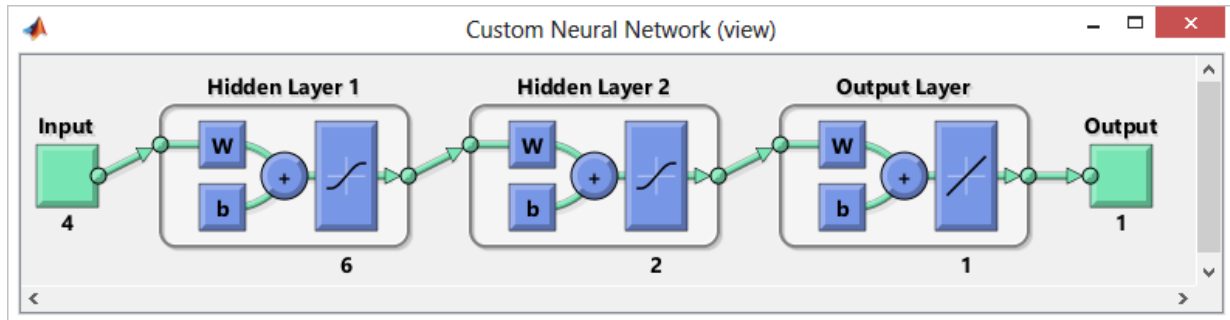


Figure 3. Used neural network for short-term wind-speed forecasting.

3. FORECAST ERROR

To determine the best model in terms of quantity ,three methods including Mean Square Error ,MSE; Medium ; and Absolute Error, MAE ; and Medium Absolute Percentage Error , MAPE were used to evaluate and compare the model .MAPE is as following [10]:

$$MAPE = \frac{1}{n} \sum_{t=1}^n |PE_t| \tag{1}$$

Where n is the number of inputs and PE indicates relative error as following:

$$PE_t = \left(\frac{y_t - F_t}{y_t} \right) \times 100 \tag{2}$$

If y_t is the real observation for t and F_t is forecasting for similar duration, then forecast error will be defined as following:

$$e_t = y_t - F_t \quad (3)$$

4. SIMULATION

Used inputs for the network are temperature and wind speed by one-hour format. After data normalization for more accurate training, they were classified in to sample up to one week before. In the next stage , they were prepared by initial data processing including omitting similar cases as well as focusing on effective factors .Then neural network is trained . To determine the best model in terms of quantity , three methods including Mean Square Error ,MSE; Medium ; and Absolute Error, MAE ; and Medium Absolute Percentage Error , MAPE were used to evaluate and compare the model .Figure (4) shows the results obtained from this forecasting method of artificial neural network as well as forecast in figures 5 and 6 .

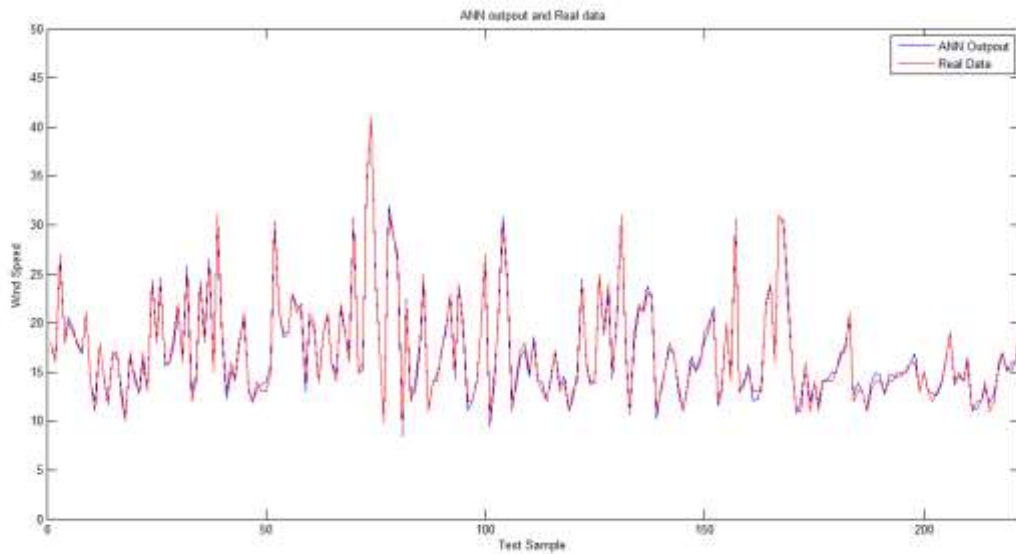


Figure 4. Obtained results of artificial neural network forecast error for wind-speed forecasting.

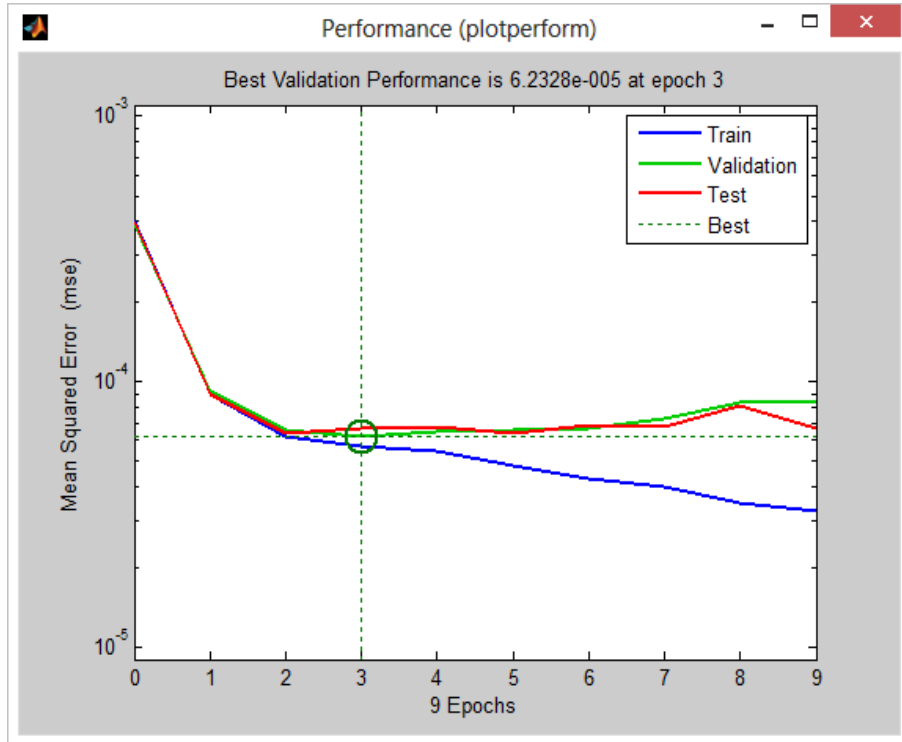


Figure 5. Neural network errors for wind-speed forecasting.

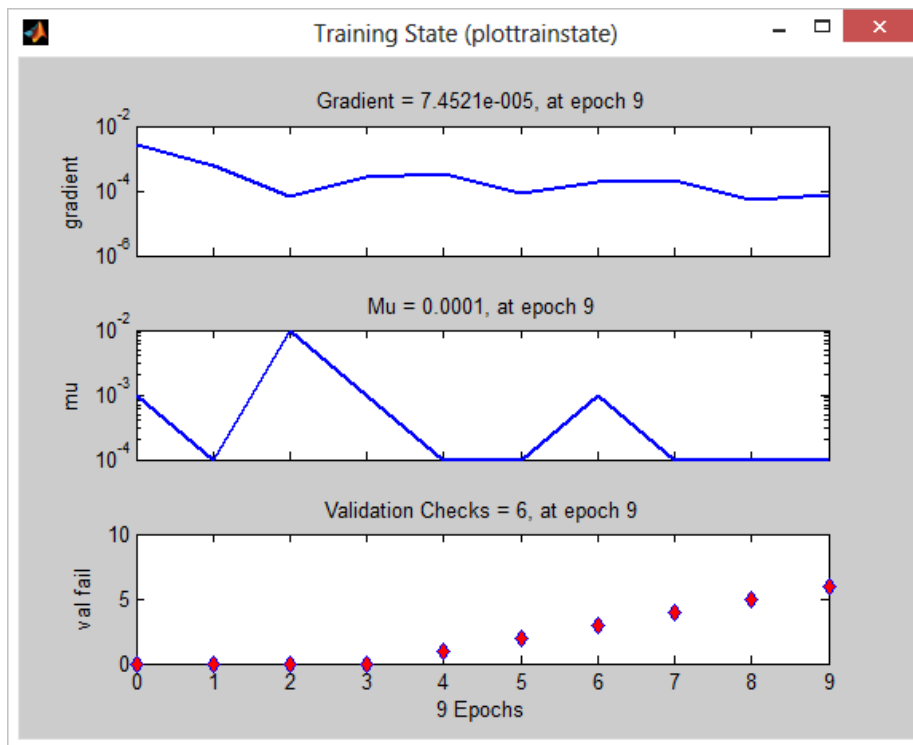


Figure 6. Results of neural network errors for wind-speed forecasting.

While forecasting neural network, absolute error and Mean forecasting error are reported 2.269725 and 0.100809 percent .The related results of artificial neural network forecasting are listed in table (1).

Table 1. MAPE errors and maximum value.

Method	MES	MAPE (%)
Artificial neural network	0.100809	2.269725

5. CONCLUSION

In this article ,artificial neural network was raised to study wind-speed forecasting .The results of neural network forecasting method were studied .Moreover, to determine the best model in terms of quantity , three methods including Mean Square Error ,MSE; Medium ; and Absolute Error, MAE ; and Medium Absolute Percentage Error , MAPE were used to evaluate and compare the model. The results show that artificial neural network forecasting method is a good way to forecast short-term forecasting of electricity market price and the forecasting error is acceptable.

6. REFERENCES

- [1] Cao, L., & Ran, L. (2008). "Short-term wind speed forecasting model for wind farm based on wavelet decomposition". IEEE International Conference, pp. 2525-2529
- [2] Zhang, W., Zeng-Bao, Z., Han, T., Kong, L. (2011). "Short Term Wind Speed Forecasting for Wind Farms Using an Improved Auto regression Method ", IEEE International Conference, pp. 195-198.
- [3] Tong, J., Zeng-Bao, Z., Zhang, W. (2012). "A New Strategy for Wind Speed Forecasting Based on Auto regression and Wavelet Transform.", IEEE International Conference, pp. 1-4.
- [4] Ling-ling, L., Jun-Hao, L., Peng-Ju, H., Cheng-Shang, W. (2011). "The use of wavelet theory and ARMA model in wind speed prediction.", IEEE International Conference, pp. 395-398.
- [5] Tarade, R.S., Katti, P.K. (2011). "A comparative analysis for wind speed prediction", IEEE International Conference, pp. 1-6.
- [6] Zhou, H., Fang, J., Huang, M. (2010). "Numerical analysis of application GARCH to short-term wind power forecasting.", IEEE International Conference, pp. 1-6.
- [7] Xingpei, L., Yibing, L., Weidong, X. (2009). "Wind speed prediction based on genetic neural network",
- [8] Hassoun, M. (2003). "Fundamentals of Artificial Neural Networks". *MIT Press*, 2(3):23-45 IEEE International Conference, pp. 2448-2451.