

# Application of Artificial Neural Network for Wind Speed Prediction

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**Abstract** – This paper presents the application of Artificial Neural Network (ANN) for predicting wind speed in Malaysia by using a historical of meteorological data. Wind energy depends on the wind speed, which is random variable. The artificial neural network was trained using error back propagation learning rule. Meteorological data measured during four years from Kuala Terengganu weather station were used to form learning patterns. The trained artificial neural network was tested with different patterns. As a result, the model based on the neural network showing that the predicted wind speed values are in good agreement with the actual wind speed values.

**Keywords:** *Wind speed, artificial neural network (ANN), back propagation*

## 1.0 Introduction

Wind energy being socially beneficial, economically competitive, and environmentally friendly, has become the world's fastest growing renewable energy source of electricity generation. Utilization of wind energy as an energy source has been growing rapidly in the whole world due to consumption of the limited fossil fuels, environmental pollution and global warming. Wind energy has many advantages like cleanliness, low cost, and abundance in everywhere on the world. It does not have a transportation problem and does not require a high technology to utilize [1].

There are different types of model that can be used for wind speed prediction such as Statistical, Intelligent system, Time series, Fuzzy logic and Artificial neural network. Models are constructed based on meteorological, topological data and wind turbine technical information using numerical methods that suited for a long time predictions since it have difficulties in fast acquisition of data and complicated computations [2].

Artificial Neural Network (ANN) is a branch of the artificial intelligence (AI). The term artificial neural network (ANN) has been conducted right after the recognition of the way the human brain computes. The human brain computes in an entirely different way from the conventional computer, the brain is a highly complex, nonlinear and parallel information processing system. The brain computing process to perform a certain computation is many times faster than the fastest digital computer in existence today, due to the capability to organize its structural constituents, known as neurons. The brain accomplishes perceptual recognition tasks routinely. A neural network is a machine that is designed to model the way in which the brain performs a particular task [3].

Although computing these days is truly advanced, there are certain tasks that a program made for a common microprocessor is unable to perform even so a software implementation of a neural network can be made with their advantages. A neural network can perform tasks that a linear program cannot do. When an element of the neural network fails, it can continue without any problem by their parallel nature. A neural network learns and does not need to be reprogrammed. It can be implemented in any application and without any problem [16]. Due to the advantages above, many researchers have applied ANN in their studies and research.

This paper presents ANN based technique for wind speed prediction based on the historical wind speed and meteorological data. In order to achieve the highest possible prediction accuracy, the methods should consider appropriate parameters and data that may indicate future trends and to determine the best ANN model, three layer feed forward back propagation were constructed [4]. As a result, the model based on the neural network showing that the predicted wind speed values are in good agreement with the actual wind speed values.

## 2.0 Methodology

Artificial neural networks are a network system which is built by simulating the learning behavior of human being. Figure 1 shows the developing of the wind speed prediction, there are two main stages which are data collection and development of ANN.

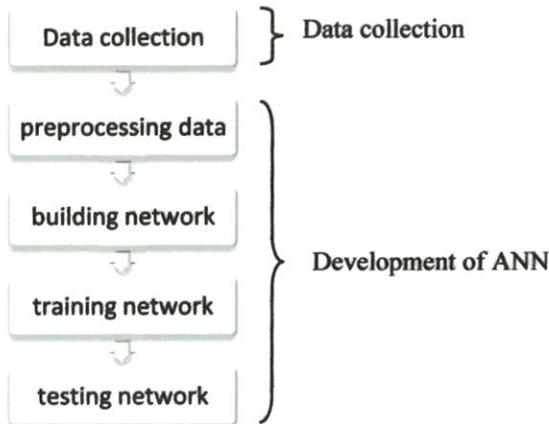


Figure 1 : Block diagram of ANN

### 2.1 Data collection

There are two types of data used in the ANN which is meteorological data as the input data and average wind speed as the targeted output. All the data are taken from Kuala Terengganu whether station (Lat : 5.3° N and Lon: 103.1° E), a city in Terengganu state. All the daily data have been collected for a period from January 2007 to December 2010 [14].

### 2.2 Development of ANN

The fundamental processing element of it is neurons, which are placed in successive layers with three components: the input layer, the hidden layer and the output layer. The data enters the network from the input layer to the output layer through the hidden layer[1]. The figure 1 shows the block diagram of the neural network model. The hidden layer is the logarithmic sigmoid function and the output layer is the linear activation function in the neural network architecture.

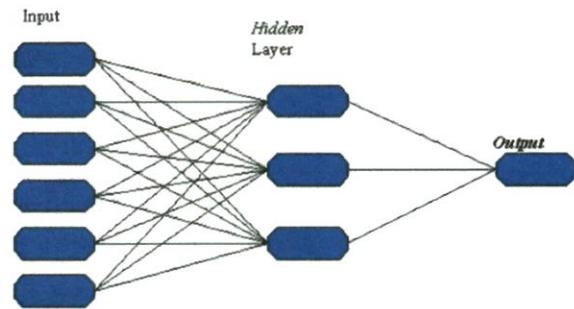


Figure 2 : Neural network model

The network possesses sixteen input neurons, representing the daily temperature, daily humidity, daily dew point, daily sea level pressure and daily visibility. Finally, the network has one output layer with one neuron, representing the average wind speed output of the considered station.

#### 2.2.1 Training the network

Training the ANN with a set of input and output data, the weights in the ANN are adjusted to make the ANN give the same outputs as seen in the training data to avoid ANN become too specific, making it give precise results for the training data, but incorrect results for all other data. When this happens, it shows that the ANN has been over-fitted. The training process can be seen as an optimization problem, where to minimize the mean square error of the entire set of training data [10]. This problem can be solved by using back propagation algorithm, but this algorithm has some limitations concerning, the extent of adjustment to the weights in each iteration.

For the training process, the meteorological data from Kuala Terengganu weather station which are measured in 2 years, between January 2007 and December 2008 [14], were used. In this case, the learning signal was composed of 730 x 16 (730 days with 16 different input parameter) [5]. Figure 3 shows the ANN algorithm for training process.

#### 2.2.2 Testing the network

Testing process is carried out to measure the performance of the trained network, which can be measured to some extent by the errors on the training and validation sets and the testing data; or by performing a linear regression analysis between the network response and the corresponding target. Regression coefficient, R lies between '-1' and

'+1'. The correlation is perfect and positive if ' $r=1$ ' and is perfect and negative if ' $r=-1$ '. If ' $r=0$ ', then there is no correlation between the two variables and thus the variables are said to be independent. Figure 4 shows the ANN algorithm for testing process.

**ANN Training Flow Chart**

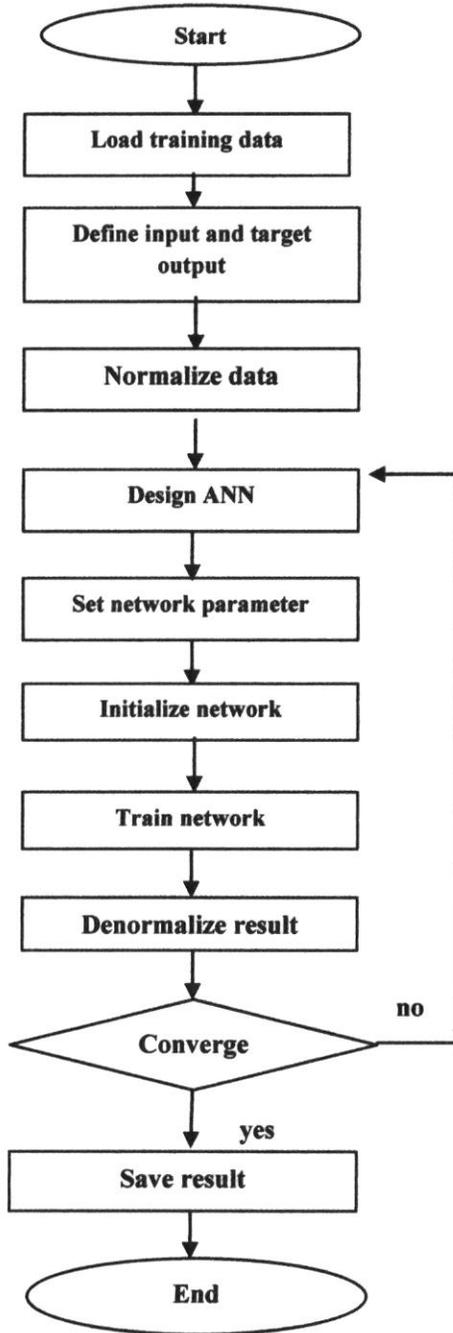


Figure 3 : ANN for training flowchart

**ANN Testing Flow Chart**

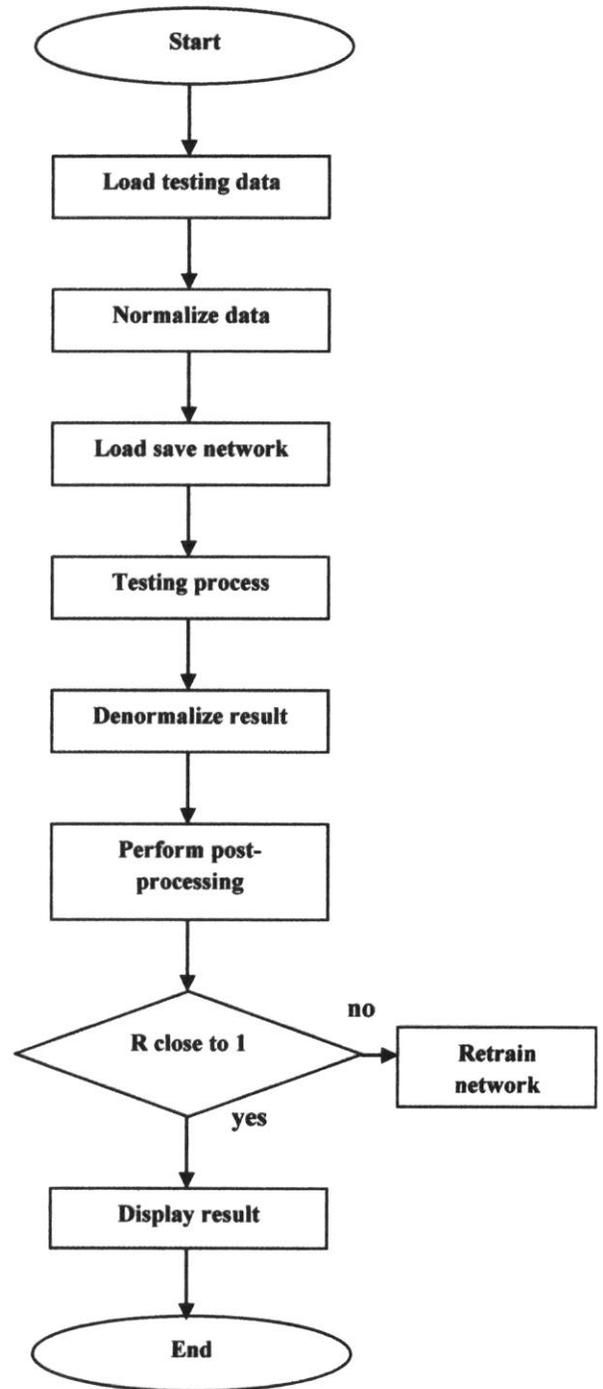


Figure 4 : ANN for testing flowchart

### 3.0 Result and Discussion

The historical data were collected from the meteorological and wind speed record. There are 1460 of pattern. Out of the total pattern, 730 were utilized for training the network while the remaining patterns are used for testing process. The meteorological data was combined with date and indicator to form the input data while data of average wind speed are assigned as the targeted output. There were 32 input data and a single output. The developed ANN receives the input data and also the target output to produce network output [4]. The ANN training process was carried out many times until it meets stopping criterion which is solution will be converge which can be seen from Figure 5.

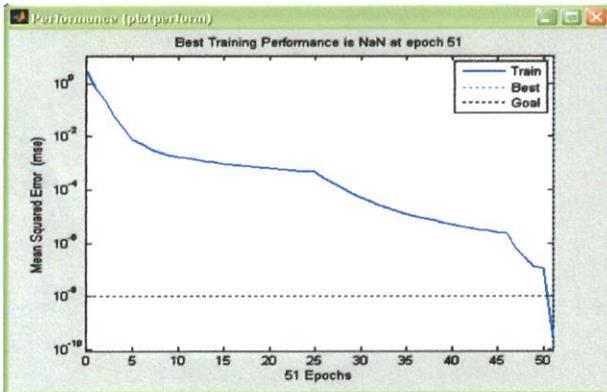


Figure 5 : Graph of network training window

Then, the testing process was executed right after training process. In the ANN testing process, if the value of regression coefficient, R close to one, that means there is a strong correlation between the targeted output and network output. Figure 6 show the result of regression test.

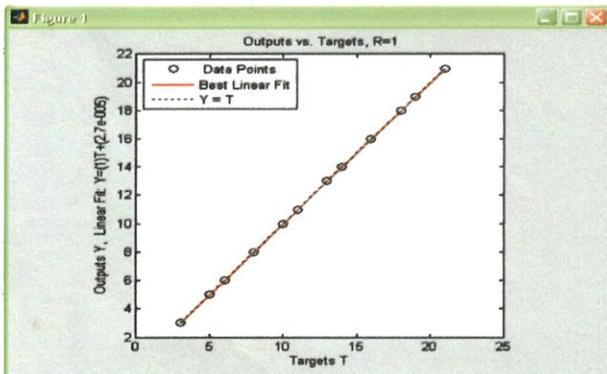


Figure 6 : Graph of regression test, R=1

The value of target output and network output was taken from testing process has been shown in the Table 1. There are not big different between both of value.

Table 1: Sample data of target and network output in testing process

Targeted output	Network output
10.0000	10.0000
6.0000	5.9999
6.0000	6.0002
6.0000	5.9999
6.0000	6.0002
10.0000	10.0000
14.0000	14.0001
14.0000	14.0003
8.0000	7.9997
13.0000	12.9999

From the Table 2, that shows the properties that need to develop network for the wind speed prediction

Table 2: Properties for developed network for the wind speed prediction

ANN properties	Properties
Network configuration	[16,9,5,1]
Transfer function	Tansig, logsig, logsig, purelin
Learning rate	0.80
Momentum constant	0.354
Training technique	trainlm
Epochs	51
Regression coefficient, R	1
Training Patterns	730
Testing Patterns	730
No of input variable	16

### 4.0 Conclusion

In this work, daily wind speed is predicted by the artificial neural network. It contains 32 input variable and single output. Meteorological historical weather data between 2007 and 2008 are used for training the neural network, while data between 2009 and 2010 are used for testing. The feed forward back propagation was used in developed ANN model. As a result, the model based on the neural network showing that the predicted wind speed values are in good

agreement with the actual wind speed values based on the regression analysis.

## 5.0 Acknowledgement

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## 6.0 Referances

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