Prediction of natural wind using neural networks for Wind turbine generator for install at Samut-Prakan, Thailand in year 2011

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***Abstract*-This research, the Artificial Neural Networks (ANN) is proposed to estimate wind speed using wind turbine generator in comparison with data from the Thai Meteorological Department at Samut-Prakan station where is 1 km away. The results are studied to estimate the accuracy estimation of ANN. In experiment, data of wind speed from 150 W wind turbine generator are compared with data from Thai Meteorological Department at Samut-Prakan station where is 1 km away using MatLAB program. The stimulation of ANN is investigated using input data from wind speed collected at the station from 2009 to 2010. The network of ANN use Tansig of transfer function for input and Purelin of transfer function for output. Input data was value between 0 – 1 from neural weights and bias value of ANN network will start from random value. There requirement of goal is zero and ANN has learning from wind speed record in year 2009 and year 2010 for 500 cycle. And has obtained 0.0573294 at Epochs, which that nearest of goal. The wind speed data average must error was 1.29 meter per second. The error of the lowest wind speed average was 0.03 m/s and the total average error is zero m/s. However the Neural network can be used to predict the wind speed from different location but there are some errors from unstable wind speed. However, the average of estimation is acceptable.**

Introduction

Energy is one of the important factors to effect country development in many ways. Electricity is the main source of energy for industrial production. At present, the demand of electricity has increased continuously. Moreover, the present electricity resources in Thailand are petrochemical products such as natural gas, oil and coal which were non-renewable. For this reason, renewable resources to produce electricity are interested, such as wind, solar, wave, biomass and hydro-energy. Energies from natural resource are renewable, clean and non-polluted. Wind can be use as a resource for electricity production but the unstable wind speed and directions are main problems. Therefore, it is interesting to study wind speed from local area to estimate the probability to install wind turbine.

In this research, the Artificial Neural Networks (ANN) is proposed to estimate wind speed using wind turbine generators in comparison with data from the Thai Meteorological Department at Samut-Prakan station where is 1 km away show Fig 1. The results are studied to estimate the accuracy estimation of ANN.

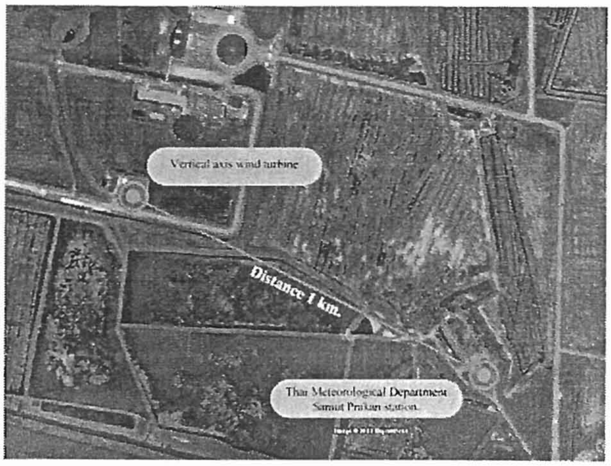


Fig 1. Location for Forecasting of wind speed

Neural network

Neural network from nervous system is a network to be used as a Mathematical modeling tool. Nervous system is the system with massively parallel distributed processor which has an ability to store and recall data from learning experience. Nervous system is brain alike where data are stored via learning process in a form of free parameter in the network. In general, nervous system composes of computing node or neuron in a form of network

The normal structure of ANN is composed of input, hidden, and output layers. In input layer, the neurons accept the outside stimulation as input. By inputting the training data, the experience values in the network are changed by the training. Such a "learning experience" is stored in thresholds and weights. Normally, these inputs are often critical parameters that affect the system are shown in Fig 2.

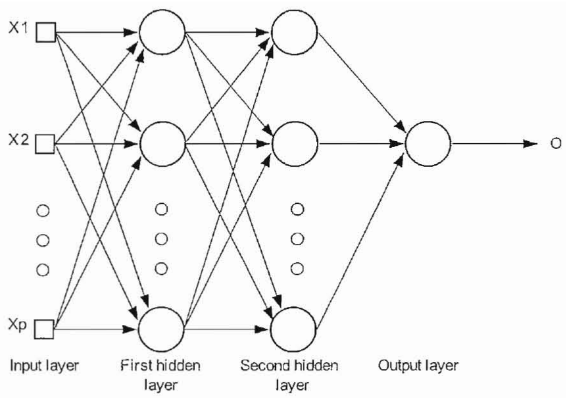


Fig 2. Structure of ANN

Model of neural network

Neural model is a nervous system composss of a single neuron with weight balance. Connection and threshold are shown in Fig 3.

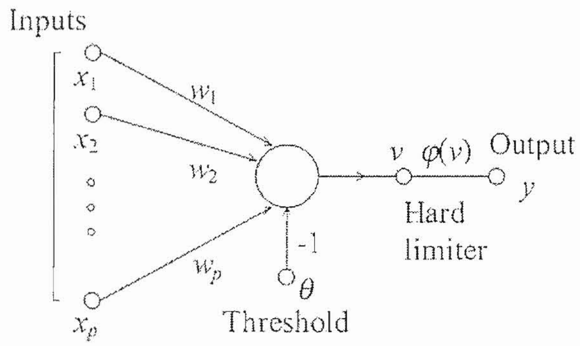


Fig 3. Model of ANN

so

xi : Data input into I of neuràl
wi : weight of neural
θ : Threshold
φ : vector input

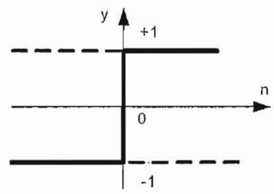
From model can be written as an equation.

$$v = \sum_{i=1}^{p} w_i x_i$$

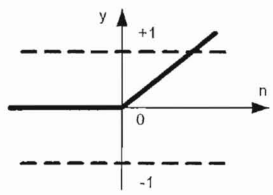
Transfer function

To be able to choose transfer function, the analysis is performed to suite the system or problems which is to be solved. There are several types, for example

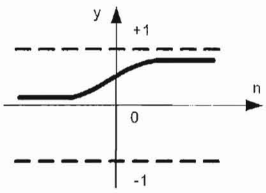
1. Hard limit
   $y = 0 \; if \; n < 0$
   $y = 1 \; if \; n \geq 0$



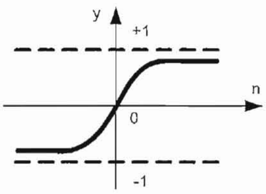
2. Positive linear
   $y = 0 \; if \; n < 0$
   $y = n \; if \; n \geq 0$



3. Log-sigmoil
   $$y = \frac{1}{1 + e^{-n}}$$



4. Hyperbolic tangent sigmoil
   $$y = \frac{e^{n} - e^{-n}}{e^{n} + e^{-n}}$$



Learning Rule

In the learning rule or trainingalgorith to design neural network, the main part is to find the parameter of the system which are neural weight and bias value which can be divided into 3 groups.

1. Supervised ANN:

The supervised ANN requires the sets of inputs and the outputs for its training. During the training, the output from the ANN is compared with the desired output (target) and the difference (error) is reduced b y employing some algorithm. This training is repeated till the actual output acquires an acceptable level.

2. Unsupervised ANN:

The artificial neural network which does not require a superior or teacher for training is known as unsupervised ANN. In competitive or unsupervised learning units of the output layer compete for the chance to respond to a given input pattern.

3. Re-enforcement ANN:

In this learning method, the learning of an input-output mapping is performed through continued with the environment in order to minimize a scalar index of performance.

Experimental

In this experiment, data of wind speed from 150 W wind turbine generators are compared with data from Thai Meteorological Department at Samut-Prakan station where is 1 km away using MatLAB program. The stimulation of ANN is investigated using input data from wind speed collected at the station from 2009 to 2010. show Fig 4. and Fig 5.

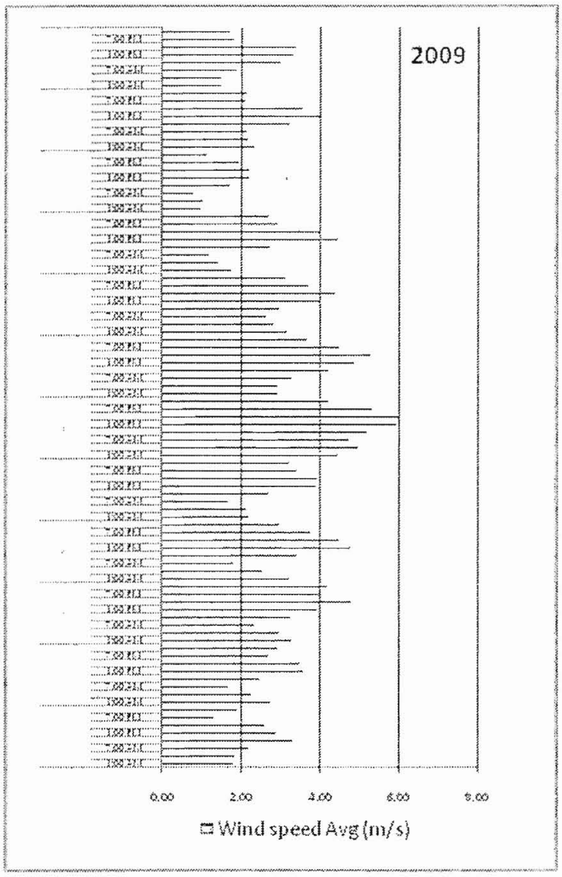


Fig 4. Wind speed in year 2009

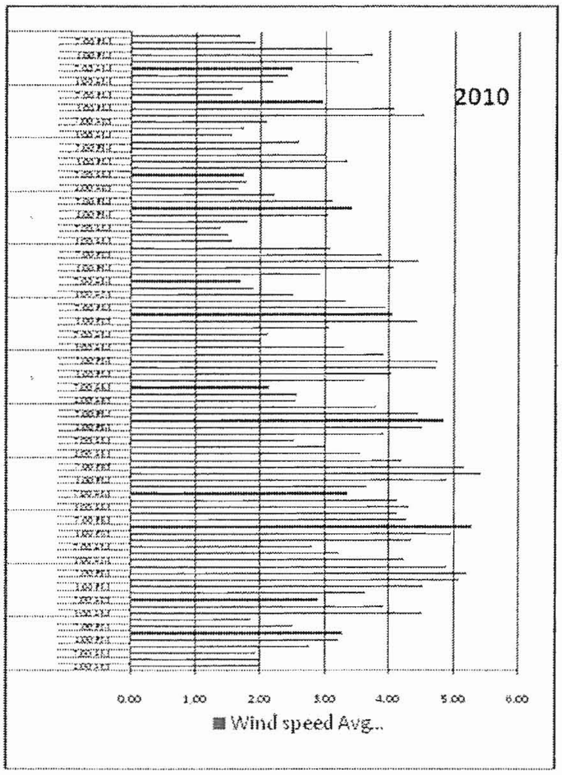


Fig 5. Wind speed in year 2010

Then they must predict 1 year from January 2011 to December 2011, compared to the measurement of wind speeds at to vertical axis wind turbines at the distance interval about 1 kilometer.

Result

In this Section results are presented. Then ANN will modify the weights and thresholds to learn the optimum behavior of the system by many epochs of learning samples. The learning method used during the process is gradient descent with moment weight change and historical learning experience.

The network of ANN use Tansig of transfer function for input and Purelin of transfer function for output. Input data was value between 0 – 1 from neural weights and bias value of ANN network will start from random value. There requirement of goal is zero and ANN has learning from wind speed record in year 2009 and year 2010 for 500 cycle. And has obtained 0.0573294 at Epochs, which that nearest of goal from this data group show Fig 6.

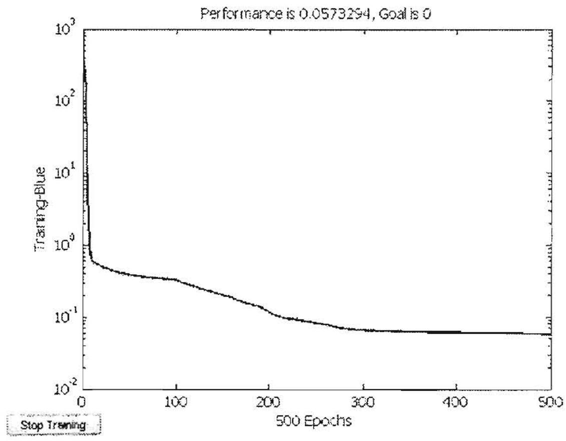


Fig 6. Training Epochs by ANN

Table 1. Show the predicted and measured of wind speed in year 2011 with the installation a wind turbine generator at distance about 1 kilometers.

Table 1. Predict, Actual and DC. voltage

Data		Week 1	Week 2	Week 3	Week 4
January 2011	Prediced wind speed Avg. (m/s)	2.66	2.50	2.18	3.69
	Actual wind speed Avg. (m/s)	2.50	2.54	2.48	3.85
	D.C. Voltage Avg. (V)	10.2	10.3	9.8	15.6
February 2011	Prediced wind speed Avg. (m/s)	2.53	3.71	3.97	2.97
	Actual wind speed Avg. (m/s)	2.32	3.51	5.20	3.20
	D.C. Voltage Avg. (V)	8.6	15.4	18.4	13.2
March 2011	Prediced wind speed Avg. (m/s)	3.00	3.02	2.58	3.05
	Actual wind speed Avg. (m/s)	2.80	4.80	3.40	3.05
	D.C. Voltage Avg. (V)	11	16.7	14.6	11.4
April 2011	Prediced wind speed Avg. (m/s)	2.83	3.50	3.59	2.43
	Actual wind speed Avg. (m/s)	3.30	4.30	4.50	3.30
	D.C. Voltage Avg. (V)	13.2	16.2	16.4	13.3
May 2011	Prediced wind speed Avg. (m/s)	3.37	3.71	3.22	2.55
	Actual wind speed Avg. (m/s)	4.20	3.10	2.50	3.46
	D.C. Voltage Avg. (V)	16.4	11.8	10.3	14.3
June 2011	Prediced wind speed Avg. (m/s)	3.07	4.10	4.03	4.77
	Actual wind speed Avg. (m/s)	3.64	5.30	4.20	5.20
	D.C. Voltage Avg. (V)	15.6	19.8	16.5	19.6
July 2011	Prediced wind speed Avg. (m/s)	3.22	3.61	3.09	4.26
	Actual wind speed Avg. (m/s)	3.6	3.8	4.2	4.8
	D.C. Voltage Avg. (V)	14.2	15.1	16.5	16.7
August 2011	Prediced wind speed Avg. (m/s)	3.69	2.43	3.18	2.79
	Actual wind speed Avg. (m/s)	2.4	2.1	3.5	3.2
	D.C. Voltage Avg. (V)	9.7	8.0	15.2	12.2
September 2011	Prediced wind speed Avg. (m/s)	2.87	3.47	2.80	2.75
	Actual wind speed Avg. (m/s)	3.6	3.81	2.1	2.2
	D.C. Voltage Avg. (V)	14.2	15.2	8.0	8.2
October 2011	Prediced wind speed Avg. (m/s)	1.83	1.27	1.74	2.08
	Actual wind speed Avg. (m/s)	2.1	2.3	1.9	2.8
	D.C. Voltage Avg. (V)	8.0	8.5	7.5	11.0
November 2011	Prediced wind speed Avg. (m/s)	1.54	1.88	2.27	2.36
	Actual wind speed Avg. (m/s)	1.9	1.6	1.8	2.4
	D.C. Voltage Avg. (V)	7.5	7.1	7.3	9.7
December 2011	Prediced wind speed Avg. (m/s)	2.27	2.12	2.69	2.09
	Actual wind speed Avg. (m/s)	2.7	2.5	3.2	2.02
	D.C. Voltage Avg. (V)	10.4	10.2	13.2	7.6

The wind speed data average must error was 1.29 meter per second. The error of the lowest wind speed average was zero m/s and the total average error is 0.29 m/s can observed from Fig 7.

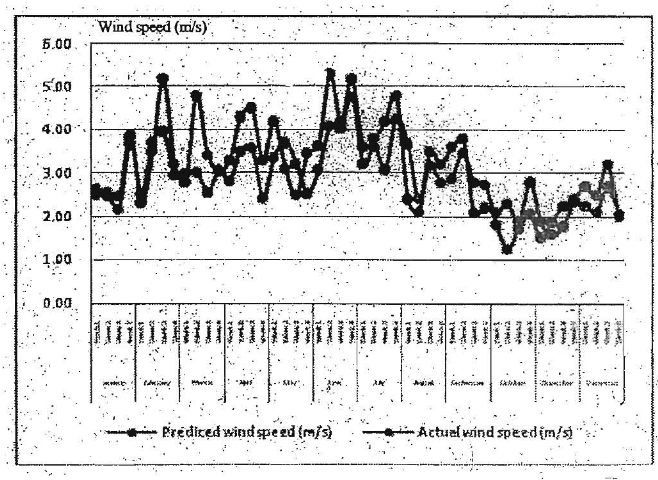


Fig 7. Compare predict with actual of wind speed

Conclusion

The Neural network can be used to predict the wind speed from different location but there are some errors from unstable wind speed. However, the average of estimation is acceptable. The average of wind speed for the whole year 2011 at the installation point is less than 2.9 m/s from predicted wind speed by ANN and average wind speed from actual is 3.19 m/s.

We make this research in Samut-Prakan, Thailand so near seaside (less than 2.5 km.) and it possible at wind speed is more 2.5 m/s with average wind speed of Thailand. However, wind turbine for seaside of Samut-Prakan in Thailand is supposed to generate electric for charging battery at wind speed less than 2.5 m/s because wind have unstable both speed and direction.

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