International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-5, March 2020

Adaptive Neuro-fuzzy Inference System Based Short Term Wind Speed Forecasting

V.Vanitha, D.Magdalin Mary, G.Sophia Jasmine, Akhil Balagopalan

***Abstract:** Due to the stochastic nature of wind speed, accurate wind power prediction plays a major challenge to power system operators for unit commitment and load dispatching. To predict wind power production with great accuracy, wind speed forecasting in different time horizons is gaining importance nowadays. This paper explores the application of Adaptive Neuro-Fuzzy Inference Systems (ANFIS) to forecast the wind speed in Logan international airport, USA for one year in every one hour time interval. ANFIS with different structures and membership functions are trained to find out the best model to do short term wind forecasting. Simulation with the best model is performed in MATLAB and the results show that the three input model with wind speed, direction and air pressure as inputs using Gaussian bell membership function provides the smallest errors.*

***Keywords** : ANFIS, Logan airport, MAPE, Wind speed*

I. INTRODUCTION

As wind is intermittent in nature, Independent Power Producers (IPP) need to forecast wind power upto a few hours ahead with reasonable accuracy for proper scheduling of electrical power in a power system[1]. Accurate prediction of wind is necessary to help the Load Dispatch Centers to manage the grid operations in an optimal fashion and power trading. Because of high penetration of wind energy into electric grids, bulk intermittent generation affects grid security, system operation and market economics. Further, deregulation of electric industry as well as power trading increase the importance of accurate forecasting. Operation and maintenance of wind turbine can also be planned based on the information of wind data at the specific location. Different techniques such as statistical methods, persistence method, numerical weather prediction method, artificial intelligent methods and hybrid methods[2] are used for accurate wind forecasting. This paper focuses on wind speed forecasting in Logan international airport by Adaptive Neuro-Fuzzy Inference Systems (ANFIS)[3], which is a combination of Artificial Neural Network (ANN) and Fuzzy Inference System (FIS). ANN has the capability of looking for patterns in the information presented to it and thus learns about the system. FIS produces output by analyzing previous experience. Self decision making capacity makes FIS suitable for prediction purpose. Combination of ANN and Fuzzy logic approaches perform better than individual ANN and Fuzzy forecasts, and ANN-Fuzzy approach provides excellent performance. When added with ANN, FIS acts as a feedback and gains more experience and produces accurate output[4][5].

Revised Manuscript Received on March 30, 2020.
* Correspondence Author
V.Vanitha*, Department of Electrical and Electronics Engineering, Sri Krishna College of Technology, Coimbatore, India. Email: vvanitha55@gmail.com
D.Magdalin Mary,Department of Electrical and Electronics Engineering, Sri Krishna College of Technology, Coimbatore, India. Email: magdalinmary.d@skct.edu.in
G.Sophia Jasmine, Department of Electrical and Electronics Engineering, Sri Krishna College of Technology, Coimbatore, India. Email: sophiajasmine.g@skct.edu.in
Akhil Balagopalan, Department of Electrical and Electronics Engineering, Amrita School of Engineering, Coimbatore, India. Email: akhilb09cc@gmail.com

II. METHODOLOGY OF PRESENT STUDY

In the present study, wind speed prediction based on fuzzy logic and artificial neural network is used, which provides significantly less rule base but also increased estimated wind speed accuracy when compared to traditional fuzzy logic alone. It involves the following steps:(i)Data collection (ii) Data normalizing (iii) ANFIS structure selection (iv) Data training and (v) Data testing. Fig.1 shows the flow chart of methodology for the proposed study.

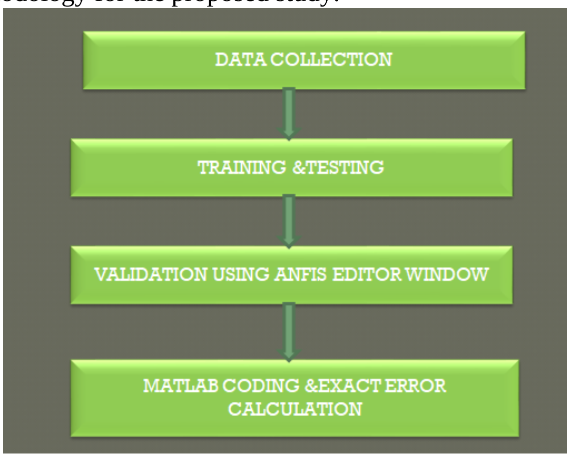

Fig. 1. Flow chart of the methodology.

A. Data Collection

Good Hourly average values of wind speed, wind direction, air pressure and temperature have been used for the study from MIT site.

The data was collected from a site that had a weather monitoring system having sensors for the four parameters. The hourly average values over a period of one year were available for the study. The annual data obtained from the site had missing and out of range values to the tune of 22% due to poor site conditions and communication errors.

These deformities have been rectified by manual extrapolation using the values at the nearest time step and the refined data are used for generating the FIS system. These measured data have been averaged for every 30 min interval.

B. Data Normalization

The historical data gathered is then normalized such that each value falls between 0 and 1 using MATLAB, as FIS membership function lies between 0 and 1.

C. ANFIS structure selection

The ANFIS model is flexible and very much capable of handling random data patterns and can be easily used for different sites. Any number and shape of Membership Functions (MFs) can be selected for outputs and inputs. More number of MF means more accuracy in wind forecasting, but the fast micro-controller is required for real time implementation of wind speed predictor. The required ANFIS model is constructed in MATLAB by defining the number of inputs, the number of MFs and their shape, and the number of training epochs. Here ANFIS model is selected in such a way that a mean square error between output and target is minimized during training by changing number of MFs, their shapes and number of epochs for convergence. Fig. 2 shows the ANFIS membership function editor in MATLAB.

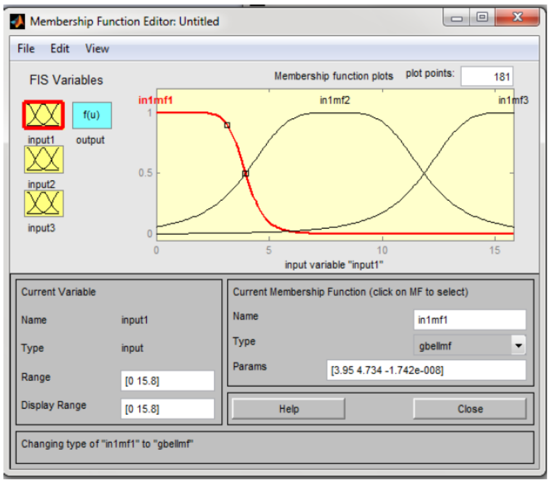

Fig. 2. Membership function editor.

D. Training and Testing

The Fuzzy Inference System is developed using Sugeno type with three bell MF by grid partitioning technique. For each month, 672 samples are used as train data. Fig. 3 shows ANFIS GUI and Fig. 4 and Fig. 5 show the results of training and testing processes of ANFIS. Fig. 6 shows the inputs and outputs of ANFIS structure. Fig. 7 presents the rules[7] defined between membership functions and normalization layer for the three inputs of air pressure, wind speed and wind direction. Fig. 8 shows the structure of the FIS created with 1080 days data.

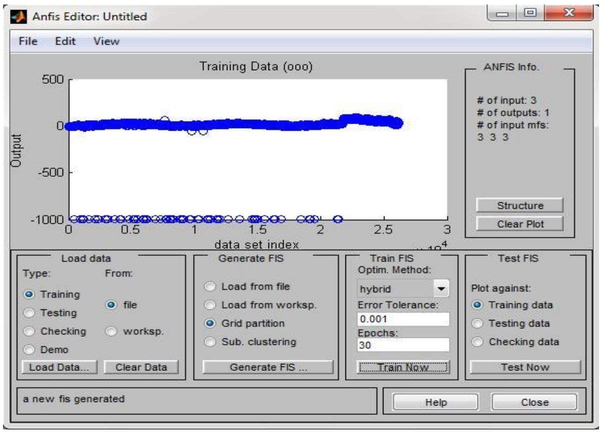

Fig. 3. ANFIS GUI.

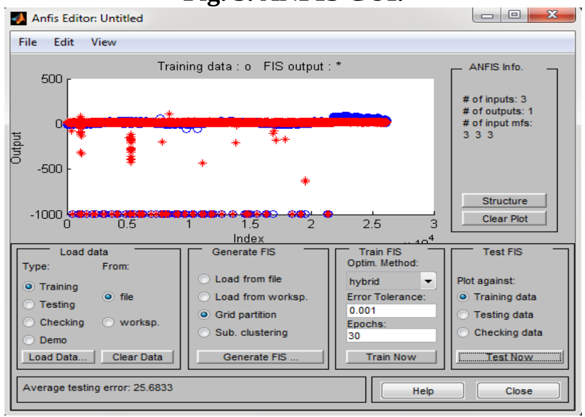

Fig. 4. Training in ANFIS.

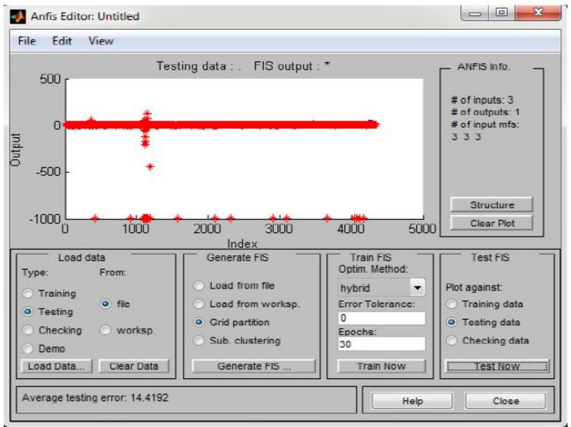

Fig. 5. Testing in ANFIS.

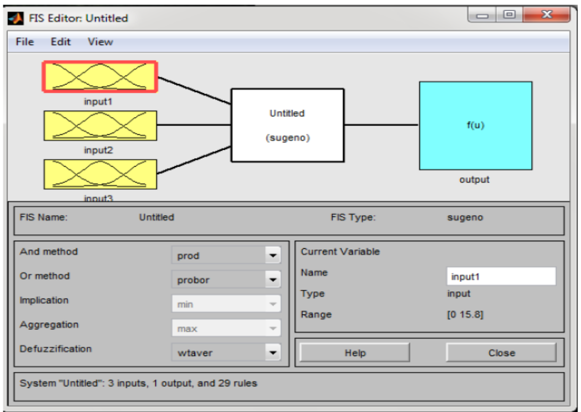

Fig. 6. Inputs and output of the ANFIS system under study.

Retrieval Number: E2252039520/2020©BEIESP
DOI: 10.35940/ijitee.E2252.039520
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

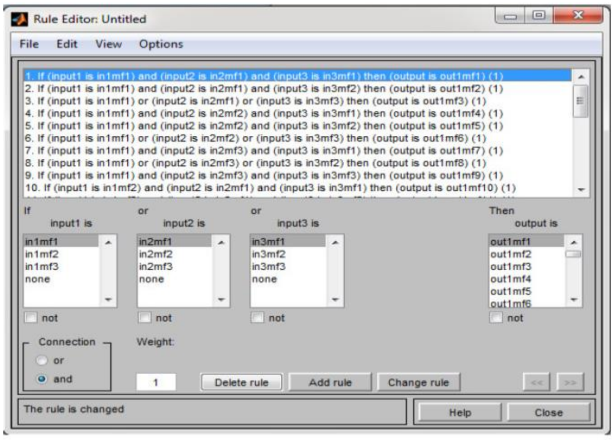

Fig. 7. Rule editor in ANFIS.

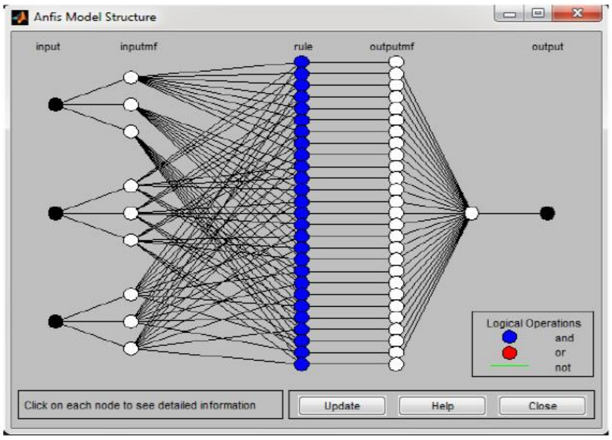

Fig. 8. ANFIS Structure of the system under study.

III. SIMULATION RESULTS

Forecast error is calculated in different ways, such as (i) Mean Absolute Percentage Error (MAPE), (ii) Root Mean Squared Error (RMSE), (iii) Mean Error. MAPE is the most important measure of error and is the mean of the absolute values of the errors[6][8]. MAPE of the wind speed forecast in Logan airport is found out in the present study. Fig. 9 shows the graphical representation of the sample results.

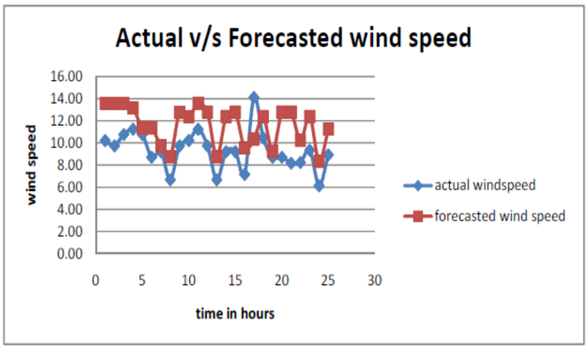

Fig. 9. Graphical representation of actual and forecasted wind speed for the site under study.

IV. CONCLUSION

In this paper, ANFIS is utilized for forecasting the wind speed in Logan international airport, USA for one year from the MIT data of wind speed, wind direction, temperature and pressure. The three inputs model generated by grid partitioning using Gaussian bell membership function provided the smallest errors. The results show that MAPE varies with different data samples. The average MAPE obtained is 24.3%. If more years of data are used for ANFIS training, accuracy can be improved further.

REFERENCES

1. Indian Electricity Grid Code (IEGC), 2010
2. David Barbosa de Alencar et al, Different Models for Forecasting Wind Power Generation-Case Study", Energies, Vol.10, pp.1-27,2017
3. J.S.R. Jang, "ANFIS: adaptive network-based fuzzy inference systems," IEEE Trans. Syst., Man, Cybern., vol. 23, no. 3, pp. 665–685,May-Jun. 1993.
4. Yordanos Kassa, " Short term wind power prediction using ANFIS", International Conference on power and renewable energy", 2016.
5. S.R.Nanda Kishore, V.Vanitha,"Wind speed forecasting for grid code compliance", Journal of Renewable and Sustainable energy", pp.1-9,2013.
6. Krishnaveny Nair, Vanitha V and Jisma M, "Forecasting of wind speed using ANN, ARIMA and Hybrid Models", IEEE International Conference on Intelligent Computing, Instrumentation and Control Technologies, 2017.
7. Wang LX and Mendel M., "Generating fuzzy rules by learning from examples", IEEE Transactions on Systems, Man and Cybernetics, pp.1414–26,1992.
8. J..Scott J. Scott Armstrong and Fred Collopy, "Error Measures for Generalizing About Forecasting Methods: Empirical Comparisons" International Journal of Forecasting, Vol. 8, No.1, June 1992, pp. 69-80.

AUTHORS PROFILE

Dr.V.Vanitha received her Bachelor's degree in Electrical and Electronics Engineering from Madurai Kamaraj University and Masters degree in Power Systems from Bharathidasan University. She got her Ph.D degree from Anna University, Chennai. She is currently working as Professor at Sri Krishna college of Technology, Coimbatore. Her research interests are in the areas of Wind energy, Power System and Electrical Machines.

Ms.D.Magdalin Mary graduated in Electrical and Electronics Engineering from Karunya Institute of Technology, Coimbatore in 2007, received Master of Engineering with Distinction in Control and Instrumentation from Anna University in 2010 and Pursuing Ph.D. in Electrical Engineering from Anna University, Chennai. She is currently working as Assistant Professor, Sri Krishna college of Technology, Coimbatore. Her research areas are Power Electronics and soft computing.

Dr.G.Sophia Jasmine graduated in Electrical and Electronics Engineering from University of Madras in 2001, received Master of Engineering with Distinction in Power Systems Engineering from Anna University in 2009 and Ph.D. in Power Systems Engineering from Anna University, Chennai. She is currently working as Associate Professor, Sri Krishna college of Technology, Coimbatore. Her research areas are power system and soft computing. She is a life member of Indian Society of Technical Education (ISTE). She is a reviewer of reputed journals.

Mr.Akhil Balagopalan completed his post graduate diploma in wind resource assessment at Amrita School of Engineering, Coimbatore. His research interests are wind energy and wind resource assessment.