ISSN:0975-9646

Sushmita Tiwari et al, / (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 6 (3) , 2015, 2121-2126

An Intelligent System For Forecasting Electric Load And Price

Sushmita Tiwari
Department of Computer Science and Engineering
Sharda University
Greater Noida, India

Vaishali singh
Department of Computer Science and Engineering
Sharda University
Greater Noida, India

Rajiv Kumar
Department of Computer Science and Engineering
Sharda University
Greater Noida, India

Abstract—Electric load forecasting is an important research field to increase reliability of power supply and provide optimal load and minimum price scheduling in an intelligent manner. This paper presents the development of advanced neural networks to face successfully the problem of the short term Electric load forecasting. Artificial neural network (ANN) has been used for many years in various sectors and disciplines like medical, robotics, electronics, meteorology, economy, forecasts, etc. This report present the development of an Adaptive Neuro Fuzzy Inference System (ANFIS) Based short-term load forecasting model which forecast the electric load. It predict electric load by considering these information as input like date, time, humidity and previous data sets taken from the various power corporation. This model is derived by modifying the method of forecasting technique using Adaptive Neuro Fuzzy Inference System (ANFIS) which is the process of formulating the mapping from a given input to an output using fuzzy logic Fuzzy systems are expert decision making tools that require support from Artificial Neural Network (ANN) for the generation of inference. This leads to the formation of Neuro-Fuzzy Inference system (NFIS) and ANFIS are a class of adaptive networks that are functionally equivalent to fuzzy inference systems. Experimental results show that such system is effective in controlling, managing, planning and organizing the electric load by forecasting the load.

Keywords— Electric Load and Price Forecasing; Aritifitial Neaural Network(ANN); FIS(Fuzzy Inference System); Adaptive Neural and Fuzzy Inference System(ANFIS).

I. INTRODUCTION

In India consumption of electricity increasing approximately 10-11% per year. A proper management and control on electric load is very necessary for this purpose most important factor is an efficient forecasting system of electric load is required. Load forecasting has always been important for organizing, planning and operation decision. Forecasting can be of any type like – long term, medium term & short term. Sort term forecasting is used to forecasting the load of within week, mid term forecasting is used for more than a week and less than a year and Long term forecasting is used for more than a year. Several operations of load like real time control on load generation, spinning reserve allocation, security analysis, load interchanges with other utilities, temperature variation analysis and planning of energy transactions are based on short term load forecasting. It is very essential to forecast the load correctly in the power system because errors in load forecast results suboptimal unit commitment decisions. Relationship between electric load and its derived factors make it complex and non-linear which yields difficulties to process it with traditional techniques line linear and multi regression model auto regression [1], autoregressive moving average (ARMA), exponential smoothing methods [2], dynamic linear[3], Kalman-filter-based methods [4], etc. After that some of the models were used for STLF (Short Term Load Forecast). In recent times, much research has been carried out on the application of artificial intelligence techniques to the load forecasting problem. ANN (artificial neural networks) based on multilayered perceptrons [5] ,Expert systems have been tried out , and compared to traditional methods. Fuzzy inference [6], fuzzy-neural models [7] and Neural Network [8 , 9] have also been tried out. But and Adaptive Neuro Fuzzy Inference System (ANFIS) is new concept in electric load forecasting. ANFIS is a multilayer adaptive network-based fuzzy inference system proposed by Jang integrates both neural networks and fuzzy logic principles [10].

ANFIS has been widely used in automation control and other areas. Fuzzy logic (FL) and fuzzy inference systems (FIS),[11, 12] first proposed by Zadeh, which provide a solution for making decisions based on indefinite, ambiguous, imprecise and missing data. So by using ANFIS a novel approach for forecasting load can be implemented. Fuzzy logic can have different meanings. Fuzzy logic in its narrow sense is a branch of FL. Even in its wider sense, fuzzy logic differs both in concept and substance from traditional multi-valued logical systems.

Fuzzy Inference Process [13, 14]

Fuzzy inference is the process of formulating the mapping from a given input to an output using fuzzy logic(FL). The mapping then provides a basis from which decisions can be made, or patterns recognized. The process of fuzzy inference involves all of the pieces that are described in Logical Operations, Membership Functions, and If-Then Rules [15, 16, 17].

Two types of fuzzy inference systems **Mamdani** and **Sugeno**

Mamdani-type inference, expects the output membership functions to be fuzzy sets and after the aggregation process, there is a fuzzy set for each output variable that needs de-fuzzification.

Takagi-Sugeno-Kang, method of fuzzy inference. Introduced in 1985 , similar to the Mamdani method in various aspects. The first two parts of the fuzzy inference process, fuzzifying the inputs and applying the fuzzy operator, are exactly the same and the main difference between Mamdani and Sugeno is that the *Sugeno* output membership functions are either linear or constant .

ANFIS

The acronym ANFIS is **Adaptive Neuro-Fuzzy Inference System**. It construct a fuzzy inference system (FIS) whose membership function parameters are tuned using either a back propagation algorithm only or in combination with a least squares type of method. This adjustment allows fuzzy systems to learn from the data they are modeling. Some features of ANFIS: Fuzzy inference is the process of formulating the mapping from a given input to an output using fuzzy logic. ANFIS are a class of adaptive networks that are functionally equivalent to fuzzy inference systems. It represent Sugeno fuzzy models. ANFIS uses a hybrid learning algorithm. It is a universal approximator [18, 19, 20].

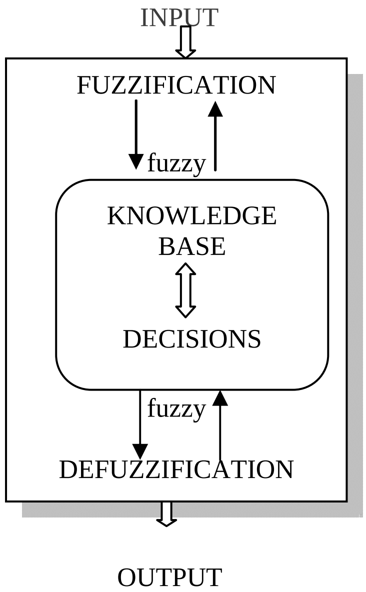

Fig.1.1.Components of Fuzzy Inference Systems

Using IF–THEN rules in the form of [if X and Y then Z]. A fuzzy inference system consists of fuzzy rules and membership functions and fuzzification and defuzzification operations as shown in above figure.

Fuzzy Clustering [21,22].

Clustering involves the task of dividing data points into homogeneous classes or clusters so that items in the same class are as similar as possible and items in different classes are as dissimilar as possible. Clustering can also be thought of as a form of data compression, where a large number of samples are converted into a small number of representative prototypes or clusters. Depending on the data and the application, different types of similarity measures may be used to identify classes, where the similarity measure controls how the clusters are formed. Some examples of values that can be used as similarity measures include distance, connectivity, and intensity.

In non-fuzzy or hard clustering, data is divided into crisp clusters, where each data point belongs to exactly one cluster. In fuzzy clustering, the data points can belong to more than one cluster, and associated with each of the points are membership grades which indicate the degree to which the data points belong to the different clusters

II. LITERATURE REVIEW

Different researchers are using different techniques in this field but all the techniques have some advantages and disadvantages. In this paper different paper survey has been carried out in which Support Vector Regression (SVR) with Locally Weighted Regression (LWR) is used by Ehab E. Elattar and it is more significance and superior than LWR, local SVR, and other conventional models. By using Fixed-Size Least Squares Support Vector Machines is possible to build a large scale nonlinear Regression for large dataset. The larger values of subsample will improve the accuracy but further improvement is needed. Various ANN's parallel implementations is used in another model which is different from usual time-series prediction models because Additional load and/or weather information is not necessary. Forecasting load demands for the daily operational planning can be done by using back propagation. A brief comparative survey in tabular form is shown in table.

REFERENCES	YEAR	FORECASTING MODELS	ACCURACY /PERFORMANCE	REMARKS
Ehab E. Elattar [23]	2010	Support Vector Regression (SVR) with Locally Weighted Regression (LWR)	0.5 % more significance level than LWR, local SVR, and other conventional models.	This model is superior over LWR, local SVR, and other conventional models. Using weighted distance algorithm.
Moor et. al [24]	2005	Fixed-Size Least Squares Support Vector Machines	Good performance with MSE's around 2%-3%	This model is possible to build a large scale nonlinear Regression for large dataset. The larger values of subsample will improve the accuracy but further improvement is needed.
K. Kalaitzakis G.S. Stavrakakis and E.M. Anagnostakis [25]	2002	Uses various ANN's parallel implementations.	RMSE range is 1.0-1.5%. for STLF	This model is different from usual time-series prediction models. Additional load and/or weather information is not necessary.
Muhammad Buhari [26]	2012	Uses back propagation method	Best Mean Squared Error Performance of **$5.84e^{-6}$**	This is robust technique for forecasting load demands for the daily operational planning.

Table 1.Technique comparison from survey

A. *Findings From Literature Survey:*

Different researchers are using different techniques for electric load forecasting but all the researchers faces the same problem like accuracy of the proposed system. It is found that there is also a method in which additional load and/or weather information is not necessary and building a large scale forecasting system is possible.

Use of Adaptive Neuro Fuzzy Inference System (ANFIS) is new in concept for electric load forecasting. ANFIS can be considered as universal estimator because ANFIS integrates both neural networks and fuzzy logic principles.

III. WORKING

It will collect datasets from power corporations and cluster the dataset using k-mean algorithm and use load forecasting model train and test the datasets using adaptive neuro fuzzy inference system(ANFIS) then compare forecast load and actual load and finally it will generate the load report.

a) *ANFIS model structure:*

Adaptive Network-Based Fuzzy Inference System (ANFIS) is a kind of artificial neural network that is based on inference system. Since it integrates both neural networks and fuzzy logic principles, it has potential to capture the benefits of both in a single framework. Its inference system corresponds to a set of fuzzy IF–THEN rules that have learning capability to approximate nonlinear functions. Hence, ANFIS is considered to be a universal estimator.

Model architecture

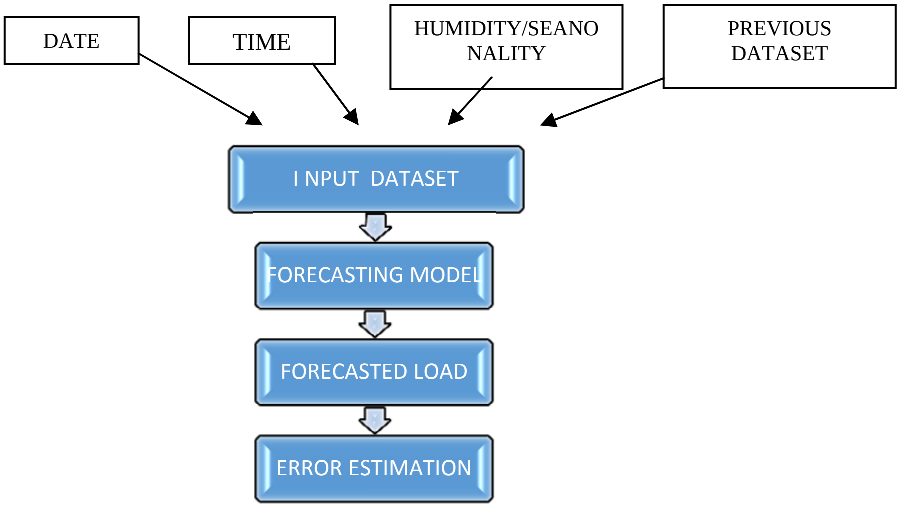

Figure 2: Model Architecture

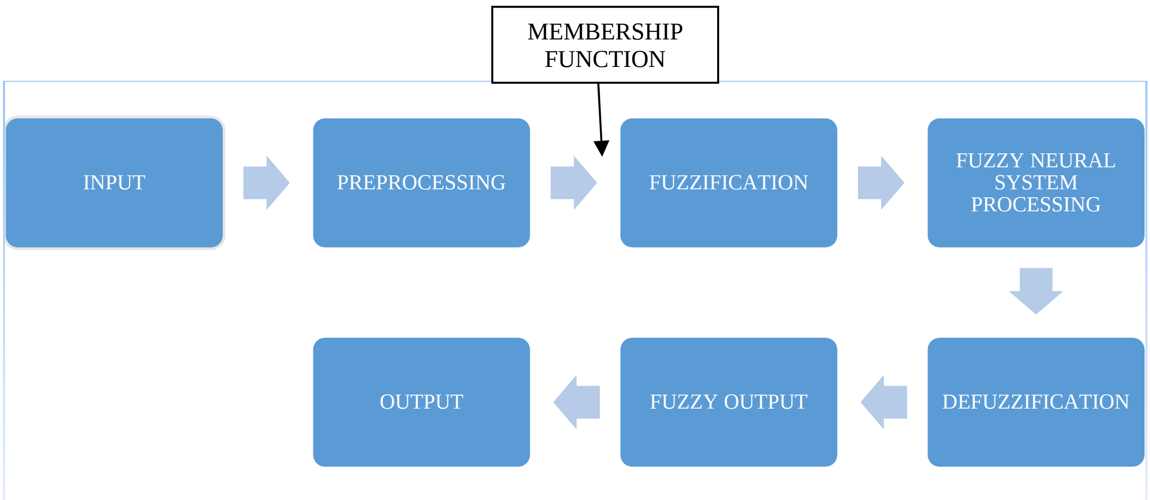

Figure 3.System model using ANFIS

b) Flow chart of the model

Firstly it will initialize all the parameters that are taken as input then it will train the datasets using ANFIS then perform clustering on the basis of dataset using KMC (K-Mean Clustering) afterward calculation of Euclidian distance takes place for predicting the values. After training the dataset it will perform testing using ANFIS and test the result with the actual result and check if its predicted accuracy is achieved then end the process otherwise it will again start the same process from initializing training, clustering, testing and then checking until it will not achieved its predicted accuracy flow chart is shown in the figure 4

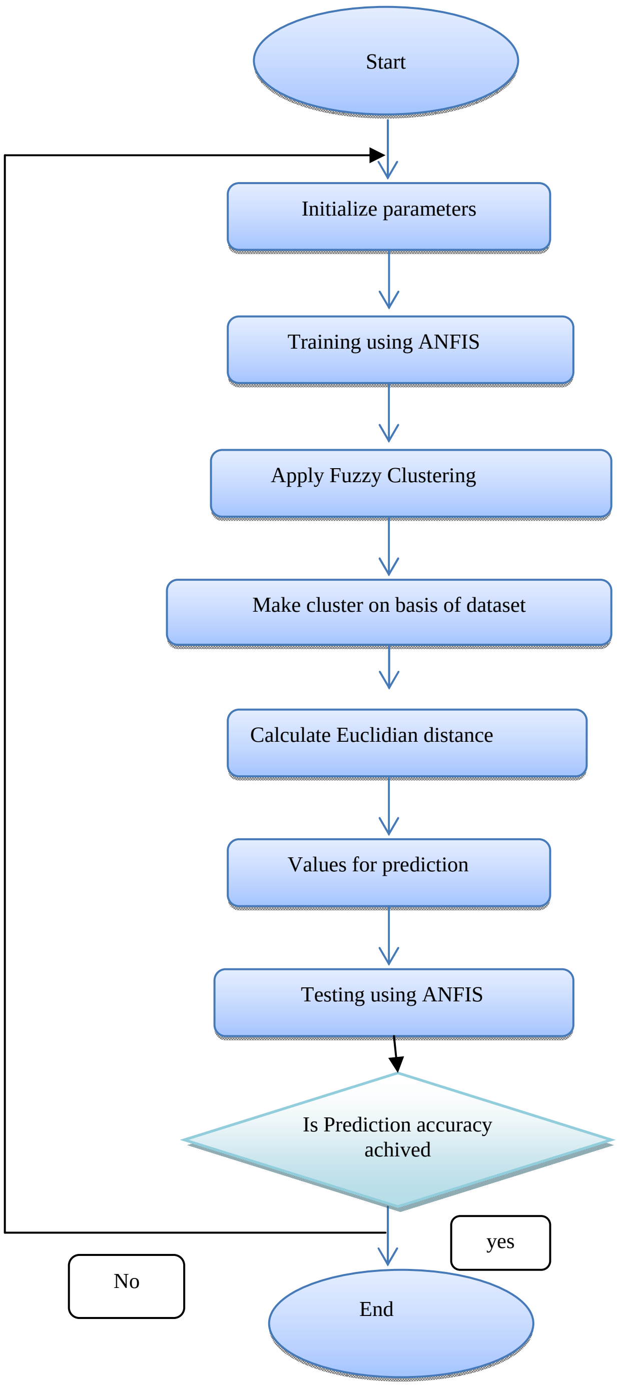

Figure 4: Flow chart of the model

c) Adaptive Neuro-Fuzzy Inference System (ANFIS)

There are two types of FIS: Mamdani-type and Sugeno-type. Depending upon the way outputs are determined, these two types of inference systems vary in their nature. The Mamdani FIS was first proposed by E.H. Mamdani at the University of London in 1974. It applies the system logic in a system controlled by fuzzy logic. This type of FIS results the output membership functions as fuzzy sets which needs defuzzification process to get the result in crisp form. Depending upon the number of inputs and number of outputs along with the maximum number of rules a Mamdani type FIS model can be constructed with definite grades of membership functions. A Mamdani NFS uses a supervised learning technique which is a back propagation learning to retain the variations in the parameters of the membership functions. There are different layers of this type of system as:

Input Layer: Each node represents one input variable which only transmits input to the next layer.

Fuzzification Layer: Each node represents one label to one of the input variable of first layer. The output link of this layer represents the membership value. This layer specifies the degree to which an input value belongs to a fuzzy set. A clustering algorithm determines the number and type of membership functions.

Rule Antecedent Layer: The nodes in this layer represents the type of operator (T-norm operator) used in this node. The output of this layer results the strength of the corresponding fuzzy rule.

Rule Consequent Layer: This node combines the incoming rule antecedents and determines the degree to which they belong to the output label. The number nodes here are equal to the number of rules.

Combination and Defuzzification Layer: The combination of all rules consequents is done in this node and finally after defuzzification it computes the crisp output.

Takagi, Sugeno and Kang proposed the Sugeno Fuzzy model when they were supposed to develop a systematic approach for generating fuzzy rules from a given input-output data set. In general, Sugeno-type systems can be used to model any inference system in which the output membership functions are either linear or constant.

This model uses a mixture of back propagation and least mean square estimation. Different layers of this system model are as follows:

Input Layer, Fuzzification Layer and Rule Antecedent Layer: These three layers function as the Mamdani type NFS model.

Rule Strength Normalization: Every node in this layer calculates the ratio of the i-th rule's strength to the sum of all rules strength,

$$\mathbf{W_i = W_1/(w_1+w_2)}$$

Where i=1, 2, 3…

Rule Consequent Layer: Every node i in this layer is with a node function,

$$\mathbf{W_i f_i = w_i(p_i x_1+q_i x_2+r_1)}$$

Rule Interference Layer: This layer has a single node. It computes the overall output as the summation of all incoming signals and is expressed as,

Overall output=

$$\sum_i \mathbf{Wifi} = \frac{\sum_i \mathbf{Wifi}}{\sum_i \mathbf{Wi}}.$$

IV. RESULT AND ANALYSIS

Fuzzy Logic Toolbox

The Fuzzy Logic Designer and *Neuro-Fuzzy Designer* apps are included in Fuzzy Logic Toolbox. *neuroFuzzyDesigner* opens the *Neuro-Fuzzy Designer* app which allows you to load a data set and train Adaptive Neuro-Fuzzy Inference Systems (ANFIS).

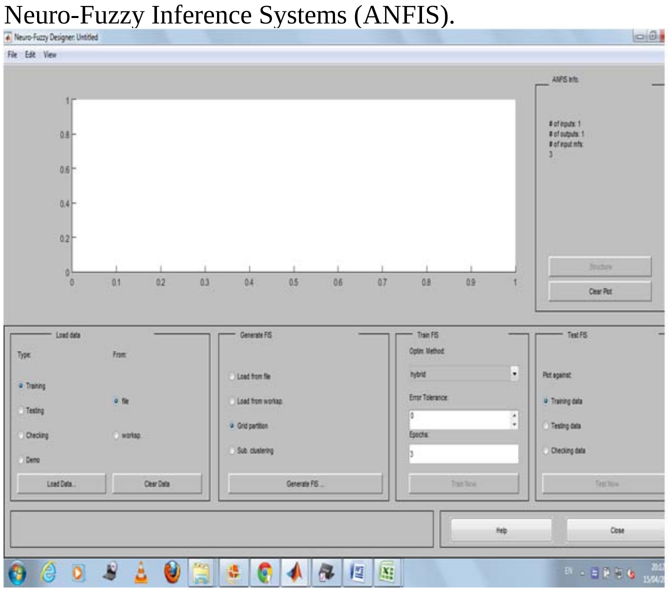

Figure 5.: *Neuro-Fuzzy Designer*

Loading the training dataset: It will generate the FIS with * through training the dataset with actual data shown by dot (**.**).

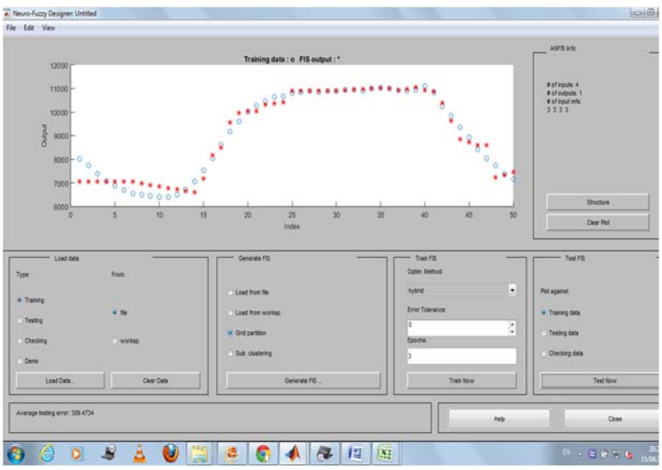

Figure 6. Training Data Plot

This graph shows the comparision between taining and testing datasets with the FIS . Testing data is shown by circle (o).

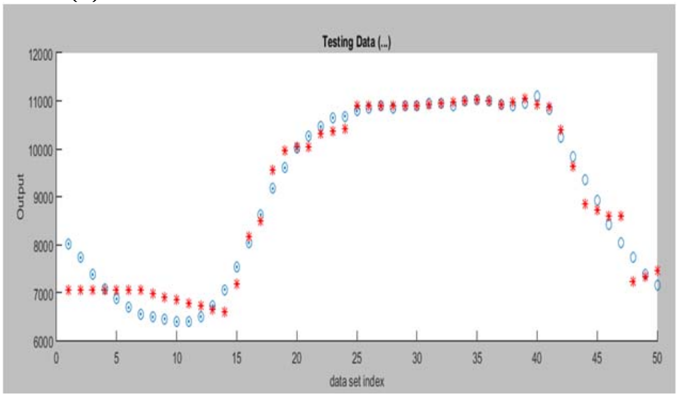

Figure 7.:Testing data plot

This generate the result of checking the data data with actual datasets.

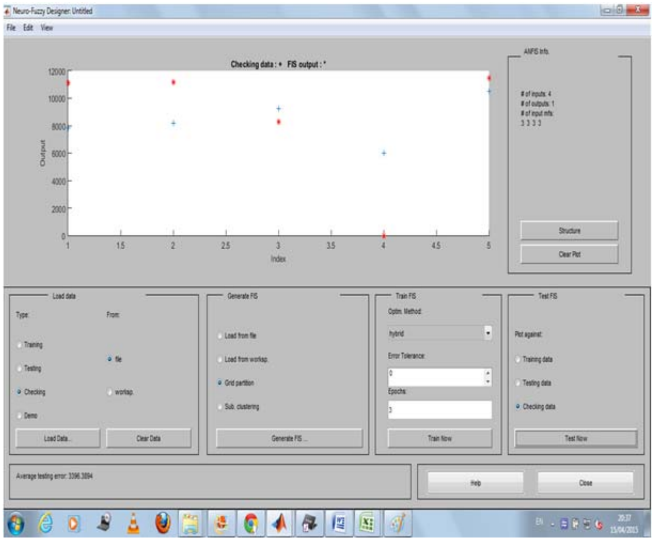

Figure 8.: checking data plot

Overall accuracy of this system is 76.8%

V. CONCLUSION

The result of our this system is based on the dataset we are using for forecasting the load and price of the electricity. This system is using latest version MATLAB R2015a which provide a good fuzzy logic toolbox that has *Neuro-Fuzzy Designer* app which allows you to load a data set and train Adaptive Neuro-Fuzzy Inference Systems (ANFIS) which is relatively new tool and give comparative good result easily with good interface Our proposed system showing a good performance and reasonable prediction accuracy with overall accuracy of this system is 76.8%.. Its forecasting reliabilities were evaluated by computing the mean absolute error between the exact and predicted values. ANFIS integrates both neural networks and fuzzy logic principles. Experimental results show that such system is effective in controlling, managing, planning and organizing the electric load by forecasting the load.

REFERENCES

[1] G. A. N. Mbamalu and M. E. El-Hawary, " Load forecasting via sub optimal seasonal auto regressive models and iteratively reweighted least squares estimation," IEEE Trans. Power Systems, vol.8, no.1, 1993, pp. 343–348.

[2] J. W. Taylor, L. M. de Menezes, and P. E. McSharry, "A comparison of univariate methods for forecasting electricity demand up to a day ahead,"*Int. J. Forecasting*, vol. 22, no. 1, pp. 1–16, 2006.

[3] Douglas , A.P. Breipohl, A.M. Lee, F.N. Adapa , R. " The impact of temperature forecast uncertainty on Bayesian load forecasting " , IEEE Transactions on Power Systems, vol. 13, no.4, 1998, pp. 1507–1513.

[4] J. H. Park, Y. M. Park, and K. Y. Lee, "Composite modeling for adaptive short-term load forecasting," *IEEE Trans. Power Syst.*, vol. 6, no. 2,pp. 450–457, May 1991.

[5] H. S. Hippert, C. E. Pedreira, and R. C. Souza, "Neural networks for shortterm load forecasting:Areviewand evaluation," *IEEE Trans. Power Syst.*,vol. 16, no. 1, pp. 44–55, Feb. 2001.

[6] H. Mori and H. Kobayashi, "Optimal fuzzy inference for short-term load forecasting", IEEE Trans. Power Systems, vol.11, no.1, 1996, pp.390–396.

[7] A . G . Bakirtzis , J . B . Theocharis , S . J . Kiartzis , and K . J . Satsios , " Shortterm load Forecasting using fuzzy neural networks", IEEE Transactions Power Systems, vol.10, no.3, 1995, pp.1518–1524.

[8] A. Khotanzad, R. A. Rohani and D . Maratukulam, "ANNSTLFArtificial neural network short term load forecaster- Generation Three", IEEE Transactions PAS, Vol. 13,No. 4, Nov. 1998, pp. 1413-1422.

[9] K. Kalaitzakis , G.S. Stavrakakis, E.M. Anagnostakis, "Short-term load forecasting based on Artificial neural networks parallel implementation ", Electric Power Systems Research 63 (2002) 185_ 196

[10] S. Mitaim, B. Kosko, The shape of fuzzy sets in adaptive function approximation, IEEE Transactions on Fuzzy Systems 9 (4) (2001) 637–656.

[11] Jang J S R, Sun C T and Mizutani E, Neuro-fuzzy and soft computing a computational approach to learning and machine intelligence, PHI Learning Private Limited, 2011.

[12] Ng H. P., Ong S. H., Fung K. W. C., Goh P. S., Nowinski W. L., „Medical Image Segmentation Using K- Means Clustering and Improved Watershed Algorithm", IEEE, 2006, pp 61- 65.

[13] Pattern Classification: Richard O. Duda, Peter E. Hart, David G. Stork, 2nd Edition, Wiley India, 2007

[14] Haykin. S, Neural Networks A Comprehensive Foundation, 2nd edition, Pearson Education, New Delhi, 2003.

[15] J. Wang, X. Li, H. Li, Prediction of injection profile of an injector using a fuzzy mathematical method, CIPC2005-134, in: Proc.

[16] T Takagi, M Sugeno: Fuzzy identification of systems and its applications to modeling and control: IEEE Transactions on Systems, Man, and Cybernetics: 15:116-132, 1985

[17] Petroleum Society's 6th Canadian International Petroleum Conference (56th Annual Technical.

[18] Y. Bodyanskiy, S. Popov, and T. Rybalchenko, "Multilayer neuro-fuzzy network for short term electric load forecasting," *Lect. Notes Comput.Sci.*, vol. 5010, pp. 339–348, 2008.

[19] P. Melin, O. Castillo, Intelligent control of a stepping motor drive using an adaptive neuro-fuzzy inference system, Information Sciences 170 (2–4) (2005) 133–150.

[20] J. MacQueen, .Some methods for classi_cation and analysis of multivariate observations,. In Proceedings of 5 -th Berkeley Symposium on Mathematical Statistics and Probability.University of California Press, 1967, pp. 281.297.

[21] W. Weiss, R. Balch, How artificial intelligence methods can forecast oil production, SPE 75143, in: Proc. SPE/DOE Improved Oil recovery Symposium, Tulsa, Oklahoma, 2002.

[22] N. Kasabov, Q. Song, DENFIS: dynamic evolving neural-fuzzy inference system and its application for time-series prediction, IEEE Transactions on Fuzzy Systems 10 (2) (2002) 144–154

[23] Ehab E. Elattar , " Electric Load Forecasting Based on Locally Weighted Support Vector Regression " IEEE Transactions On Systems , Man , And Cybernetics —Part C: Applications And Reviews, Vol. 40, No. 4, July 2010.

[24] Marcelo Espinoza, Johan A.K. Suykens, and Bart De Moor, "Load Forecasting using Fixed- Size Least Squares Support Vector Machines " K. U. Leuven, ESAT-SCD-SISTA Kasteelpark Arenberg 10, B-3001 Leuven (Heverlee), Belgium.

[25] K. Kalaitzakis , G.S. Stavrakakis, E.M. Anagnostakis, "Short-term load forecasting based on Artificial neural networks parallel implementation ", Electric Power Systems Research 63(2002) 185_ 196

[26] Muhammad Buhari , " Short-Term Load Forecasting Using Artificial Neural Network" , Proceeding of the international Multi Conference of Engineers and Computer Scientists 2012 Volume I.