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Neural Nework-Based Time Series Methods for Load Forecasting

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***Abstract:** Load forecast plays an important role in power system operation and control. Significant contribution in power system economics may also be observed. Many decisions of the power system depend on the future load demand. The accuracy of STLF is necessary for the optimal and economical operation of the power systems. This paper presents a new approach to STLF. In this paper, time series methods are presented on the basis of neural networks. The time series methods are included autoregressive, nonlinear autoregressive, and non-linear autoregressive with external inputs (narx). The comparative results are presented with the ANN. In this paper, the narx method gives more efficient and accurate results than other methods.*

***Keywords: -** Short-Term Load Forecasting (STLF), Neural Network, Time Series, and MAPE, NARX.*

I. INTRODUCTION

Fundamental operational functions in the power systems such as, spinning reserve capacity, unit commitment, bidding strategies, hydro-thermal coordination, interchange evaluation, energy purchase, scheduling maintenance, and security assessment are required a reliable and accurate STLF [1]. Therefore, the load should have forecasted accurately, which is lead to give proper operation, planning and control for the power systems, So as to make a low operating cost and high reliability of the power supply [2]. The STLF is used to offer load data with lead time from one hour to one week. There are many techniques for load forecast have been discussed during the last few decades. These methods are broadly divided into two groups such as, artificial intelligence, and statistical methods.

The statistical methods have multiple linear regression, time series, SVM, and expert system, etc. The AI methods have such as ANN, Fuzzy Inference, PSO, GA, and adaptive Neuro-Fuzzy system, etc. In recent years, AI techniques play a very important role in solving non-linear problems in the power system. The load demand is non-linear in nature, So the neural network can be used to predict the future load. It has a good quality of non-linear mapping between input and output, which are very difficult to model by any other technique [3]. The NF tool of MATLAB has used to compute STLF for UK-based power utility.

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The past data of load demand has used for load forecasting. In order, to make the high prediction precision of the demanded load, the different statistical and AI techniques have been developed, which gives a more accurate result than individual applied techniques. In this paper, time series, mathematical techniques have combined with a dynamic neural network, this gives comparatively more accurate results than other methods.

The time series with a neural fitting tool is better than other tools. This tool has allowed for solving three kinds of problems with neural networks, such as, NARX, NAR, and non-linear input-output (AR).

To confirm, the effectiveness of proposed methods, have applied to real-time load demand data of UK- based power utility. The experiment results show the acceptable and reliable of the suggested method and the forecasted hourly load is very near to the real load. The comparative results have explained.

The contents of this paper are arranged as, section-II Neural Network for STLF, Section-III Time series, section-IV data preparation, section-V Simulation and results, and concluding remarks are presented in section VI.

II. NEURAL NETWORK FOR STLF

It is a mathematical model like the human brain and its activities. It consists of a large number of processing elements also called neuron cells. It works like a human brain. The artificial neural network has a great quality of independent learning, self-adapting and non- linear mapping. The neural network has an adaptive mathematical structure that is capable of recognizing composite non- linear correlation between input and output data sets [4]. Fig.1 shows, the fundamental circuit model of ANN. It consists of five main parts- inputs, weight and bias connecting the nodes, summation point, transfer function and output. There are three- layers in this network, which are shown in Fig.2. In this model supervised learning method has used, in which input data have feed -forward then weight and bias have adjusted via back propagation. In this network, the Levenberg-Marquardt backpropagation algorithm is used for learning [5].

An architecture model of the feed-forward neural network is shown in Fig.2

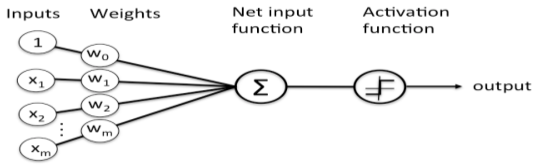

Fig. 1 Basic model of artificial neural network

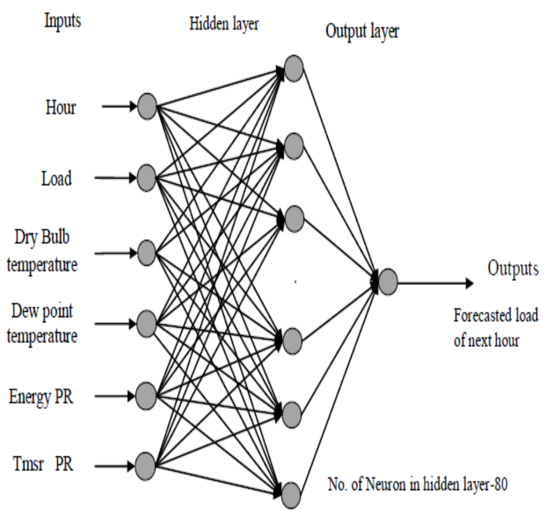

Fig 2 An Architecture of Feed Forward Neural Network

III. TIME SERIES

The time series technique can be defined as a consecutive set of data measured over time, such as hourly, daily or weekly load. The basic concept of forecasting is to first build a pattern matching of available data as accurately as possible and then it obtain the forecasted value with respect to time using the accepted model [6]. In this paper, the time series ntstool with the dynamic neural networks are used to solve three types of non-linear time series problems [13].

1. **Non-Liner autoregressive with external input (Exogenous)**

Predict series y (t) given d past values of series y (t), and other series of x (t).

2. **Non-linear autoregressive**

Predict series y (t) given d past values of y (t).

3. **Non-linear Input- output**

Predict series y (t) given d past values of series x (t)

In the **first type** of time series problem, it can be predicted, the future values of a time series y(t) from past values of that time series and past values

of a second- time series x(t). This form of prediction is called nonlinear autoregressive with exogenous (external) input, or NARX. it can be written as follows:

y(t) = f(y(t – 1), ..., y(t – d), x(t – 1), ..., (t – d)) (1)

In the **second type** of time series problem, there is only one series involved. The future values of a time series y(t) are predicted only from past values of that series. This form of prediction is called nonlinear autoregressive, or NAR, and can be written as follows:

y(t) = f(y(t – 1), ..., y(t – d)) ………….. …….(2)

The **third type** of time series problem is similar to the first type, in that two series are involved, an input series x(t) and an output/target series y(t). Here, it can be predicted the values of y(t) from previous values of x(t), but without knowledge of previous values of y(t). This input/output model can be written as follows:

y(t) = f(x(t – 1), ..., x(t – d))…………………..(3)

The NARX model will provide better prediction, than other models, because, it uses the additional information contained in the previous values of y(t). However, there may be some applications in which the previous values of y(t) would not be available [13].

IV. DATA PREARATION & TRAINING

In this paper, two months of hourly load data of UK- based power utilities have used for STLF. For which, two months from Jan 2010 to Feb 2010 hourly load data have used for developing the model. In two months, hourly load data, 75% of data have used for training the model, 15 % of data have used for testing and the remaining 15% data is for validation. The Dry bulb is taken for temperature, dew point for humidity, Energy PR and TMSR PR (Ten Minutes Spinning Reserve) as load depends on these limits. In NF, NARX and Non-linear Input-Output (AR) models have used as five advice variables with the target value for developed this model. In the NAR model, only target/output value is used to develop this model. These models have developed in MATLAB R2014b nftool and ntstool toolbox [11] [12]. These models have used for STLF from one day to seven days. The performance and accuracy of these models have expressed in the form of mean average percentage error (MAPE).

V. SIMULATION AND RESULTS

In these models, the load data of UK-Based power utility is used for short-term load forecasting. The networks have been trained with a load data set of 1440, in which a data set of 1008 has used for training and remaining data set are used for testing and validation. After training, testing and validation, these trained models have used for STLF.

After acquiring the forecasted values of the load results from the simulated models, these results are compared with the real load data values. The following expressions are used for calculating the correctness and acceptability of these methods.

Absolute Percentage Error (APE) = $\frac{L_A - L_F}{L_A}$

MAPE = $\left(\frac{1}{N}\sum_{i=1}^{N}\frac{L_A - L_F}{L_{actual}}\right)*100$

Where, L_A = Actual load for an hour

L_F = Forecasted load for an hour

N = Number of hours (N=24)

The following simulation results are shown in Fig. 1 to Fig 11

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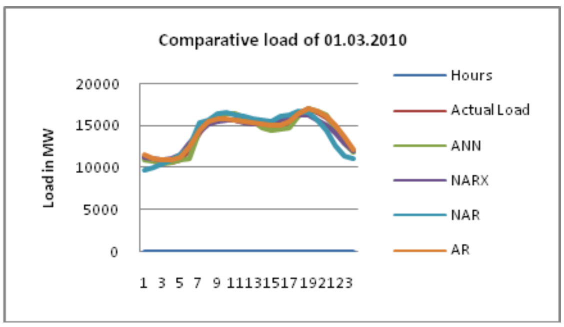

Fig.3 A day ahead forecasted hourly load of 01-03-2010 comparative results with various models

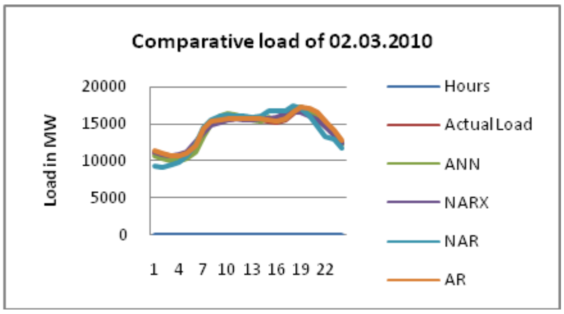

Fig.4 A day ahead forecasted hourly load of 02-03-2010 comparative results with various models

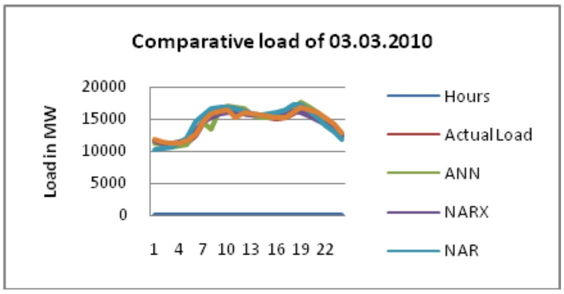

Fig.5 A day ahead forecasted hourly load of 03-03-2010 comparative results with various models

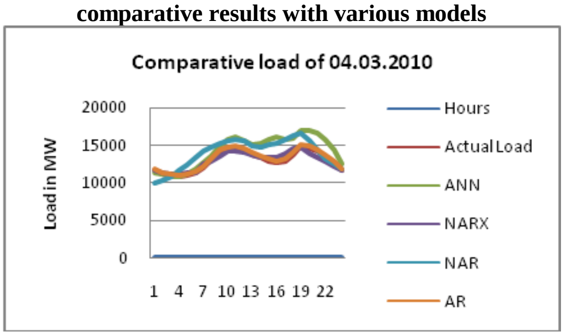

Fig.6 A day ahead forecasted hourly load of 04-03-2010 comparative results with various models

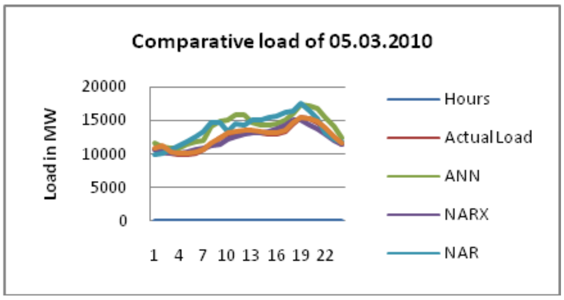

Fig.7 A day ahead forecasted hourly load of 05-03-2010 comparative results with various models

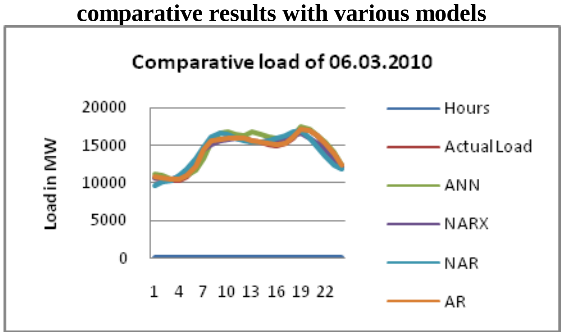

Fig.8 A day ahead forecasted hourly load of 06-03-2010 comparative results with various models

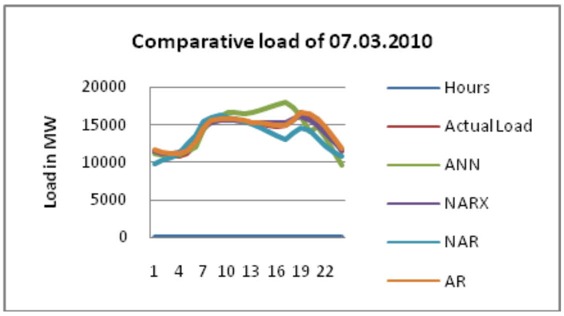

Fig.9 A day ahead forecasted hourly load of 07-03-2010 comparative results with various models

Table1. Summarize MAPE of seven days

Day	ANN	NARX	NAR	AR
Day 1	0.977	**0.097**	0.814	1.028
Day 2	1.36	**0.109**	1.732	0.956
Day 3	0.272	**0.307**	1.709	0.775
Day 4	10.385	**0.802**	8.282	1.98
Day 5	13.417	**0.229**	12.121	2.305
Day 6	3.155	**0.335**	0.685	1.055
Day 7	1.525	**0.155**	4.245	1.116

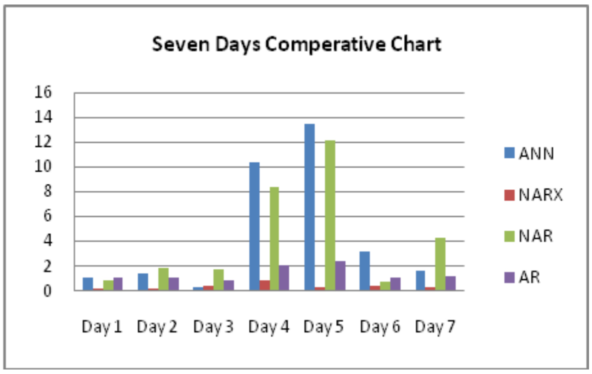

Fig. 10 Seven days comparative MAPE of different method

Table 2 Average MAPE of seven days of four models

Name of Model	Average MAPE of seven days
ANN	4.441
NARX	**0.2905**
NAR	4.226
AR	1.316

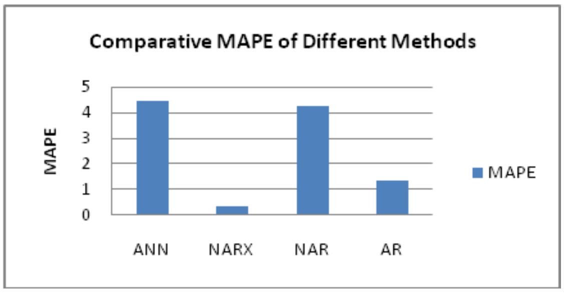

Fig.11 Performance comparison of different methods

VI. RESULTS DISCUSSION & CONCLUSION

In this paper, we have analyzed and discussed about, the neural network, time series, and the importance of STLF in the power systems. The four non-identical methods have presented to forecast hourly load data for the next one day to seven days after analyzing and training. Fig.3 to Fig.9 shows the one day to seven days forecasted hourly load of 01 March 2010 to 7 March 2010, by all four models. In Fig 10, it is clearly seen that, in all seven days, the MAPE is very less in the NARX model compare to other models. Fig 11 shows the average MAPE of all seven days of all four models, it is also clearly seen that, the NARX model is presented the lowest error. The accuracy index of the model is depending on the MAPE. The lowest MAPE of the NARX model is 0.2905. So, it is the best method than other. The NARX model can be used to forecast the one-day ahead to seven days load demand very accurately. So from the above observation, it has been observed that the combination of statistical and AI methods gives a better result than the separated design model.

REFERENCES

1. N. Amjady, “Short-term hourly load forecasting using time series modelling with peak load estimation capability.” IEEE Trans. Power Syst.,vol. 16. Pp. 498-505, Aug 2001.
2. C. Haung. C. J. Huang,, and M. Wang,” A particle swarm optimization to identifying the ARMAX model for short-term load forecasting.” IEEE Trans. Power Syst., vol. 20, no. 2, pp. 1126-1133. May 2005.
3. K. Y. Lee, Y.T. Cha and J.H. Park, “Short-term load forecasting using an artificial neural network”, IEEE Transactions on power systems, volume 1, number 2 2007 ISSN 1307-5179.
4. S.N. Sivanandam, S. Sumathi, and S.N. Deepa,” Introduction to Neural Networks using MATLAB 6.0”,Tata McGRAW-Hill 2009,
5. Saurabh Singh, Shoeb Hussain, Mohammad Abid Bazaz,” Short term load forecasting using artificial neural network”, 2017 Fourth International Conference on Image Information Processing (ICIIP), 2017
6. G.E.P. Box, G.M. Jekins and G.C. Reinsel, “Time series analysis: Forecasting and control 3rd ed. Englewood Cliffs, NJ, Prentice Hall, 1994.
7. S.N. Dodamani, V.J. Shetty, R.B. Magadum,” Short term load forecast based on time series analysis: A case study”, 2015 International Conference on technology Advancements Power and Energy (TAP Energy), 2015
8. Yu, Jungwon, Hansoo Lee, Yeongsang Jeong, and Sungshin Kim,” Short-term hourly load forecasting using PSO-based AR model”, 2014 Joint 7th International Conference on Soft Computing and Intelligent Systems (SCIS) and 15th International Symposium on advanced Intelligent Systems (ISIS), 2014.
9. Hongming He, Tao Liu, Ruimin Chen, Yong Xiao, Jinfeng Yang,” High frequency short-term demand forecasting model for distribution power grid based on ARIMA”, 2012 IEEE International Conference on Computer Science and Automation Engineering (CSAE),2012
10. Hesham K. Alfaresm and Mohammad Nazeeruddin,”Electric load forecasting: literature survey and classification of methods”. Int. Jour. Of Systems Sc.,Vol. 33, No. 1, pp 23-34, 2002.
11. Time series overview from time series ntstool box
12. Neural Network overview from neural network toolbox
13. Ch.mathworks.com

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Girraj Singh received the B.Tech degree from UPTU, Lucknow, and the M.tech degree from MNIT, jaipur in 2007 and 2010, respectively, both in Electrical Engineering. He is currently working towards the Ph.D degree in Electrical Engineering at Uttarakhand Technical University, Dehradun. His research interest include load forecasting in power system, artificial intelligence, optimization techniques. He is a member of IEEE.

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