APPLICATION OF FUZZY LOGIC IN SHORT TERM LOAD FORECASTING (ROORKEE REGION)

Abhishek Nayak*

Bharat Mahendru*

ABSTRACT

This paper presents an approach for short term load forecasting which is used for generation scheduling, economic load dispatch and security assessment at any time. In this paper, 'time' and 'temperature' of a day are taken as inputs for fuzzy logic controller and the forecasted load is the output. The 'time' is divided into nine triangular membership functions. The second input 'temperature' is divided into ten triangular membership functions and the output forecasted load has been divided into eight triangular membership functions. The real data is obtained from Sub-Station Roorkee. The fuzzy forecasted load values when compared with actual load values have MAPE within 3.6%.

Keywords: *Short term load forecasting; Fuzzy logic; Membership functions; Defuzzification; MAPE.*

*Department of electrical engineering, College Of Engineering Roorkee, Roorkee, India.

I. INTRODUCTION

Load forecasting is an integral element of power system operation and planning involving prognosis of the future level of demand to serve as the basis for the supply side and demand side planning. The load requirements are to be predicted in advance so that the power system operates effectively and efficiently.

Load forecasting can help us to estimate load flows and to make decisions that can prevent overloading. Economic and reliable operations of an electric utility depend to a significant extent on the accuracy of the load forecast. The load dispatcher at main dispatch centre must anticipate the load pattern well in advance so as to have sufficient generation to meet the customer requirements. Overestimation may cause the start up of too many generating units and lead to an unnecessary increase in the reserve and the operating costs. Underestimation of the load forecast results in failure to provide the required spinning and standby reserve and stability to the system, which may lead to collapse of the power system network [3, 5].

In power systems many uncertainties arises due to various factors like aging of machines, unforeseen load, fluctuations, losses in transmission lines, voltage and frequency instability and change of weather conditions. These factors make it difficult to effectively deal with many power system problems through strict mathematical formulations alone. Therefore, fuzzy set theory based approach, in recent years has emerged as a complement tool to mathematical approach for solving power system problems. The wonderful world of fuzzy logic is a powerful new paradigm, helping us to analyse unknown and complicated systems.

Owing to the importance of fuzzy logic various methods have been reported, that includes linear regression, exponential smoothing, stochastic process, ARMA models, etc. In this paper, we propose an approach for short term load forecasting problem, using fuzzy logic approach. This approach has an advantage of dealing with non linear parts of the forecasted load curves, and also has the ability to deal with the abrupt change in the weather variables such as temperature etc.

II. LOAD FORECASTING

The load forecasting has always been important for operational planning of electric system. Proper load forecasting with less percentage of error has to be made with the help of artificial intelligence techniques. The load forecasting can be classified into three different types according to the forecast period [2].

1. Short-term load forecasting,
2. Mid-term load forecasting,

3. Long-term load forecasting.

In each load forecasting, period of time, forecasted values and aims of forecasting are noticeably different. Because of the difference of time period, forecasted values and aims of each load forecasting type, researchers in the past proposed many different algorithms and methods in order to obtain the precise load forecasting values.

Long term load prediction is normally used for planning the growth of the generation capacity. It is used to decide whether to build new lines and sub-stations or to upgrade the existing systems.

Medium term load forecast is used to meet the load requirements at the height of the winter or the summer season may require the load forecast to be made a few days to few weeks or months in advance.

Short term load forecast is needed to supply necessary information for the system management of day to day operations and unit commitment. Short term load forecasting is necessary for the control and scheduling operations of a power system and also acts as inputs to the power analysis functions such as load flow and contingency analysis [4]. It is also important for the economic and secure operation of power systems. Out of these three types of forecasting it has been clearly indicated that the short term load forecasting is very essential and important.

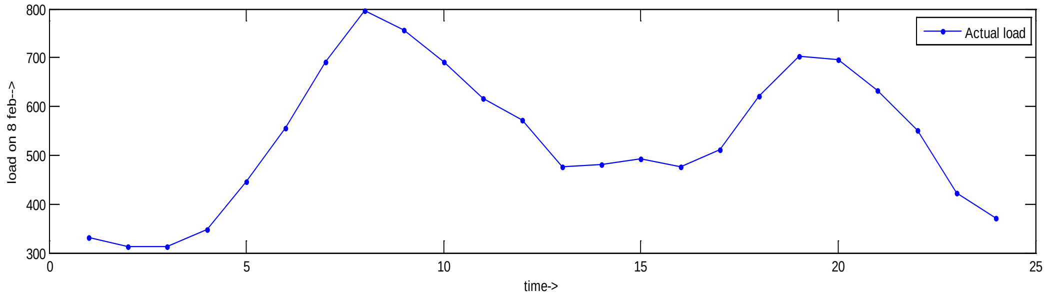

Fig 1: A typical load curve pattern for a day in Roorkee (8th Feb.2012)

Table 1: Comparison and error computation between fuzzy forecasted load and the actual load for 9th Feb. 2012.

time	9th feb 2012		
	Fuzzy Forecasted Load	Actual Load	Difference
1	324	327	3
2	324	327	3
3	322	327	5
4	360	342	18
5	370	352	18
6	527	522	5
7	724	737	13
8	775	792	17
9	724	712	12
10	650	667	17
11	580	612	32
12	510	527	17
13	510	482	28
14	510	522	12
15	510	537	27
16	580	542	38
17	510	537	27
18	650	657	7
19	772	767	5
20	775	757	18
21	773	722	51
22	530	602	72
23	477	482	5
24	405	392	13

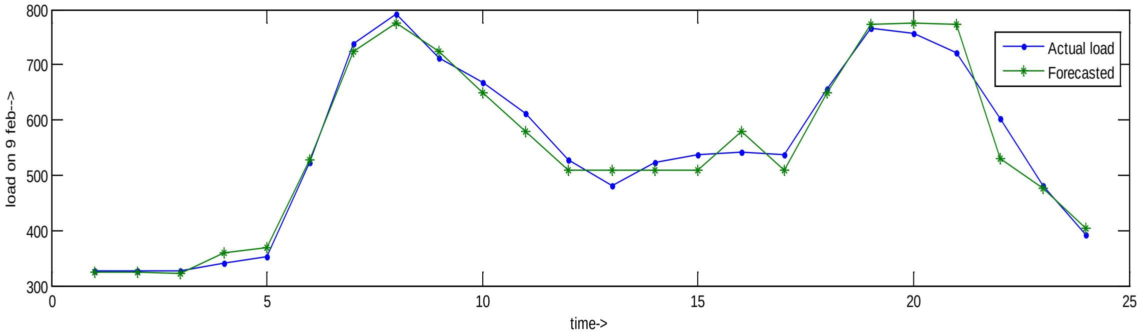

Fig 2: Graphical representation of actual load and fuzzy forecasted load

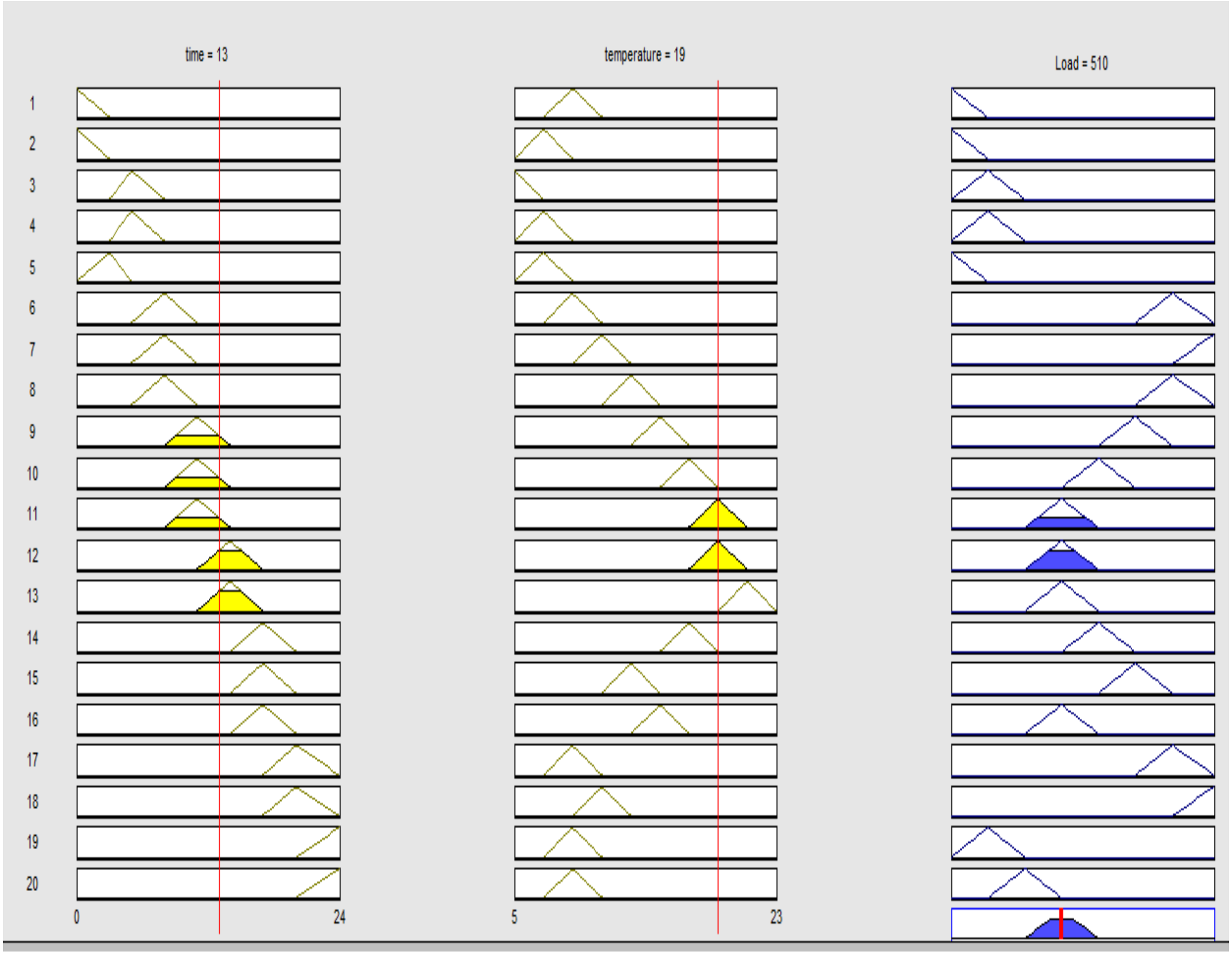

Fig 3: Fuzzy membership functions for inputs and output

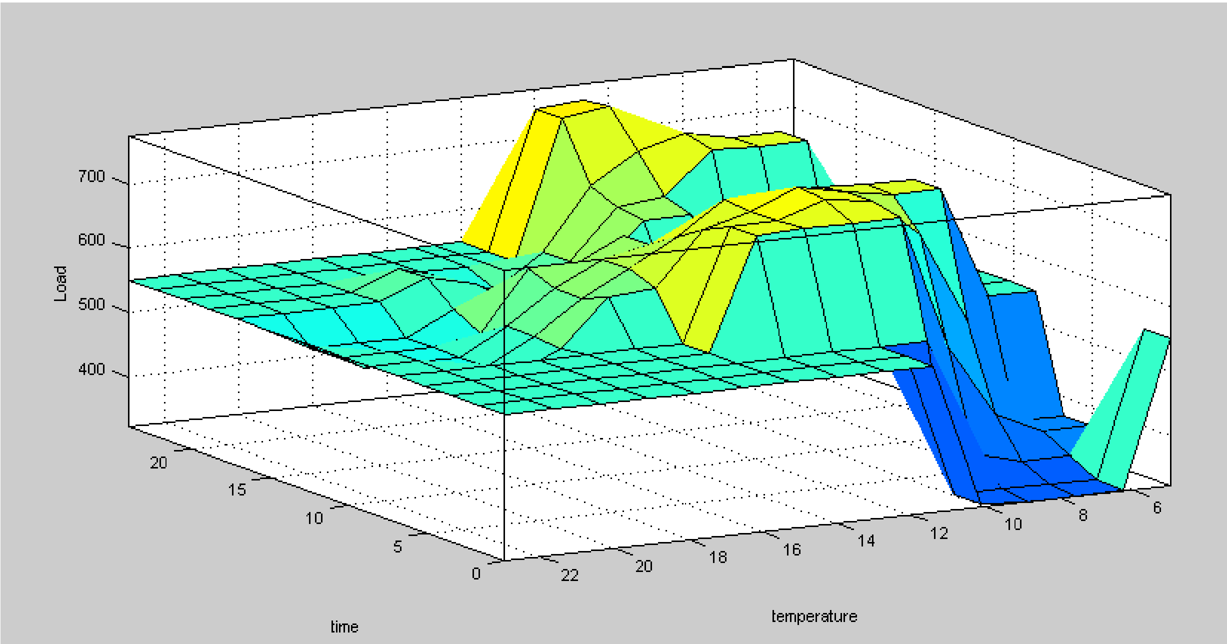

Fig 4: Three-dimensional surface view.

III. FUZZY LOGIC IMPLEMENTATION

This paper makes use of simplified fuzzy inference in which the consequence of the fuzzy rule is expressed in crisp number. We can add new membership functions as per our convenience in fuzzy approach. To make a more accurate fuzzy expert system, regions are divided into intervals [3].

The interval for time (input 1) has been divided into nine triangular membership functions which are as follows:

- Midnight (midnit)
- Dawn (dawn)
- Early morning (early morn)
- Morning (morn)
- Fore noon (F.noon)
- After noon (a.noon)
- Evening (even)
- Dusk (dusk)
- Night (night)

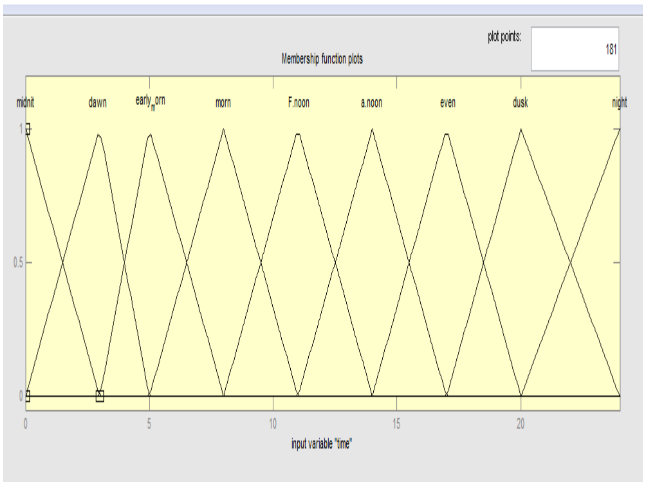

Fig 5: Triangular membership functions of time

Table 2: parameters of membership function of input variable 1(time) [1]

Midnight	(0,0,3)
Dawn	(0,3,5)
Earlymorn	(3,5,8)
Morn	(5,8,11)
f.noon	(8,11,14)
a.noon	(11,14,17)
Even	(14,17,20)
Dusk	(17,20,24)
Night	(20,24,24)

The interval for temperature (input 2) has been divided into ten triangular membership functions which are as follows:

- Very very low (v_v_low)
- Very low (v_low)
- Low (low)
- Sub-normal (sub_nor)
- Moderate normal (mod_nor)
- Average normal (avg.nor)
- Normal (nor)
- Above normal (above_nor)
- High (high)
- Very high (very_high)

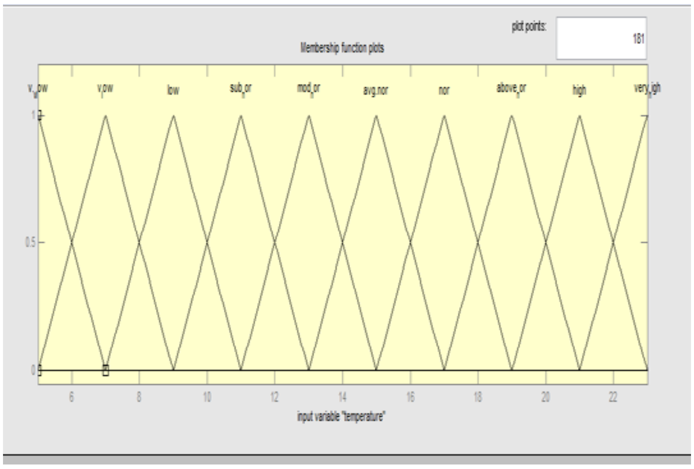

Fig 6: Triangular membership functions of temperature

Table 3: parameters of membership function of input variable 2(temperature)

V_v_low	(5,5,7)
V_low	(5,7,9)
Low	(7,9,11)
Sub_nor	(9,11,13)
Mod_nor	(11,13,15)
Avg.nor	(13,15,17)
Nor	(15,17,19)
Above_nor	(17,19,21)
High	(19,21,23)
Very_high	(21,23,23)

The interval for forecasted load (output) has been divided into eight triangular membership functions which are as follows:

- Very low (v.low)
- Low (low)
- Sub-normal (s.nor)
- Moderate normal (m.nor)
- Normal (nor)
- Above normal (a.nor)
- High (high)
- Very high (v.high)

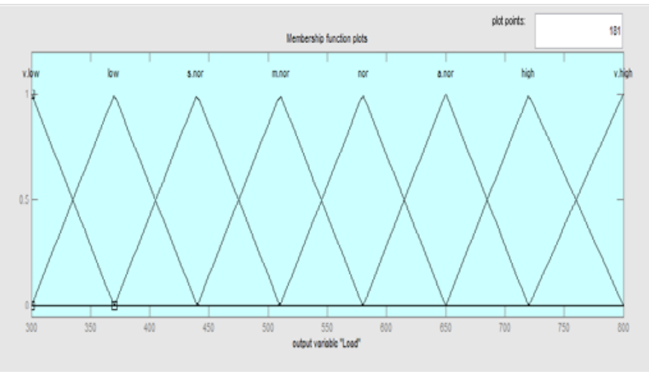

Fig 7: Triangular membership functions for fuzzy forecasted output load

Table 4: parameters of membership function of output (forecasted load)

v.low	(300,300,370)
Low	(300,370,440)
s.nor	(370,440,510)
m.nor	(440,510,580)
Nor	(510,580,650)
a.nor	(580,650,720)
High	(650,720,800)
v.high	(720,800,800)

In the fuzzy logic approach, the calculations are based on the entire profile of the membership functions rather than based on the point values. This approach is much closer to people's decision making process in real life.

IV. DEFUZZIFICATION

Defuzzification means the fuzzy to crisp conversions. The fuzzy results generated cannot be used as such to the applications, hence it is necessary to convert the fuzzy quantities into crisp quantities for further processing. This can be achieved by using defuzzification process[2].

Defuzzification can also be called as "rounding off" method. Defuzzification reduces the collection of membership function values in to a single sealer quantity.

There are seven methods used for defuzzifying the fuzzy output functions.

They are:

(1) Max-membership principle,

(2) Centroid method,

(3) Weighted average method,

(4) Mean–max membership,

(5) Centre of sums,

(6) Centre of largest area, and

(7) First of maxima or last of maxima

In this paper we have used the 'CENTROID Method' for defuzzification. This is the most widely used method. This can be called as centre of gravity or centre of area method.

It can be defined by the algebraic expression:

z*= { ∫μc□(z).zdz}/{ ∫ μc□(z)dz}

∫ is used for algebraic integration.

V. RESULT

Fuzzy logic forms the heart of the program in this paper. Emphasis is not only given to the forecast values of load but also on the errors in them. Thus, correcting these errors in the forecast values of load with the help of Fuzzy Logic, forecasts with very high accuracy have been achieved.

Mean Absolute Percentage Error (MAPE):

The deviation of the forecasted result values from the actual values are represented in the form of MAPE [1].

It is defined as:

MAPE=1/N[$\sum_{i=1}^{N}\{|Pa - Pf|\}/\{Pa\}$ **]X 100%**

Pa, Pf are the actual and forecast values of the load. N is the number of hours of the day i.e. N=24.

With the proposed method the MAPE error for the considered day i.e. 9^{th} Feb. 2012 is 3.59%.

VI. CONCLUSION

It is concluded that if the load turns out to be lower than forecasted value, then the power generated will be costlier and uneconomical. On the other hand if the load is greater than anticipated, then the security constraints such as spinning reserve margins, frequency and the reliability of the system are in danger. In this case the MAPE is less than 3.6%.

Hence for STLF, this paper is very efficient and is capable of forecasting load with high accuracy as compared to any of the existing short term load forecasting methods.

REFERENCES

[1] E. Srinivas and Amit Jain, "*A Methodology for Short Term Load Forecasting Using Fuzzy Logic and Similarity*", The National Conference on Advances in Computational Intelligence Applications in Power, Control, Signal Processing and Telecommunications (NCACI-2009).

[2] S. N. Sivanandam, S. Sumathi and S. N. Deepa, "*Introduction to Fuzzy Logic using MATLAB*", 2007.

[3] S. C. Pandian, K. Duraiswamy, C. C. A. Rajan, N. Kanagaraj, "*Fuzzy Approach for Short Term Load Forecasting*", Electrical Power System Research 76(2006) 541-548.

[4] Timothy J. Ross, "*Fuzzy Logic with Engineering Applications*", second edition, 2004.

[5] S. Chenthur Pandian, K. Duraiswamy, "*Fuzzy logic approach for the load forecasting*", International Conference by Pentagram Research Centre, Hyderabad, India, 6–9th January, 2005.