Rain Prediction using Fuzzy Logic

Manish Kumar Singla, Harkamal Deep Kaur, Parag Nijhawan

***Abstract:** Power system energy management system is observed as the breakthrough element for load forecasting. Load forecasting is advantageous so as to reduce the generation cost, spinning reserve capacity and increase the reliability of power system. The unit commitment, economic allotment of generation preservation schedule is crucial for short term load forecasting (STLF). In the current times, many techniques are being utilized for load forecasting, but Artificial Intelligence Technique (Fuzzy Logic and ANN) provides improved efficiency as in contrast with conventional technique (Regression and Time Series). In this particular paper, the author main purpose is to reduce flood conditions and drought. The main focus of the author is in the prediction of rainfall with the help of wind variation and temperature, speed. The paper represents a technique of STLF using fuzzy logic. Using Mamdani implication the fuzzy rule base is prepared. The software used for this is Matlab Simulink and fuzzy tool box. By using triangular membership function the forecasted results are obtained.*

***Keyword** - Fuzzy logic, Fuzzy interface system, Mamdani, STLF.*

I. INTRODUCTION

The energy quality and reliability to the customer is the main objective of the utility (Esener, I.I., et.al. 2015). As energy requirement of the customers changes every minute, as the human activities regulates throughout the day. Therefore estimating the load demand of the future becomes the priority task in order to meet the desired energy requirements in the future. The load forecasting plays an important role in the planning, operation and control of the system load and loss in energy. Load forecasting is the assessment of the value of a variable (or a set of variables) at an upcoming point in time (Singla, M.K., et.al. 2019).

In this paper the author have dealt with Short term load forecasting (Kandari, A.A., et.al. 2004). It is crucial and useful operation for planning and control of power generation as it help in establishing the work plan of the power plant and helps in determine the production group for the power plant. STLF also helps utility in designing of infrastructure, switching of load, purchasing etc Feinberg, (E.A., & Genethliou, D., 2005). So it becomes the necessity to forecast the load correctly for required energy production in order to compete in the market (Fan, S., & Hyndman, R.J., 2012), (Singla, M.K, 2018), (Singla, M.K., & Gupta, J., 2018). (Singla, M. K., & Hans, S., 2018), (Singla, M.K., et.al. 2019).

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Due to uncertainties in power system like wear and tear in the machines, various drops in the transmission line, instability in voltage and frequency, fluctuations and change in weather condition, makes it very difficult to deal with power system problem through mathematical formulation. For STLF the mathematical model used is fuzzy logic. Fuzzy logic is multi value logic which evaluate its data with respect to Boolean logic (yes or no, true or false). The fuzzy logic uses weather data like temperature, load as input and load as output data for load forecasting. The below Figure.1. represents the configuration of fuzzy logic.

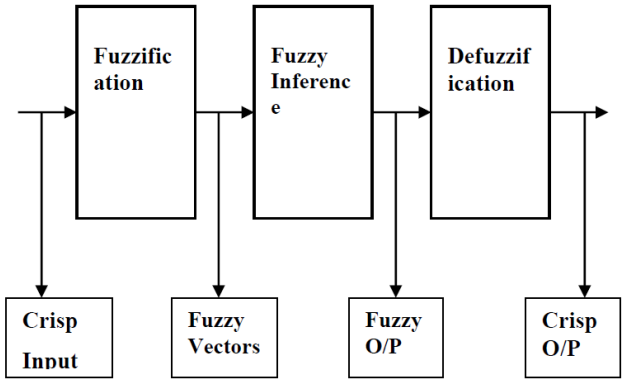

Figure.1. Fuzzy Logic Configuration

The application of fuzzy logic is that it can do without the mathematical model mapping inputs to output and precise inputs are not necessary. Fuzzy logic load over other mathematical model or method because of its less forecast error than the other mathematical model. During reasonable fluctuation of the input data i.e. weather parameter like humidity, temperature etc. Fuzzy set, IF-Then fuzzy rule base, linguistic variables, possibility distribution are the basic concept of the fuzzy logic system. The mathematical input data relationships are decoded with the If-Then rule base (Singla, M.K., et.al. 2019).

II. FUZZY LOGIC MODEL DESCRIPTION

The application of fuzzy logic of STLF is consists of three stages. The Figure.2. shows the methodology of fuzzy logic.

(i) Fuzzy rule's base design:

The fuzzy rule base design consists of five steps:

Step: 1: Compose a list of input and output variables by means of statistical analysis, and/or operator. In this paper there are two input variables and one output variables (Ranaweera, D.K., et.al. 1996). The output variable load is forecasted load and the input variables are:

a) Temperature
b) Speed of wind

Step: 2: The input and output variable is prepared by resolving the input and output performance to the membership value [0, 1].

Step: 3: After resolving the input and output variables now select the character of fuzzy membership for each of the variable (Wang, F.Y., et.al. 1997).
Step: 4: For each input and output variable, number of fuzzy membership function has to be defined (Wang, F.Y., et.al. 1997).
Temperature data when fuzzified classifies into five fuzzy sets as:
(i) very low,
(ii) low,
(iii) normal,
(iv) high
(v) very high.

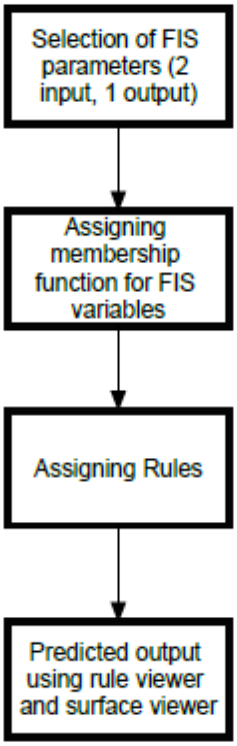

Figure 2. Methodology using Fuzzy Logic

Step: 5: Now we have to train the data in fuzzy model. Training data can be inferred as pair of input data and output data. For e.g. if 'time' is midnight and 'load' is usual leading to high 'load'.
Computing the forecast value:
From input to output space a nonlinear surveying implements a fuzzy inference system. The surveying is done by a fuzzy If-Then rule.
To estimate the forecast from the fuzzy forecast then the defuzzification is performed. An analytical forecast to the entire rule is centroid of area.

$$\text{Centroid of area Mcoa} = \frac{\int z u_A(Z) dz}{\int z\ u_A(Z)\ Z\ dx} \quad (1)$$

Testing the rule base performance:
In the STLF the accuracy is tested by using a historical data to acquire the fuzzy rule base. In case it is unacceptable then the and/or character of fuzzy membership function is changed and new rule base is prepared. To design the correct rule base system, the testing of system is repeated many times and shapes of membership function also [12]. This method is known as train and set. This is the most useful for the large data set.

A. Fuzzification

Method of conversion of the crisp values to the degree of membership in relation with the fuzzy set is known as fuzzification. The input and output might be non-linear but linear membership function is applied for the ease. In this paper rectangular membership function is utilized for the input and output. The Figure.3. represents how to create the FIS variables.

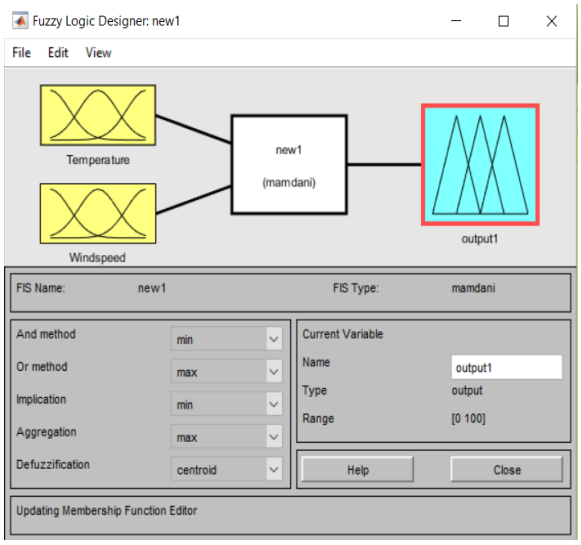

Figure.3. Creating FIS variables

The Temperature and wind speed data are the two inputs taken for the STLF as shown in Figure.4. Temperature is divided into five fuzzy sets:
(i) very low
(ii) low
(iii) normal
(iv) high
(v) very high

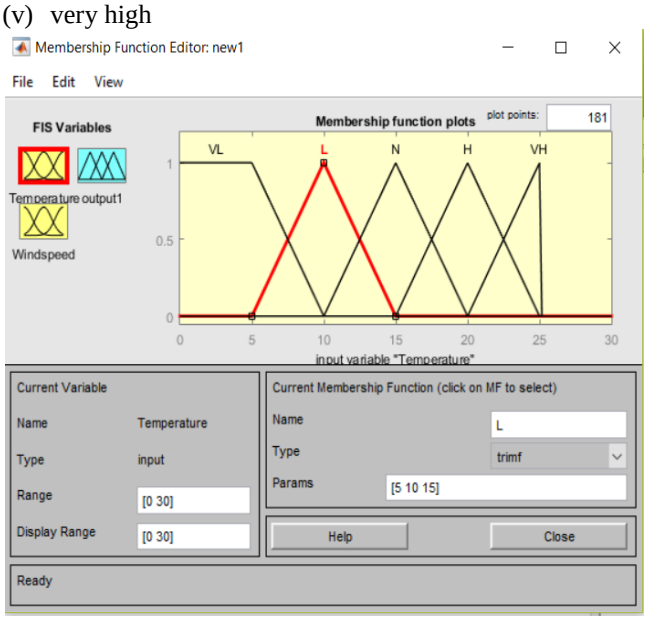

Figure.4. Membership functions for Temperature input

The Figure.5 Shows wind speed input divided into five fuzzy sets of member ship function:
(i) very low
(ii) low
(iii) normal
(iv) high
(v) very high

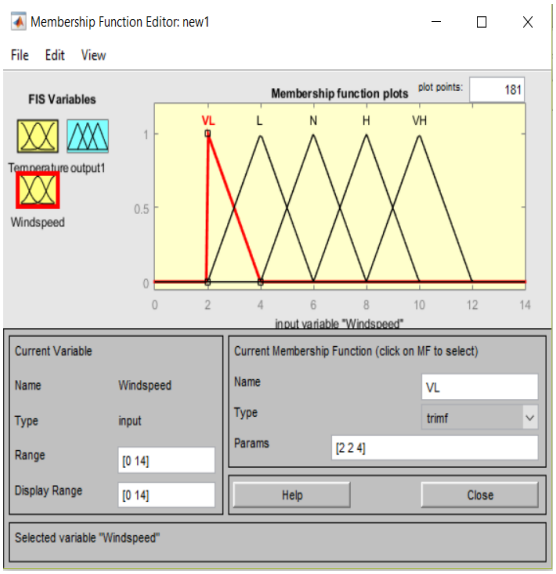

Figure.5. wind speed input membership function

Figure.6. shows rainfall (output) divided in to five fuzzy sets membership function.

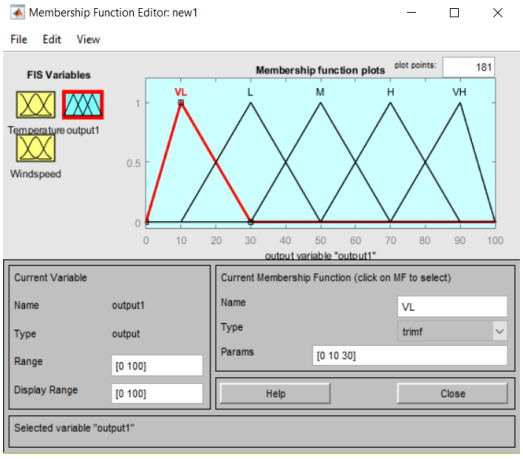

Figure.6. Rainfall output membership function.

B. Fuzzy rule base

The fuzzy system's backbone is the fuzzy rule base. To get the forecasted output in the fuzzy rule base, the If-Then rule is used. A few rules are shown in Figure.7. and Figure.8.

WS / TEMP.	VL	L	N	H	VH
VL	VL	VL	L	L	N
L	VL	VL	L	N	N
N	L	L	N	N	H
H	L	N	N	H	H
VH	N	N	H	H	VH

Figure.7. Assigning rules

- If (temperature is very low) and (wind speed is very low) then (output is very low).
- If (temperature is very low) and (wind speed is low) then (output is very low).
- If (temperature is very low) and (wind speed is normal) then (output is low).
- If (temperature is very low) and (wind speed is high) then (output is medium).
- If (temperature is very low) and (wind speed is very high) then (output is very low).

C. Predicted Output Rainfall

In this step, rainfall prediction is made by rule viewer and surface viewer. Refer Figure. 9 to 12.

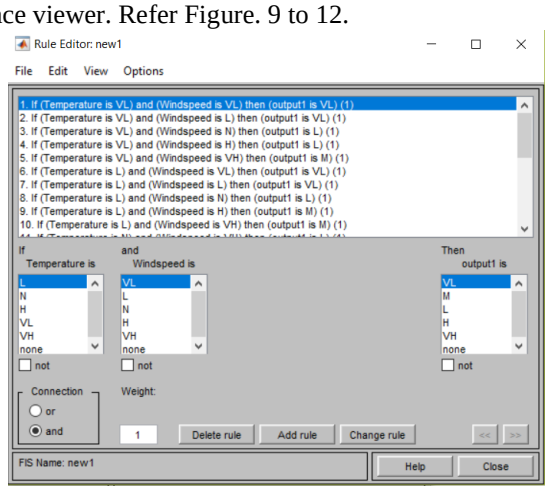

Figure.8. Fuzzy Rule Base

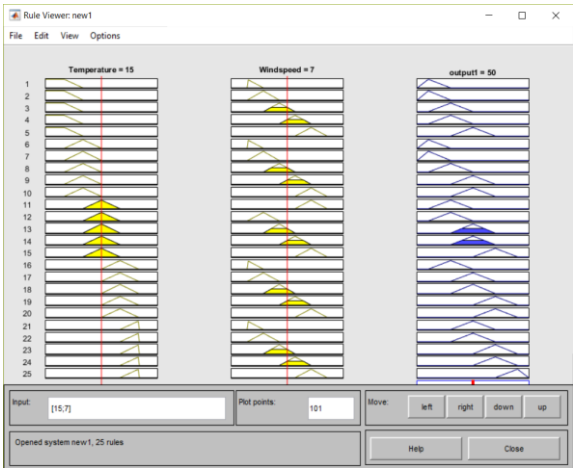

Figure.9. Predicted output rainfall

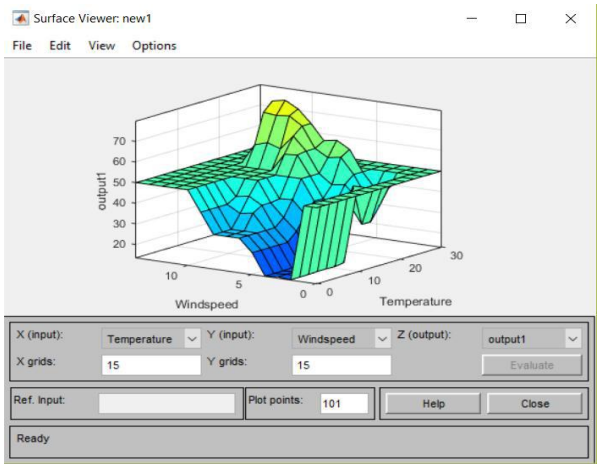

Figure.10. 3D output based on inputs

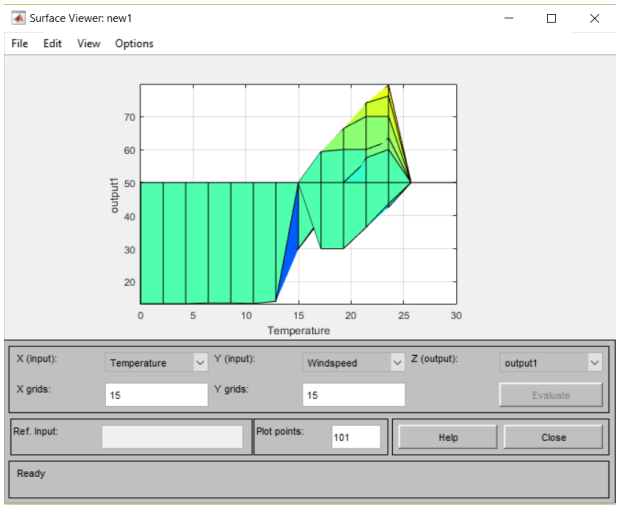

Figure.11. Predicted Rainfall and temperature variation

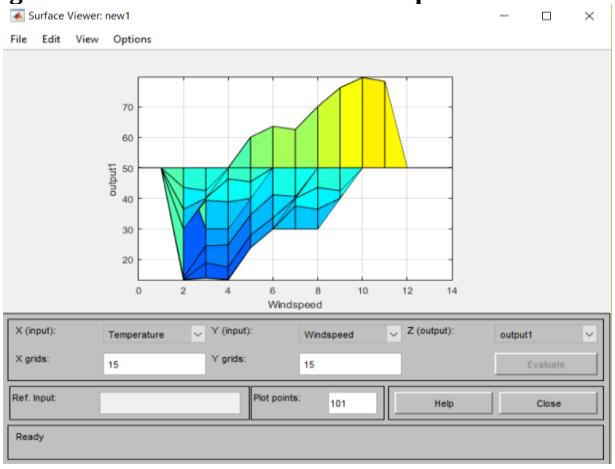

Figure.12. Predicted Rainfall and wind speed variation

III. CONCLUSION

In this paper the author discuss about the rain prediction using fuzzy logic approach which ultimately helps in short term load forecasting. For the unit commitment, security analysis of generation STLF is very useful tool. From the results so obtained, it is observed that the application of fuzzy logic to predict the amount of rainfall based upon the wind speed and temperature is pretty accurate. Rainfall prediction can also help in better water management. The drought and flood conditions can be easily monitored and/or avoided if the water bodies in the different parts of the country are inter-connected and the rain prediction is accurate and precise. This will also improve the agricultural yield. In the end, it can be safely concluded that the scope or applications of accurate rain prediction are enormous.

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