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COMPARISON OF MAMDANI & SUGENO TYPE FUZZY INFERENCE SYSTEM ON ENROLLMENT DATASETS

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ABSTRACT

As the Application of Computer is increasing day by day. Computers are also used in the field of Business Analysis and Forecasting. There is various approaches in the field of forecasting. Fuzzy logic is the branch of Soft Computing that is widely used in the field of forecasting. Fuzzy Inference System is used to map inputs to outputs. In this Paper both the Mamdani and Sugeno model of Fuzzy Inference System are compared based on Performance and Error Rate.

KEYWORDS: Fuzzy Logic,Crisp data,Forecasting,fuzzification, Forecasting Errors.

INTRODUCTION

Forecasting is supposed to be one of the oldest management activities. Nowadays it is becoming increasing necessary for companies to make forecast [2]. There are various methods in the field of forecasting which categories into three fields are:

1. Quantitative or Statistical
2. Qualitative or Judgmental
3. Time Horizon.

Quantitative or Statistical:

It is based on mathematical Models and suppose that past data and other relevant factors can be combined into reliable predictions of the future. In preparing a quantitative forecast it should begin with a number of observed values, past data, or observation. This data help to compare the actual data with Forecasted data in order to find the average forecasting error and mean square error [2].

Qualitative or Judgmental:

It is based on opinions, knowledge and skills rather than Formal analysis. They are used where there is no historical data.

Time Horizon

Forecasting can be classified in terms of time span they cover in the future. The basic types of time horizon forecasts are long-term, medium-term and short-term. The long-term forecasts cover a time span of 3-10 years and they are used in the analysis of standard commitments and can be characterized as strategic decisions.

Soft Computing technique Fuzzy Logic is used in many Fields. By using Quantitative approach we determine the futuristic enrollment with the help of Fuzzy Logic. Fuzzy Logic, which reproduces the approximate reasoning process of human mind by representing knowledge via linguistic variables and if-then rules, allows for precise output inference starting from imprecise input. The Figure 1 describe the Fuzzy Logic System. The aim of this paper is to find the better inference engine between Mamdani and Sugeno Fuzzy Inference Model based on Forecasting error and Computation work.

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Figure 1: Fuzzy Logic

This paper is organized as follows. In Section II we describe the concept of Fuzzy Inference System with difference between Mamdani-type and Sugeno-type Fuzzy Inference System. Section III describes the algorithm used. Section IV and Section V describe the development of Mamdani-type and Sugeno-type FIS, respectively. Experimental results and discussions are presented in Section VI along with comparative performance analysis involving the two types of Fuzzy logic System. Finally Section VII provide some Concluding remark.

FUZZY INFERENCE SYSTEM

Fuzzy inference is the process of mapping from given input(s) to output(s) using fuzzy logic. The mapping in the fuzzy inference system provides a basic from which decision is made. Fuzzy Inference System has various fields such as automatic control, data classification, decision analysis, expert system, and robotics etc. Because of multidisciplinary nature, the fuzzy inference system is known by numerous other names such as fuzzy-rule based system, fuzzy expert system, fuzzy model and many more.

A Fuzzy Inference System first takes crisp data as input and convert it into fuzzy data by the process of fuzzification. Then the mapping is accomplished by number of fuzzy if-then rules, each of which describe the local behavior of mapping. The antecedent of a rule defines a fuzzy region in the input space, while the consequent specifies the output space which is again the fuzzy data. By the process of defuzzification the fuzzy data is again converted into the crisp data. The fuzzy inference system consists of five function blocks as shown in Figure 2.
1. The Structure of the Fuzzy Inference System is described as follows.

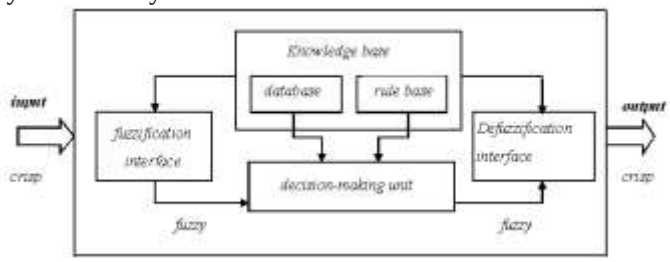

Figure2: Structure of Fuzzy Inference System

- A rule base containing a number of fuzzy if-then rules.
- A database which defines the membership functions of the fuzzy sets used in fuzzy rules.
- A decision-making unit which performs the inference operation on the rules.
- A fuzzification interface which convert the crisp data into fuzzified dta.
- A defuzzification interface that converts the fuzzified data backed to crsip data.

The rule base and the database are jointly referred to as the knowledge base. Fuzzy if-then rules are the expression of the form: If x is A Then y is B .where, x and y are the input and output linguistic variables. A and B are the two fuzzy sets.

The steps of fuzzy reasoning (inference operations upon fuzzy IF-THEN rules) performed by FIS are:

- Fuzzified the crisp input values to obtain fuzzy values.
- Combine (usually multiplication or min) the membership values on the input part to get firing strength (weight) of each rules.
- Generate the output of each rule depending on the firing strength.
- Defuzzied the output.

The most common types of fuzzy reasoning that have been applied to different application are Mamdani and Sugeno type models. The main difference between both the model is the way in which crisp output is generated from fuzzy

inputs. Mamdani-type FIS uses the technique of defuzzification of a fuzzy output, while Sugeno-type uses the weighted average to find crisp output. Hence Mamdani FIS has output membership functions while Sugeno FIS has no output membership function. Mamdani is widely used because it allows describing the expertise, more human like manner. The results obtained by Mamdani have fewer errors. But Mamdani requires more computation time. On the other hand, Sugeno method is computation efficient and works well with optimization and adaptive technique. Mamdani is less flexible in system design as compared with Sugeno because Sugeno can be integrated with ANFIS tool to optimize the output.

ALGORITHM USED

The various steps and the algorithm used is described below:

- The historical enrollment of university of Alabama is taken as dataset.
- Define the universe of discourse U and partition it into different length.
- Get mean of the original data and get frequency of each interval
- Compare the means of original and frequency and divide the largest interval into four sub interval, the second largest into three sub interval, the third largest into two and the remaining keep unchanged.
- Define Fuzzy set based on divided interval.
- Output will be taken from inference engine.

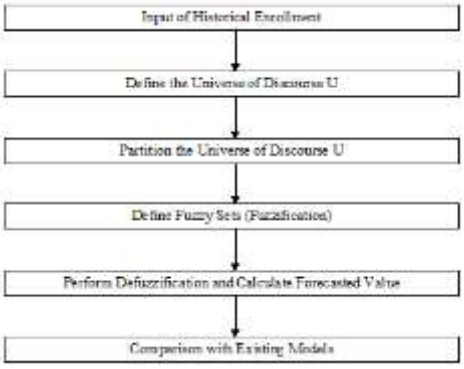

Figure 3: Steps in implementation

DEVELOPMENT OF MAMDANI-TYPE FIS

The results and discussion may be combined into a common section or obtainable separately. They may also be broken into subsets with short, revealing captions.

The proposed FIS for the data forecasting has two inputs: year and percentage change. The System has one output that shows the percentage change in next year enrollment. There are 13 linguistic variable used in input variables. The following figure shows the input variable.

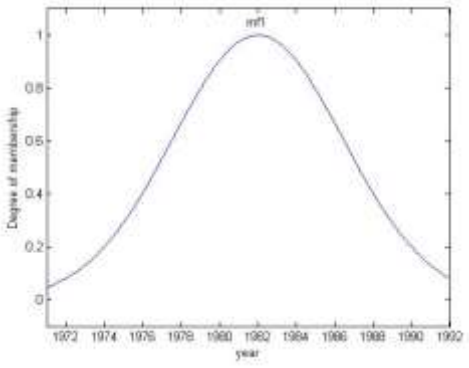

Figure 4: Input variable1

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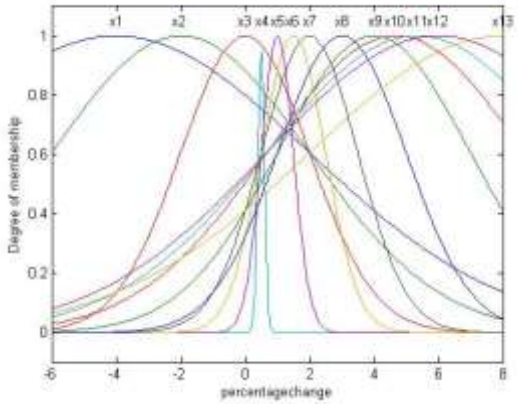

Figure 5: Input Variable 2

The System has one output variable the next year percentage change which is shown below:

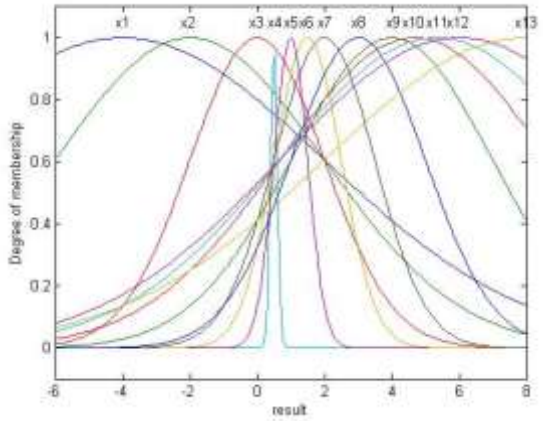

Figure 6: Output Variable

Figure shows the structure of Mamdani-type FIS.

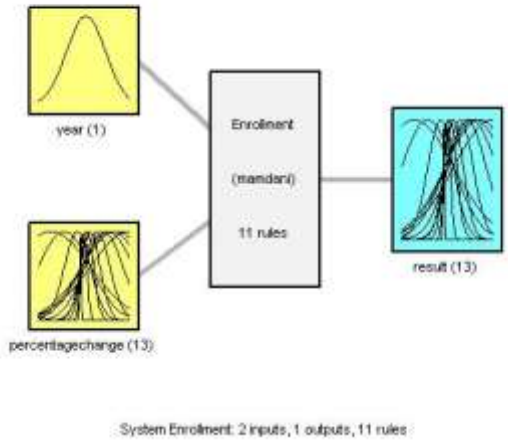

Figure 7: Mamdani-type FIS

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The implementation diagram of rules is shown below:

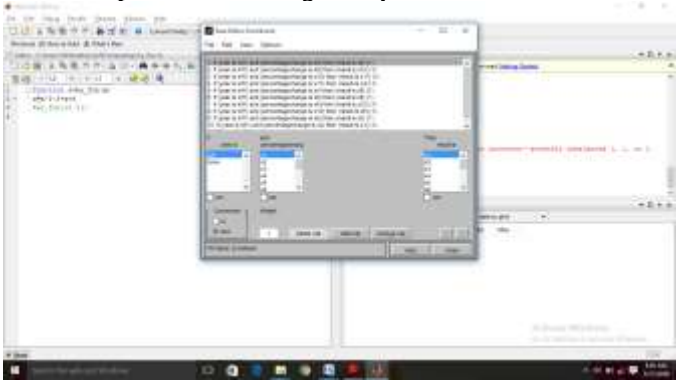

Figure 8: Implementation of System

DEVELOPMENT OF SUGENO-TYPE FIS

The initial steps and the setting of Sugeno-Type FIS are same as of Mamdani-type FIS. It also consist of two inputs percentage change and year of enrollment and produce one output that indicate the next year percentage change. The year uses only one linguistic variable while 13 linguistic variables are used in percentage change. It uses either the constant or linear in the output of the system.

The FIS of Sugeno-type is shown below:

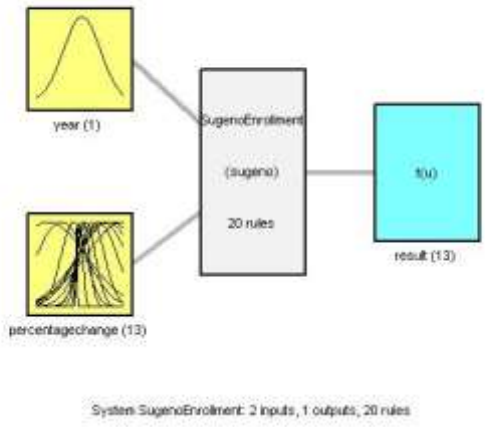

Figure 9:Sugeno-type FIS

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RESULTS AND DISCUSSION

The following results were obtained during the simulation of both FIS.
The table given below shows the enrollment by both the methods:

Table 1:Forecasting by Mamdani Methods

Year	Enrollmen	entage Ch	FuzzySet	redicted%	Forecaste	(Ai-Fi)^2	(Ai-Fi)/Ai
1971	13,055						
1972	13563	3.89%	x9	2.67%	13,058	2,55,025	0.0371
1973	13867	2.24%	x9	1.76%	13,565	91,204	0.0217
1974	14696	5.98%	x12	6.48%	13,876	6,74,041	0.0557
1975	15460	5.20%	x11	5.01%	14,703	5,73,049	0.0489
1976	15311	-0.96%	x4	-1.00%	15,458	21,904	0.0096
1977	15603	1.91%	x8	1.23%	15,313	84,681	0.0185
1978	15861	1.65%	x8	1.26%	15,605	66,049	0.0161
1979	16807	5.96%	x12	6.43%	15,871	8,76,096	0.0556
1980	16919	0.67%	x6	0.75%	16,808	12,321	0.0065
1981	16388	-3.14%	x2	-3%	16,914	2,76,676	0.032
1982	15433	-5.83%	x1	-4.97%	16,380	8,96,809	0.0613
1983	15497	0.42%	x5	2.34%	15,437	3,721	0.0038
1984	15145	-2.27%	x3	-2.88%	15,493	1,21,104	0.0229
1985	15163	0.12%	x5	1.81%	15,148	256	0.001
1986	15984	5.41%	x12	5.63%	15,172	6,60,969	0.0508
1987	16859	5.47%	x12	5.67%	15,993	7,49,956	0.0513
1988	18150	7.66%	x13	6.98%	16,871	16,38,40	0.0704
1989	18970	4.52%	x10	4.33%	18,158	6,60,969	0.0428
1990	19328	1.89%	x8	1.25%	18,972	1,26,736	0.0184
1991	19337	0.05%	x5	0.74%	19,329	64	0.0003
1992	18876	-2.38%	x3	-2.84%	19,332	2,07,936	0.0241
						79,97,966	**0.6499**

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Table 2:Forecasting By Sugeno Method

Year	Enrollment	Percentage Change	FuzzySet	Predicted%	Forecasted	(Ai-Fi)^2	(Ai-Fi)/Ai
1971	13,055						
1972	13563	3.89%	x9	3.16	13467.5	9112.99	0.00704
1973	13867	2.24%	x9	2.43	13892.6	654.382	0.00184
1974	14696	5.98%	x12	3.51	14353.7	117148	0.02329
1975	15460	5.20%	x11	3.4	15195.7	69873.5	0.0171
1976	15311	-0.96%	x4	1.43	15681.1	136958	0.02417
1977	15603	1.91%	x8	2.22	15650.9	2294.81	0.00307
1978	15861	1.65%	x8	2.05	15922.9	3826.85	0.0039
1979	16807	5.96%	x12	3.51	16417.7	151538	0.02316
1980	16919	0.67%	x6	1.75	17101.1	33168.6	0.01076
1981	16388	-3.14%	x2	0.414	16989	361255	0.03668
1982	15433	-5.83%	x1	-0.422	16318.8	784717	0.0574
1983	15497	0.42%	x5	1.78	15707.7	44397.6	0.0136
1984	15145	-2.27%	x3	0.814	15623.1	228623	0.03157
1985	15163	0.12%	x5	1.72	15405.5	58803.3	0.01599
1986	15984	5.41%	x12	3.43	15683.1	90546.3	0.01883
1987	16859	5.47%	x12	3.44	16533.8	105723	0.01929
1988	18150	7.66%	x13	3.68	17479.4	449689	0.03695
1989	18970	4.52%	x10	3.29	18747.1	49668.8	0.01174
1990	19328	1.89%	x8	2.2	19387.3	3521.24	0.00307
1991	19337	0.05%	x5	1.72	19660.4	104614	0.01673
1992	18876	-2.38%	x3	0.76	19484	369617	0.03221
						3175750	**0.09359**

The following graph shows the Actual enrollment, Enrollment by Mamdani-Method and Enrollment by Sugeno-method.

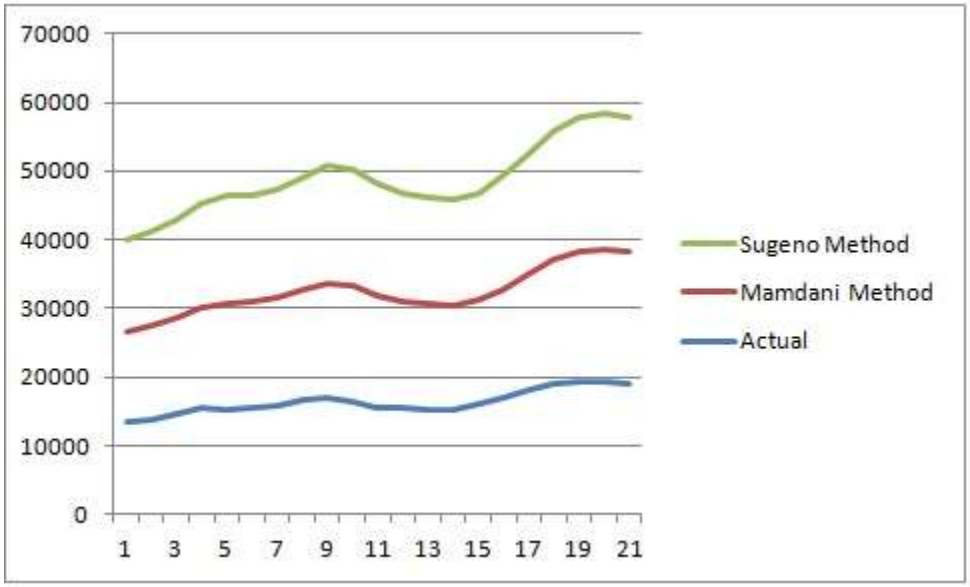

Figure 10:Graph of Comparsion

Mamdani-type has greater accuracy rate as compared to Sugeno-type, Mamdani-type provides human like reasoning and is widely used. On the other hand Sugeno-type is computational feasible and require less computation time.

Both the models has wide range Mamdani doesn't make feasible system while Sugeno make feasible system because Sugeno can be integrated with the ANN in order to create hybrid System.

CONCLUSION

This paper helps to define the two most commonly used Fuzzy Inference systems to forecast the data. It can be concluded that Mamdani-type FIS and Sugeno-type FIS perform in a similar manner, but Sugeno-type FIS allows the prediction of data to work at its full capacity with smooth operational performance. Although the designing of both systems is same but the output membership functions of Sugeno-type can only be either constant or linear and also the crisp output is generated in different ways for both FISs. Sugeno-type FIS has also an advantage that it can integrated with neural networks and genetic algorithm or other optimization techniques so that the system can adapt to system characteristic efficiently. However, extension of this work to compare the performance between the Fuzzy inference system and the data prediction system is an interesting topic for further research. Other possible direction for research is investigating the FISs with more possible fuzzy rules.

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