A Fuzzy Logic Multi Criteria Approach For Evaluation Of Teachers Performance

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Abstract

The methods available for evaluation of teacher in educational institute are based on crisp data in the form of rigid boundaries. For any uncertainty this evaluation has limitations. To evaluate the faculty in educational institute there are several sub criterions which can contribute on performance evaluation in the form of linguistic terms. In ranking the quality of teacher's performance, we have proposed fuzzy expert system on the basis of multi inputs as required by the institution. The proposed method introduces fuzzification of crisp data which depends on the extreme value that exists in the data. The use of the model is suitable for evaluating teacher on number of input variables, vagueness and imprecise information in the data. Experimental results are compared with the actual crisp output.

Keywords: Fuzzy Expert System, Linguistic Variable, Fuzzy rule base, Teaching Quality.

1. INTRODUCTION

Performance appraisal system is used by the most of the institutions and organizations to evaluate the teacher's performance. The teacher's performance is very important to the students as well as management, which usually involves crisp and uncertain values to evaluate performance [9]. In this paper we evaluate teacher's performance on the basis of different factors. Evaluation of the overall performance of a teacher is very necessary for betterment of the students, development of institution and betterment of the society & Nation.

In developing countries like India, higher education is considered to be an essential means for creation and development of resources and for betterment of the life of people. A highly reliable and effective performance evaluation rule is essential in decision making environments [4]. By decision making in fuzzy environment is meant a decision process in which the goals and /or the constraints, but not necessarily the system under control, are fuzzy in nature [2].There is increased consensus that highly qualified, quality, and effective teachers and teaching is necessary to improve the academic performance of the students and there is growing interest in identifying individual teacher's impact on student's achievement and also improvement of image of the educational institutes [6]. Every faculty should be assessed regularly to meet this requirement. Though students gain on standardized achievements is one important aspect of teaching ability, it is not only the comprehensive and robust view of teacher effectiveness. Proposals to use teachers' performance incentives as the basis for institutional reforms have recently attracted considerable attention and support among researchers and policy makers. There is a vast potential of the applications of fuzzy logic & expert system in teachers' assessment [7]. The process is designed to foster teacher's development and identify opportunities for additional support where required.

2. OBJECTIVE

The main objective of the paper is to evaluate the overall performance of a teacher for the betterment of students, institution and society. For this purpose, by discussing with teachers and experts various factors have been considered on which teacher's performance is based. These factors are (i) Result (Last 3 years) (ii) Student's Feedback (iii) Teaching-Learning process (iv) Research & Development (v) Involvement in college work for last year (vi)Social Activities etc which are treated as input factors by overcoming the uncertainties by using Fuzzy Technique.

3. FUZZY LOGIC APPROACH

The concept of Fuzzy logic was introduced by Lofty A. Zadeh in1965, [11][12][13]. A new mathematical tool to describe and handle vague or ambiguous notions such as "a set of fat girls" has been given by him. Since then fuzzy set theory has been rapidly developed by Zadeh himself and numerous researchers. The main idea of fuzzy set theory is quite intuitive and natural instead of determining the exact boundaries as in an ordinary set; a fuzzy set allows no sharply defined boundaries because of generalization of a characteristic function to a membership function.

3.1 Fuzzy Logic

Basically, Fuzzy Logic (FL) is a multivalued logic that allows intermediate values to be defined between conventional evaluations like true/false, yes/no, high/low, etc. Notions like rather tall or very fast can be formulated mathematically and processed

by computers, in order to apply a more human−like way of thinking in the programming of computers. This powerful tool to tackle imprecision and uncertainty was initially introduced by[11] to improved tractability, robustness and low-cost solutions for real world problems. Fuzzy sets have been applied in many fields in which uncertainty plays a key role. Fuzzy set theory is a response to the demand for ideas and approaches for handling non-statistical uncertainty [6].
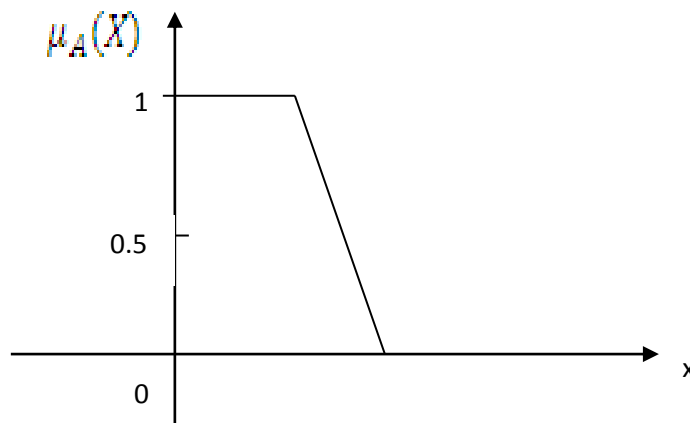
3.2 Fuzzy Set

A fuzzy set is a set with fuzzy boundaries. Defined fuzzy sets or classes for each variable allows intermediate grades of membership in them, which means each set could have elements that belongs partially to it; the degree of belonging is called membership functions ranging from 0 to1. If X is the Universe of discourse and its elements are denoted as x, in contrast with crisp set, then the fuzzy set A of X has characteristics function associated to it.

The fuzzy set is represented by a characteristic function, defined as follows:

$$\mu_A : X \to [0,1]$$

$$\mu_A(X) = \begin{cases} 1 , \textit{if } X \textit{ is totally in } A \\ 0, \textit{if } X \textit{ is not in } A \\ (0,1) , \textit{if } X \textit{ is partially in } A \end{cases} \quad \text{-----------------------(1)}$$

Figure 1: Membership Function of a Fuzzy Set

The value 0 corresponds to the absolute non-membership and the value 1 corresponds to the full membership. Therefore, a fuzzy membership function $\mu_A(X)$ indicates the degree of belonging some element x of the universe of discourse X.

3.3 Membership Function

Definition: A membership function (MF) is a curve that defines how each point in the input space is mapped to a membership value (or degree of membership) between 0 and 1. The input space is sometimes referred to as the universe of discourse, a fancy name for a simple concept.

It maps each element of X to a membership grade between 0 and 1. It provides the degree of belongingness for element to a fuzzy set. Membership function has many forms, either we choose arbitrarily or based on user's experience.

Types of Membership Functions

There are different types of membership functions used for representing fuzzy sets. Some of the commonly used membership functions are mentioned below.

1. *Triangular membership function*
The triangular curve is a function of a vector, x, and depends on three scalar parameters a, b, and c, as given by Fig (2).
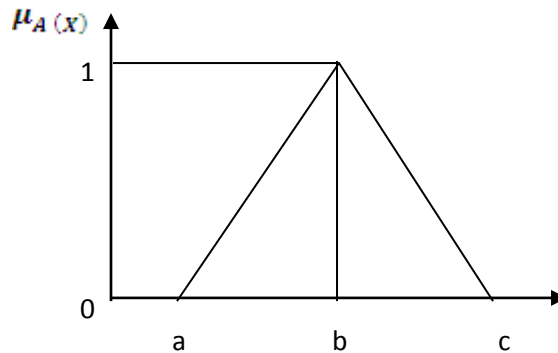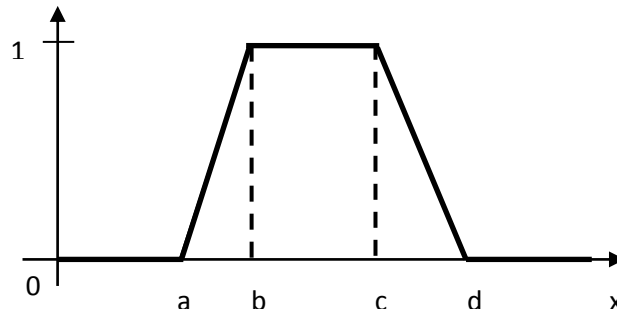

Figure 2: Triangular membership function

Triangular membership function is used for the present study. Membership function $\mu_A(X)$ is represented by equation no. (2)

$$\mu_A(x) = \begin{cases} \dfrac{x-a}{b-a} & \text{if } a \le x \prec b \\ 1 & \text{if } x = b \\ \dfrac{c-x}{c-b} & \text{if } b \le x \prec c \\ 0 & \text{otherwise} \end{cases} \quad -----(2)$$

2. *Trapezoidal Membership Function*
Trapezoidal membership function can be calculated as following as shown in Fig(3)

Figure 3: Trapezoidal Membership Function

The trapezoidal curve is a function of a vector, x, and depends on four scalar parameters a, b, c, and d, as given by equation (3).

$$\mu_A(x) == \begin{cases} \dfrac{x-a}{b-a} & if\ a \le x \prec b \\ 1 & if\ b \le x \le c \\ \dfrac{d-x}{d-c} & if\ c \le x \le d \\ 0 & otherwise \end{cases} \quad ---------(3)$$

The function with parameter (a, b, c, d) reduces to triangular membership function when b is equal to c.

3. Gaussian Membership Function

A Gaussian MF is specified by two parameters given by equation (4):

$$\mu_A(x) = e^{\frac{-1}{2}\left(\frac{x-c}{\sigma}\right)^2} \quad -----------(4)$$

Where c represents the MFs center and σ determines the MFs width. They are smooth & non-zero at all points.
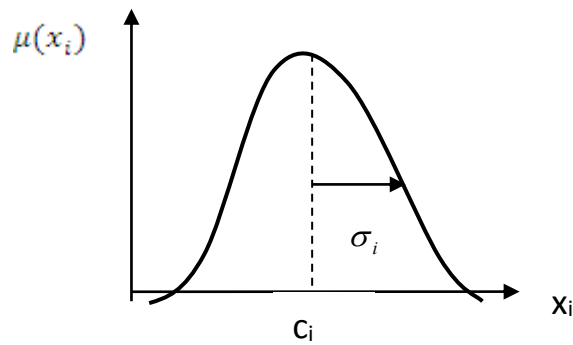
Figure 4: Gaussian Membership Function

A small σ will generate a thin membership function while big σ will lead to flat membership function.

4. FUZZY LOGIC MODELING

4.1 Input Variables

Achieving effective performance of human resources is primary goal of every organization. In this regard performance management practice of human resource management provides the sound basis of evaluating and developing employee performance in order to get enhanced institutional success. Similar to any organization, education institutions evaluates its teacher's performance for effective human resource management. Although, both teaching and non-teaching (administrative) staff in institution plays an important role in escalating institution's performance, yet teachers are considered to be imperative human resource of education institutions. Performance evaluation of teachers in terms of their teaching learning process and research outcome is the primary area of concern for any education institution. It also depends on the result of the students they are teaching, the feedback provided by the students. Besides these factors two more factors have been used to assess the overall performance of teacher such as involvement in college work and social activities.

For our study we have considered here six input variables used in the evaluation of teacher's overall performance as per the input from institution which are, Result (Last 3 years), Student's Feedback, Teaching-Learning process, Research & Development, Involvement in college work for last year and Social Activities

4.2 Output Variable

Overall teacher's performance is evaluated for the betterment of the educational institution. So, output is teacher's overall performance to be evaluated by the institution considering the specific criterion decided by the institution according to their order of preference involving the flexibility.

4.3 Linguistic Variable

At the root of fuzzy set theory lies the idea of linguistic variables. A linguistic variable is a fuzzy variable. For example, the statement "John is tall" implies that the linguistic variable John takes the linguistic value tall.

The range of possible values of a linguistic variable represents the universe of discourse of that variable. For example, the universe of discourse of the linguistic variable overall teacher's performance might have the range between 0 and 100 and

may include such fuzzy subsets as very poor, poor, average, good, very good etc. depending on the actual range.

For present study, various linguistic variables used for input and output variables are Poor, Satisfactory, Remarkable, Very Good and Outstanding.

The diagram of conceptual modeling using Fuzzy Logic is shown in the figure 5 which represents basic elements of fuzzy modeling which gives at the end Teacher's Overall Performance (TOP) as the final output for the educational institution in terms of input factors.
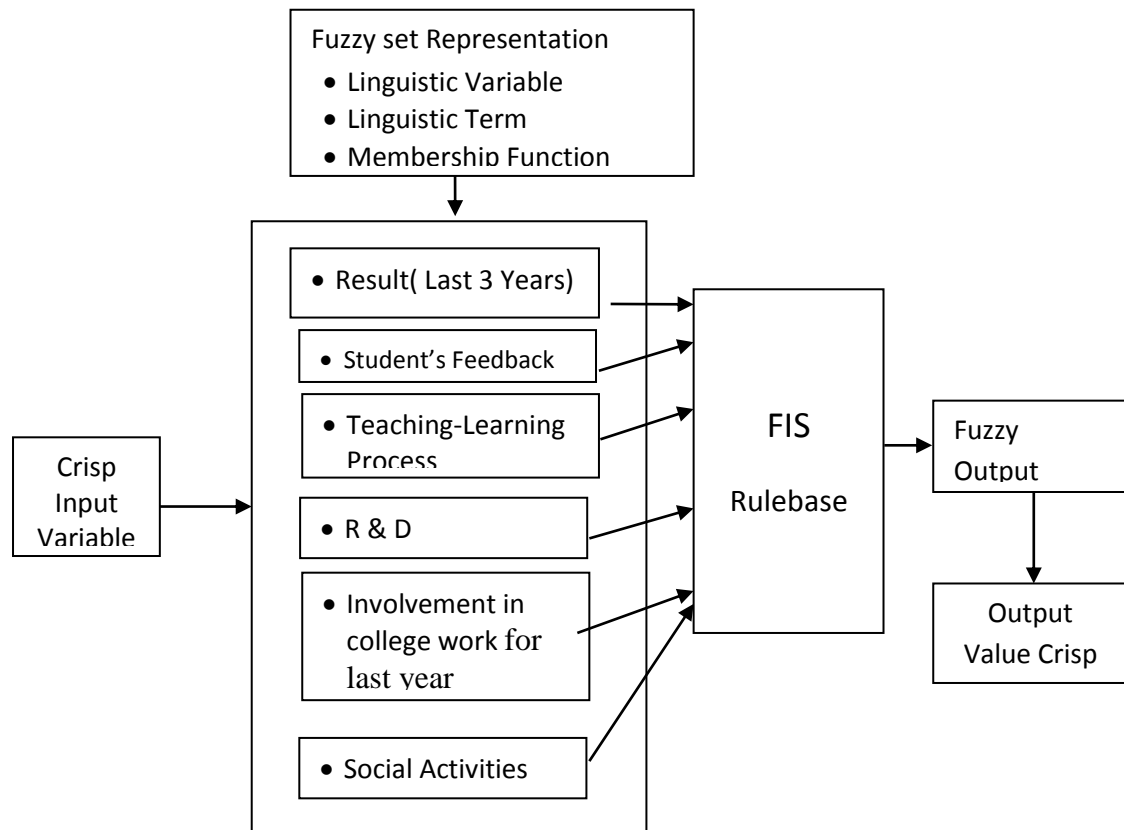
Figure 5: Elements of Fuzzy Modelling

4.4 Application

The data used for the study is taken from educational institution for the above mentioned input variables and final output which is teacher's overall performance. The corresponding values of above variables from the data are used for deciding the suitable values of input to evaluate the teacher's overall performance by institution using Fuzzy Rule of Inference.

5. MEMBERSHIP FUNCTIONS

5.1 Membership Functions for Input Variables

The inputs of fuzzy system classified into linguistic variables according to the range values as Poor, Satisfactory, Remarkable, Very Good, Outstanding by using triangular membership function. The fuzzified values are symmetrically distributed according the universe of discourse. Table (1) shows the Fuzzy Linguistic variable ranges for given input variables

Table 1: Linguistic variable ranges for Input Variables

Input Variable	Linguistic Terms	Range
Result (Last 3 years)	Poor	(0,0,4,8)
	Satisfactory	(6,8,10)
	Remarkable	(8,10,12)
	Very Good	(10,12,14)
	Outstanding	(12,16,20,20)
Student's Feedback	Poor	(0,0,4,8)
	Satisfactory	(6,8,10)
	Remarkable	(8,10,12)
	Very Good	(10,12,14)
	Outstanding	(12,16,20,20)
Teaching-Learning process	Poor	(0,0,6,12)
	Satisfactory	(10,12.5,15)
	Remarkable	(12.5,15,17.5)
	Very Good	(15,17.5,20)
	Outstanding	(17.5,21,25,25)
Research & Development	Poor	(0,0,4,6)
	Satisfactory	(4,6,8)
	Remarkable	(6,9,11)
	Very Good	(9,12,15)

	Outstanding	(12,16,20,20)
Involvement in college work for last year	Poor	(0,0,1.5,3)
	Satisfactory	(1.5,3.5,5.5)
	Remarkable	(3.5,5.5,7.5)
	Very Good	(5.5,7,8.5)
	Outstanding	(7.5,9,10,10)
Social Activities	Poor	(0,0,0.5,1)
	Satisfactory	(0.5,1.5,2.5)
	Remarkable	(1.5,2.5,3.5)
	Very Good	(2.5,3.5,4.5)
	Outstanding	(3.5,4.5,5,5)

Figure 6 shows the triangular membership function for input variables 1 to 6.
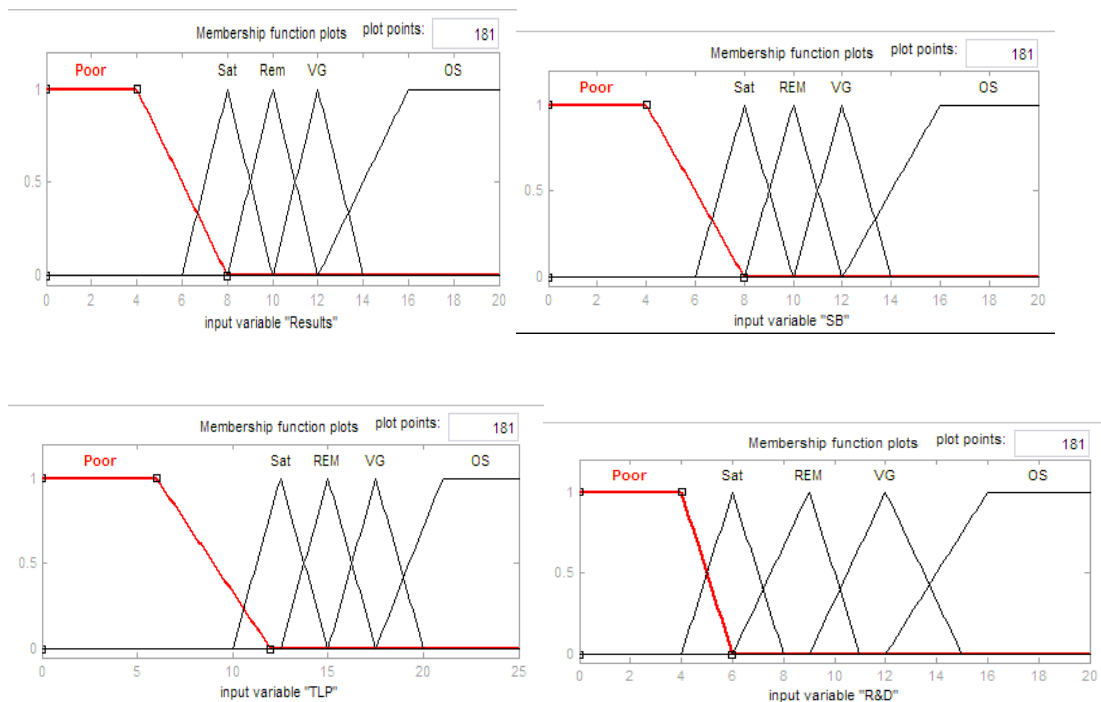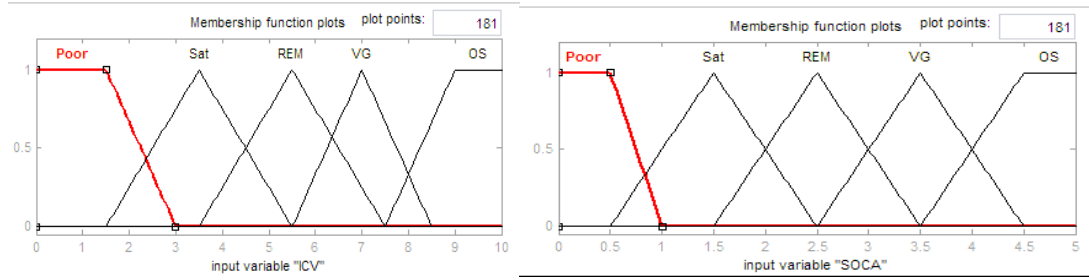
Figure 6: Membership function of input variables 1 -6

Membership grades for all linguistic variables of the input variables are determined from the relation shown in equation (2).

5.2 Membership Function for Output Variable

For the development of college it is very important to evaluate the performance of teacher not only student point of view but as a whole so that the weaknesses and strengths can be identified and accordingly measures can be taken. This will lead to the improvement in teacher and hence in students, college and nation.

In this system we have only one output which is teacher's overall performance. Its fuzzy membership function is shown in Table 2

Table 2: Fuzzy variable ranges and Membership grades for Teacher's Overall Performance.

Output Variable	Teacher's Overall Performance				
Fuzzy Variable	Poor	Satisfactory	Remarkable	Very Good	Outstanding
Crisp Output Range	(0,0,15,30)	(20,35,45)	(35,50,65)	(50,65,80)	(70,85,100,100)

Figure (7) shows the triangular membership function for output variable Teacher's Overall Performance.
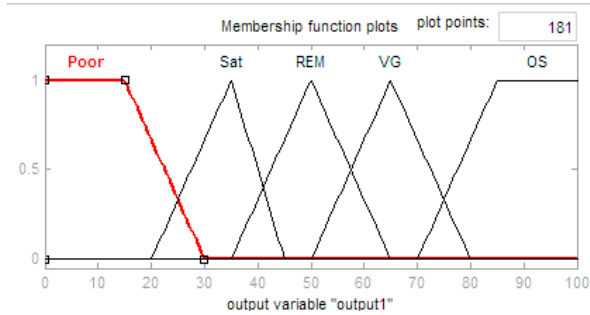
Figure 7: Membership function of output variable TOP

Membership grades for all linguistic variables of the output variable Teacher's Overall Performance are determined from the equation (5).

$$\mu_{OutputVariable}(x) = \begin{cases} \dfrac{x - a^1}{b^1 - a^1} & if \ a^1 \prec x \prec b^1 \\ 1 & if \ x = b^1 \\ \dfrac{c^1 - x}{c^1 - b^1} & if \ b^1 \prec x \prec c^1 \\ 0 & Otherwise \end{cases} \quad ----- (5)$$

6. FUZZY RULE BASE

Fuzzy Rule Base Modeling is important particularly where the relations between the components of the system are not exactly known, if there is insufficient statistical data for analysis and if the data is uncertain about a particular thing which the user needs. The Rule Based System was developed using many linguistic rules with "IF—THEN" rules along with some fuzzy mathematical operators as mentioned in Table 3.

Table 3: If-Then Rule base

SN	Input Variable1 (R)	Input Variable2 (SF)	Input Variable3 (TLP)	Input Variable4 (R&D)	Input Variable5 (ICW)	Input Variable6 (SA)	Output Variable (TOP)
1	OS	VG	OS	OS	OS	OS	OS
2	OS	R	OS	P	VG	OS	OS
3	OS	OS	OS	VG	VG	OS	OS
4	OS	OS	VG	P	R	VG	R

5	OS	VG	R	OS	R	VG	VG
6	VG	VG	R	VG	VG	VG	VG
7	VG	VG	R	S	S	P	R
8	VG	VG	P	R	VG	R	S
9	VG	VG	P	P	P	P	S
10	VG	R	OS	OS	S	S	VG
11	R	R	R	R	VG	VG	R
12	R	VG	R	OS	VG	VG	VG
13	R	R	R	R	P	P	R
14	R	P	S	S	VG	S	S
15	R	P	S	P	P	P	S
16	S	S	S	S	S	S	S
17	S	P	R	VG	S	OS	R
18	S	VG	VG	VG	R	R	R
19	S	P	S	R	P	P	S
20	S	S	P	P	P	P	P
21	P	P	P	P	P	P	P
22	P	S	S	S	R	S	S
23	P	S	R	R	VG	R	S
24	P	R	S	S	OS	S	S
25	P	P	P	P	S	P	P
26	OS	VG	OS	OS	VG	VG	VG
27	VG	R	VG	VG	VG	VG	VG

| 28	R	S	R	R	P	OS	R
29	P	S	P	P	S	P	P
30	S	P	S	S	VG	R	S
31	OS	VG	OS	R	VG	R	VG
32	R	R	VG	VG	R	R	R
33	OS	OS	OS	OS	S	OS	OS
34	VG	VG	VG	VG	VG	VG	VG
35	R	OS	VG	OS	OS	OS	VG
36	S	P	OS	OS	VG	VG	VG
37	P	VG	VG	VG	R	P	R
38	R	R	R	R	R	R	R
39	P	S	S	S	P	VG	S
40	S	S	P	P	S	OS	S
41	S	VG	S	S	VG	VG	S
42	VG	OS	VG	VG	OS	OS	VG
43	VG	P	VG	R	VG	R	R
44	VG	OS	VG	R	S	OS	VG
45	VG	VG	OS	S	P	VG	VG
46	VG	S	OS	P	S	OS	S
47	VG	S	OS	VG	R	OS	R
48	S	VG	OS	R	R	VG	S
49	R	VG	OS	S	R	OS	S
50	R	OS	VG	OS	VG	OS	R

Where, **OS- Outstanding**

VG-Very Good
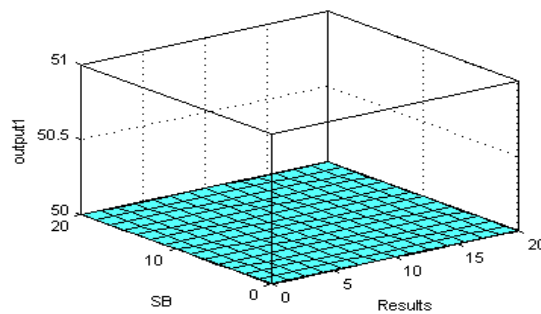
R-Remarkable

S-Satisfactory

P-Poor

6.1 Output

Fuzzy rule base can be applied through MATLAB to get the output for the designed fuzzy model. Various alternatives can be cross-examined using a developed model, as shown in fig.8.
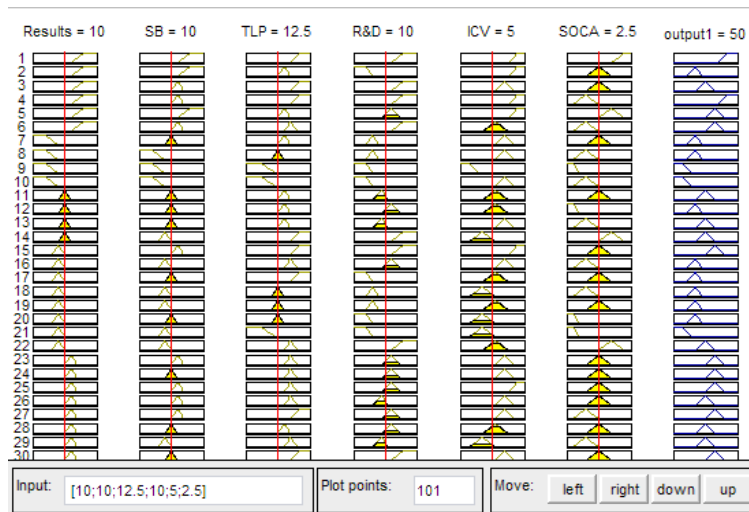
Figure 8: Fuzzy Rule Viewer

Figure 9 shows the relationship between input variables and output variable

Figure 9: Surface Viewer

6.2 Result & Discussion

The most common way for measuring the overall performance of teacher in education institution is, to use conventional ways of assigning a numerical numbers according to their achievements in respective criterion. Unfortunately, this method often results with fix numbering and ignoring the vagueness in system. From this point of view, this work is proposed to measure the overall performance of teacher using fuzzy logic model. Fuzzy interface system with Mamdani method was used for this multi-criteria fuzzy logic model for evaluation of teacher's performance.

From Table 4 we can compare the overall performance of teacher by direct method and the proposed fuzzy logic model on the basis of rules framed.

Table 4: TOP by direct method and Fuzzy logic

Sr. No.	Input-1 (20)	Input-2 (20)	Input-3 (25)	Input-4 (20)	Input-5 (10)	Input-6 (5)	Total (100)	Fuzzy Value
f1	11	12	16	16	7	3	65	58
f2	13	15	22	20	10	5	85	86.2
f3	11	10	22	14	8	1	66	62
f4	13	14	19	16	6	0	68	64
f5	10	15	25	17	10	3	80	78
f6	18	16	25	20	10	1	90	87.4
f7	8	15	19	17	8	1	68	63
f8	12	14	23	16	8	2	75	76
f9	13	12	22	7	10	3	67	64
f10	16	16	22	19	10	5	88	88.6
f11	12	14	25	20	7	3	81	79
f12	17	18	17	3	10	2	67	65
f13	14	17	25	14	10	5	85	87
f14	19	15	19	20	10	4	87	86.8
f15	20	16	25	13	6	0	80	81

f16	15	15	22	7	8	2	69	60
f17	13	15	20	18	10	1	77	72
f18	16	12	18	15	6	4	71	73
f19	11	13	23	18	9	2	76	77
f20	12	11	20	19	7	4	73	69
f21	10	9	25	10	5	1	60	50
f22	17	14	19	14	9	2	75	65
f23	15	13	18	13	7	2	68	64
f24	16	17	13	15	10	3	74	72
f25	18	17	20	12	8	0	75	78
f26	19	18	21	16	6	2	82	80
f27	16	16	25	13	9	1	80	77
f28	13	12	24	17	3	4	73	66
f29	9	12	22	15	7	0	65	58
f30	14	14	24	12	8	2	74	69

7. CONCLUSION

The complexity in deciding the best teacher on the basis of his overall performance considering multi input variables in uncertain situations, the fuzzy logic model can provide the realistic results. Top management can decide the multiple criteria for every input variable case and situation wise and according to the criteria, the results of this fuzzy logic model are calculated as an output variable which is mapped to the actual results to the good extent. These results overcome all uncertain situation and so are more reliable and flexible to measure the teachers overall performance. The contribution of this fuzzy world is based on the rules set by the institution on the basis of past experiences and future plans.

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