Prediction of Quality of Technical Education Using Fuzzy Logic

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Abstract

Fuzzy logic can be used as an effective technique for prediction of quality in various sectors. Its adoption has been proved to be very effective in sectors like manufacturing, automation, etc. Adoption of fuzzy logic for predicting the quality of technical education can be successful. In this paper, fuzzy logic tool of MAT LAB software has been applied for analyzing the effects of various factors on quality of Technical education. The results thus obtained would be very helpful in precise decision making. It is quite difficult to predict the quality of education by considering the effect of various parameters with human intelligence. There is always a possibility of diverting from the exact path with conventional methodology due to huge amount of data which involves large mathematical calculations. Fuzzy logic technique provides a reasonable solution to complex decision situations. Fuzzy logic is a powerful tool for analyzing the data and reduces large amount of mathematical calculations required for evaluation of the data.

Keywords – Fuzzy Logic, Quality of Technical Education, Membership function.

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1. Introduction

Technical Education is an integral part of the Higher Education System. The target for the "change" is to give to the University an important role in the development of the community with new standards of quality. Technical Universities must offer the human community models and landmarks regarding quality management. Thus there is need for universities to prove this by reforming the curriculum with aspiration towards the achievement of quality. At Global level; the quality management of education has become a priority. The general policy of the Technical Universities is focused on continuous improvement of the educational and research process that has developed within the departments as well as the formation of competent and competitive specialists, capable to respond to the demands of a modern society. This educational policy [1] has the following basic principles:

- The compatibility of the curriculum of specialties with the standards of Global education.
- The harmonization of the offer of specialties with the demands of the labor market and with the new directions of society's development.
- The continuous improvement of the university's offer, through development of a performing system of communication with students and foreign partners;
- The appropriation of resources designated to the improvement of the quality of didactic and research processes.

1.1 Quality Criterion in Education

Among multiple meanings of the term "quality", two have critical importance for the improvement of quality [2]:

a. "Quality" means those characteristics of processes that satisfy the needs of customers and thus ensure their satisfaction. In this sense, the significance of quality is oriented toward income. The purpose of such higher quality is to ensure a greater satisfaction of clients and, separately, to increase income

b. "Quality" means absence of deficiencies – absence of such errors that result in exploitation. accident, non satisfaction of customers, claims of customers toward costs etc

In education, quality means good academic culture, excellent academic results, progressive and adaptive management, clean administration and prominent profile of outgoing students. It involves the expectations and perceptions of students, faculty, supporting staff, administrators, parents of the students, government, industry (recruiters) and society etc. They interact with the system in different ways and their objectives may be different. So the implementation of a quality improvement programme necessitates the identification of various factors in an educational set-up and determination of their criticality. Sometimes the stakeholders are classified into three groups: input, transformation and output. Students and parents are included in input stakeholders, the faculty is the transformation stakeholders and the corporations and society are the output stakeholders. The main objective of a TES is the development of methodologies for improving the quality of education and establishment of a new brand of their own.

The education sector, particularly the Technical Education System (TES), has direct bearing on society for society's growth and socio-economic development. One of the key skills required of an engineer is the ability to produce systems that satisfy users' requirements by correct selection, configuration, integration, operation and control of proprietary building blocks. Today, many engineering colleges and technical universities with different courses in undergraduate, postgraduate and research levels are in existence and compete with each other for imparting education. Among the limited number of state-funded institutions and the mushrooming of - private institutions, quality has become a competitive weapon for the institutions to serve and attract their primary customers (students). Some of the important parameters for quality in education are as follows [3]:

Training on state-of-the-art technology, Comprehensive learning resources, Opportunities for campus training & placement, Close supervision of students' work, Expertise in subjects and well-organized lectures, Good communication skill of academic staff, Well-equipped laboratories with modern facilities, Design of course structure based on job requirements, Encouragement for sports, and cultural activities, Cleanliness, orderliness, systematic and methodical, Available regularly for students' consultation, Effective classroom management, Recognition of the students, Adaptability to modern techniques. These factors have been considered further in following analysis.

1.2 The Proposed Method

All these considerations offer sufficient premises for applying the new curriculum thus having the guarantee that the process of education will fit within the parameters of quality. There are large numbers of parameters for improvement in technical education and most of them are very ill defined i.e. very imprecise, vague and involve uncertainty. With traditional methods of human intelligence it is quite difficult to predict the precise conclusion. Thus Fuzzy approach is applied because this helps to take decision with simple collection of rules based on linguistic approach.

1.3 Fuzzy Logic Features

The intrinsic possibilities of the fuzzy formalization to easily transcribe into mathematical terms the current language, by the simple allocation of some membership degrees to linguistic variables, lead inherently to the necessity of reflection on the possibility of adoption of fuzzy mathematics as a possible common language in the improvement of quality. The operations of reunion, intersection (and further on, complementary, Cartesian product, etc) are reduced to operations of determination of some maximums and minimums. The fuzzy logic is at present perfectly coagulated, offering the mathematical support necessary for the modeling of uncertainty, specific to the domain of quality

improvement. Some specialist firms offer an abundance of software products dedicated to the operation with fuzzy systems that have already imposed in the field of automatic adjustment, modeling of great or incomplete systems, etc.

1.4 Fuzzy Set Theory

Fuzzy set theory introduced by Zadeh [4] (1965) is used to represent the vagueness of human thinking; it expands traditional logic to include instances of partial truth. In traditional set theory, elements have either complete membership or complete non-membership in a given set. With fuzzy set theory, intermediate degrees of membership are allowed. The coding of the degree of membership to each of the elements in the set is defined as the membership function of the fuzzy set. The membership function is commonly depicted as a membership curve. The membership curve contains three main components: the horizontal axis consisting of domain elements (usually real numbers) of the fuzzy set, the vertical axis consisting of the degree of membership scale from 0 to1, and the surface of the set itself which relates the degree of membership to the domain element. These membership curves can take on several shapes, but the triangular and trapezoidal are the most frequently used. This type of methodology is very useful when the model requires human perception as inputs where ambiguity and vagueness exists. In particular, systems requiring linguistic descriptions are more easily modeled using fuzzy sets. There are two main inputs to the evaluation process of data. The first is the decision maker's perception regarding the importance weight of the criteria of interest. The second input is how the decision-maker rates each parameter with respect to objective. However, it is very difficult to obtain exact assessments from the decision maker. The nature of these assessments is often subjective and qualitative and thus forcing the decision makers to express their opinion in pure numeric scales. It does not allow any room for subjectivity. Subjectivity of human assessments and beliefs can be expressed by using linguistic terms such as "low importance" or "highly likely." The fuzzy set theory and fuzzy numbers allow such qualitative expressions. As a result, their use in modeling of our proposed system seems a logical choice.

1.5 The Trapezoidal Fuzzy Membership Functions

Here, the decision maker's perception is solicited in areawise importance of each factor, and the performance of each factor. The trapezoidal curve is a function of vector x, and depends on four scale parameters a, b, c, d. The parameters a and d locate the"feet" of the trapezoidal and parameters b and c locate the "shoulders.

$$f(x,a,b,c,d)=\begin{cases} 0, & x \le a \\ \dfrac{x-a}{b-a}, & a \le x \le b \\ 1, & b \le x \le c \\ \dfrac{d-x}{d-c}, & c \le x \le d \\ 0, & d \le x \end{cases}$$

2. The Present Research Objectives

In the education sector there are large number of parameters that need attention. The criticality of the factors is not defined precisely hence we are not able to decide that on which factor we should pay attention and how much attention. This can be easily found by using fuzzy logic technique and hence decision making becomes a lot easier. Following objectives can be drawn up for this study:

- To develop an instrument for predicting improvement in quality of technical education.
- To determine the firing strength of various factors on quality of technical education.
- To test the adequacy of Fuzzy logic for modeling the customer evaluation of service quality in education.

2.1 Applications

There are numerous parameters or factors that can be analyzed to predict the quality of technical education. Here we have taken fourteen factors as per previous research and expert suggestions that includes the areas where the improvements in the service are required for a TES in the context of this study. Thus a

2.2 Data Collection & Analysis

Data was collected from the experts of different Technical Institutions (both private and government) & Industry through various mode of communication by attaching the questionnaire comprising of 14 factors on expectations as well as perceptions related to quality of Technical Education. The respondents were requested to answer in a scale from 1 to 10. Thus from the survey carried out in the NCR zones, we obtained responses of 25 experts from the profession of teaching as well as industry having enough experience to provide feedback. After getting responses we carried out the process of giving weightage to each factor. For that purpose, we compared the opinion of each expert and then found out the average or mean rating for the factors. Rating is done by evaluating the data in the form of a matrix of factors and expert opinion (as shown below). This data was used as the firing strength of each rule while carrying out MatLab fuzzy logic analysis to predict the result regarding the quality of education.

Table 1. Data for finding the firing strength of individual parameter

Sr. No	Parameters for Expert Opinion													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	8	7	9	9	10	9	10	9	7	9	8	8	8	9
2	8	9	10	9	9	8	10	8	8	7	9	6	7	9
3	8	9	10	8	10	8	10	9	7	7	9	10	8	9
4	9	8	10	10	10	10	9	10	8	8	7	7	9	9
5	9	9	10	10	7	7	10	7	7	6	6	6	7	10
6	6	5	3	7	7	8	9	6	2	3	3	5	2	9
7	8	4	6	5	8	7	9	4	3	2	3	4	6	9
8	9	9	10	7	7	7	9	7	6	5	5	5	6	7
9	8	7	9	9	10	9	10	9	7	9	8	8	8	9
10	8	9	10	9	9	8	10	8	8	7	9	6	7	9
11	8	9	10	8	10	8	10	9	7	7	9	10	8	9
12	8	9	10	8	10	8	10	9	7	7	9	10	8	9
13	9	8	10	10	10	10	9	10	8	8	7	7	9	9
14	9	9	10	10	7	7	10	7	7	6	6	6	7	10
15	9	9	10	10	7	7	10	7	7	6	6	6	7	10
16	6	5	3	7	7	8	9	6	2	3	3	5	2	9
17	8	4	6	5	8	7	9	4	3	2	3	4	6	9
18	8	4	6	5	8	7	9	4	3	2	3	4	6	9
19	9	9	10	7	7	7	9	7	6	5	5	5	6	7
20	9	9	10	10	7	7	10	7	7	6	6	6	7	10
21	6	5	3	7	7	8	9	6	2	3	3	5	2	9
22	8	7	9	9	10	9	10	9	7	9	8	8	8	9
23	9	9	10	10	7	7	10	7	7	6	6	6	7	10
24	6	5	3	7	7	8	9	6	2	3	3	5	2	9
25	8	4	6	5	8	7	9	4	3	2	3	4	6	9
Sum	201	181	203	201	207	196	238	179	141	138	147	156	159	226
Mean	0.80	0.72	0.81	0.80	0.83	0.78	0.95	0.72	0.56	0.55	0.59	0.62	0.64	0.90

From the above analysis of expert opinion, effect of various factors was calculated after getting mean value of opinion for individual factor. So from expert point of view impact of individual factor that determines the firing strength of individual rule while applying fuzzy technique is shown below. For further analysis only those factors that have mean value above or equal to 0.58 were considered. This has been shown in the table 2 below:

Table 2. Ranking as per firing strength

FACTORS	Mean	Rank
(1)Training on state-of-the-art technology	0.80	5
(2)Comprehensive learning resources	0.72	7
(3)Opportunities for campus training & placement	0.81	4
(4)Close supervision of students' work	0.80	5
(5)Expertise in subjects and well-organized lectures	0.83	3
(6)Good communication skill of academic staff	0.78	6
(7)Well-equipped laboratories with modern facilities	0.95	1
(8)Design of course structure based on job requirements	0.72	8
(9)Encouragement for sports, games and cultural activities	0.56	12
(10)Cleanliness, orderliness, systematic and methodical	0.55	13
(11)Available regularly for students' consultation	0.59	11
(12)Effective classroom management	0.62	10
(13)Recognition of the students	0.64	9
(14)Adaptability to modern techniques	0.90	2

2.3 Assessing Importance of a Factor

The important weight of a factor has three membership functions in its universe, or domain of possible values: "low" "medium" "high". Each is modeled into trapezoidal membership function (trapmf). For each membership function, the average value is the point at which the degree of membership reaches one, or full membership for that set. The upper and lower limits are those points at which the degree of membership reaches zero, or no membership. Fuzzy set for the range is classified as shown in table:

Table 3. The Linguistic Importance Scale

Range	Trapmf Values	Fuzzy sets
Low	-5 - 5 (-5,-4, 4, 5)	(0,0),(1,1),(2,1),(3,1),(4,1),(5,0)
Medium	4 - 8 (4, 5, 7, 8),	(4,0),(5,1),(6,1),(7,1),(8,0)
High	7 - 10 (7, 9, 10, 12)	(7,0),(8,1),(9,1),(10,1)

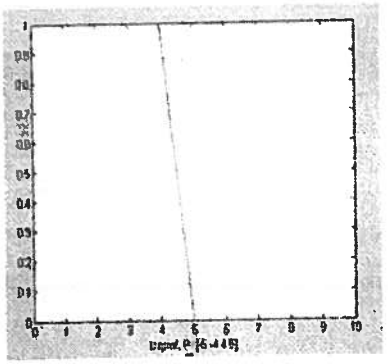

Figure.1

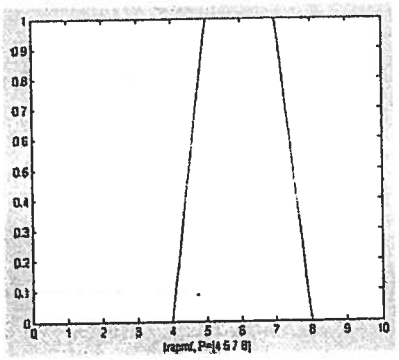

Figure2

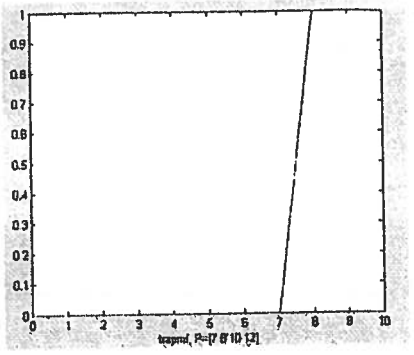

Figure.3

Figure (1) Membership function of variable Small (-5 -4 4 5) Figure (2) Membership function of variable Medium (4 5 7 8), Figure (3) Membership function of variable large (7 8 10 12) The membership function for output i.e. Improvement in Quality of Technical Education is also Trap mf and is classified as Weak, Better, Superior.

Table 4. The Linguistic Importance Scale

Weak	0 - 40 %
Better	30 - 70 %
Superior	60- 100 %

2.4 Fuzzy Rule generation

The decision which the fuzzy controller makes is derived from the rules which are stored in the database. These are stored in asset of rules. Basically the rules are if-then statement that are easy to understand, as they are common English statements. Rules used here are derived from common sense. Fuzzy sets and fuzzy operators are the subjects and verbs of fuzzy logic. These if-then rules statements are used to formulate the conditional statements that comprise fuzzy logic.

A single fuzzy if-then rule assumes the form if x is A then y is B where, A and B are linguistic values defined by fuzzy sets on the ranges (universes of discourse) X and Y, respectively. The if-part of the rule "x is A" is called the antecedent or premise, while the then-part of the rule "y is B" is called the consequent or conclusion. Number of rules purely depends on the number of inputs. These rules are meaningful with its fuzzy linguistic representationRules used in MATLAB fuzzy tool box (Rule editor window) are shown below.

1 if Effect of "Training on state-of-the-art technology is low than Improvement in quality of education is weak" ( )
2 if Effect of "Training on state-of-the-art technology is medium than Improvement in quality of education is better" ( )
3 if Effect of "Training on state-of-the-art technology is High than Improvement in quality of education is superior" ( )

Similarly, rules for other factors can be generated.

3. Result & Discussion

Here the input variables are defined in fuzzy tool box of MATLAB and finding the output i.e.- Prediction of improvement in quality of education (Fuzzy file =Improve)

Step 1: Here the various input variables are added as input to FIS EDITOR WINDOW as shown in figure below.

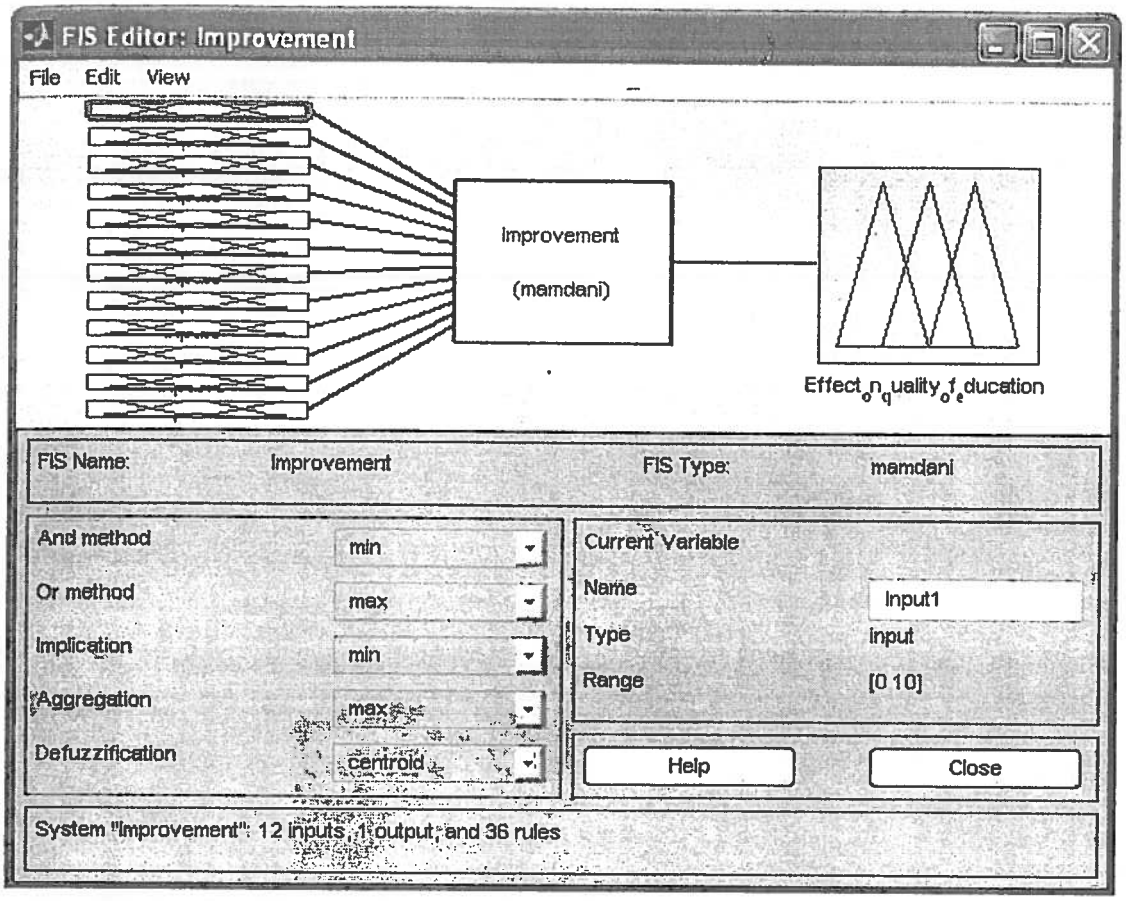

Fig 4.Mat Lab presentation of Input & output variables (FIS Editor Window)

Step 2: For each input factor membership function is added. Here membership function selected is trapmf with range Small, Medium, Large As shown below. For various input (factors) and outputs (Improvement in Technical education).

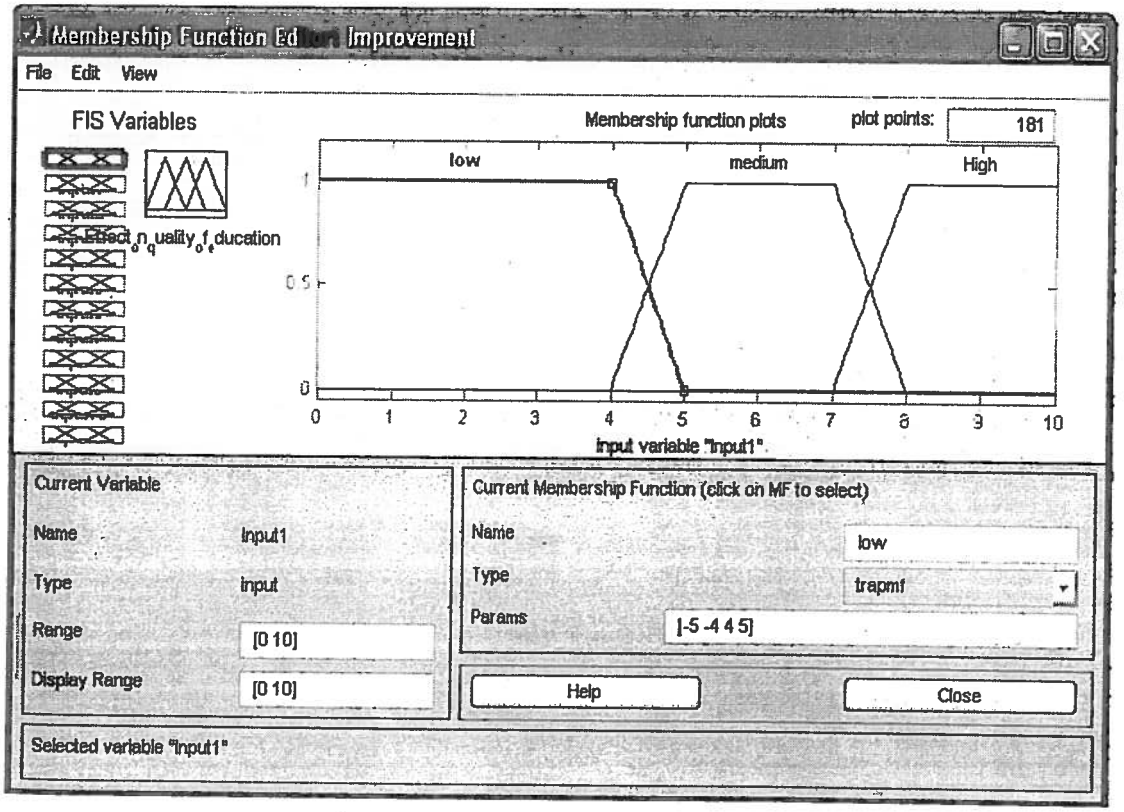

Fig. 5 Membership function for input variables

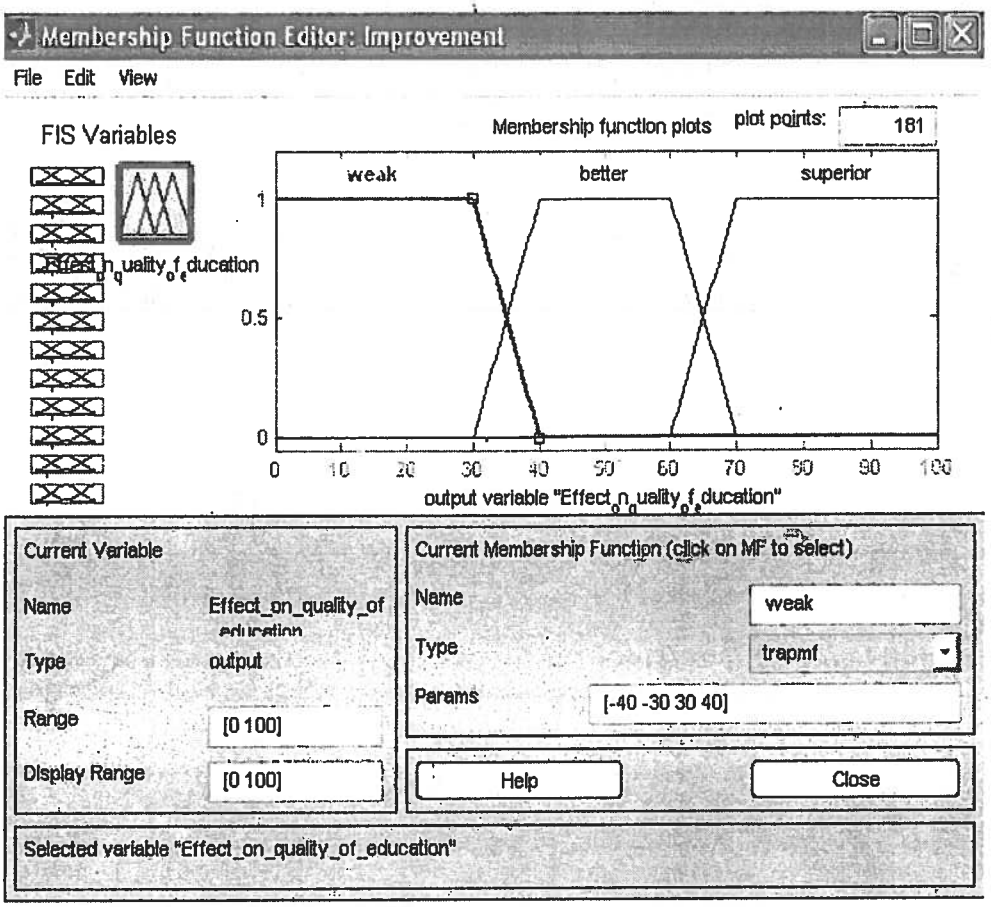

Fig. 6 Membership function for output

Step 3: After adding input to FIS and generating membership function for each input next step is rule generation where rule generated for each factor is based on minimum of x and y. Number of rules for each factor depend upon number of fuzzy sets. Rules are generated in rule editor window. Here we use the mean value of expert opinion as firing strength or weight age to each rule. There are around forty-two rules that are active.

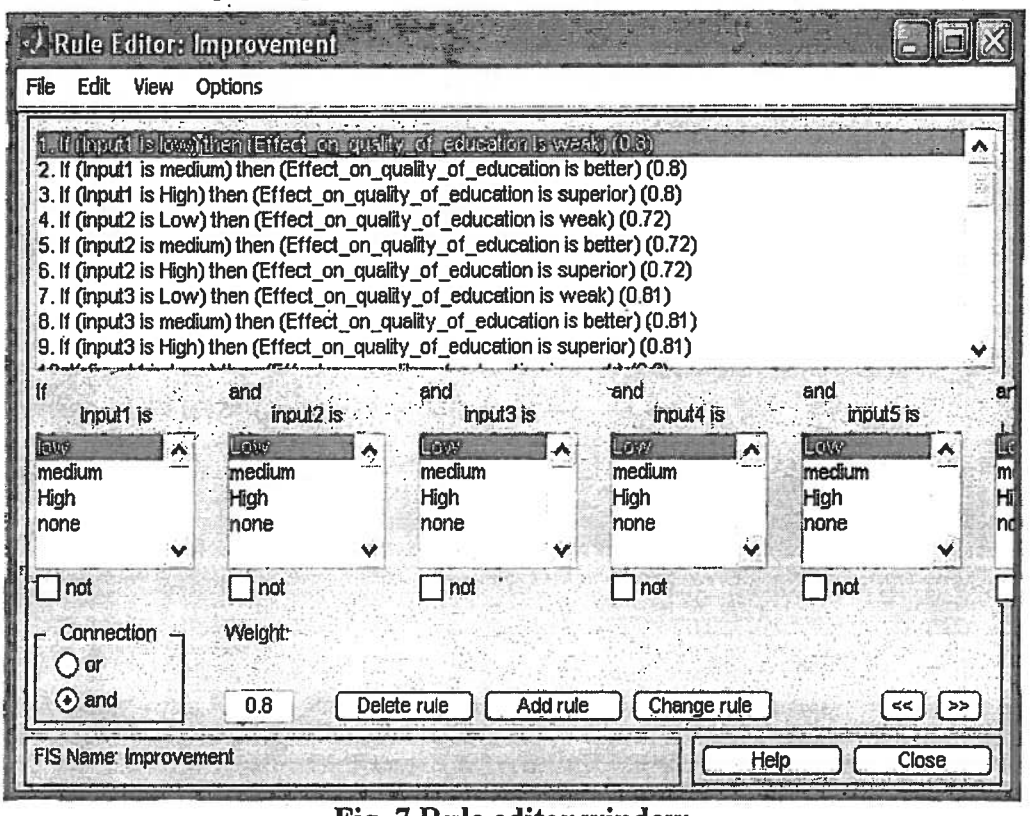

Fig. 7 Rule editor window

Step 4: After generating rules, it is easy to predict the improvement in quality of Technical Education by change in effort for improvement over each factor Figure below shows the rule viewer window. Here we can see that by setting the each input for possible improvement in rule viewer window, the effect on output can be observed. From figure it is clear that when effort on each individual factor is made around 7 or 8 then improvements in quality would be around 66 %.

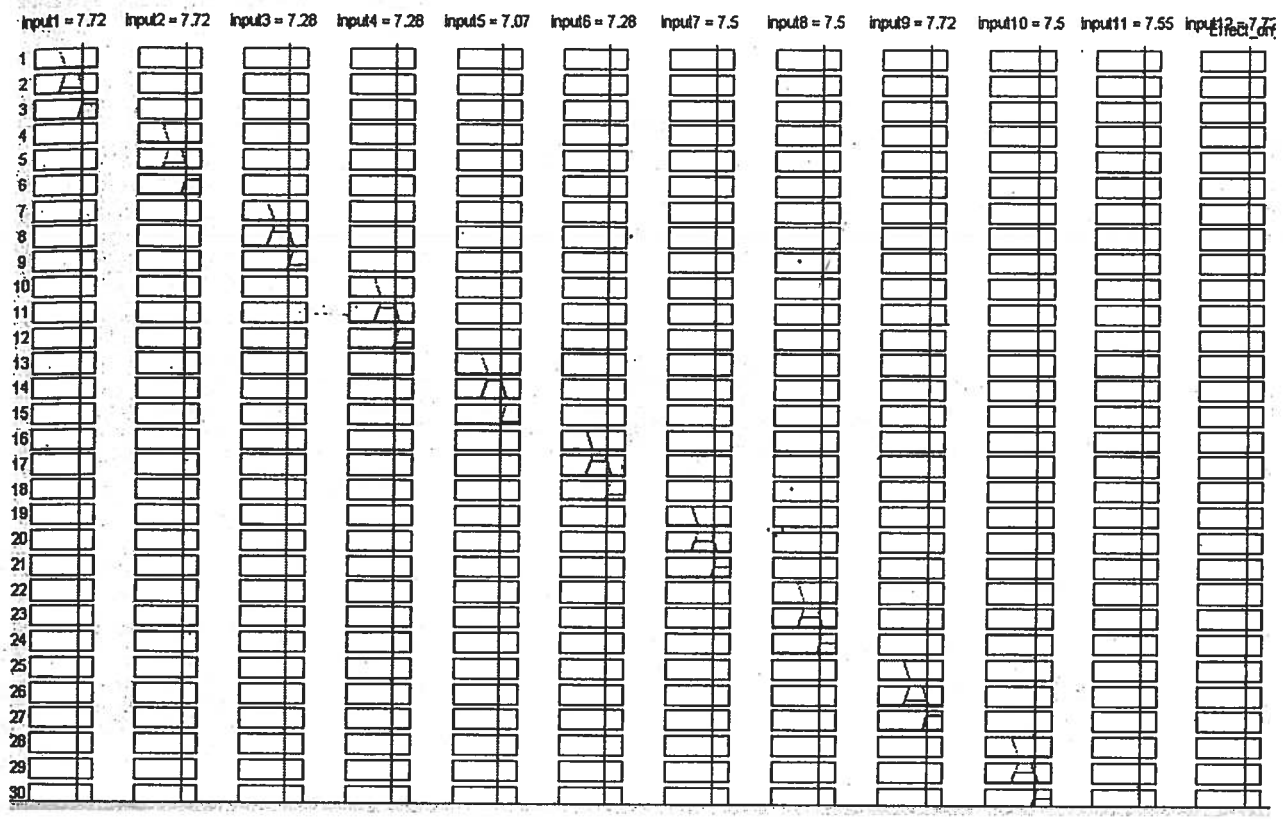

Fig. 8 Rule Viewer (Effect of Input)

Effect on Quality of Education is 65.6

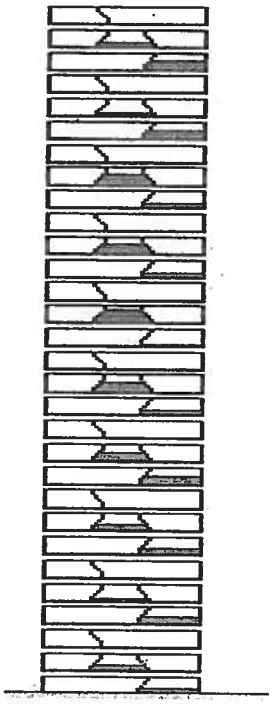

Fig. 9 Rule Viewer (Output)

Step 5: Surface viewer: (Figure 10) shows the effect of two highly favored factors (Adaptability to Modern Techniques & Well equipped laboratories with modern facilities) by experts with their effect on Improvement in quality of education. The figure. suggests that if both the factor are rated around 10, then improvement in quality of education will be around 75%. Hence these are the most critical factors for upgrading the standard of education.

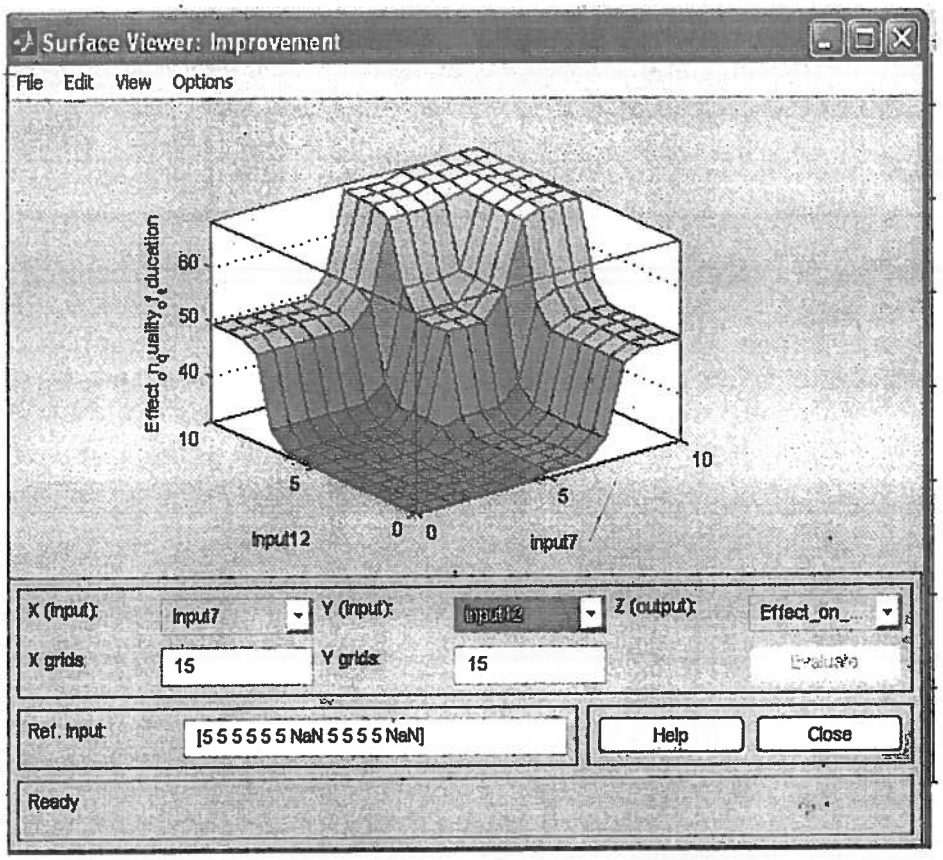

Fig.10. Surface Viewer-Surface relation between two most critical factor & output.

4. Conclusion

A non traditional approach has been proposed to infer statistical and fuzzy rules from quantitative database. Each factor was assigned to several fuzzy sets. Using fuzzy set concepts, fuzzy rules were inferred and then Mat Lab Fuzzy logic tool box was used for generating rules. Here we have used only few parameters for analysis but this approach suggests that for large data base, decisions can be taken more effectively than traditional methodology with less mental fatigue.

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