Fuzzy Rule Based Students' Performance Analysis Expert System

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***Abstract*—In this era of globalization and technological revolution, education is considered as a first step for every human activity. It plays a vital role in the development of human capital and is linked to an individual's well-being and opportunities for better living. It ensures the acquisition of knowledge and skills that enable individuals to increase their productivity and improve their quality of life. But there are number of factors which deviate student from the actual path resulting in degradation of academic performance. A series of variables is to be considered when to identify the affecting factors towards quality of academic success. Identifying the most contributing variables in the quality of academic performance is a very complex and challenging job. In this proposed work, a fuzzy rule based expert system has been designed to evaluate the performance of students on the basis of various parameters. Firstly, a discussion is held with highly experienced authorities of Lovely Professional University (LPU) with the reason to identify the critical factors that may be affecting students' performance. Five critical factors came into the light namely teaching methodology, university system, university environment, personal reasons and family issues. After that, a one to one formal interaction with engineering students of LPU, is done to identify which kind of factors are affecting particular student. Based upon the collected information, a system is developed which will tell whether the performance of a student will be increased or decreased or remain consistent based on factors provided by the user and counsel him/her against those affecting parameters.**

Keywords- Fuzzy Expert System; Fuzzy Rule; Major factors; sub-factor

I. INTRODUCTION

In today's world, the use of an expert system is increasing day by day. It has been playing a major role in many disciplines such as in agriculture for crop management, insect control, in medicines, assist physician in diagnosis of diseases and in space technology. Some expert systems have been developed to replace human experts and to aid humans. The integration of fuzzy logic with an expert system enhances its capability and is called a fuzzy expert system, as it is useful for solving real world problems which do not require a precise solution. So, there is a need to develop a fuzzy expert system as it can handle imprecise data efficiently and reduces the manual working while enhancing the use of expert system.

In 2011, Ramjeet Singh Yadav et.al. [2] used the student's marks as input and evaluate the student's academic performance as excellent, good, or bad. They didn't consider the factors affecting the performance of the student, they only evaluated the performance. Whereas in 2012, Mamatha S Upadhya [4] proffered the fuzzy inference system for the evaluation of student's performance on the basis of students' attendance, teaching effectiveness, facilities provided to students. These three factors are not enough to assess the performance of the student. There are various factors that can influence a student in their academic performance whether it is negative or positive. Individual differences in academic performance have been linked to differences in intelligence and personality [3].

Parental education and family levels have positive correlations with the student's quality of achievement and therefore parent's academic socialization becomes necessary i.e. the way parents influence students' academic achievement by shaping students' skills, behaviors and attitudes towards education.

In this research work, five major factors are considered that may affect the students' performance. These are personal factors, family issues, university environment, university system and teaching effectiveness. All these factors are further divided into sub-factors. So, a fuzzy expert system has been developed for

978-1-4799-2900-9/14/$31.00

evaluating the learning achievement of students as the key for realizing the purpose of education. All information (statistical measures, statistical parameters, statistical decisions, probabilities of significance and fuzzy measures) is used as input for a fuzzy rule based expert system. This system has been developed by taking the data of students of Lovely Professional University (LPU). The data are collected by performing one-to-one interaction with students.

The main goal of this system is to extracting the factors leading to variation in performance and after that counsel the students against those factors.

II. FUZZY EXPERT SYSTEM

All the real world problems don't require precision. Problems like parking a car, backing up a trailer, navigating a car among others on a free way, washing clothes, controlling traffic at intersections, judging beauty contestants don't need an exact solution, the information available for solving such types of problems, is vague and certain. So, these types of problems can't be solved by two-value classical theory which provides solution as true or false and requires complete and precise information. In that case, some means of imprecision are needed, thus, fuzzy system would be useful for formulation and solution of problems that are uncertain and vague. Fuzzy expert system is an expert system that draws conclusion by using fuzzy logic and a set of rules unlike in conventional system which uses Boolean logic to draw inference [2,5]. The rules in the fuzzy expert system are in human-readable form i.e. it can be easily interpreted by the human beings.

The major difference between the two i.e. expert system and conventional system arises when it comes to interface.

The interface of an expert system when compared to the conventional system permits questions to be asked and answers to be given using a natural language style. The command interface found with most conventional programs is not easily accepted by the end-users as compared to the readily acceptability of the expert system. Interaction with an expert system also follows the conversation between one human obtaining advice from another human who is absent in conventional system. During the conversation, explanations are provided by the expert to queries as to "why" a question is being asked, and "how" a given conclusion was reached. Unlike a conventional program, an expert system provides a final answer.

Therefore, Fuzzy systems are useful in two contexts: 1) when the system is complex and its behavior is misunderstood 2) and in situations where exact solution is not needed and fast response is required.

The concept of fuzzy logic was introduced by Lotif Zadeh in 1965 [6]. It was found to be useful for handling complex real world problems and integration of fuzzy logic with expert system enhances the decision making capability of the expert system. Fuzzy logic starts with concept of fuzzy sets. Fuzzy set is a set containing elements that can have partial degree of membership unlike in crisp sets, in which element either belongs to set or not, there is nothing like partial membership [3]. For example, age can be considered as linguistic variable whose members are young and old.

Different human beings have different interpretation for various terms. Consider the term "young", Ex-age >60. Suppose, two sets are there, a set A which defines the people above 60 years of age to be considered old and set B consists of the people less than 60 years of age as young. What can be said about person whose age is 50? According to classical set theory, that person is considered as young. But if talk about real world, we can't say exactly that person is young. So to represent this type of data, fuzzy set is needed which determines up to which degree that person belongs to set A and set B. Fuzzy set is useful for representing linguistic variables.

A fuzzy set A in X is defined as a set of ordered pairs.

$$A = \{x, \mu_A(x) \mid x \in X\}$$

Where $\mu_A(x)$ is called the membership function of x in A. This function maps each element of X to a membership value between 0 and 1.

A membership function is a curve which shows the mapping of an input space to a membership value between 0 and 1 [2].

A. Components of a Fuzzy Expert System

The fuzzy expert system consists of two main components which are shown in the "*Fig. 1*".

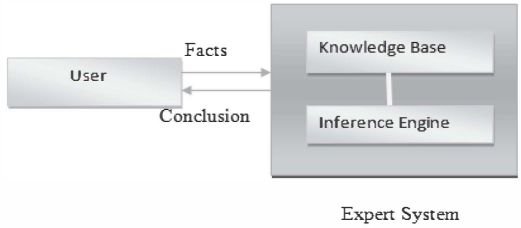

Fig. 1. Components of Fuzzy Expert System.

- *Fuzzy Knowledge Base:* The fuzzy system support decision-making by using the knowledge which is accumulated in the knowledge base of the fuzzy expert system. The knowledge bases contain large number of simple if-then rules and are formed by collecting knowledge from various domain experts. The fuzzy system draws inference by integrating the rules based on the fact supplied by the user. Example:

  if p is A then q is B

Where A and B are linguistic values defined by fuzzy sets on the ranges P and Q, respectively. The part of the rule "if p is A" is called the *antecedent* or premise, while the part of the rule "then q is B" is called the *consequent* or conclusion.

Firstly, factors are identified that may affect student's performance either directly or indirectly by interacting with students. After identifying the factors, some values are assigned to the factors based on their effect on student's performance and then the fuzzification of these values is done and knowledge base is created which is a collection of simple if then rules. All these steps are discussed in the later section in detail.

- *Fuzzy Inference Engine:* It matches the fact supplied by the user with the rules that are superimposed in the knowledge base of the expert system and applies some logic to draw inference. Various fuzzy operators and implication method are used for inference process [2,3].

In this proposed system, the facts provided by the users are the factors that are affecting the performance of the student. Based on the factors provided by the user, and by using the rules that are already superimposed in the system, the system automatically tells whether the performance of the student will increase or decrease or remain consistent. Mapping of input variables to output variables is shown in *"Fig. 2"*.

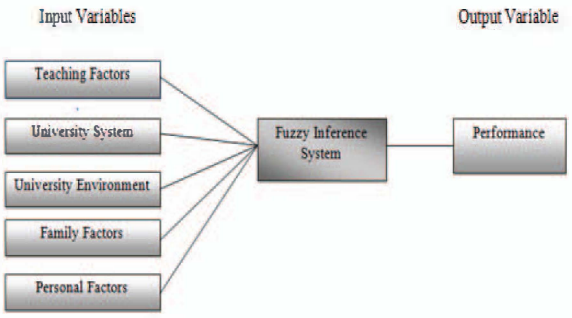

Fig. 2. Mapping of input to output.

III. RESEARCH METHODOLOGY

The development of the fuzzy rule based expert system for student performance analysis is carried out in the order as shown in "*Fig. 3*".

Fig. 1. Research Methodology.

A. Data Collection

It is the very first step that is to be carried for the development of the fuzzy expert system for the student performance analysis as it helps in identification of factors that may be affecting students' performance. Firstly, five major factors namely, teaching methodology, university system, university environment, personal reasons and family issues are identified by interacting with highly experienced authorities. These critical factors are further subdivided into 36 sub factors like sometimes the students don't have clear vision, don't have knowledge about the subject, due to which he/she ultimately faces difficulties in studies. Sometimes due to lack of proper guidance, students are unable to get good marks, etc. Then, one to one formal interaction with approximately 600 students of LPU pursuing B.Tech in CSE or ECE is performed to identify what factors are affecting particular students.

B. Categorization

We categorized students by comparing their performance in X and XII standard with their performance in B.Tech in university. Categorization is done as the students whose performance remains consistent, the students whose performance are increasing and the students whose performance are decreasing. Graphs in *"Fig. 4,"*, *"Fig. 5,"* and *"Fig. 6,"* are depicting the pattern for performance.

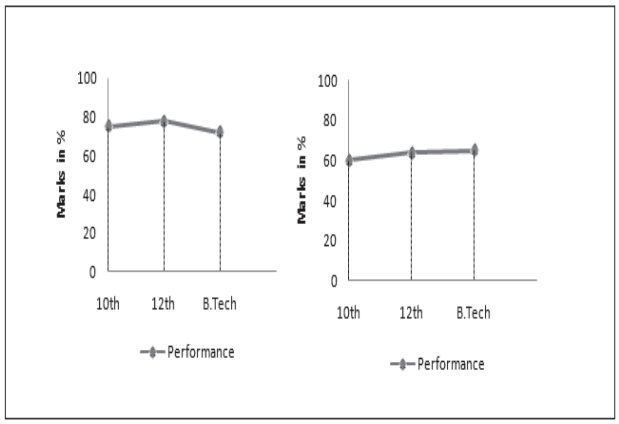

Fig. 4. Graphs depicting the consistent performance.

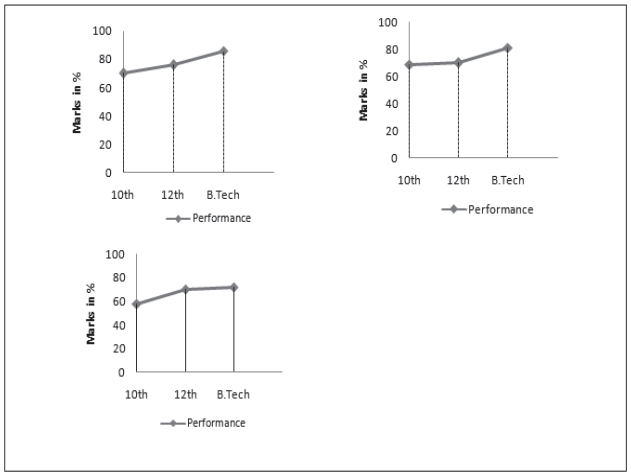

Fig. 5. Graph depicting the consistently increasing performance.

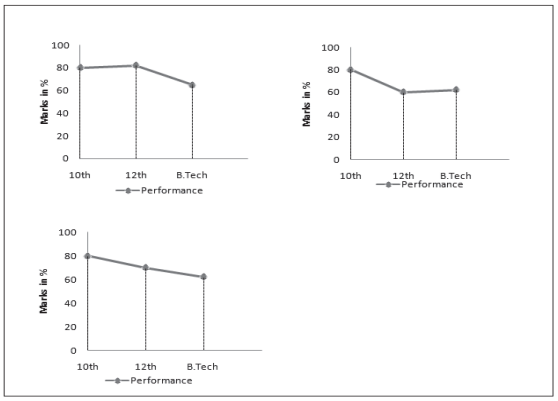

Fig. 6. Graph depicting the consistently decreasing performance

C. *Data Analysis*

Once the data is collected and categorized, it is further analyzed to check the quality of the data so gathered. Quality involves checking the data as per expectations of experts (experienced authorities) or not.

This analysis is done to check whether the data provide useful results or not. Based on the information collected from the students as well as from experts, all the identified sub factors are ranked according to their role in student's performance and some values are assigned to them. Major factors are also weighted according to their role in student's performance. This step also helps in formulation of rules.

For example: When one to one interaction is performed, it is found that large number of students say that among all the family factors, their performance are affected by "over expectation of their parents", so it is assigned the highest value among all the family factors. In this way, we assigned the value to all the sub-factors. The sub-factors which are more affecting factors, have been assigned value '2' and the least affecting factors have been assigned value '1' and rest have been kept as '1.5'.

D. *Fuzzy System Design*

This phase involves the designing of the fuzzy expert system for student's performance analysis. Once the rule formation is done, these rules must be incorporated into the knowledge base of the expert system so that the inference can be drawn by the system. The input i.e. the major factors are fuzzified and are represented in the form of linguistic variables and we have used trapezoidal membership function to assign fuzzy membership to each variable. Fuzzy Linguistic Variables and their membership values are shown in Table I.

TABLE I. FUZZY LINGUISTIC VARIABLES AND THEIR MEMBERSHIP VALUES

Factors	**Fuzzy Input Variables and their Membership range**			**Fuzzy Output Variables and their Membership range**		
	Low	***Avg***	***Severe***	***Decrease***	***Consistent***	***Increase***
Personal Factors	0-3	2-8	7-17.5	0-10	8-30	25-45
Family Factors	0-1.5	0.75-3	2.25-6			
University Environment	0-1	0.5-2.5	2-4.75			
University System	0-1.5	0.75-3.75	3-7.5			
Teaching Factors	0-2	1-5	4-10.5			

- *Result Analysis:* First of all, interaction with student is performed to identify the factors that are affecting their performance and then the system will automatically tell about the performance of the student. The user interface is shown in *"Fig. 7," and "Fig. 8,".* The interviewer marked the factors based on answer given by the student.

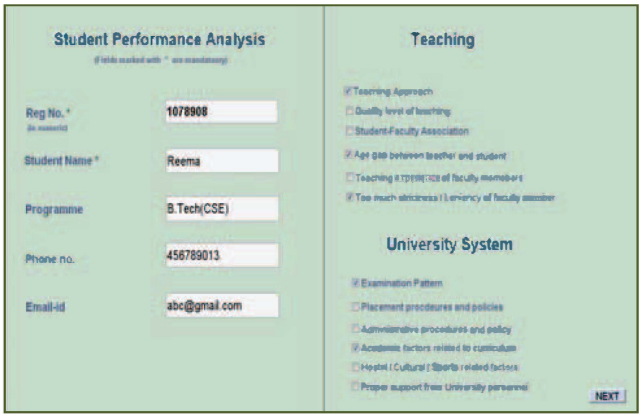

Fig. 7. User Interface of sample form page 1 of 2

Fig. 8. User Interface of sample form page 2 of 2

When the user clicks the finish button, the values of all the major 5 factors are calculated which is the sum of values of

their sub-factors is. After that, these values are mapped to the inputs of the fuzzy variables. The fuzzy input variables and output variables are shown in "*Fig. 9"* and example fuzzification of input variable is shown in "*Fig. 10"*.

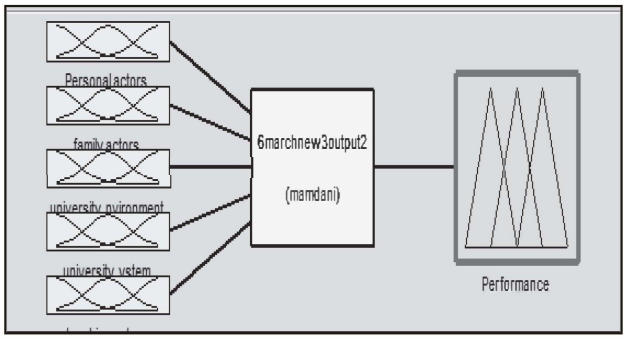

Fig. 9. Fuzzy Input and Output Variables

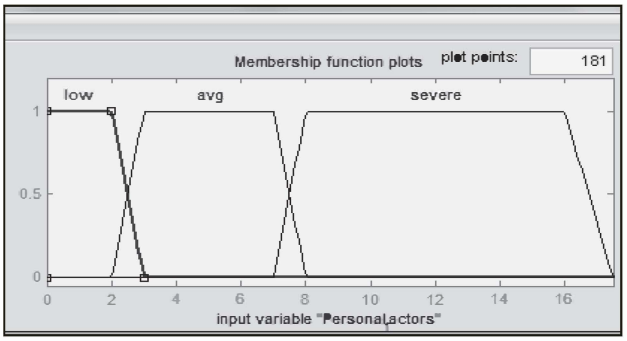

Fig. 10. Fuzzification of input variables

- *Rules Formation:* After fuzzification, rules are constructed. The knowledge base of the fuzzy expert system stores knowledge in the form of the rule and the fuzzy system draws inference by using these rules. So for engineering the knowledge base, the formation of rules takes place. This is the most important task as the performance of the overall system depends on the accuracy of the rule. The rule in the fuzzy system is in simple if-then statements. These if-then rule statements are used to formulate the conditional statements that are a part of fuzzy logic. For example

$$\text{if } p \text{ is } A \text{ then } q \text{ is } B$$

Where *A* and *B* are linguistic values defined by fuzzy sets on the ranges. P and Q, respectively. The part of the rule "if *p* is *A*" is called the *antecedent* or premise, while the part of the rule "then *q* is *B*" is called the *consequent* or conclusion.

We constructed 243 rules for Fuzzy Rule Based Expert System for Student Performance Analysis. Some of the rules are as shown in "*Fig. 11"*.

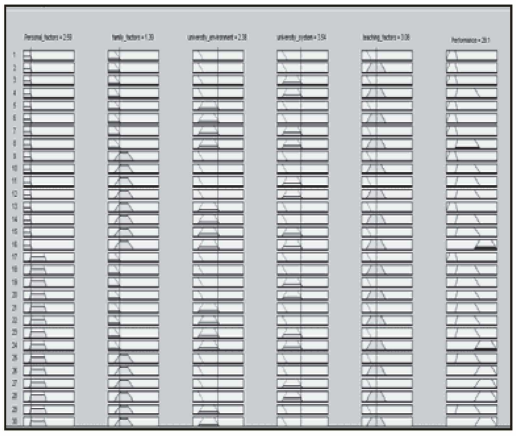

Fig. 11. View of Fuzzy Rule Base for Student Performance Analysis.

The surface view is shown in *"Fig. 12"*.

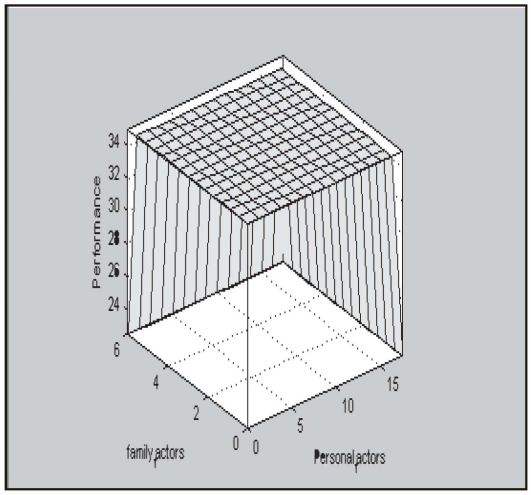

Fig. 12. Surface View for Student Performance Analysis.

- *Apply Fuzzy Operators and Implication Method:* The rules are used for implications. Facts are provided by the user that matches with the fuzzy rules in the knowledge base and the output is obtained. The most commonly used implication method is Mamdani Min Implication method.

E. Defuzzification

Defuzzification is the process of converting fuzzy set into crisp set. The output value obtained is a fuzzy set, so to get a single output value, defuzzification is needed [1, 2]. System is defuzzified on Centroid method, Bisector, SOM, LOM, MOM to test the robustness of the rules and knowledge engineering of tool.

The Table II shows that the ranks of the performance values by using different defuzzification techniques are approximately same. So, we are getting the same result by using different defuzzification techniques. This also shows that the system which we developed is vigorous.

IV. CONCLUSION AND FUTURE WORK

This expert system assesses the performance of the student based on the various factors by using fuzzy logic. This fuzzy expert system for student performance analysis helps in identifying the factor that are affecting the student's performance and counsel the student. By identifying the factors on which the performance of particular student depends, the performance of that student can be improved by working on the factors which are responsible for the degradation of their performance. So, this system is useful in improving the performance of the student. It can be implemented in any university or college.

As the factors considered in this system, are in accordance with LPU. So, this system can also be extended to include more factors that may affect the performance of the student.

TABLE II. DEFUZZIFIED VALUES AND THEIR RANKING

Student ID	Personal Factors (0-17.5)	Family Factors (0-6)	University Environment (0-4.75)	University System (0-7.5)	Teaching Factors (0-10.5)	Defuzzified values of Performance									
						Centroid		*LOM*		*MOM*		*SOM*		*Bisector*	
						Values	*Rank*	*Values*	*Rank*	*Values*	*Rank*	*Values*	*Rank*	*Values*	*Rank*
S1	0	0	1	1.125	2	14.76	4	27.45	3	14.62	4	1.8	5	14.85	4
S2	1.5	0	1	1.5	1	5.22	5	7.65	5	5.4	5	3.15	4	5.4	5
S3	2	0	0	5.25	9	18.29	3	24.75	4	17.55	3	10.35	2	18.45	3
S4	1.5	0.75	1	0	0	5.22	5	7.65	5	5.4	5	3.15	4	5.4	5
S5	1.5	0	0.75	1.125	2	14.76	4	24.75	3	14.62	4	1.8	5	14.85	4
S6	2	1.5	1	1.5	1.5	26.11	2	42.3	1	25.65	2	9	3	26.1	2
S7	1.5	0	0	1.5	2	18.29	3	24.75	4	17.55	3	10.35	2	18.45	3
S8	2	1.125	3.25	1.5	4	26.11	2	42.3	1	25.65	2	9	3	26.1	2
S9	1.5	1.5	3.5	0	5.5	34.99	1	39.6	2	34.87	1	30.15	1	35.1	1
S10	1.5	1.5	1	2.625	2	34.99	1	39.6	2	34.87	1	30.15	1	35.1	1

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