A Study of Academic Performance Evaluation Using Fuzzy Logic Techniques

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Abstract – **The paper presents a New Fuzzy Expert System (NFES) for student academic performance evaluation based on Fuzzy Logic techniques. It introduces the principles behind fuzzy logic and illustrates how these principles could be applied by educators to evaluating student academic performance. The aim of proposed NFES to adaptively adjust the training for each particular students on the basis of his/her own pace of learning. This means that the NFES will monitor the student's progress and have the ability to make decision about next step training. Several approaches using fuzzy logic techniques have been proposed to provide a practical method for evaluating student academic performance and compare the results (performance) with existing statistical method.**

Keywords-Fuzzy Logic; Expert System; Membership Functions; Academic performance Evaluation; Intelligent Tutoring Systems (ITS); Computer Assisted Instruction (CAI).

I. INTRODUCTION

The applications of fuzzy logic approach for student academic performance evaluation is in general new. However, it has reached a wide range of application areas in educational systems in addition to evaluation of student academic performance, including the evaluation of curriculum and that of the educators such as lecturers and tutors [6, 13, 14]. In student academic performance evaluation, the fuzzy logic techniques have been adapted for evaluation based on numerical scores obtained in an assessment of semester examination marks [14]. The Fuzzy Logic techniques were proposed for determining the level of a student's understanding of a certain subject matter in the context of Intelligent Tutoring System, and in a fuzzy approach was proposed to assess student performance based on several criteria with a strong suggestion that the method be applied to Computer Assisted Instruction [7, 14].

Interesting work has been reported along this line of research. This includes evaluation of journal grades, evaluation of vocational education performance, collaborative assessment, and performance appraisal systems of academics in higher education [3, 11, 12]. The focus of attention of this research work is an evaluation of student academic performance. It proposes the use of a fuzzy logic techniques and fuzzy rule induction approach to obtain user-comprehensible knowledge from historical data to justify any evaluation. This research work shows the advantages of the approach in student performance evaluation as it can be built not only based on information in a given dataset but also allowing expert knowledge to be added if such knowledge is available. Information induced from the dataset, especially that not formerly known by experts in the domain, can be very useful in developing fuzzy models for practical applications [7].

Evaluation of student academic performance usually consists of several components, each involving a number of judgments often based on imprecise data. This imprecision arises from human (teacher/tutor) interpretation of human (students) performance. Arithmetical and statistical methods have been used for aggregating information from these assessment components [14]. These methods have been accepted by many educational institutions around the world although there are limitations with these traditional approaches.

The use of fuzzy logic approach for the evaluation of teachers and students' performance is newly introduced in academic environment. However, it has reached a wide range of application areas in educational systems in addition to evaluate of students' academic performance, including the evaluation of curriculum and that of the educators [8, 9, 10].

It has been observed that there are factors, other than academic ones, pose barriers to students attaining and maintaining high. Therefore, grouping or clustering students using cognitive as well as affective factors into different categories, and then defining performance measure may be a realistic approach. Let us consider a scenario where two students score 50, 60, 70, and 70, 60, 50 in three tests respectively. The average mark obtained by each of the two students is 60. Can we conclude, from the average, that the level of intelligence of both the students is same? Of course not! The data indicates that one student is improving while the other is deteriorating consistently-it implies that one student is learning consistently from his experience. In this proposed study, it is argued that the current method of classifying and grading student academic performance using arithmetical and statistical techniques does not necessarily offer the best way to evaluate human acquisition of knowledge and skills. It is

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expected that reasoning based on fuzzy models will provide an alternative way of handling various kinds of imprecise data, which often reflects the way people think and make judgments. The fuzzy logic, handles, imprecision, and uncertainty in a natural manner by providing a human oriented knowledge representation is possible, but it is weak in self-learning and generalization of rules. In this research paper, we have used fuzzy logic techniques for students' academic performance evaluation.

II. FUZZY LOGIC

Fuzzy logic is branch of logic specially designed for representing knowledge and human reasoning in such a way that it is amenable to processing by a computer. Thus, it is applicable to artificial intelligence, control engineering, and expert systems [5]. The more traditional propositional and predicate logic do not allow for degrees of imprecision, indicated by words of phrases such as poor, average and good. Instead of truth values such as true or false, it is possible to introduce a multi valued logic consisting of Unsatisfactory, Satisfactory, Average, Good, and Excellent. Fuzzy systems implement fuzzy logic, which uses sets and predicates of this kind. As the classic logic is the basic of ordinary expert logic, fuzzy logic is also the basic of fuzzy expert system. Fuzzy expert systems, in addition to dealing with uncertainty, are able to model common sense reasoning which is very difficult for general systems. One of the basic limitations of classic logic is that it is restricted to two values, true or false and its advantage is that it is easy to model the two-value logic systems and also we can have a precise deduction. The major shortcoming of this logic is that, the number of the two-value subjects in the real world is few. The real world is an analogical world not a numerical one. We can consider fuzzy logic as an extension of a multi-value logic, but the goals and application of fuzzy logic is different from multi-value logic since fuzzy logic is a relative reasoning logic not a precise multi-value logic. In general, approximation or fuzzy reasoning is the deduction of a possible and imprecise conclusion out of a possible and imprecise initial set.

III. FUZZY SET

A fuzzy set A in a universe of discourse X is defined as the following set pairs

$$A = \{\mu_A(x): x \epsilon X\} \tag{1}$$

Where, $A = \{\mu_A(x): x \epsilon X\}$ is a mapping called the membership function of fuzzy set *A* and $\mu_A(x)$ is called the degree of belongingness or membership value or degree of membership of $x \epsilon X$ in the fuzzy set *A*. We write (1) in the following form:

$$A = \left\{\frac{\mu_A(x)}{x}: x \epsilon X\right\} \tag{2}$$

For brevity; however, we often equate fuzzy sets with their membership functions, i.e., we will often say fuzzy sets, [4, 7]. Example: Suppose *X = {6, 2, 0, 4}*. A fuzzy set of *X* may be given by *A = {0.2/6, 1/2, 0.8/0, 0.1/4}*.

IV. MEMBERSHIP FUNCTIONS

In this paper we have used the triangular and trapezoidal membership function for converting the crisp set into fuzzy set. The triangular and trapezoidal membership functions are specified by three parameters *(a, b, c)* and four parameters *(a, b, c, d)* as follows [8]:

$$trian(x,a,b,c) = \max\left(min\left(\frac{x-a}{b-a},\frac{c-x}{c-b}\right),0\right) \tag{3}$$

$$trap(x,a,b,c,d) = max\left(min\left(\frac{x-a}{b-a},1,\frac{d-x}{d-c}\right),0\right) \tag{4}$$

Due to their simple formula and computational efficiency, the triangular and trapezoidal membership functions have proven popular with fuzzy logic and been used extensively in student academic performance evaluation [8].

V. EXPERT SYSTEM

An Expert System is a set of program that manipulates encoded knowledge to solve problem in a specialized domain that normally requires human expertise [1]. Expert System knowledge is obtained from expert sources and coded in a form suitable for the system to use in its inference or reasoning processes. The expert knowledge must be obtained from specialists or other sources of expertise such as texts, journal articles and database. This type of knowledge usually requires much training and experience in some specialized field such as medicine, geology, system configuration, or engineering design. Once a sufficient body of expert knowledge has been acquired, it must be encoded in some form, loaded into a knowledge base, then tested, and refined continuously throughout the life of the system. Expert system differs from conventional computer system in several important ways:

1. Expert systems use knowledge rather than data to control the solution process.
2. The knowledge is encoded and maintained as an entirely separate from the control program.
3. Expert systems are capable of explaining how a particular conclusion was reached, and why requested information is needed during a conclusion.
4. Expert system use symbolic representations for knowledge (rules, networks, or frames) and perform their inference through symbolic computation that closely resemble manipulations of natural language.

VI. A REVIEW OF YADAV AND SINGH'S METHOD

In Yadav and Singh [8] presented a method called Fuzzy Expert System for evaluating academic performance evaluation based on fuzzy logic using five linguistic variables as input namely Very Low (VL), Low (L), Average (A), High (H) and Very High (VH) and five linguistic variables as output namely Very Unsuccessful (VU), Unsuccessful (U), Average (A), Successful (S), Very Successful (VS). In this method, there are twenty five IF-THEN fuzzy rules are used for fuzzy inference.

The drawback of this method is that it involves complex computational process and cannot integrate different fuzzy environments. In the next section, we will propose a new method called New Fuzzy Expert System (NFES) for evaluating academic performance evaluation using triangular and trapezoidal fuzzy membership functions and fuzzy rules.

VII. PROPOSED METHOD

One of the drawbacks of the current academic evaluation methods is the lack of information behind the evaluation methods that have been used and what criteria for the 'final result'. To do so, a fuzzy approach has been used to perform the proposed method of student performance evaluation [8]. It is important to point out that the aim of the proposed method is not to replace the current traditional method of evaluation, instead it will strengthen the present system by providing additional information to be used for decision making by the user. The proposed method (Fuzzy Expert System) of student academic performance evaluation is shown Fig. 1.

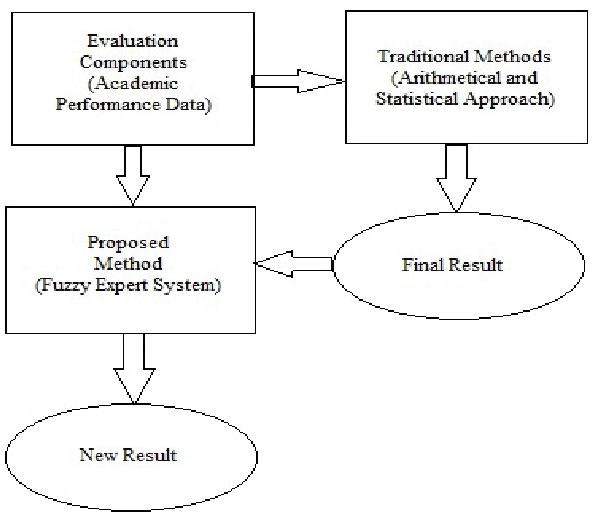

Fig. 1: Proposed Method (Fuzzy Expert System)

VIII. ARCHITECTURE OF PROPOSED NFES

The architecture of proposed NFES for academic performance evaluation is given bellow (Fig. 2):

1. Crisp Value: Crisp value is student mark obtained in semester's examination.
2. Fuzzification: Fuzzification means crisp value (student mark) is converted into Fuzzy input value with help of suitable membership function (triangular membership function).
3. Inference Mechanism: Define different type fuzzy rule ("If Then" Rule) for student academic performance evaluation.
4. Fuzzy Output: Determines an output membership function value for each active rule ("If Then" rule).
5. Defuzzification (Performances): Defuzzification means calculate the final output (Performance Value) with the help of suitable defuzzification method. In this proposed research work, we have used Centre of Area (COA) for Defuzzification (performance evaluation).

IX. FUZZY EXPERT SYSTEM FOR ACADEMIC PERFORMANCE EVALUATION

The proposed NFES for student academic performance evaluation is shown in Fig. 3 which based on triangular and trapezoidal membership functions.

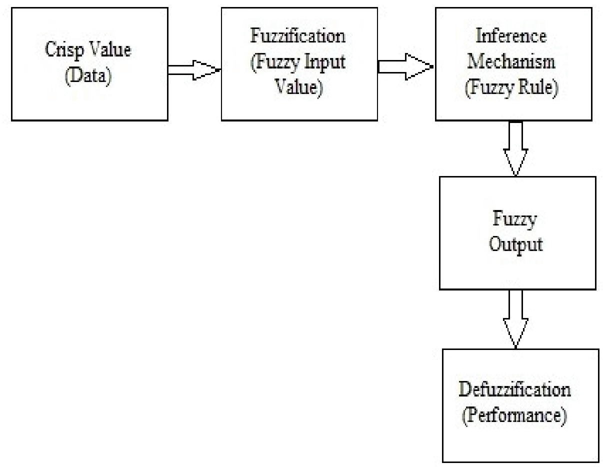

Fig. 2: Architecture of Proposed NFES

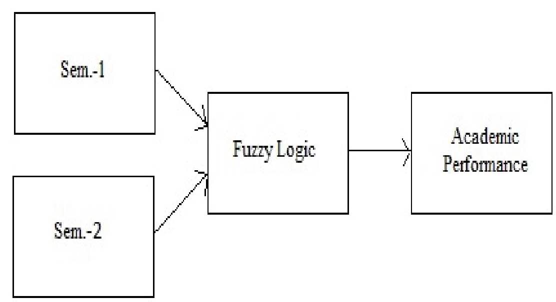

Fig. 3: New Fuzzy Expert System for Academic Performance Evaluation

Students appeared in semester1 and semester-2 examination, so there are two input variables say semester-1 and semester-2. The output variable called performance value, which is determined by fuzzy logic. The academic performance evaluation with NFES comprised with three steps:

1. Fuzzification of inputs semester examination results and output performance value.
2. Determination of application rules and inference method.
3. Defuzzification of performance value.

A. Fuzzification of Semester Examination Results and Performance Value

Fuzzification of semester examination results was carried out using input variables and their membership functions of fuzzy sets. Each student has two semester examination results both of which from input variables of the fuzzy logic based expert system. Each input variable has three membership functions, i.e., 2 trapezoidal and 1 triangular membership functions has been used in this proposed research work. The fuzzy sets of the input variables are given in Table I and different type inputs membership functions are shown in Fig.4:

TABLE I: FUZZY SET OF INPUT VARIABLE

Linguistic Variable	Interval
Low	(0, 0, 20, 40)
Medium	(30, 50, 70)
High	(60, 80, 100, 100)

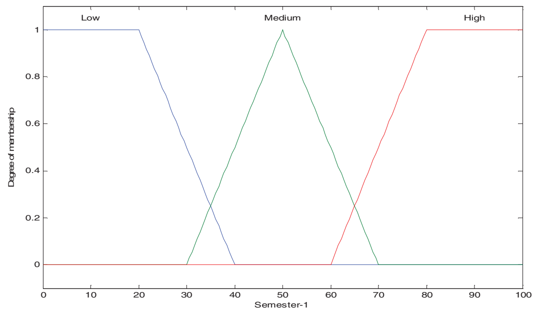

Fig. 4: Membership Functions of Sem.-1 and Sem.-2 Marks

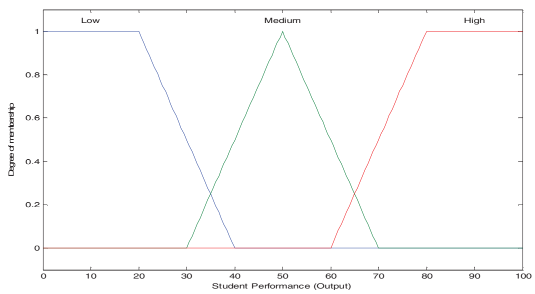

Fig. 5: Membership Function of Performance Value

The fuzzy set of output variables are shown in Table II which is the performance value and has three membership functions Low, Medium and High).

TABLE II: FUZZY SET OF OUTPUT VARIABLES

Linguistic Variable	Membership Function	Interval
Low	Trapezoidal	(0, 0, 20, 40)
Medium	Triangular	(30, 50, 70)
High	Trapezoidal	(60, 80, 100, 100)

B. Rules and Inference Generation

The rules determine input and out membership functions that will be used in inference process. These rules are linguistic and are entitled "IF-THEN" RULES:

1. If Semester-1 is High and Semester-2 is High then Student Performance is High.
2. If Semester-1 is High and Semester-2 is Medium then Student Performance is Medium.
3. If Semester-1 is High and Semester-2 is Low then Student Performance is Medium.
4. If Semester-1 is Medium and Semester-2 is High then Student Performance is High.
5. If Semester-1 is Medium and Semester-2 is Medium then Student Performance is Medium.
6. If Semester-1 is Medium and Semester-2 is Low then Student Performance is Low.
7. If Semester-1 is Low and Semester-2 is High then Student Performance is Medium.
8. If Semester-1 is Low and Semester-2 is Medium then Student Performance is Low.
9. If Semester-1 is Low and Semester-2 is Low then Student Performance is Low.

In case of several rules are active for the same output membership function. It is necessary that only one membership value is chosen. This process is entitled "fuzzy decision" or "fuzzy inference". In this paper, we use the method proposed by Mamdami [8], is given below:

$$\mu_C = max\left(min\left(\mu_A\left(input(i),\ \mu_B\left(input(j)\right)\right)\right)\right) \tag{5}$$

This expression determines an output membership function value for each active rule. When one rule is active, an AND operation is applied between inputs. The smaller input value is chosen and its membership value is determined as membership value of the output for that rule. This method is repeated, so that output membership functions are determined for each rule. To sum up, graphically AND (min) operation are applied between inputs and OR (max) operations are between output [8].

C. Calculation of Performance Value

After completing the fuzzy decision process, the fuzzy number obtained must be converted to a crisp value. This process is known as Defuzzification. Many methods have been developed for Defuzzification. In this paper, a centre of area (Centriod) technique was applied, which one of the most common methods [5]. The crisp value is calculated of the formula given below:

$$Z = \frac{\int \mu_C(z) \times x \times dz}{\int \mu_C(z) \times dz} \tag{6}$$

D. Experiment Results

In this research paper, proposed New Fuzzy Expert System for student academic performance evaluation has been implemented in MATLAB. We have used Fuzzy Tool for this research work. The proposed New Fuzzy Expert System was tested with 20 student's marks obtained by semester-1 and semester-2 examinations. Table III shows the scores achieved by 20 students appeared in semester-1 and semester-2 examinations. For each student, both semester examination scores were fuzzified by means of the triangular membership and trapezoidal membership functions. Active membership functions were calculated according to IF THEN rules, using the Mamdami Fuzzy Decision Techniques. The output (Performance Value of student) was calculated and then defuzzified by calculating the center (centroid) of the resulting geometrical shape. This sequence was repeated using the semester examination scores for each student. Both inputs had same Triangular Membership Functions in Fuzzy-1 and

Fuzzy-2 [8]. We replacing Semester-1 with Semester-2 would not change the calculated performance value (45 and 65) and (65 and 45). Therefore, in this proposed method, we have used triangular and trapezoidal membership function for converting the crisp scores values into Fuzzy sets. The surface viewer of proposed fizzy expert system for academic performance evaluation is shown in Fig. 7.

Table III: Scores of 20 Students

S.No.	Sem-1	Sem-2	S.No.	Sem-1	Sem-2
1.	40	65	11.	65	45
2.	20	35	12.	89	100
3.	50	65	13.	100	100
4.	10	20	14.	65	35
5.	45	65	15.	45	50
6.	34	60	16.	45	55
7.	48	55	17.	55	25
8.	56	90	18.	84	80
9.	74	70	19.	63	65
10.	45	50	20.	28	30

The comparison between the classical method, fuzzy-1 and fuzzy-2 methods [8] and proposed method for student academic performance evaluation is shown in Table IV. If a student is successful in the classical assessment method, they will also be successful in the fuzzy-1 method. Comparison of the classical, fuzzy-1, Fuzzy-2 and proposed method reveals differences in the performance values. For scores below 50, the performance value of proposed method is smaller than the classical method, fuzzy-1 and fuzzy-2; however, for scores above 50, the performance value is larger than the classical method. For example, a student scoring 34 in Semester-1 examination and 60 in semester-2 examination is unsuccessful in the classical method, but is successful in the fuzzy-2 method and improved in proposed Fuzzy Expert System method in comparison to classical, Fuzzy-1 and Fuzzy-2 methods.

X. CONCLUSION AND FUTURE RESEARCH

In this paper, the proposed a NFES for students' academic performance evaluation based on fuzzy logic techniques. When the results are evaluated from fuzzy expert system, a difference in outcomes is seen between the classical and proposed fuzzy logic based expert systems methods. While the classical method adheres to a constant mathematical rule, evaluation with fuzzy logic has great flexibility and reliability. In this paper, we have compare the classical method, fuzzy-1 and fuzzy-2 and proposed method. It is observed that the proposed method (NFES) is more suitable for students' performance evaluation in comparison to classical Fuzzy Logic.

In future, I will use fuzzy C-Means clustering algorithm for academic performance evaluation because fuzzy C-means clustering algorithms capable for automatic generation of membership function. In addition, I will develop Intelligent Adaptive Learning Systems and Intelligent Tutoring Systems (ITS) for Internet based Education. I will also develop dynamic fuzzy expert system to create the feedback information about the broadness, the depth and the overall performance of the student. Based on this new information about the students' performance the dynamic fuzzy expert system also decides what is the next course material is with which the student should preferred.

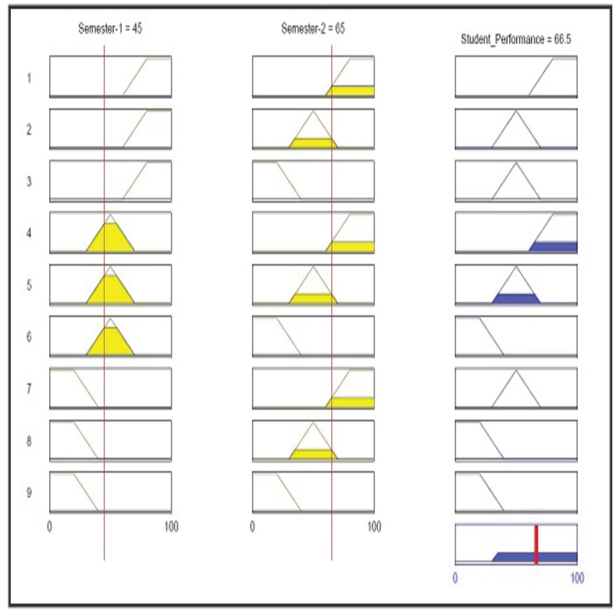

Fig. 6: Active rules and performance value

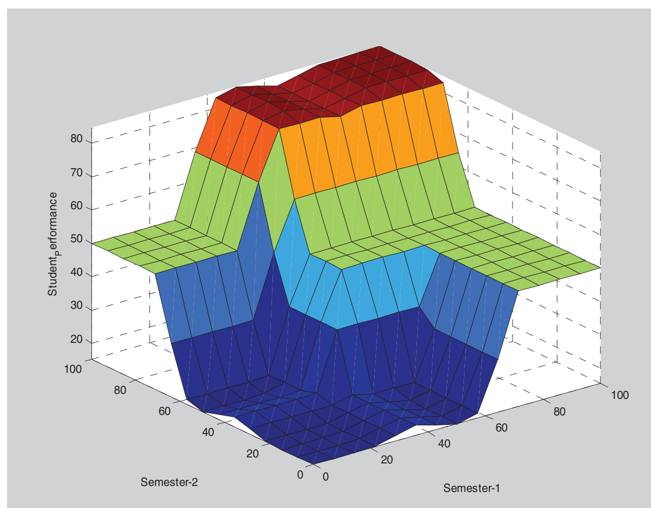

Fig. 7: Surface viewer of academic performance evaluation

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Table IV: Comparison of Performance Evaluation Methods

S. No.	Sem-1	Sem-2	Classical Method	Student Performance for Yadav and Singh Method		Students Performance For Proposed Method
				Fuzzy-1	Fuzzy-2	
1.	40	65	0.525	0.530	0.627	66.50
2.	20	35	0.275	0.243	0.243	18.50
3.	50	65	0.575	0.645	0.750	66.50
4.	10	20	0.150	0.203	0.203	15.30
5.	45	65	0.550	0.576	0.676	66.50
6.	34	60	0.470	0.462	0.625	65.40
7.	48	55	0.515	0.533	0.530	55.00
8.	56	90	0.730	0.759	0.758	83.50
9.	74	70	0.720	0.735	0.759	82.60
10.	45	50	0.475	0.440	0.440	50.00
11.	65	45	0.550	0.576	0.575	60.00
12.	89	100	0.945	0.908	0.908	91.70
13.	100	100	1.000	0.920	0.920	90.10
14.	65	35	0.500	0.500	0.387	36.50
15.	48	50	0.490	0.473	0.473	50.00
16.	45	55	0.500	0.500	0.490	50.00
17.	55	25	0.400	0.310	0.310	33.10
18.	84	80	0.820	0.765	0.770	84.70
19.	63	65	0.640	0.639	0.753	66.60
20.	28	30	0.290	0.260	0.241	29.23

REFERENCES

[1]. D. W. Patterson, "Introduction to Artificial Intelligence and Expert Systems", Prentice Hall of India Private Limited, New Delhi, pp. 326-327, 2006.

[2]. The Mathworks, "Fuzzy Logic Toolbox User's Guide", The Mathworks, 2009.

[3]. G. Gokmen, T. C. Akinci, M. Tektas, N. Onat. G. Kocyigit, N. Tektas, "Evaluation of Student Performance in Laboratory Applications Using Fuzzy Logic", Procedia Social and Behavioral Science, pp 902-909, 2010.

[4]. L.A. Zadeh, "Fuzzy sets", Information and Control, (8), pp. 338-353, 1965.

[5]. N.P. Padhy, "Artificial intelligence and Intelligent System", Oxford University Press, p.p. 337, 2005.

[6]. S.M. Bai and S.M. Chen "A new method for students' learning achievement evaluation using fuzzy membership functions", Proceeding of the 11th Conference of Artificial Intelligence and Applications, Kaohsiung, Taiwan, Republic of China, pp. 177-184, 2006.

[7]. R.S. Yadav, S. Kumar, "The Effective Utilizations of Fuzzy Logic Approach for Student Academic Performance Evaluation", M.Phil. Dissertation, YCMOU, Nashik, India, pp 6-7, 2009.

[8]. R.S. Yadav and V.P. Singh, "Modeling Academic Performance Evaluation Using Soft Computing Techniques: A Fuzzy Logic Approach", International Journal on Computer Science and Engineering, 3(2), pp. 676-686, 2011.

[9]. Mamatha S. Upadhyay, "Fuzzy Logic Based on Performance of Students in College", Journal of Computer Applications (JCA), 5(1), pp. 6-9, 2012.

[10]. Wan Suhana Wan Daud, Khairu Azlan Abd Aziz and Elyana Sakib, "An Evaluation of Students' Performance in Oral Presentation Using Fuzzy Approach", Empowering Science, Technology and Innovation towards a Better Tomorrow, UMTAS, pp. 157-162, 2011.

[11]. O.K. Chaudhari et al, "Soft Computing Model for Academic Performance of Teachers Using Fuzzy Logic", British Journal of Applied Science and Technology, 2(2), pp. 213-226, 2012.

[12]. V. Sreenivasarao and G. Yohannes, "Improving Academic Performance of Students of Defense University Based on data Warehousing and Data Mining", Global Journal of Computer Science and Technology, 12(2), pp.201-209, 2012.

[13]. S. Pavani, P.V.S.S. Gangadhar and K. K. Gulhare, "Evaluation of Teacher's Performance Evaluation Using Fuzzy Logic Techniques", International Journal of Computer Trends and Technology, 3(2), pp. 200-205, 2012.

[14]. K. A. Rasmani and Q. Shen, "Data-Driven Fuzzy Rule Generation and its Application for Student Academic Performance Evaluation", International Journal of Applied Intelligence, 25(3), pp. 305-319, 2006.