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Application of Fuzzy Logic for Evaluation of Academic Performance of Students of Computer Application Course

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Abstract— Institutes evaluate students' academic performance through a conventional evaluation system which is framed by the institutes under educational policies and/or the institutional rules and regulations. This research study proposes a new fuzzy logic based performance evaluation method. In this method, we consider three parameters attendance, internal marks and external marks which are considered to evaluate students in an IT related undergraduate course. Then an expert system using fuzzy logic based on Mamdani technique has been designed and tested on a real sample and the two results have been compared.
Keywords— Academic Performance evaluation, fuzzy logic technique, Students Performance, expert system, IT course

I. INTRODUCTION

Students' academic success is evaluated by their performance in exams conducted by the institutes or Universities. Considering the high demand of IT professionals and the gap between academia and IT Industry it is important that we must explore the possibilities of automated system which can effectively evaluate the performance of students in computer science and IT related courses. The authors had proposed an expert system using fuzzy logic in another paper[1].In this paper the system has been tested for real data of third year students of a computer application course(BCA) for the subject Linux. The result generated by the expert system is then compared with the result of the convention method to test the difference in the result of two systems.

II. LITERATURE REVIEW

For last few years, fuzzy logic theory is being used in the education system. Implementation of the fuzzy logic for various activities of assessment of students' performance such as evaluation of answer scripts of students in an examination [2][3][4], evaluation of lab examination [5][6], projects evaluation [7] and many more. Fuzzy rules have been developed to check how fuzzy rules can be used to model and evaluate the achievement of the learning outcomes in information systems courses[8]. It was proposed to use of the fuzzy set technique to be applied in the evaluation process of the industrial automation systems learning area, which aimed to lessen the evaluation complexity and ambiguity[9].Neural fuzzy sets containing fuzzy linguistic constructors in rule and query expressions and logical statements were developed, to model the structure of fuzzy linguistic expressions [10]. It has also been investigated whether use of fuzzy logic is suitable for the resolutions of achieving fair assessment. To apply fuzzy logic along with standard numerical grading, a case study was carried out for a poster competition for postgraduates. It was observed that that this fuzzy logic based grading method has many advantages over the traditional method [11]. The outperformance of a Fuzzy Probabilistic Neural Network model to predict personalized student performance was observed in comparison to traditional statistical models as well as traditional back-propagation neural networks [12]. An approach based on fuzzy set was presented to evaluate the results of student-centered learning where there was participation of students to determine the criteria for assessment with their weightage [13]. It was also found in another study that the evaluation with Fuzzy Logic renders great flexibility and robustness in the evaluation process [14]. A dynamic automated converter of crisp set into fuzzy set based on C-Means clustering algorithm was developed and tested. This system has the capabilities to handle imprecise and missing data [15].The fuzzy inference system has also been used to obtain Performance of Students for different input values of Teaching Effectiveness, Student Attendance, and other Facilities [16].
These researches have been the motivation to develop a fuzzy expert system for the evaluation system followed in the institutes

of India and test the results for the students of undergraduate IT related courses.

III. METHODOLOGY

The fuzzy expert system designed by the authors is explained as below
The fuzzy logic model comprises of following stages:

A. *Crisp Value (Data)*

The values for input variables may be collected from the records of the students' end term result with internal assessment (f1), external Assessment (f2) and overall attendance of the Semester (f3) shown in Table I

TABLE I.INPUT VARIABLES (ELEMENTS) OF THE PROPOSED EVALUATION MODEL

Input Variables	Criteria
f_1	Student's Attendance
f_2	Internal Marks
f_3	External Marks (Term Examination)

B. *Fuzzification (Fuzzy Input Value)*

Fuzzification of three input variables (elements) is done by using variable which are similar to verbal human language such as average, good, very good, excellent etc.. Then each input variable is assigned a trapezoidal Membership function, defined by a lower limit 'a', an upper limit 'd', a lower support limit 'b', and an upper support limit 'c', where a < b < c < d, for the degree of association for respective linguistic variables is represented in eqn.(1).

$$\mu_A(x) = \begin{cases} 0, & (x < a) \text{ or } (x > d) \\ \frac{x-a}{b-a}, & a \le x \le b \\ 1, & b \le x \le c \\ \frac{d-x}{d-c}, & c \le x \le d \end{cases}$$

The process of fuzzification of the three input variable is as follows

1) *Fuzzification of Input Variable Students 'Attendance:* The Students' attendance in the subject Linux was taken every day in each lecture. The percentage of attendance is calculated from the number of classes attended by the students in the subject throughout one term of four months.

TABLE. II.CALCULATION OF CRISP VALUES OF STUDENTS' ATTENDANCE

S.No.	Month	Subject	Students Monthly attendance	Overall Students Attendance%
(1)	(2)	(3)	(4)	(5)
1	M_1	S1	A1	Avg.of Col.4
2	M_2		A2	
3	M_3		A3	
4	M_4		A4	

TABLE III.STUDENTS' ATTENDANCE IN TERMS OF LINGUISTIC VARIABLES

Student Attendance	Poor	Average	Good	Very Good	Excellent
f_1	<50	50-54.9	55-64.9	65-75	>75

Membership Function of the input variable Students Attendance (f_1) is shown in Fig.1.

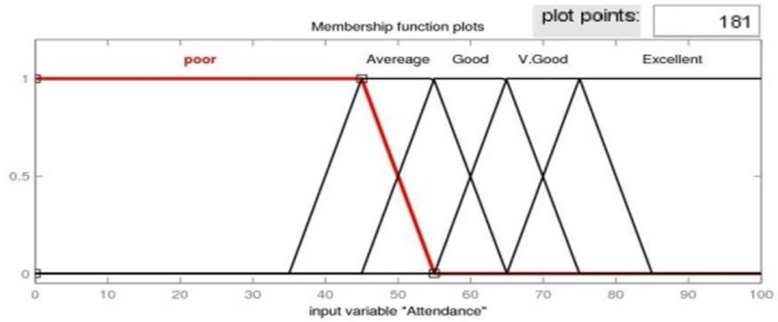

Fig.1 Membership function of input variable Attendance (f_1)

2) Fuzzification of Input Variable Internal Marks

TABLE IV.CALCULATIONS OF CRISP VALUES OF INTERNAL MARKS

Sr. No.	Subject	Assignment Marks	TestMarks	Internal Marks
(1)	(2)	(3)	(4)	(5)
1	S_1	A_1	f_{21}	Avg.of Col.3
2		A_2	f_{22}	

TABLE V INTERNAL MARKS IN TERMS OF LINGUISTIC VARIABLES

Internal Marks	Poor	Average	Good	Very	Excellent
f_2	<50	50-59.9	60-69.9	70-79.9	>80

Membership Function of the input variable Internal Marks (f_2) is shown in Fig.2

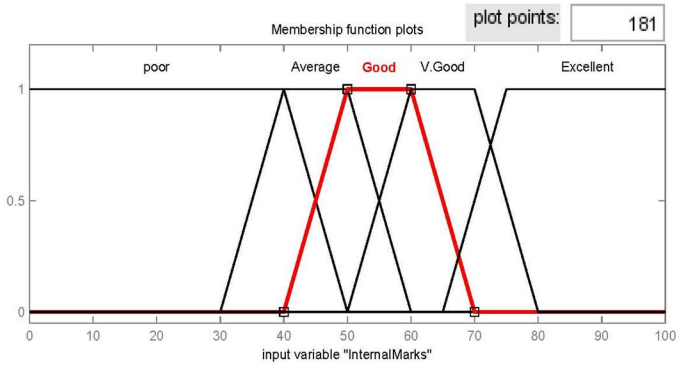

Fig.2.Membership function of input variable Internal Marks (f_2)

3) Fuzzification of Input Variable External Marks

After the end of the term, final exam is conducted for all subjects. The crisp value of external marks in Linux

TABLE VI CALCULATION OF CRISP VALUE OF EXTERNAL MARKS

Sr. No.	Subject	External Marks
(1)	(2)	(3)
1	S_1	f_{31}

TABLEVII.RANGE FOR LINGUISTIC VARIABLES OF THE EXTERNAL MARKS FOR FUZZY INPUT **F3**

External Marks	Poor	Average	Good	Very Good	Excellent
f_3	<50	50-59.9	60-69.9	70-79.9	>80

Membership Function of the input variable Internal Marks (f_3) is shown in Fig.3

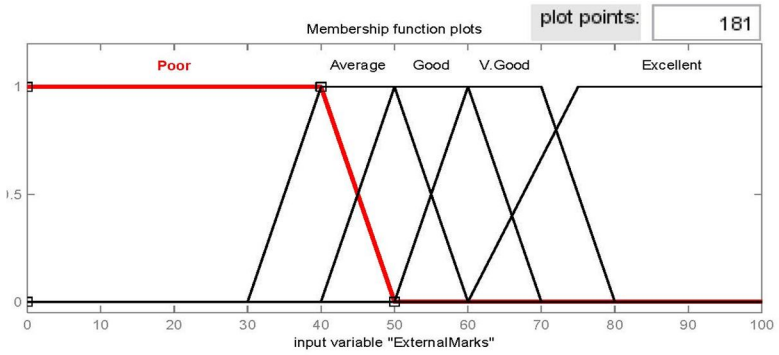

Fig.3.Membership function of input variable External Marks (f_3)

C. Development of Fuzzy Rule and Inference Mechanism

To relate the inputs and output membership functions, fuzzy inference rules are used in inference process. These linguistics rules use “IF-THEN” statements. These rule are flexible and can be formulated depending upon the importance to be given to a particular input with the discussion with the academic experts.

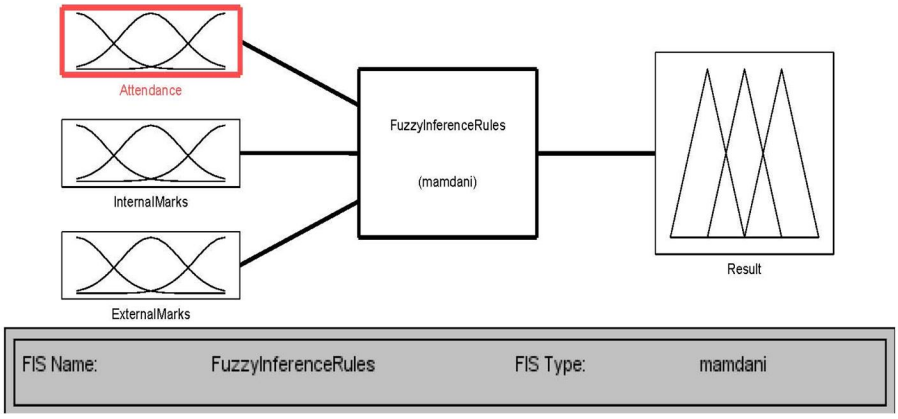

Fig.4 FIS System with input and output

Table VIII represents the rules for the three inputs and corresponding output

TABLEVIII CONSTRUCTION OF FUZZY INFERENCE RULES

S.No.	Attendance f_1	Internal Marks f_2	External Marks f_3	Final Result (Output) F
1	Poor	Poor	Poor	Poor
2	Poor	Poor	Average	Poor
3	Poor	Poor	Good	Average
4	Poor	Poor	V.Good	Average
5	Poor	V.Good	Good	Good
6	Poor	Average	Poor	Poor
7	Poor	Average	Average	Average
8	Poor	Average	Good	Average
9	Poor	Good	Good	Good
10	Poor	Good	Excellent	V.Good
11	Average	Good	Average	Average
12	Average	Good	Good	Good
13	Average	Good	V.Good	Good
14	Average	V.Good	V.Good	V.Good
15	Average	Excellent	Average	Good
16	Average	Average	Average	Average
17	Average	Poor	Poor	Poor
18	Average	Good	Poor	Average
19	Good	Average	Average	Average
20	Good	Excellent	Excellent	V.Good
21	Good	Average	Good	Good
22	Good	Poor	Poor	Poor
23	V.Good	V.Good	Excellent	V.Good
24	V.Good	V.Good	V.Good	V.Good
25	V.Good	Poor	Poor	Poor
26	V.Good	V.Good	Good	V.Good
27	V.Good	Excellent	Excellent	Excellent
28	Excellent	V.Good	Excellent	V.Good
29	Excellent	Average	Average	V.Good
30	Excellent	V.Good	Average	Good
31	Excellent	Good	Average	Good
32	Excellent	Poor	Poor	Poor
33	Excellent	Poor	Average	Average
34	Excellent	Average	Poor	Poor
35	Excellent	Poor	Good	Good
36	Excellent	Good	Poor	Average
37	Excellent	Poor	V.Good	V.Good
38	Excellent	V.Good	Poor	Average
39	Excellent	Excellent	Poor	Good
40	Excellent	Excellent	Average	V.Good
41	Excellent	Excellent	Good	V.Good
42	Excellent	Excellent	V.Good	V.Good
43	Excellent	Excellent	Excellent	Excellent

D. Defuzzification Of Fuzzy Output (To Find Out The Final Result With The Help Of Suitable Defuzzification Method)

The output variable F is the students' final performance. If the three input variables are expressed as f_1, f_2, f_3 and membership functions of the three input variables are $\mu(f_1)$, $\mu(f_2)$, $\mu(f_3)$ respectively for rule k=1,2,3,4,.....r, then

The membership function of the output variable F is given by equation (2).

$\mu_F(x)=Max_k[\min[\mu(f_1),\mu(f_2),\mu(f_3)]]$, $k= 1,2,3,4,.....r$(2)

This expression expresses the value of membership function for output variable overall performance for active rules for each input. The logical operator AND is used among the three inputs. Similar to the fuzzy linguistic variables of input we have used the linguistic variables for output which have been shown in Table IX

TABLE IX. STUDENTS' OVERALL PERFORMANCE IN TERMS OF LINGUISTIC VARIABLE

Overall performance	Poor	Average	Good	Very Good	Excellent
P	< 50	50 ≤ P <65	65 ≤ P <75	75 ≤ P <85	≥85

Membership Function of the output variable Overall Performance of a student (P) is shown in Fig. 5

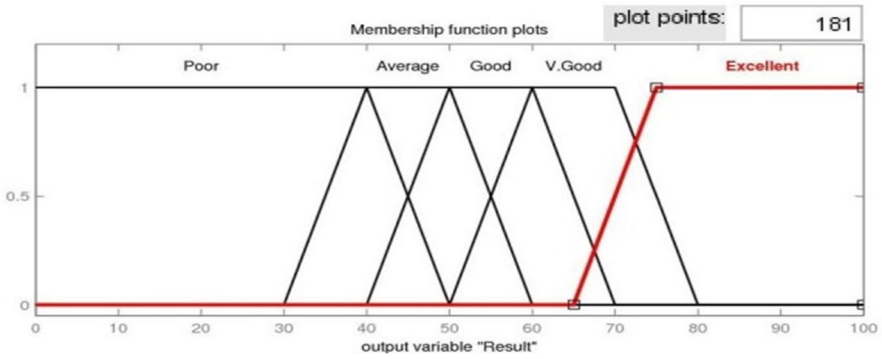

Fig.5.Membership function of students' overall performance

Rule viewer of the proposed fuzzy expert system for the evaluation of overall students' performance is shown in Fig.6

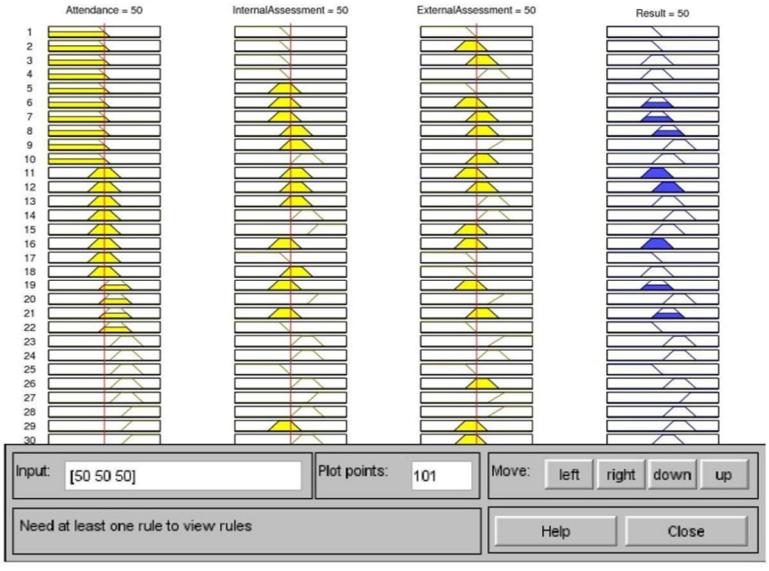

Fig.6. RuleViewerof fuzzyexpertsystem

Surface viewer of proposed fuzzy expert system for academic performance valuation is shown in Fig.7

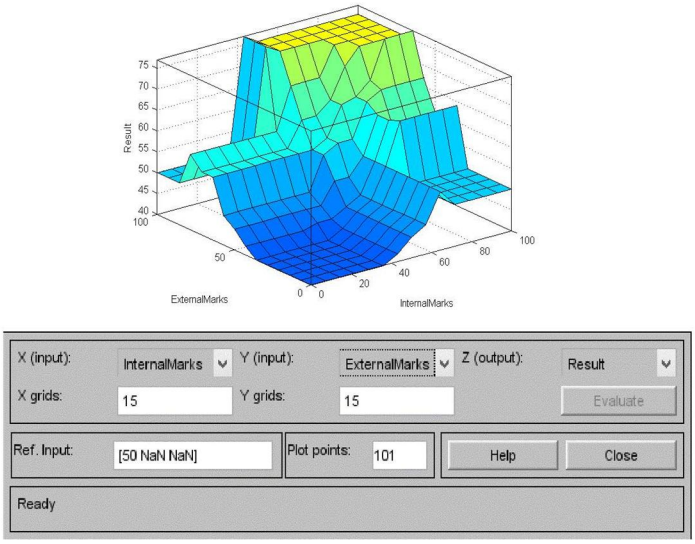

Fig.7. Surface Viewer of fuzzy expert system with input variables internal marks and external marks.

IV. EXPERIMENT RESULTS

In this paper, we have used MATLAB (version R2013a) for implementing proposed fuzzy system for student s' academic performance evaluation. The proposed Fuzzy Expert system was tested with 54 Student's term attendance, internal marks and external marks in the subject Linux for one term. The result from the fuzzy expert system along with the final result from conventional method of assessment is shown in Table X. Two sample t-test was also performed on the two results obtained from conventional method and from fuzzy expert system which is shown in Table XI. The null hypothesis considered as that there is no difference in the mean value of two samples.(two results are similar)

Table X COMPARISON OF STUDENT'S PERFORMANCE

Marks Range from	Marks Range to	Frequency	
		Conventional Method	Fuzzy System
45	50	2	4
51	55	5	2
56	60	4	6
61	65	11	6
66	70	11	16
71	75	15	10
76	80	3	9
81	85	1	0
86	90	1	0
91	95	1	0
96	100	0	1

Table XI t-Test: TWO-SAMPLE ASSUMING EQUAL VARIANCES

Statistical Tools	Conventional Method	Fuzzy Approach
Mean	67.46	67.63
Variance	87.91	88.76
Observations	54	54
Pooled Variance	88.33979734	

Hypothesized Mean Difference	0
df	106
t Stat	-0.092140896
P(T<=t) two-tail	0.92676001
t Critical two-tail	1.982597262

V. CONCLUSION

The t-test is conducted using MS Excel. As per value of t test we cannot reject the null hypothesis that two results are similar as p-value of test statistics is 0.927(< 0.975) and the t-statistic is -0.09, which does not fall into the rejection region. In other words, we accept the null hypotheses that means conventional result is equal to the mean fuzzy system result with 95% confidence level. This shows that that the expert system can provide the same results as conventional method. Therefore one can apply computer based Fuzzy System Approach in plane of time consuming conventional method. However, in some cases, the variations in results from fuzzy system have been observed for some students who have same result through conventional method. It was due the difference in their attendance which shows that expert system incorporates input attendance effectively. On the contrary in the conventional system, for a regular course, a student must have mandatory attendance failing to which the student may not be allowed to appear in exams. This shows that the expert system provides flexibility to the inflexible conventional system which is greatly required in present age of technology.

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