Performance Evaluation by Fuzzy Inference Technique

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Abstract: The education domain offers a fertile ground for many interesting and challenging data mining applications. These applications can help both educators and students, and improve the quality of education. The ability to monitor the progress of student's academic performance is a critical issue to the academic community of higher learning. The present work intends to approach this problem by taking the advantage of fuzzy inference technique in order to classify student scores data according to the level of their performance In this proposed approach we have performed fuzzification of the input data(students marks) by creating fuzzy inference system(FIS) subject wise, next each FIS output is passed to next level FIS with two inputs, outputs of the final FIS are performance value calculated based on all subject marks with/without lab marks. In the proposed approached a combination of two membership function is carried out (trapezoidal and triangular).The experimental results are compared with traditional evaluation method, it helps in identifying students lying at overlapping section of two class distribution   the results also could help educators to monitor the progress and provide timely guidance to students to achieve better performance score.

Keywords: Performance Evaluation, Academic Institute, Fuzzy Classification, Fuzzy Inference

I.   INTRODUCTION

In Educational Institutions the success is measured by academic performance, or how well a student meets standards set out by Governmental Educational policies and/or the Institutional rules and regulations. As career competition growing ever fiercer day by day the importance of students doing well in all sectors including Academic Institutes has caught the attention of Parents, Legislators and Government Education Departments and alike. performance (Gagne *et. al*.[11])

Educational assessment is the process of documenting, usually in measurable terms, knowledge, based on the criteria incorporated in the process of In view of this methodologies used are legion but lack of standardization yields different outcomesassessment. The assessment is formally defined as a measure ofskills, attitudes and beliefs. Assessment of students has two fold benefits. On one hand through student's assessment the institute can foresee the student progression and inform the students well in time in respect to areas that are not doing well and there is need to concentrate and workout the remedial coaching or training programmes.

On the other hand the assessment is a mechanism for providing instructors with data for improving their teaching methods and for guiding and motivating students toward active involvement in their own learning. As such, assessment provides important feedback to both instructors and students. Thus, in addition to providing the instructors with valuable information about their students' learning, assessment would assist the students in diagnosing *their own* learning. That is, assessment should help students become *more effective, self-assessing, self-oriented learners*.

The purposes of assessment are *Selection, Certification, Describing, Aiding learning* and *Improving teaching*.

Assessment helps in **selection** of future plan or course of action. At every juncture of completion of one course and going for higher course or thinking of going for employment a student find himself in the midst of dilemma, where he needs a kind of guidance or direction. Assessment in this context is used for prediction, for instance which students will be benefited from the further study or how the individuals might perform well in the employment. Selection has been linked to the ranking of students and assessment in this form has been a means of positioning students in order of merit or achievement. **Certification** indicates the conforming that a student has reached a particular level of standard. This may be in the form of simple "*pass*" or "*fail*" (as the driving test) and if pass with what class or "competent" or 'not yet competent' and if competent then to what degree of competencyAssessment in these and similar circumstances certifies that a particular level of performance has been achieved. The outcome of assessment may be a simple statement such as a certificate, grade, percentage marks and/or class. In recent times, towards **describing** what a student has learned or can do in greater detail different types of documentations are in use. This can be done in **Performance Evaluation by Fuzzy Inference Technique** the form of a profile or a bio-data or resume etc. A great deal of analysis of student by Teacher or by student himself is necessary and describing it involves a skill and referencing to data relevant to past performance and/or achievements. Assessment can be used for **Learning** that addresses to a very important purpose in early stage of career development in student's life. Assessment can stimulate learning in many different ways-

- Prompting or otherwise motivating the students.
- Offering the students guidance so they can see how well they are achieving learning outcomes
- Following the remedial practices based on the feedback to help students diagnose their strong areas for further enrichment and weak areas for improvement.
- Providing the information that helps student for future plan of action.

- Helping students and others concerned with their learning to track progress.

II. SIGNIFICANCE OF PERFORMANCE EVALUATION

A. Students

Student's perceptions about assessment and their approaches to learning are strongly interrelated. ThesePerception and Learning Approach can both be positive and/ or negative, however the study of *Trigwell and Prosser [9]* suggests that the deep approaches to learning are especially encouraged by assessment methods and teaching practices which aim at deep learning and conceptual understanding rather than by trying to discourage surface approaches to learning. Student's perceptions about conventional and alternative assessment can endow the valuable ideas and stimulating tip-offs to bring this deep conceptual learning into practice. Students' perceptions about conventional and alternative assessment indicate different mindsets associated either by birth or cultivated depending on the climate around them. Within conventional assessment practices, namely multiple choice and essay typed examinations the students perceive the multiple choice format as more favourable than the constructed response/essay type items. Especially student's perceptions on the perceived difficulty, lower anxiety and complexity, and higher success expectancy have greater tendency towards the preference for objective type of Examination format. Students with both the good learning skills and with low test anxiety rates seem to favour the essay type Examinations, while students with poor learning skills and low test anxiety have unfavourable inclination towards long answer based assessment mode.

Learners experiencing alternative assessment modes think positive about new assessment strategies, such as *portfolio assessment*, *self and peer assessment*, *simulations*. From student's point of view, assessment has a positive effect on their learning and is 'fair' the assessment relates to authentic tasks, represents reasonable demands, encourages students to apply knowledge to realistic contexts, emphasizes the need to develop a range of skills, and perceived to have long-term benefits (*Sambell, McDowell & Brown,[10]*).

B. Teachers

Performance evaluation of students can help a Teacher to review the effectiveness of all instructional and instrumental practices. If student regularly finds the assignments difficult, it might suggest to the Teacher that it is too much demanding and he needs to change the instructional methods, revise the competencies or help the student gains some relevant technical skills. Comments made by Examiners on various reports suggested that the candidate taking the examination needed to be exposed to the required content on the syllabus to prepare them for the examination. If this exposure was not provided to students, then it could be a contributory factor to the poor performance displayed by students. The students who are motivated can achieve higher mean scores than the students who left out unmotivated.

C. Management

Management body and Students form the main pillars of Educational Institute while Teacher stands in between. Practicing performance evaluation time and again has two fold benefits. On one hand students will know their progress and on the other hand the Management can see as a whole the system doing well which definitely helps in pursuing the Institutional academic development and Teacher's contribution in the overall process of Education. In case of unfavourable situation the Management can enforce the institutional decisions and adopt the policies about the state-of-art curriculum and recruitment of Teachers to cope with up-gradation of curriculum in attempt to enhance the performance of student and maintain the name and fame of the Institute.

III. DIFFERENT WAYS OF PERFORMANCE EVALUATION

Different scaling patterns are adopted by Academic Institutes as a Performance-Index. *Average Percentage* and *10 point GPA(Grade Point Average) system* are the two patterns popularly employed in majority of Institutes[12]. In first case an average percentage of score of marks are computed and reported as a Performance Index. The scaling pattern followed could be as shown in Table-1.

Table 1: Scaling Pattern of Average Percentage

Average Percentage (AP)	Performance Index (PI)
AP ≥ 80 %	Excellent
80 % > AP ≥ 60 %	First Division
60 % > AP ≥ 50 %	Second Division
50 % > AP ≥ 40 %	Third Division
AP < 40 %	Fail

The terminology used for PI and classification of AP differs from one Board of Education to other or University and also depends on the Stream of Education. In second case of 10 *point GPA system* grading system followed in Universities and Colleges. The 10 point GPA is categorized as shown in Table-2.

Table- 2: Scaling Pattern of GPA

Grade-Points	Performance Index (PI)	
10	*Excellent*	(Ex)
9	*Very Good*	(A)
8	*Good*	(B)
7	*Average*	(C)
6	*Fair*	(D)
5	*Pass*	(P)
4-0	*Fail*	(F)

Terminology for grade label and grade point scaling varies from one University to other and also upon the stream of education.

IV. ROLE OF FUZZY IN PERFORMANCE EVALUATION

According to *Prof. L. A. Zadeh*[8] '*words*' or '*sentences*' used in day to day conversation can be looked upon as the '*linguistic variables*' and can be assigned with '*linguistic values*'. These variables represent the gradual transition from high to low, true to false and are called '*fuzzy variables*'. A set containing such variables is known as '*Fuzzy Set*'. The use of linguistic terms in assessing performance has been the main reason for Researchers for applying the Fuzzy Techniques in the process of Student

Performance Evaluation. It has been argued that one of most appropriate ways of handling multiple variables that contain imprecise data is to use *Fuzzy Logic Reasoning* which reflects the way of human-thinking. Fuzzy Logic can be incorporated into Expert System to enhance the performance and reliability of Expert System in decision making even in the midst of uncertainty.

Recently, many Researchers have reported a work on the applications of Fuzzy Logic in Education and Assessments. *Khairul A. Rasmani and QiangShen* [1] have presented a fuzzy rule-based approach for aggregation of student academic performance. The membership values produced by this method were more meaningful compared to the values produced by statistical standardized-score. *Ramjeet Singh Yadav et al [2]* proposed a Fuzzy Expert System (FES) for student academic performance evaluation based on Fuzzy Logic techniques. A suitable Fuzzy Inference mechanism and associated rule has been discussed in the paper. It introduces the principles behind Fuzzy Logic and illustrates how these principles could be applied by Educators to evaluate the student's academic performance. *Chiang and Lin* [5] presented a method for applying the Fuzzy Set Theory to teaching and assessment. *Bai and Chen* [4] presented a new method for evaluating student's learning achievement using Fuzzy Membership Functions and Fuzzy Rules. *Chang and Sun* [7] presented a method for fuzzy assessment of learning performance of Junior High School Students. *Chen and Lee* [6] presented two methods for student's evaluation using Fuzzy Sets. *Ma and Zhou* [3] presented a Fuzzy Set approach to the assessment of student centered learning. Olufunke O. Oladipupo et.al [12] study examines the relationship between students' preadmission academic profile and academic performance by analyzing the data using Fuzzy Association Rule Mining apriori-like algorithm.

A. Possible Benefits

Evaluation of student's 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. The current method of classifying and grading the student academic performance using AP and/or GPA, does not necessarily offer the best way to evaluate human acquisition of knowledge and skills. It is expected that reasoning based on fuzzy models will provide an alternative way of handling various kinds of imprecise data, which often reflects the way the people think and make judgments.

B. Methodology:
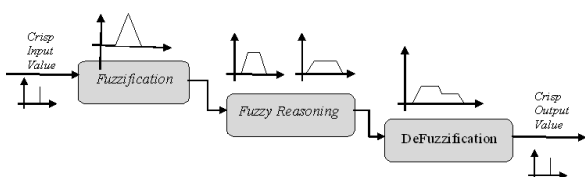
Fuzzy Methodology involves the steps as shown in Fig.1.

Fig.1. Steps of Fuzzy Methodology

1. Crisp Value:

Crisp value is nothing but the student's mark obtained in semester's examination.

2. Fuzzification:

Fuzzification means the crisp value (student's mark) is converted into Fuzzy input value with help of suitable membership function (In the present work the combination of triangular and trapezoidal membership functions have been employed).

3. Inference Mechanism:

Defines different type Fuzzy Rules in the form of *If-Then* for student academic performance evaluation have been devised based on the criteria approved by Institute or University Bodies.

4. Fuzzy Output:

It is nothing but the output membership value that Clips the output variable Fuzzy Set for each active rule invoked from the rule base there by generating the Clipped Fuzzy Sets.

5. Defuzzification (Performances):

Defuzzification means to compute the final output (Performance Value) with the help suitable defuzzification method. In present work, we have used Centre of Area (COA) for Defuzzification to obtain the performance evaluation.

V. THE OBJECTIVE OF THE PROPOSED RESEARCH WORK

The objective of the study is to determine students' performance using a fuzzy logic model in place of Traditional assessment method. Develop and implement a Fuzzy Inference System (FIS) for such an application, which allows inference to be performed in a more natural way using linguistic variables rather than numerical values and method handling multiple attributes, containing imprecise data, to perform human-like reasoning.

A. Proposed Method

Fuzzification of Subject Wise Scores of Semester Examination and Performance Value:
The overall structure of Fuzzy Module is depicted in fig. 2. It is a MIMO (Multiple Input-Multiple Output) type Fuzzy Inference System (FIS)
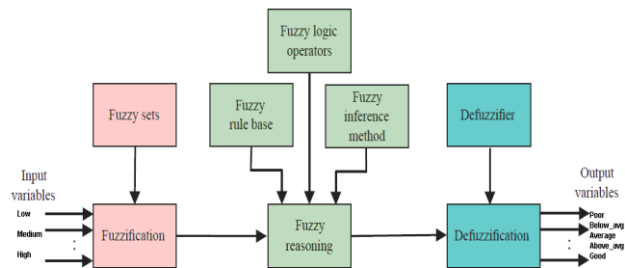

Fig. 2. Structure of Fuzzy Inference System(FIS)

In the proposed model triangular and trapezoidal membership functions are used for converting the crisp set into fuzzy set, due to their simple formula and computational efficiency, the triangular and trapezoidal membership function have proven popular with fuzzy logic and been used extensively in student academic performance evaluation[1][2][12]
Fuzzification of subject wise scores of Semester Examinationresults has been carried out as the input variables using the triangular membership functions. Using Fuzzy Tool Box of MATLAB,

one input - one output FIS are created for each theory subjects and two input - one output FIS for practical subject. For theoretical subject papers each input variable has been partition in to three Fuzzy Sets defined using three membership functions (two trapezoidal and one triangular in shape). The fuzzy sets of the input variables are given in Table-3 and input variable membership functions are shown in fig.3. Each output variable has three membership functions (two trapezoidal and one triangular) corresponding to performance evaluation. The fuzzy sets of the output variables are given in Table-4 and the membership functions are shown in fig.4.

Table-3: Subject wise Fuzzy set of input variable for theoretical paper

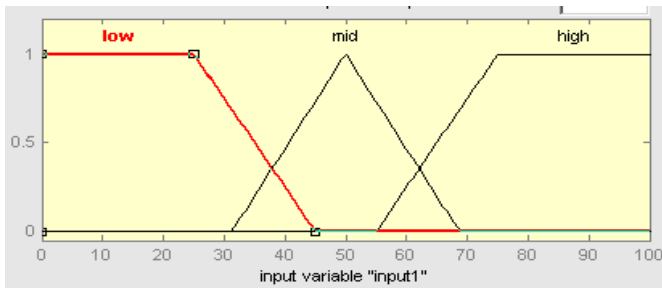| Linguistic Variable	Interval
low	(0, 0, 25, 45)
mid	(30,50,70)
high	(55,75,100,100)

Fig.3. Membership functions for Input Variable (Theoretical subject paper)

Table-4: Subject wise Fuzzy set of output variable for theoretical paper

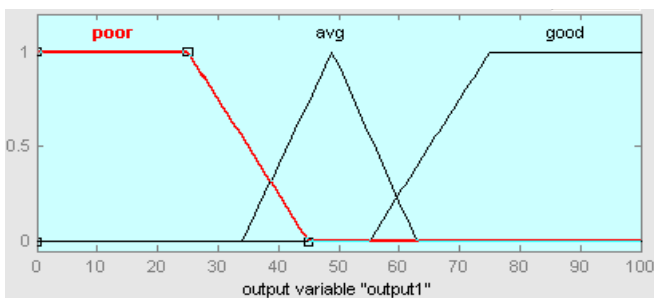| Linguistic Variable	Interval
poor	(0, 0, 20, 35)
below_avg	(25,35,45)
avg	(40,50,60)
above_avg	(55,65,75)
good	(65,75,100,100)

Fig.4. Membership functions for Output Variable heoretical subject paper)

For practical (Laboratory Work) paper each input variable has three membership functions (two trapezoidal and one triangular). The fuzzy sets of the input variables are given in

Table-5 and inputs membership functions are shown in fig.5. Each output variable has five membership functions (two trapezoidal and three triangular). The fuzzy sets of the output variables are given in Table-6 and inputs membership functions are shown in fig.6.
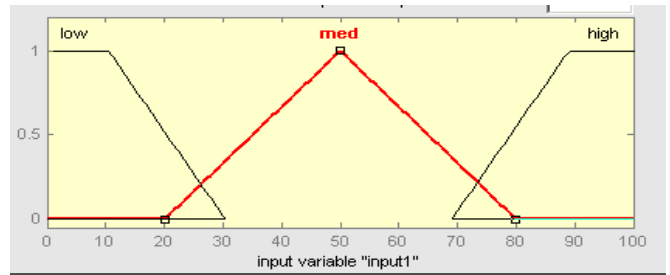

Fig.5. Membership functions for Input Variable (Practical)

Table-6: fuzzy set of Output variable for Practical (lab) paper

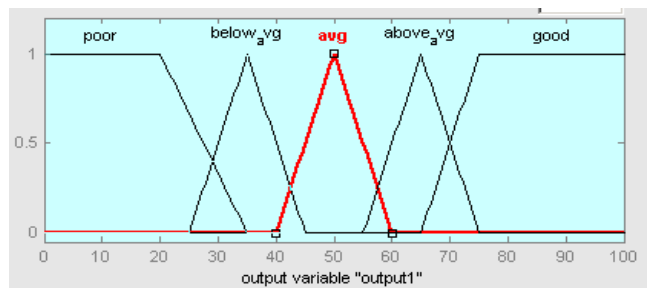| Linguistic Variable	Interval
poor	(0, 0, 25, 45)
avg	(35,50,65)
good	(55,75,100,100)

Fig.6. Membership functions for Output Variable (Practical)

The Linguistic variable in this experiment is based on an interval that refers to the level of performance given by experts as shown in Table 3,4,5,6.

The output of these FIS gives the subject wise performance value of each student appeared for semester examination. Similarly to get the total performance value of each student a combined FIS driven by outputs of individual FIS has been created as shown in fig.7. The FIS 3 output is all subjects performance value and FIS 4 output is performance value including Lab input, which are then used to classify the students.
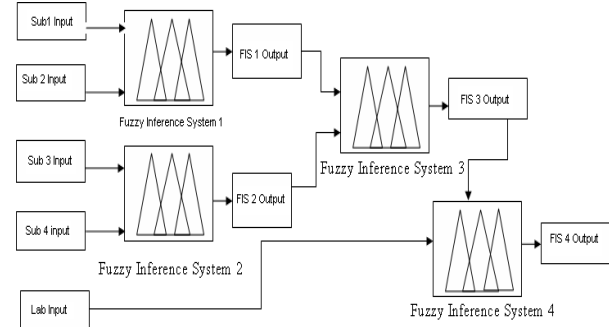

Fig 7: Fuzzy classification model

Sub1, Sub2, Sub3, Sub4 input are marks obtain in theoretical

subject papers and Lab input is marks obtain in practical paper

5.2 Rules and Inference Generation:

The rules determine the input and out membership functions that will be used in inference process. These rules are in linguistic form called "IF-THEN" fuzzy rules. The rules pertaining to fuzzy logical decision making are shown in Table-7.From the discussion with the academic experts rules are formulated from their practical and past experiences

Table-7: Set of Fuzzy Rules

		all_Subjects		
		low	*med*	*high*
Lab	*low*	poor	below avg	avg
	med	below avg	avg	above avg
	high	avg	above avg	good

In fuzzy inference one or several rules are invoked by input data and integrated pattern of output membership functions is generated. This corresponds to the fuzzy decision on performance value of a student. In this paper the method proposed by Mamdami [15] has been employed and it operates based on inference mechanism described by equation (1).

$$\mu_c(y) = \max_K [\min[\mu_A(input(i), \mu_B(input(j))]],$$
$$k = 1, 2, 3, 4 \dots r \qquad (1)$$

It determines an output membership function value for each rule in active mode. 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. In short the AND (min) operation are applied between inputs and OR (max) operations are between outputs. The fuzzy inference process for *all_subject* score of 60 and lab score of 80 generating *performance_value* of 71.6 is depicted in fig.8.
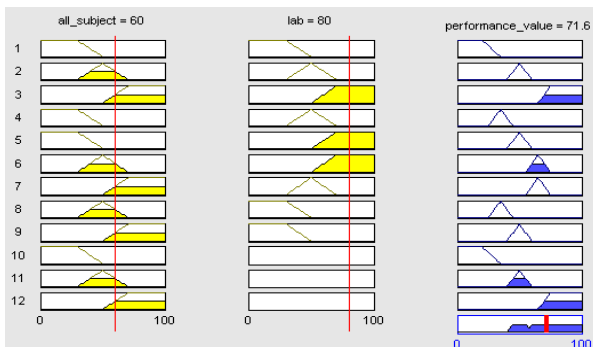

Fig: 8: Active rules and performance value for all_subject and lab scores of 60 and 80

The overall performance evaluation space is depicted in fig.9. This is has distinct areas of performance with transition from one space to another. Space for' *Good*' and

'*Poor*' do not impose any strain on the Evaluator, however the space in between is conflicting and impose challenge to the Evaluator. The variations in adjudication consolidated by *Human Evaluator* may bring in the uncertainty in the outcome on performance of student. The fuzzy approach by its ability to handle uncertainty handles the conflicting space of evaluation rather smoothly.
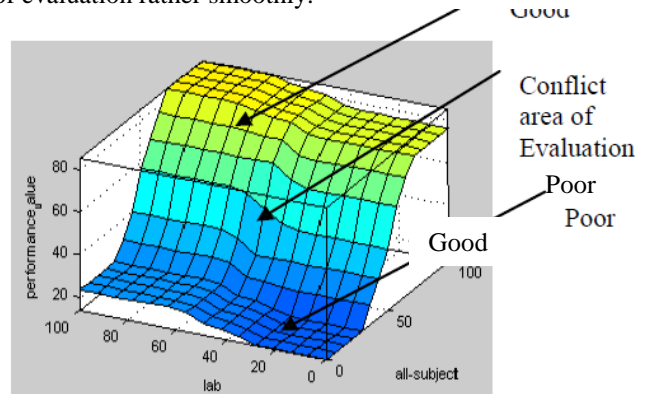

Fig.9: Surface view of performance evaluation space

It can be seen from fig.9 that the academic performance for lower range and higher range of both the inputs (i.e. all_subject input and lab input) the output value of performance remains stable. The output value is greatly affected for input range value between 40-75 on marking scale.

VI. RESULTS AND DISCUSSION: TRADITIONAL VERSUS FUZZY APPROACH

Experiments are carried out using Matlab fuzzy toolbox on Windows XP platform.

Performance Evaluation by Fuzzy Inference Technique

The proposed Fuzzy model was tested with 51 student's marks obtained by semester-2 examinations. Appendix- A shows the both the traditional and fuzzy scores achieved by 31 MSc. I year students of the Department of Computer Science ,ShivajiUniversity,Kolhapur.

A. Traditional: Performance calculated by statistical method (calculation of percentage)

As a case study one semester result has been referenced for the computation of performance output and based on statistical averaging method the performance classes were formed as shown in fig.10.
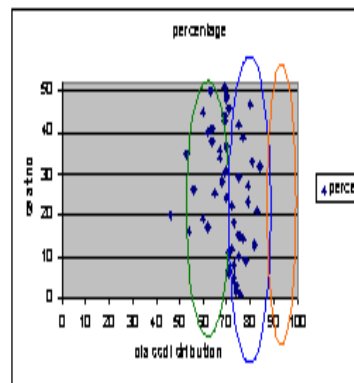
Fig. 10: Performance evaluation by traditional approach

The class distribution is plotted based on calculation of percentage obtained by students in semester examination. It is observed that there are large number of students fall into class of *'above average'* and very few into *'average'* and *'good'* classes.

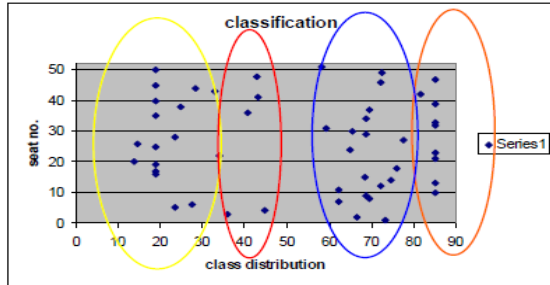### B. Results by Fuzzy Approach: Fuzzy Classification Including Practical Paper

Fig. 11 Classification by Fuzzy Approach (Including practical paper)
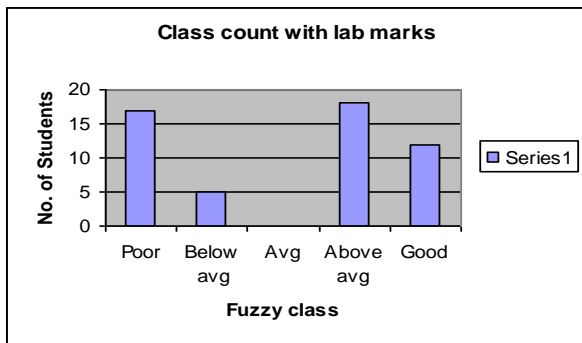

Fig.12: Histogram of Fuzzy Classes (Including Practical paper)

The results obtained as shown fig.11 is an outcome of classification on defuzzified data of Fuzzy Inference System-3 (fig.7). The results differ from the results obtained by traditional method and it is observed that by using Fuzzy method the performance value is distributed on the either sides of average class.

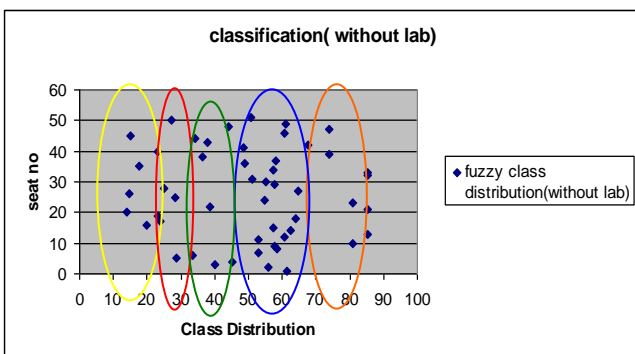### C. Results by Fuzzy Approach: Fuzzy Classification Excluding Practical Paper

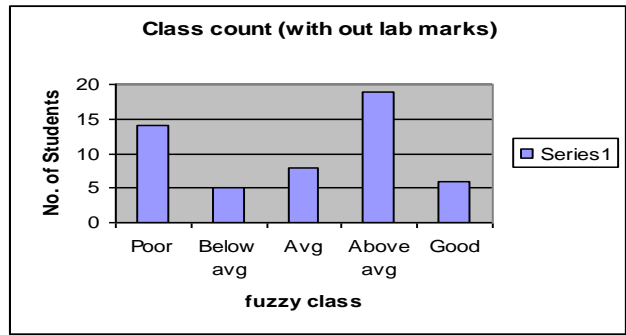Fig.13: Classification by Fuzzy Approach (Excluding Lab Practical Paper)

Fig.14: Histogram of Fuzzy Classes(Excluding Lab Practical Paper)

Fig.13 and fig.14 show the result obtained by classification of defuzzified data of Fuzzy Inference System- 4 (fig.7). The results obtained by using Fuzzy method on student's performance excluding laboratory

marks reveals that the student's performance value has drifted up from poor and *'belowaverage'* class to *'average'* class and students performance value has drifted down from *'good'* and *'above average'* to *'average'*. The distribution of performance based on performance evaluation using Fuzzy Approach has been smooth and density of classes is
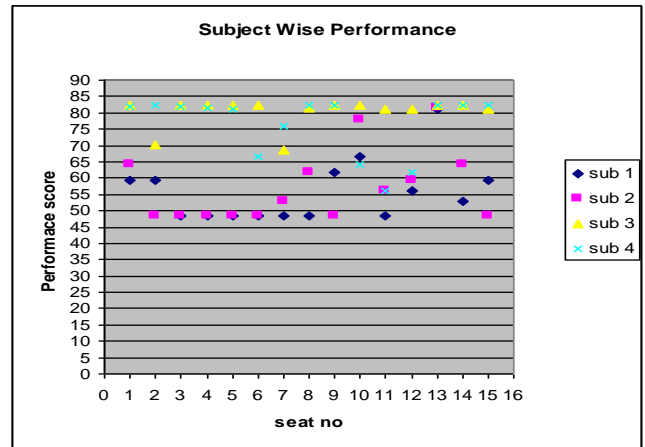
distinctly different from that of Traditional Approach. Subject wise performance of each student using classification based on Fuzzy Inference for sample of 15 students is shown in fig.15.

Fig.15: Subject wise performance Evaluation

VII. CONCLUSION

The paper describes a new method of classifying the student's academic performance based on Fuzzy Logic Technique. When the results are evaluated the variance in outcome is seen between the classes are created based on the non-fuzzy and proposed Fuzzy Logic Method. As the non-fuzzy methods adhere to precise mathematical rules, the evaluation with Fuzzy Logic renders great flexibility and robustness in the evaluation process. It is observed that for students lying at the border of two classes/grades if proper timely guidance and motivation are given can shift to higher classes/grade, otherwise unmotivated students may fall back to lower class/grade. A different class distribution was observed for the performance evaluation including and excluding the Lab Work. When lab marks were excluded then either student tends to shift to lower class distribution or to

upper class distribution, thus lab marks could be a factor contributing for obtaining class, and also helps to know the practical knowledge and problem solving ability. Scenario displayed in Fig.15 can be used to track the performance of individual student subject-wise (intra-cluster) and also in designing of bridge courses. We have used Fuzzy Logic as a soft computing technique to evaluate the student's academic performance. It worth of future research to use combine techniques of Fuzzy Logic and Artificial Neural Networks called Neuro-Fuzzy Systems to evaluate student academic performance and also develop Intelligent Adaptive Learning Systems (IALS) and Intelligent Tutoring Systems (ITS) for Internet based Education.

VIII.   APPENDIX- A

Seat no.	sub1	sub2	sub3	sub4	lab1	lab2	total	Traditional method	Fuzzy method
1	58	78	74	60	96	95	461	76	73.33673265
2	58	63	85	52	96	95	449	74	66.5746822
3	54	62	66	56	96	95	429	71	62.36406066
4	55	71	75	59	91	89	440	73	69.53598995
5	59	92	78	52	95	93	469	78	68.82545942
6	61	75	60	67	96	94	453	75	85.1147541
7	54	70	57	57	96	96	430	71	62.36406066
8	57	69	59	58	95	95	433	72	72.23050557
9	70	81	80	71	96	96	494	82	85.1147541
10	56	80	80	60	95	95	466	77	74.60994838
11	58	69	81	53	96	93	450	75	68.46405399
12	58	59	72	60	96	93	438	73	75.93170413
13	73	84	73	81	95	95	501	83	85.1147541
14	76	77	71	62	96	96	478	79	85.1147541
15	53	63	56	59	96	96	423	70	64.81013437
16	59	86	82	60	96	96	479	79	77.72311828
17	60	82	65	52	96	96	451	75	68.79410665
18	55	66	55	56	91	95	418	69	65.52379412
19	57	69	64	49	92	94	425	70	59.16326176
20	81	87	78	71	96	94	507	84	85.1147541
21	72	80	83	64	96	92	487	81	85.1147541
22	61	51	54	56	91	94	407	67	68.78721201
23	63	13	84	57	93	96	406	67	40.6565265
24	65	70	65	47	90	84	421	70	69.4116489
25	70	79	71	57	93	94	464	77	85.1147541
26	58	47	47	57	82	96	387	64	43.09490227
27	61	75	72	60	91	93	452	75	81.57431407
28	54	49	73	59	96	96	427	71	72.34072599
29	73	75	86	60	96	94	484	80	85.1147541
30	65	56	60	51	96	96	424	70	72.51637283
31	56	62	71	50	90	90	419	69	58.07633539

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