Use of Fuzzy Logic in Evaluating Students' Learning Achievement

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***Abstract* – Every student is unique. Evaluation of student answersheet should be done in more fair and transparent manner. Whenever subjective evaluation is there it may lead to difference of opinion. Fuzziness arises by virtue of difference in opinion. To improve the classical statistics of the teaching assessment this paper combines the various methods. It uses fuzzy logic to solve the said problem of Evaluating Student learning achievement.**

Keywords- Computational Intelligence (CI), Defuzzification, Fuzzy systems, Fuzzification, Students evaluation

I. INTRODUCTION

Students' evaluation if not done properly it will affect their present and future opportunities. It is necessary that students' evaluation should be done in more fair and transparent manner. Reforms in education systems are necessary not just in curriculum but also in students' evaluation process. Content of curriculum are updated on regular basis. Recent technology is added as a part of curriculum so that students should get up-to-date knowledge about the new technologies. Education reforms should be significant as a part of educational policies. With the vision of education reforms we keep on updating our curriculum but there is less concerns about how to provide a fair and appropriate evaluation method to students. Evaluation system should be regularly reviewed and improved and should be fair and beneficial to all students.

The problem of evaluation becomes critical if evaluation is not done properly. It may affect ones opportunities to get admission in desired college or for higher education. Because of bad evaluation some students may not be promoted to higher standards. They may not be allowed to appear in front of recruitment panel hence losing the opportunities to get job or promotion . This will severely affect one's career.

Each student is unique so evaluation i.e. determining performance of student with utmost care should be done. Biswas [2] highlighted the importance of education system. "The chief aim of education institutions should be to provide students with the evaluation reports regarding their test/examination as sufficient as possible with unavoidable error as small as possible so as to make evaluation system more transparent and fairer to students".

A. Problems associated with evaluation

Following are some of the problems associated with the evaluation system

- Current evaluation doesn't tell on what basis students get marks
- Multiple Evaluators
- System is not transparent
- Cognitive Science –Based on mood
- Checking type
  - Lenient type
  - Strict type
  - Normal type
- Personal factors: like fatigue, stress, etc.
- Lack of details of criteria.

B. Criteria for evaluation

Following are some of the criteria which can be considered, at the time of evaluation as per requirement of curriculum.

- Accuracy of information
- Adequate coverage
- Conciseness
- Clear Expression

- Time required
- Difficulty
- Complexity
- Importance
- Ambiguity of question

C. *Why Fuzzy logic in student's evaluation*

Fuzzy Logic was proposed by Prof. Lotif Zadeh in 1965 as a means of representing or manipulating data that is not precise but rather fuzzy. Fuzzy set theory is use to solve problems involving the absence of sharply defined criteria. Because fuzziness and vagueness are common characteristics in many decision-making problems, good decision-making models should be able to tolerate vagueness or ambiguity. A Fuzzy set has a membership function that allows various degrees of membership for the elements of a given set.

Fuzzy Controller : A fuzzy controller works similar to a conventional system: it accepts an input values, performs some calculations and generate an output value. Fig. 1 shows four main components of fuzzy system. *A Fuzzifier:* It translates crisp (real valued) inputs into fuzzy values. *An Inference Engine:* That applies a fuzzy reasoning mechanism to obtain a fuzzy output. *A Defuzzifier:* Which translates this latter output into a crisp values. *A Knowledge Base:* It contains both fuzzy rules (rulebase), and membership functions, known as the database.

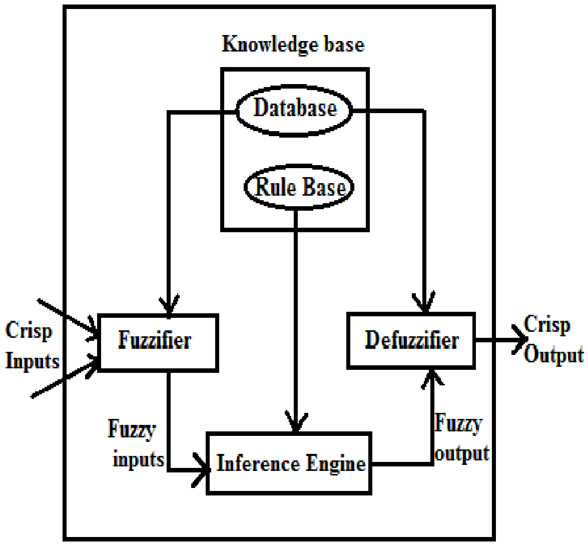

Fig. 1: Basic structure of a fuzzy inference system

This paper is organized as follows: section II review various methods suggested by other authors. Section III Combines them to get best out of them. Section IV contains experimental results and conclusion will be in section V.

II. Literature Review: Methods used in proposed model

Traditional system of evaluation are of two types: awarding numbers or grade. But in proposed method fuzzy assessment can be used and it combines the best features of the methods proposed by [5][4][9].

A. *Evaluating Answerscripts using Fuzzy Numbers associated with Degree of Confidence: Module2*

As per Wang and Chen[9], a new method for students' answerscripts evaluation using fuzzy numbers associated with degrees of confidence of the evaluator between zero and one, where nine satisfaction levels are used to evaluate students' answerscripts regarding a question of a test or examination, These nine satisfaction levels are represented by triangular fuzzy numbers shown as follows:

Extremely Good(EG) = (100, 100, 100)

Very Good(VG) = (90, 100, 100)

Good (G)= (70, 90, 100)

More or Less Good(MG) = (50, 70, 90)

Fair (F)= (30, 50, 70)

More or Less Bad(MB) = (10, 30, 50)

Bad(B) = (0, 10, 30)

Very Bad(VB) = (0, 0, 10)

Extremely Bad (EB)= (0, 0, 0).

Table I

A Fuzzy Grade Sheet With Satisfaction Levels Associated With Degrees of Confidence

Question No.	Satisfaction Levels	Degree of Confidence of satisfaction level
Q.1	F1	A
Q.2	F2	B
Q.3	F3	Γ
:	:	:
Q.n	Fn	Δ
	Total Marks= The Degree of Confidence of the Total Marks=	

Table I shows a fuzzy grade sheet with satisfaction levels associated with degrees of confidence of the evaluator between zero and one, where F_1, F_2, …. and Fn are satisfaction levels represented by triangular fuzzy numbers corresponding to the questions Q_1, Q_2 , …, and Q_n, respectively. α, β, …., and δ are the degrees of confidence of the satisfaction levels F_1, F_2, …. and Fn, respectively, where $\alpha \in [0,1]$, $\beta \in [0,1]$, ……… and $\delta \in [0,1]$. The concept of “the degree of confidence” associated to a satisfaction level awarded to the answer of a question is regarded as “the degree of certainty” of the evaluator.

Consider the situation where the total mark of a student’s answerscript is 100 marks for n questions to be answered,

TOTAL MARKS = 100

Q.1 carries s1marks

Q.2 carries s2 marks

Q.3 carries s3 marks

:

Q.n carries s_n marks

Where $0 < s_i \leq 100$, $\sum_{i=1}^{n} s_i = 100$, and $1 \leq i \leq n$. Assume that an optimism index between zero and one determined by the evaluator. It is obvious that different evaluators have different characteristics to evaluate students’ answerscripts. Some evaluators belong to pessimistic evaluators, where they award lower scores (i.e., strict-type grades) to students. Some evaluators belong to optimistic evaluators, where they award higher scores (i.e., lenient-type grades) to students. Some evaluators belong to normal evaluators, where they award normal scores (i.e., normal-type grades) to students. Therefore, we can use an optimism index λ [5] to indicate the degree of optimism of an evaluator, where $\lambda \in [0,1]$. If $0 \leq \lambda < 0.5$, then the evaluator is a pessimistic evaluator. If $\lambda = 0.5$, then the evaluator is a normal evaluator. If $0.5 < \lambda \leq 1.0$, then the evaluator is an optimistic evaluator.

The proposed method for the student’s answerscript evaluation is now presented as follows.

Step 1: Calculate the α –cut $(F_1)\alpha$ of the fuzzy number F_1, the β-cut $(F_2)\beta$ of the fuzzy number F_2, the γ–cut $(F_3)\gamma$ of the fuzzy number Fn,….. and the δ–cut of the fuzzy number Fn, respectively, where

$$(F_1)\alpha = [a1, a2]$$
$$(F_2)\beta = [b1, b2]$$
$$(F_3)\gamma = [c1, c2]$$
$$\vdots$$
$$(Fn)\delta = [z1, z2]$$

$\alpha \in [0,1]$, $\beta \in [0,1]$, $\gamma \in [0,1]$,….. and $\delta \in [0,1]$.

Step 2: Calculate the interval-valued total mark [m1,m2] of the student’s answerscript, where

$$[m1,m2] = \left[\frac{s1}{s1+s2+\cdots+sn} \times (F1)\alpha + \frac{s2}{s1+s2+\cdots..+sn} \times (F2)\beta + \frac{s3}{s1+s2+\cdots.+sn} \times (F3)\gamma + \ldots..\frac{sn}{s1+s2+\cdots+sn} \times (Fn)\delta\right]$$

$$=\left[\frac{s1}{s1+s2+\cdots+sn} \times [a1,a2] + \frac{s2}{s1+s2+\cdots.+sn} \times [b1,b2] + \frac{s3}{s1+s2+\cdots.+sn} \times [c1,c2] + \ldots\ldots.+ \frac{sn}{s1+s2+\cdots..+sn} \times [z1,z2].\right] \quad (1)$$

Step 3: The total mark of the student is evaluated as follows:

$$(1-\lambda) \times m1 + \lambda \times m2$$

where λ denotes the optimism index determined by the evaluator and $\lambda \in [0,1]$. The degree of confidence of the total mark awarded to the student is equal to Min (α, β, γ,….,δ) where Min (α, β, γ,….δ) $\in [0,1]$. Put this total mark and the degree of confidence in the appropriate box at the bottom of the fuzzy grade sheet.

B. *Marks given by ‘N’ Examiners : To find the type of examiner : Module3*

In this module,we have used method of Bai and Chen[5], is useful to find the type of examiner i.e. lenient, strict or normal. This method is useful when there are ‘n’ examiners to assess the ‘m’ answersheets. Let E_i be the answerscript of the *i* th student, where $1 \leq i \leq m$. Assume that there are n teachers $T_1, T_2, \ldots$, and Tn to grade the answerscripts, then we can get a grade matrix G, shown as follows

$$G = \begin{array}{c c} & \begin{array}{cccc} T_1 & T_2 & \cdots & T_n \end{array} \\ \begin{array}{c} E_1 \\ E_2 \\ \vdots \\ E_m \end{array} & \begin{bmatrix} g_{11} & g_{12} & \cdots & g_{1n} \\ g_{21} & g_{22} & \cdots & g_{2n} \\ \vdots & & \ddots & \vdots \\ g_{m1} & g_{m2} & \cdots & g_{mn} \end{bmatrix} \end{array},$$

Where g_{ij} denotes the grade of the *i*th answerscript E_i graded by teacher T_j, $g_{ij} \in [0,100]$, $1 \leq i \leq m$, and $1 \leq j \leq n$. The proposed method for constructing the grade membership functions of strict-type grades, lenient-type grades and normal-type grades of fuzzy rules, respectively, is now presented as follows:

Step 1: For each answerscript E_i, calculate its temporary average grade TAvgE_i,

$$\text{TAvg}E_i = \frac{\sum_{j=1}^{n} g_{ij}}{n} \quad (2)$$

Where $g_{ij} \in [0,100]$, n denotes the number of teachers, m the number of answerscripts, $1 \leq i \leq m$, and $1 \leq j \leq n$.

Step 2: Calculate the distance d_{ij} between each grade g_{ij} and TAvgE_i where d_{ij} = | TAvgE_i _ g_{ij}|, to get the distance matrix D, where 1 ≤ i≤ m, and 1 ≤ j≤ n. For each answerscript E_i, where 1 ≤ i ≤ m, choose the top 40% of the teachers who have higher distance to be the ''outlier'', where 1 ≤ i ≤ m and 1 ≤ j ≤ n. The teacher who is an outlier and whose awarded grade is smaller than TAvgE_i will be classified into the class of strict-type teachers; the teacher who is an outlier and whose awarded grade is larger than TAvgE_i will be classified into the class of lenient-type teachers, where 1 ≤ i ≤ m. Otherwise, the teacher is classified into the class of normal-type teachers.

Step 3: For each answerscript E_i, where 1 ≤ i ≤ m, count the number j of strict-type teachers T_{L1}, T_{L2}, … , T_{Lj} and count the number k of lenient-type teachers $T_{H1}, T_{H2}, \ldots\ldots T_{Hk}$. Then, for each answerscript E_i, where 1 ≤ i ≤ m, calculate the average grade g_{Li} of strict-type teachers and calculate the average grade g_{Hi} of lenient type teachers, respectively, where

$$g_{Li}=\frac{\sum_{p=1}^{j} L_{ip}}{j} \qquad (3)$$

$$g_{Hi}=\frac{\sum_{q=1}^{k} H_{iq}}{j} \qquad (4)$$

L_{ip} denotes the grade of the answerscript E_i graded by strict-type teacher T_{Lp}, H_{iq} denotes the grade of the answerscript E_i graded by lenient-type teacher T_{Hq}, 1≤ p ≤ j, and 1 ≤ q ≤ k.

For each answerscript E_i, where 1 ≤ i ≤ m, if j > k, then it means that the number of teachers in the class of strict-type teachers is larger than the number of teachers in the class of lenient-type teachers and we apply Eq. (5) to get the more appropriate grade AvgE_i. If k > j, then it means that the number of teachers in the class of lenient type teachers is larger than the number of teachers in the class of strict-type teachers and we apply Eq. (5) to get the more appropriate grade AvgE_i. Otherwise (i.e., j = k), it means that the number of teachers in the class of lenient-type teachers is equal to the number of teachers in the class of strict-type teachers, and AvgE_i is equal to TAvgE_i, shown as follows

$$\text{Avg}E_i=\begin{cases}\text{TAvg}E_i+\frac{(j-k)\times 0.5\times(g_{in}-g_{il})}{n}, \text{if } j>k\\ \text{TAvg}E_i+\frac{(-(k-j)\times 0.5\times(g_{in}-g_{il})}{n}, \text{if } k>j\\ \text{TAvg}E_i, \text{if } k=j\end{cases} \qquad (5)$$

Then, calculate the total average strict-type grade $AvgG_L$ of g_{Li}, calculate the total average normal-type grade AvgGN of AvgEi and calculate the total average lenient-type grade $AvgG_H$ of g_{Hi}, respectively, where

$$AvgG_L = \frac{\sum_{i=1}^{m} g_{Li}}{m} \qquad (6)$$

$$AvgG_N = \frac{\sum_{i=1}^{m} \text{Avg}E_i}{m} \qquad (7)$$

$$AvgG_H = \frac{\sum_{i=1}^{m} g_{Hi}}{m} \qquad (8)$$

Step 4: Use the interpolation techniques to get the most appropriate relational function between g_{Li} and AvgE_i and to get the most appropriate relational function between g_{Hi} and AvgE_i, respectively, where 1 ≤ i ≤ m. For simplicity, we use a concave-downward curve through the points (0, 0), (100, 100) and (50 + $AvgG_L$ - $AvgG_N$, 50) to fit the relational function between g_{Li} and AvgE_i, where (0, 0), (100,100) and (50 + $AvgG_L$ - $AvgG_N$, 50) are called the starting point, the ending point and the central point of the concave downward curve, respectively, 1 ≤ i ≤ m, and m is the number of students' answerscripts. Here use a concave-upward curve through the points (0, 0), (100, 100) and (50 +$AvgG_H$ - $AvgG_N$, 50) to fit the relational function between g_{Hi} and AvgE_i, where (0, 0), (100, 100) and (50 + $AvgG_H$ - $AvgG_N$, 50) are called the starting point, the ending point and the central point of the concave-upward curve, respectively, 1 ≤ i ≤ m, and m is the number of students' answerscripts.

Step 5: Transform the values of the Y axis into the values between zero and one (i.e., divide each value in the Y axis by 100).

C. *Three –Node Evaluation system: Module4*

As per Saleh and Kim[4], they have modified method proposed by [15]. Assume that there are there are *'n'* students to answer *'m'* questions. It takes inputs like accuracy rate , time rate as evaluation criteria. Accuracy rate means score of student's anserscript marks in each question divided by the maximum score.

$A = [a_{ij}]$, $m \times n$,

Where $a_{ij} \in [0, 1]$ denotes the accuracy rate of student *j* for question *i*. Time rate is the time consumed by a student to answer a question divided by maximum time allowed for that question and time rate can be defined as *m* × *n* dimensions as follows:

$T = [t_{ij}]$,$m \times n$,

Where $t_{ij} \in [0, 1]$ denotes the time rate of student *j* for question *i*. A Grade vector is the maximum score assigned to each question *i* and is as follows:

G = [g_i] ,$m \times 1$;

Where g ∈ [1,100] ,satisfying the following constraints:

$\sum_{i=1}^{m} g_i \;= 100$

In this paper difficulty, importance and complexity of questions are taken into consideration. Domain expert will determine the values of complexity and importance. We have l levels of importance to describe the degree of importance of each question in the fuzzy domain. Following is the importance matrix of dimension $m \times l$

$P = [p_{ik}]\,, \quad m \times l,$

Where $p_{ik} \in [0, 1]$ denotes the membership value (degree of the membership) of question i belonging to the importance level k. In this paper, five levels (fuzzy sets) of importance (l = 5) are used. Their MFs are shown in Fig. 2. k= 1 (low), k = 2 (more or less low), k = 3(medium), k = 4 (more or less high), and k = 5 (high).

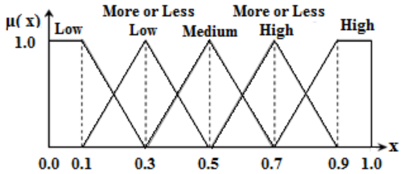

Fig. 2: Fuzzy membership functions of the five levels.

The complexity of questions which indicates the ability of students to give correct answers and is given below as matrix of dimension $m \times l$,

$C = [c_{ik}]\,, m \times l \;,$

Where $c_{ik} \in [0,1]$ denotes the membership value of question i belonging to the complexity level k.

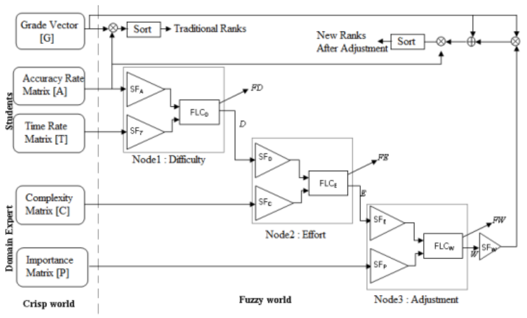

Fig. 3: Block diagram of the three node fuzzy evaluation system

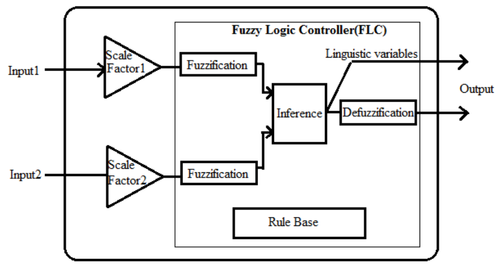

Fig. 4 : Representation of node structure as a Fuzzy Logic Controller(FLC)

Three –Node Fuzzy Logic Evaluation system

This can be represented as a block diagram of fuzzy logic systems as shown in Fig. 3. The system consists of three nodes: the difficulty node, the effort node, and the adjustment node. Each node of the system behaves like a fuzzy logic controller (FLC) with two scalable inputs and one output. Fig. 4 shows the node structure of each fuzzy Logic controller. It maps a two-to-one fuzzy relation by inference through a given rule base. The inputs to the system, in the left part of the Fig 3, are given either by examination results or domain expert. The inputs are fuzzified based on the defined levels (fuzzy sets) shown in Fig. 2. In the first node, both inputs are given by examination results, whereas in the later nodes, one input is the output of its previous node and the other is given by a domain expert. The output of each node can be in the form of a crisp value (defuzzified) or in the form of linguistic variables (MFs). Each node has two scale factors, here both scaling factors have the same value of unity.

Step 1 (Fuzzification) : In the first step, inputs are converted into membership values of the fuzzy sets (Fig 2). Triangular Membership Function is used because of its simplicity and easy computation.

Based on accuracy rate(A) and time rate matrix(T), calculate the average accuracy rate average time rate

$\bar{A} = [a_i \cdot]\,, \quad m \times n,$

Where $a_i \cdot$ denotes the average accuracy rate of question i which is obtained by

$$a_i \cdot \; = \sum_{j=1}^{n} a_{ij}/n \qquad (9)$$

and the average time rate vector of the same dimension,

$\bar{T} = [t_i \cdot]\,, \quad m \times n,$

$$t_i \cdot \; = \sum_{j=1}^{n} t_{ij}/n \qquad (10)$$

Next, by fuzzification, obtain the fuzzy accuracy rate matrix of dimension $m \times \; l$,

$FA = [fa_{ik}\,], \quad m \times l,$

Where $fa_{ik} \in [0, 1]$ denotes the membership value of the average accuracy rate of question i belonging to level k, and the fuzzy time rate matrix of dimension $m \times l$,

$FT = [ft_{ik}\,], \quad m \times l,$

Where $ft_{ik} \in [0 , 1]$ denotes the membership value of the average time rate of question i belonging to level k, respectively.

Step 2 (Inference) : In second step, inference is performed based on the given rule base, in the form of IF-THEN rules. Mamdani's max–min inference mechanism is used to produce fuzzy sets for defuzzification.

Based on the fuzzy accuracy rate matrix, FA, the fuzzy time rate matrix, FT, and the fuzzy rules, $\Re_D$, given in the form of IF-THEN rules, obtain the fuzzy difficulty matrix of dimension $m \times l$,

$$D = [d_{ik}], \quad m \times l,$$

Where $d_{ik} \in [0, 1]$ denotes the membership value of the difficulty of question i belonging to level k. When the level of accuracy, l_A, and the level of time, l_T, are given, the level of difficulty, l_D, is determined by the given fuzzy rule base in Table II (a),

$$l_D = \Re_D(l_A, l_T)$$

The inference mechanism can be written into the form

$$d_{ik} = \max_{\{(l_A, l_T) | \Re_D(l_A, l_T) = k\}} \{\min(fa_{i,l_A}, ft_{i,l_T})\} \qquad (11)$$

Next, based on the fuzzy difficulty matrix, D, and the fuzzy complexity matrix, C and given the fuzzy rules, $\Re_E$, Table II (b) obtain the effort (which is the answer-cost) matrix of dimension $m \times l$, in the same manner as how the difficulty matrix obtained above

$$E = [e_{ik}], \quad m \times l,$$

Next, based on the fuzzy effort matrix, E, and fuzzy importance matrix, P, given the fuzzy rule base in Table II (b) (same for both $\Re_E$ and $\Re_W$), obtain the adjustment matrix of dimension $m \times l$

$$W = [w_{ik}], \quad m \times l,$$

Where $w_{ik} \in [0,1]$ denotes the membership value of the adjustment of question i belonging to level k.

$$\overline{W} = [w_{i\bullet}], \quad m \times 1,$$

Where $w_{i\bullet} \in [0,1]$ denotes the final adjustment value required by question i obtained by

$$w_{i\bullet} = \frac{0.1 * w_{i1} + 0.3 * w_{i2} + 0.5 * w_{i3} + 0.7 * w_{i4} + 0.9 * w_{i5}}{0.1 + 0.3 + 0.5 + 0.7 + 0.9} \qquad (12)$$

Where 0.1, 0.3, 0.5, 0.7 and 0.9 are the centers of the fuzzy MFs shown in Fig. 2.

Table. II : Fuzzy rule bases to infer difficulty,the efforts and the adjustment

(a) Difficulty

Accuracy \ Time rate	1	2	3	4	5
1	3	4	4	5	5
2	2	3	4	4	5
3	2	2	3	4	4
4	1	2	2	3	4
5	1	1	2	2	3

(b) Cost

Difficulty \ Complexity	1	2	3	4	5
1	1	1	2	2	3
2	1	2	2	3	4
3	2	2	3	4	4
4	2	3	4	4	5
5	3	4	4	5	5

1 is "Low", 2 is "More or Less Low", 3 is "Medium", 4 is "More or Less High", 5 is "High".

Step 3 (Defuzzification) : In third step, fuzzy output values are converted into a single crisp value or final decision. The Center of Gravity method is used. This step, adjust the original ranks of students. The adjustment vector, W, is then used to obtain the adjusted grade vector of dimension $m \times 1$,

$$\hat{G} = [\bar{g}_i], \quad m \times 1$$

Where $\bar{g}_i$ is the adjusted grade of question i,

$$\bar{g}_i = \bar{g}_i \cdot (1 + w_{i\bullet}), \qquad (13)$$

and $w_{i\bullet}$ is the average adjustment of question i. Then, the value is scaled to its total grade (i.e., 100) by using the formula

$$\hat{g}_i = \bar{g}_i \cdot \sum_{j=1}^{m} g_j / \sum_{j=1}^{m} \bar{g}_j \qquad (14)$$

Finally, obtain the adjusted total scores of students by

$$\hat{S} = A^T \hat{G} \qquad (15)$$

After sorting the element values of $\hat{S}$ in descending order NEW rank of student can be obtained.

III. Proposed Model Of New Fuzzy Logic Evaluation System

In the proposed model,we have use four modules as shown Fig. 5.

Module-1:Input without fuzzy numbers –Normal Marks

First block is called Without Fuzzy Marks, in which assessment of answersheet is done by traditional or classical method.This block gives the numeric but normalized input i.e. mark scrore by student divided by maximum marks allocated to each question. This input is given to the Three-node-fuzzy-controller.

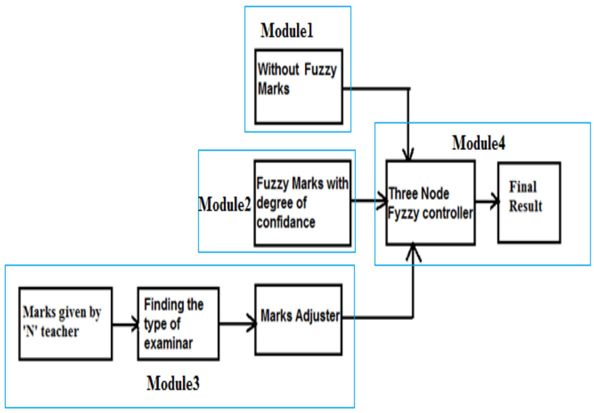

Fig. 5 : Proposed fuzzy evaluation system with four modules.

Module 2: Fuzzy marks with degree of confidance

In the second module the students' answerscript are assess using satisfactions levels of examinar with the degree of confidance. To award marks fuzzy grade sheet is prepared.

Module3: Finding type of examinar

This module accept marks given by 'N' examinar for 'M' numbers of answerscripts(i.e. students). This module is useful when the number of examinars are more than one to correct the answerscripts. Here all 'M' answersheet will be asses by all 'N' Teachers.Then for given input this will find out the type of examinar-Normal,strick or Lenient type.This input is given to mark adjuster which will adjust the score for each student according to input. Then it will give input to Three-node-fuzzy-controller.

Module 4 : Three- node-fuzzy-controller and Final Result Adjuster

In this module, input is taken from one of the above three modules. On the basis of values given by domain expert for Complexity, Importance and from the given inputs, system will calculate difficulty,Efforts and final Adjustment of questions marks. Finally it will sorts the results of students into decsending order to produce scores and ranks.

IV. Exprimental Results

In this paper we have considered the data of three students S1, S2 and S3. Here the assessment of answerscript is done by both the methods i.e. traditional (Normal) and fuzzy. In traditional method numbers are awarded and are represented by matrix 'A' which is Accuracy matrix(Normalized). Fuzzy assessment is done as per module 2[9], where satisfaction level is awarded along with degree of confidence to each question. Table III shows the fuzzy assessment sheet of three students. Fuzzy Marks of each question is converted into normalized marks, which is represented by matrix 'SA'. In this paper we have considered only one examiner who has assessed all answersheets (so no need to use Module 3) and the type of examiner is of normal type, so value of λ =0.5. Total number of questions to be attempted are six ,Q1,Q2…Q6, maximum weightage of each question is given in grade vector G. Normalized Time matrix is denoted by 'T' which is time taken by each student to solve question divided by maximum allocated time to each question. Value of Complexity and Importance is given by domain expert and is represented by matrix C and P respectively.

In this paper n=3, which is number of students and m=6, which is number of questions. So matrices A, T, SA are of size m x n i.e. 6X3.

$$A=\begin{bmatrix} 0.666667 & 0.333333 & 0.833333 \\ 0.833333 & 0.5 & 0.666667 \\ 1 & 0 & 1 \\ 1 & 0.75 & 0.25 \\ 1 & 0.5 & 0.75 \\ 0.833333 & 0.541667 & 0.833333 \end{bmatrix} \quad G=\begin{bmatrix} 12 \\ 12 \\ 12 \\ 20 \\ 20 \\ 24 \end{bmatrix}$$

$$T=\begin{bmatrix} 1 & 0.857143 & 0.714286 \\ 0.714286 & 0.714286 & 0.571429 \\ 0.857143 & 0.857143 & 1 \\ 0.5 & 0.7 & 0.8 \\ 0.8 & 0.8 & 0.5 \\ 0.789474 & 0.894737 & 0.947368 \end{bmatrix}$$

$$C=\begin{bmatrix} 0 & 0.3 & 0.7 & 0 & 0 \\ 0 & 0 & 0 & 0.8 & 0.2 \\ 0.1 & 0.9 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0.1 & 0.9 \\ 0 & 0 & 0 & 0.9 & 0.1 \\ 0 & 0 & 0.8 & 0.2 & 0 \end{bmatrix}$$

$$P=\begin{bmatrix} 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0.9 & 0.1 \\ 0 & 0 & 0.8 & 0.2 & 0 \\ 0 & 0 & 0.4 & 0.6 & 0 \\ 0 & 0.7 & 0.3 & 0 & 0 \\ 0.4 & 0.6 & 0 & 0 & 0 \end{bmatrix}$$

Table III : Fuzzy assessment

Student 1		Student 2		Student 3	
SLevel	DOC	SLevel	DOC	SLevel	DOC
G	1	MB	0.75	G	0.75
G	0.9	F	0.8	MG	0.8
EG	0.75	EB	1	VG	0.75
VG	1	G	0.75	B	0.9
EG	0.8	F	0.75	MG	1
G	0.9	MB	0.8	VG	0.8

*SLevel is Satisfaction Level; DOC is Degree of Confidence

'SA' is fuzzy accuracy normalized matrix for each question and three students calculate based on Table III and module2. Table IV shows comparisons among Normal Marks, Fuzzy Marks, and then these both Normal and Fuzzy Marks given to three-node system. Three node system considers factors like accuracy of answer, time taken to attempt question, complexity and importance of question into consideration and adjusted the marks accordingly.

$$SA=\begin{bmatrix} 0.9 & 0.3 & 0.885 \\ 0.89 & 0.5 & 0.7 \\ 1 & 0 & 0.99 \\ 1 & 0.885 & 0.11 \\ 1 & 0.5 & 0.7 \\ 0.89 & 0.3 & 0.9925 \end{bmatrix}$$

Table IV : Comparisons among Normal Marks, Fuzzy Marks, Normal and fuzzy Marks given to three-node system.

Sr. No.	Normal Marks	Fuzzy Marks	Normal Marks given to 3- node system	Fuzzy Marks given to 3- node system
Student1	90	94.8400	90.3400	94.9268
Student2	48	44.5000	50.1393	47.1359
Student3	70	70.9200	67.8171	68.2617

V. CONCLUSION

Promoting educational reforms is a need for the betterment of the evaluation of student performance-learning achievement. Proposed method is very helpful in evaluating subjective types of answer. Proposed method combines the three methods. Depending on question paper's complexity, importance and difficulty faced by students to write answers, final marks of students are adjusted to generate new ranks. Proposed system is fairer, transparent and beneficial to all students.

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