A computerized grading system based evaluation of students

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ABSTRACT

Pressing need of evaluation of students based on grading system is becoming essential to reduce the burden on the students. In this paper we considered three existing approaches for evaluation of students' answersscripts (traditional marking method, grading method and fuzzy evaluation method) and a better method of evaluation called vague evaluation method (VEM) is a computer and vague set based approach where a vague valued (satisfaction based) marking is used. The considered example is for an open university. The paper shows a good and successful application of vague set theory described by Gau et al. in 1993.

Keywords: *Vague set, Standard vague set, Universal set, Vague grade sheet.*

I. INTRODUCTION

Presently in India, the discussion is going on from top (Ministry of Human Resource Development) to bottom (School level) to reduce the burden on students. In present scenario, there are three popular existing evaluation systems: traditional marking system, grading system and fuzzy evaluation system. The type of questions in the examination system are assumed to be such that answers are subjective types but not the objective type. In traditional system of evaluation, "marking" i.e. awarding of marks is done arithmetically whereas in the Grading system of evaluation, "grading" i.e. awarding of grades (equivalent to an interval of two integer numbers) is done. Grading system is introduced, in fact, due to evaluator's inability to measure with precision the human nature and qualities with all their intricate levels of variation and mix up of observable as well as non-observable attributes Black [2], Mohina [8] and Turksen [12]. Mossin et al. [9] prposed fuzzy evaluation system for the students to orient them during the complete learning process, indicating potentialities and deficiencies. Chetia and Das [4] proposed vague soft sets concept for students' answer scripts evaluation through a hypothetical example. Biswas [1] and Nambudiripad et. al. [10] proposed the third method based on fuzzy set theory and termed as fuzzy evaluation method (FEM). The idea of fuzzy sets and membership values provides a possible model for inexact concepts, subjective judgments, for all types of evaluations. This method of evaluation is good and is able to handle the hedges like *poor, satisfactory, good, very good and excellent* etc. but it considers only membership values Gouen [6] and Klir [7], which is not giving any idea about the accuracy of values.

There may be situations where truth-membership (membership) and false-membership (non-membership) values both simultaneously may play a significant role Gau et. al. [5]. We have considered a set, which considers the values, truth-membership and false-membership both

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and known as vague set, for proposing our new evaluation method termed as *vague evaluation method* (VEM), which is better than FEM.

We consider, for the purpose of an example only, the guidelines of an open university for evaluation of answerscripts of some of its academic programmes, which are furnished below:

i) Each question in the answerscripts will be awarded letter grade according to the level of performance judged by the evaluators.

ii) For letter grade, a ***five*** point scale has been adopted. "A" being the highest and "E" being the lowest. The notional values assigned to them are as follows,
A: Excellent, B: Very good, C: Good, D: Satisfactory and E: Unsatisfactory are notional values and A = 5, B = 4, C = 3, D = 2 and E = 1 are grade points.

iii) Answer to each question may be gone through carefully into its minute details and its strength and weaknesses may be marked to facilitate its overview. The level of performance may then be judged in terms of the hedges good, very good, excellent etc.

iv) Having decided the level of performance in qualitative terms, corresponding grade may then be marked against each answer to a question. Every answer to each question therefore, will have separate grades such as C, A, E, B etc.

v) These grades have to be combined into an Overall Grade for the whole paper.

The guidelines may go on and on.

This grading system of evaluation involves many hedges like good, bad, satisfactory etc. which are the sources of vagueness and this involve a substantial amount of fuzziness and vagueness. The fuzzy set theory was initiated by Zadeh [14,15] in 1965 and vague sets were explained by Gau et al. [5] in 1993. According to Zadeh, the ultimate aim of fuzzy set theory would be, to represent how the human mind perceives and manipulates information. "*Indeed the pervasiveness of fuzziness in human thought processes suggests that much of the logic behind reasoning is not the traditional logic but a logic with fuzzy truths, fuzzy connectives, fuzzy rules of inference*". According to Gau et al., "*the major advantage of vague sets over fuzzy sets is that vague sets separate the positive and negative evidence for membership of an element in the set*". Furthermore, they also pointed out that the single value tells nothing about its accuracy. Consider a real world example, a resolution is to be considered for voting and there are 10 votes in total. If we consider fuzzy set theory and assign the membership function value 0.6, this means that the chance of passing the resolution are more but what will be the voting pattern it is not known. The possibilities are: the resolution may pass if 6 voters abstain and 3 vote in favor, 3 abstain and 3 vote in against and 4 vote in favor, 2 vote in against and 3 in favor and 5 abstain etc. Here, it is not clear, by which option the resolution passed. In contrary, if we take vague set and assign the membership and non-membership values [0.4,0.3] then it is clear that resolution will pass with 4 votes in favor, 3 in against and 3 abstentions, so here complete accuracy and correct option is known.

It is easy to realize that man frequently uses fuzzy and vague concepts when he perceives the outside world and when he thinks. It seems that human brain processes many hedges like good, very good, similar to, tall, large, very large, very long, almost similar, brilliant, extra-ordinary etc. One of the most important facts of human thinking is its ability to summarize information (here, it is evaluation). To be able to represent and manipulate these we are to yield tools for modeling humanistic or man machine systems in which information is often vague and respective evaluation is a challenge for usual techniques.

We claim that a potentially fruitful solution to the problem of finding out a better and better method of evaluation is nothing but a vague set based approach. The method presented in this paper is a confluence of vague set theory and it is potentially better than the existing above said methods and it is presented here is abbreviated as VEM. In fact, it is an extension of fuzzy evaluation method.

The sequence of development of the methods of evaluation is shown in Fig.1. In this VEM, a vague set based approach for the representation of detailed student performance is used.

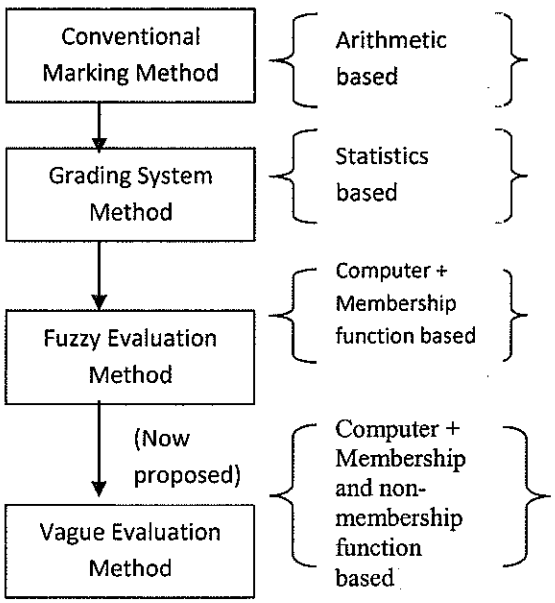

Figure 1: Methods of Evaluation

II. Background

We now give the formal definition of vague sets. The theory of vague sets is a generalization of theory of fuzzy sets. Some of the properties of vague sets are explained by Singh et. al. [11].

Definition 2.1 Vague set : Let U be the universe of discourse U = $\{u_1,u_2,\ldots. u_n\}$, with a generic element of U denoted by u_i A vague set A in U is characterized by membership function t_A: U® [0,1] and a non-membership function f_A: U® [0,1]. Where $t_A(u_i)$ is a lower bound on the grade of membership of u_i derived from the evidence for u_i, $f_A(u_i)$ is a lower bound on the negation of u_i derived from the evidence against u_i, and $t_A(u_i) + f_A(u_i)$ £ 1.

The grade of membership of u_i in the vague set A is bounded to a sub interval $[t_A(u_i), 1- f_A(u_i)]$ of [0,1]. The vague value $[t_A(u_i), 1- f_A(u_i)]$ indicates that the exact grade of membership $m_A(u_i)$ of u_i may be unknown, but is bounded by $t_A(u_i)$ d" $m_A(u_i)$ d" 1- $f_A(u_i)$, where $t_A(u_i) + f_A(u_i)$ £ 1.

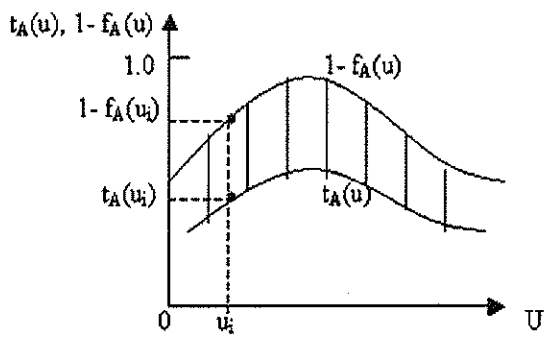

Figure 2: Illustration of Vague Set

When the universe of discourse U is continuous, a vague set A can be written as

$$A = \int_U [t_A(u_i), 1- f_A(u_i)] / u_i$$

When the universe of discourse U is discrete, a vague set A can be written as

$$A = \sum_{i=1}^{n} [t_A(u_i), 1- f_A(u_i)] / u_i$$

Example 1: Let U = {6,7,8,9,10} be the universe of discourse. A vague set "LARGE" of U may be defined by

LARGE = [0.1,0.2]/6 + [0.3,0.5]/7 + [0.6,0.8]/8 + [0.9,1]/9 + [1,1]/10.

Definition 2.2 Similarity Measures: Let A and B be two vague sets on universe of discourse U = { u_1 u_2 … u_n}, defined as

$A = [t_A(u_1), 1-f_A(u_1)]/u_1 + [t_A(u_2), 1-f_A(u_2)]/u_2 + \ldots..+[t_A(u_n), 1-f_A(u_n)]/u_n$

$= [t_A(u_1), f^*_A(u_1)]/u_1 + [t_A(u_2), f^*_A(u_2)]/u_2 + \ldots..+[t_A(u_n), f^*_A(u_n)]/u_n$

and

$B = [t_B(u_1), 1-f_B(u_1)]/u_1 + [t_B(u_2), 1-f_B(u_2)]/u_2 + \ldots..+[t_B(u_n), 1-f_B(u_n)]/u_n$

$= [t_B(u_1), f^*_B(u_1)]/u_1 + [t_B(u_2), f^*_B(u_2)]/u_2 + \ldots..+[t_B(u_n), f^*_B(u_n)]/u_n$

where

$f^*_A(u_i) = 1-f_A(u_i)$, $f^*_B(u_i) = 1-f_B(u_i)$ and $1 \le i \le n$.

Let $A = [t_A, 1-f_A]$ be a vague value, where $t_A \in [0,1]$, $f_A \in [0,1]$, and $t_A + f_A \le 1$. Then, the score of A can be evaluated by the score function S shown as follows:

$S(A) = t_A - f_A$

If $f^*_A = 1-f_A$ then

$S(A) = t_A - f_A = t_A - f^*_A - 1$

The degree of similarity is explained by Chen [3] and Tversky [11] between the vague sets A and B defined by the function F as follows:

$F(A,B) = 1- \left|(S(A)-S(B))/2\right|$

Let $V_A(u_i) = [t_A(u_i), f^*_A(u_i)]$ be the vague membership value of u_i in the vague set A and

$V_B(u_i) = [t_B(u_i), f^*_B(u_i)]$ be the vague membership value of u_i in the vague set B. The score functions for these can be defined as follows:

$S(V_A(u_i)) = t_A(u_i) + f^*_A(u_i) - 1$

$S(V_B(u_i)) = t_B(u_i) + f^*_B(u_i) - 1$ where $1 \le i \le n$,

The degree of similarity between vague sets A and B can be evaluated by the function T,

$T(A,B) = (1/n)\sum_{i=1}^{n} (1-\left|(S(V_A(u_i)) - S(V_B(u_i)))/2\right|$

Where

$T(A,B) \in [0,1]$. The larger the value of T(A,B), the more similarity between the vague sets A and B.

III. Vague Evaluation Method for Answerscripts

Now we introduce the new method of evaluation of students' answerscripts called hereforth by "Vague Evaluation Method (VEM)" which is nothing but a vague valued marking approach. For this we introduce the concept of awarding a six-component based vague valued mark for each question's answer. This kind of six-component based vague valued marks are called vague marks (defined and discussed below).

Definition 3.1 Universal set: The set U = {0, 20, 40, 60, 80, 100} is called the universal set.

Definition 3.2 Standard vague set: There are n Standard Vague Sets called in short SVS. For this paper, there are five numbers of SVS and these are the following five vague linguistic hedges:

E (Excellent) = {[0,0]/0,[0,0]/20,[0.7,0.9]/40,[0.9,0.9]/60,[1,1]/80,[1,1]/100]}

E = {[0,0],[0,0],[0.7,0.9],[0.9,0.9],[1,1],[1,1]}

V (Very Good) = {[0,0]/0,[0,0]/20,[0.7,0.9]/40,[0.9,0.9]/60,[0.9,0.9]/80,[0.7,0.9]/100]}

V = {[0,0],[0,0],[0.7,0.9],[0.9,0.9],[0.9,0.9],[0.7,0.9]}

Similarly,

G(Good) =

{[0,0],[0.1,0.1],[0.7,0.9],[0.9,0.9],[0.5,0.3],[0.1,0.3]}

S (Satisfactory) =

{[0.5,0.3],[0.6,0.2],[0.9,0.9],[0.9,0.7],[0.1,0.3],[0,0]}

U(Unsatisfactory)=

{[1,1],[1,1],[0.5,0.3],[0.3,0.1],[0,0],[0,0]}

(The truth-membership and false-membership values of the SVS may standardized by the University concerned).

Definition 3.3. Vague marks: A vague set of the universal set U whose graph is any one of the following type:

i) t_A increasing, f_A decreasing

ii) t_A decreasing, f_A increasing

iii) at first t_A increasing, f_A decreasing and then t_A decreasing, f_A increasing is called a vague mark.

A vague marks like {[0,0],[0.1,0.2], [0.2,0.4], [0.6,0.7], [0.8,0.8]} to an answer to a question shows to the respondent the degrees of evaluator's satisfaction for that answer in 0%, 20%, 40%, 60%, 80% and 100% respectively. To avoid any human biasness of the evaluator with any SVS, the evaluator at first awards vague marks at freedom to express his satisfaction at different levels, instead of directly awarding SVS-titles like Excellent, Very Good etc.

Definition 3.4 Vague Grade Sheet: A vague grade sheet is a matrix type structure containing eight columns and I number of rows, where I is the total number of questions. A sample of a vague sheet is shown in Table 1. At the bottom there is a box, which tells the total score. The first column reveals the serial number of the questions; in any row, the columns from the second to the seventh shows the vague marks awarded to the answer to the corresponding question in the first column. The eighth column shows the grade awarded to each question. The box at the bottom shows the total marks awarded to the paper. Each script will contain a vague grade sheet printed on its cover page shown as Table 1.

Table 1: Vague grade sheet

Question No.	Vague marks						Grade
Q.1							
Q.2							
Q.3							
..							
				Total marks =			

Definition 3.5 Letter-grade and mid-grade-point "A", "B", "C", "D", and "E" are called letter grades (for this paper we are considering 5 points grade) which correspond to E, V, G, S, U respectively of the SVS.

Mid-grade-points are standardized as follows:

Mid-grade-points of A = 95 is denoted by P(A), B = 80 by P(B), C = 60 by P(C), D = 40 by P(D) and E = 15 by P(E).

(Actually these are mid points of the corresponding intervals as lay down below: and can be standardized or suitably adopted by the concerned university/institution:

$0 \le E < 30$, $30 \le D < 50$, $50 \le C < 70$, $70 \le B < 90$ and $90 \le A < 100$

Definition 3.6 The Procedure for VEM : Consider an answerscript of a student. Suppose an evaluator is to evaluate the ith question i.e. Q.i of his paper, the following procedure is to be adopted:

1) The evaluator awards a vague mark to Q.i by his best possible judgment and fill up the cells of the i^{th} row for the first seven columns. Say, this vague mark is V_i.

2) Now calculate the following degrees of similarities: $T(E,V_i)$, $T(V,V_i)$, $T(G,V_i)$, $T(S,V_i)$ and $T(U,V_i)$ Where E, V, G... are SVS.

3) Find the maximum of the above five values.

4) Assigned the grade corresponding to maximum value (defined in Deinition 3.2 above)

The above steps from 2 to 4 can be performed with the help of computer.

5) Repeat the same for the answer of each attempted question in the answerscript.

6) Now calculate the total using the following formula:

Total score = $(1/100) \Sigma [TM(Q.i) \times P(g_i)]$,

Where, TM(Q.i) is the mark allotted to Q.i in the question paper, and g_i the grade awarded to Q.i by the evaluator.

7) Put this total score in the appropriate box at the bottom of the vague grade sheet.

In case, in 4) above, maximum value occurs for two degrees, say for $T(V,V_i)$ and $T(G,V_i)$, the better of V and G is to be considered.

An example showing how vague valued marking system works.

Consider a candidate's answerscript to a paper of 100 marks. In total there were four questions to be answered:

TOTAL MARKS = 100

Q.1 carries 30 marks

Q.2 carries 40 marks

Q.3 carries 10 marks

Q.4 carries 20 marks

Suppose an evaluator awards vague marks as shown in Table 2 in the vague grade sheet attached with the answerscript.

Calculations (for which computer may be used)

For Q.1:

$S(V_E(u_1)) = 0 + 0 - 1 = -1$ $S(_{V1}(u_1)) = 0 + 0 - 1 = -1$

$S(V_E(u_2)) = 0 + 0 - 1 = -1$ $S(_{V1}(u_2)) = 0 + 0 - 1 = -1$

$S(V_E(u_3)) = 0.7+0.9-1 = 0.6$ $S(_{V1}(u_3)) = 0.7+0.9-1 = 0.6$

$S(V_E(u_4)) = 0.9+0.9-1 = 0.8$ $S(_{V1}(u_4)) = 0.9+0.9-1 = 0.8$

$S(V_E(u_5)) = 1 + 1 - 1 = 1$ $S(_{V1}(u_5)) = 0.3+0.1-1 = -0.6$

$S(V_E(u_6)) = 1 + 1 - 1 = 1$ $S(_{V1}(u_6)) = 0 + 0 - 1 = -1$

$$T(E,V_1) = (1/6) \sum_{i=1}^{6} (1 - |(S(V_E(u_i)) - S(V_1(u_i)))/2|)$$

$$= 3.2/6 = 0.53$$

$T(E,V_1) = 3.2/6 = 0.53$, $T(V,V_1) = 4.5/6 = 0.75$,

$T(G,V_1) = 5.5/6 = 0.91$, $T(S,V_1) = 3.4/6 = 0.56$,

$T(U,V_1) = 2.55/6 = 0.42$.

Maximum = $T(G,V_1)$.

Therefore, Grade awarded = **C**.

Table 2: Filled vague grade sheet

Que. No.	Vague Marks						Grade
Q.1	[0,0]	[0,0]	[0.7,0.9]	[0.9,0.9]	[0.3,0.1]	[0,0]	C
Q.2	[0,0]	[0,0]	[0,0]	[0.6,0.2]	[0.9,0.9]	[1,1]	A
Q.3	[0,0]	[0.3,0.1]	[0.6,0.2]	[0.9,0.7]	[0.3,0.1]	[0,0]	D
Q.4	[0.9,0.9]	[0.7,0.3]	[0.1,0.1]	[0,0]	[0,0]	[0,0]	E
....							
						Total Marks = 63	

Similarly,

For Q.2:

$T(E,V_2) = 5.4/6 = 0.90$,

$T(V,V_2) = 4.5/6 = 0.75$,

$T(G,V_2) = 4.35/6 = 0.49$, $T(S,V_2) = 3.2/6 = 0.53$,

$T(U,V_2) = 1.3/6 = 0.21$.

Maximum = $T(E,V_2)$.

Therefore, Grade awarded = **A**.

For Q.3:

$T(E,V_3) = 4.3/6 = 0.71$, $T(V,V_3) = 3.2/6 = 0.53$

$T(G,V_3) = 4.4/6 = 0.73$, $T(S,V_3) = 4.9/6 = 0.81$

$T(U,V_3) = 3.6/6 = 0.6$

Maximum = $T(S,V_3)$.

Therefore, Grade awarded = **D**.

For Q.4:

$T(E,V_4) = 1.4/6 = 0.23$, $T(V,V_4) = 1.3/6 = 0.21$

$T(G,V_4) = 3.3/6 = 0.55$, $T(S,V_4) = 3.6/6 = 0.60$

$T(U,V_4) = 4.9/6 = 0.82$

Maximum = $S(U,V_4)$.

Therefore, Grade awarded = **E**.

Total score = $(1/100) \sum [TM(Q.i) \times P(g_i)]$

$= (1/100) \times [30 \times 60 + 40 \times 95 + 10 \times 40 + 20 \times 15]$

$= 6300/100$

$= 63$.

Table 3: Comparison of students' evaluation methods

	Existing evaluation methods			Proposed method
	Traditional	**Grading system**	**Fuzzy evaluation**	**Vague evaluation**
Methodology	The marks are awarded in the form of fixed numerals.	In place of marks grades are awarded (equivalent to an interval of two integer number having lower and upper limits)	Marks are awarded based on the membership value in a group in terms of human perceptible terms such as poor, satisfactory, good, very good and excellent	Marks are awarded based on the membership and non-membership values in a group in terms of human perceptible terms such as poor, satisfactory, good, very good and excellent. If the level of confidence and non-confidence values is fifty-fifty, this method will turn to fuzzy evaluation method.
Cons	If a student is awarded first division by getting 60% marks then a student getting 59.99% marks can not be awarded first division under this methodology . Though, the knowledge of students may be at par. Therefore, grading system is recommended by many educationists to reduce the burden of students. Many boards are now switching over to grading system	The award of grade depends upon evaluators nature and quality, observable and non-observable attributes but not on the confidence level of the evaluator. The accuracy of the evaluation of the answer scripts with full confidence varies from person to person depending upon the upon the nature.	The marks awarded are in human perceptible terms with a confidence value but there is no information about non-confidence value while awarding of marks is performed. This means the marks are awarded at fifty percent level of confidence and non-confidence, which is not always true. There may be situations where these levels may be different, this is explained in the introduction part by considering the example of "passing a resolution" with 10 votes.	This method considers both confidence and non-confidence values by separate numerals. In the considered example of "passing a resolution" with 10 votes, there may be many options but by which option resolution will pass can not be ascertained by taking only the confidence value in account since it does not have the information about non-confidence and abstentions but can be ascertained by this method clearly. Thus, it can be inferred that the level of confidence of accuracy is better in this method since exact values for confidence and non-confidence can be indicated.

IV. Conclusion

In the present paper we have initiated the idea of vague valued marking evaluation of each and every question leading towards VEM (Vague Evaluation Method), a computer and vague set based approach, for overall evaluation of any answerscript of the students potentialities and deficiencies. Here, we considered truth-membership (confidence) and false-membership (non-confidence) values both, the level of confidence of accuracy is better than the existing evaluation methods.

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