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A NEW FUZZY APPROACH FOR TEACHER'S PERFORMANCE EVALUATION

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ABSTRACT

Teacher evaluation by students is done in most educational systems to improve the quality of education as well as the teacher's own awareness of strengths and weaknesses. The summative assessment is performed at the end of the semester by asking students to evaluate aspects of the teacher and the course. Although these scores are generally linguistic, they are converted into crisp numbers that cannot completely cover the ambiguity of the words. In this paper, a new fuzzy approach is proposed that considers the vagueness and uncertainty of words throughout the evaluation process. Instead of a crisp number, linguistic words are used in the evaluation process. The proposed approach uses the Perceptual Computer (Per-C) and the Linguistic Weighted Average (LWA). To show the effectiveness of the proposed methodology, a case study with real data in Jahrom University was conducted. The results demonstrate that the proposed approach provides an effective teacher evaluation.

Keywords: Linguistic grade, Teachers' performance evaluation, Per-C, Fuzzy logic, Linguistic Weighted Average (LWA).

I. INTRODUCTION

Teacher's evaluation by students is used by many educational institutions to provide formative assessments to instructors. Evaluating the performance of a teacher is very necessary due to many reasons and help teachers improve their teaching and courses. It also provides summative assessments for personnel decisions, such as merit raises, tenure and promotion, re-hiring adjunct instructors, and post-tenure review [1].

As a result, proper evaluation of teachers can increase the quality of education and help to define efficient plans to guarantee the quality of teachers and the teaching-learning process. Students' opinions about teachers vary based on various parameters. They evaluate teachers as good in some respects and weak in others. Therefore, we need a comprehensive system that can evaluate teachers based on the opinions of all students and taking into account all the parameters.

Typically, the teacher's evaluation is administered anonymously at the end of the semester and includes a series of Likert-scale items that ask students to evaluate aspects of the instructor and the course. In addition to specific items about the course, such as course organization or course grading policy, many evaluation forms contain an overall rating of the instructor and/or course and also have open-ended items in which students are asked to comment on the course and instructor (2,3). The feedback form that is being made to evaluate the performance of teachers is based on some crisp value (fixed value) which is not appropriate. in this paper, a new fuzzy-based methodology has been proposed for the teacher's performance evaluation using the student feedback form.

The use of techniques related to fuzzy sets in education assessment is not new [4-8]. Fuzzy set theory is an efficient and effective way to display uncertainty and fuzzy terms in the assessment environments [5]. Compared to methods based on numerical grading scores, fuzzy sets offer an alternative to a linguistic evaluation in which the "fuzzy" words are used instead of numbers throughout the evaluation method.

Compared to T1 FSs, IT2 FSs provides the ability to model second-order uncertainties. Given the usefulness and flexibility of IT2 FSs, a perceptual computing method is suggested. A number of theoretical investigations with respect to the properties of IT2FSs have been developed [9, 10]. Specifically, Per-C is able to handle subjectivity, vagueness, imprecision, and uncertainty while achieving tractability and robustness in modelling human decision making behaviors. Per-C has been successfully implemented to solve a number of fuzzy decision making problems. Nevertheless, the use of Per-C in teacher's assessment is still new. In this paper a new Per-C based assessment methodology that evaluates teacher's performance is proposed.

The general structure of Per-C is depicted in Figure 1. It consists of three components [11-14], i.e., an encoder, a

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computing-with-words (CWW) engine, and a decoder. Linguistic perceptions or words from human operators are converted into IT2FSs through the encoder. The CWW engine aggregates the outputs from the encoder. Finally, the decoder maps the output of the CWW engine into a recommendation which can be in the form of word, rank, or class.

The rest of this paper is organized as follows. In Section II, basic concept of fuzzy logic is reviewed. An overview on fuzzy based teachers' assessment is presented in Section III. In section IV, a new per-c based framework for assessment explained in detail. In Section V, a case study is conducted to demonstrate the usefulness of the proposed methodology. Concluding remarks are presented in section VI.

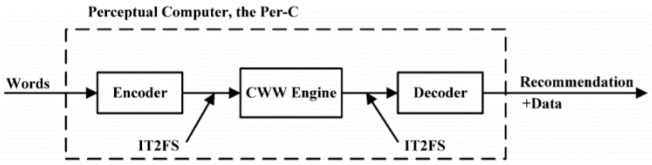

Fig.-1: The Perceptual Computer that uses IT2 FS models for words [11]

II. BASIC CONCEP OF FUZZY SETS

A number of notations and definitions related to type-1 fuzzy sets (T1FSs), interval type-2 fuzzy sets (IT2FSs) and a review on perceptual computing are presented in this Section.

Definition 1 [14]: A type-1 fuzzy set A in the universe of discourse U is a normal type-1 fuzzy set iff $\exists x \in U$, such that $\max_x \mu_A(x)=1$, where μ_A denotes the membership function of type-1 fuzzy set A.

Definition 2 [15]: A type-2 fuzzy set $\tilde{A}$ in the universe of discourseU can be represented by a type-2 membership function $\mu_{\tilde{A}}$, which is shown as follows:

$$\tilde{A} = \{((x, u), \mu_{\tilde{A}}(x, u))|\forall x \in U, \forall u \in J_x \subseteq [0, 1], 0 \le \mu_{\tilde{A}}(x, u) \le 1\} \quad (1)$$

where J_x denotes an interval in [0, 1]. The type-2 fuzzy set $\mu_{\tilde{A}}$ also can be represented as follows:

$$\tilde{A} = \int_{x\in U} \int_{u\in J_x} \mu_{\tilde{A}}(x,u)/(x,u) \quad (2)$$

where $J_x \subseteq [0, 1]$ and denotes the union over all admissible x and u.

Definition 3 [15]: Let $\tilde{A}$ be a type-2 fuzzy set in the universe of discourse U, which is represented by a type-2 membership function $\mu_{\tilde{A}}$. If all $\mu_{\tilde{A}}(x, u)=1$, then $\tilde{A}$ is called an interval type-2 fuzzy set. An interval type-2 fuzzy set $\tilde{A}$ can be regarded as a special case of a type-2 fuzzy set, which is shown as follows:

$$\tilde{A} = \int_{x\in U} \int_{u\in J_x} 1/(x,u) \quad \text{where } J_x \subseteq [0, 1]. \quad (3)$$

Definition 4 ([14, 15]): The upper membership function and the lower membership function of an interval type-2 fuzzy set are type-1 membership functions, respectively.

Let $\tilde{A} = (A^U , A^L)$ be an interval type-2 fuzzy set. If $A^U = A^L$, then the interval type-2 fuzzy set $\tilde{A}$ becomes a type-1 fuzzy set A. It is obvious that a type-1 fuzzy set A also can be extended into an interval type-2 fuzzy set $\tilde{A}$, where $A = \tilde{A} = (A^U , A^L) = (A, A)$ [26].

Definition 5 ([14, 15]). An IT2FS, $\tilde{A}$, is described by its FOU, i.e., FOU $(\tilde{A})$, where FOU $(\tilde{A})$ is described by its LMF and UMF of $\tilde{A}$, i.e., $\underline{\mu}_{\tilde{A}}, \overline{\mu}_{\tilde{A}}$ respectively, as shown in Fig. 1. Both $\underline{\mu}_{\tilde{A}}$ and $\overline{\mu}_{\tilde{A}}$ are T1FSs, as follows:

$$\text{FOU}(\tilde{A}) = \cup_{\forall x\in X} \left[\underline{FOU(\tilde{A})}, \overline{FOU(\tilde{A})}\right] = \cup_{\forall x\in X} [\underline{\mu}_{\tilde{A}}(x), \overline{\mu}_{\tilde{A}}(x)] \quad (4)$$

where ∪ is a set-theoretic union.

Definition 6 [17] The centroid c(A) of a T1 fuzzy set A is defined as follows:

$$c(A) = \frac{\sum_{i=1}^{N} x_i \mu_A(x)}{\sum_{i=1}^{N} \mu_A(x)} \quad (6)$$

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The centroid C($\tilde{A}$) of an IT2 FS $\tilde{A}$ is the union of the centroids of all its embedded T1 FSs Ae as follows:

$$C_{\tilde{A}} = \cup_{\forall A_e} c(A_e) = [c_l(\tilde{A}), c_r(\tilde{A})] \quad (7)$$

Where ∪ is the union operation, and $c_l(\tilde{A})$ and $c_r(\tilde{A})$ are the minimu and maximum values of all centroids, respectively. $c_l(\tilde{A})$ and $c_r(\tilde{A})$ are computed efficiently using EKM algorithm [18]. The average centroid of $\tilde{A}$, is also defined as the center of the centroid of $\tilde{A}$, $C_{\tilde{A}}$ as:

$$c(\tilde{A}) = (c_l(\tilde{A}) + c_r(\tilde{A}))/2 \quad (8)$$

Definition 8 [19] The Jaccard similarity measure between two IT2 FSs $\tilde{A}$ and $\tilde{B}$ is defined as follows:

$$S_J(\tilde{A},\tilde{B}) = \frac{\int_x \min(\overline{\mu}_{\tilde{A}}(x), \overline{\mu}_{\tilde{B}}(x))dx + \int_x \min(\underline{\mu}_{\tilde{A}}(x), \underline{\mu}_{\tilde{B}}(x))dx}{\int_x \max(\overline{\mu}_{\tilde{A}}(x), \overline{\mu}_{\tilde{B}}(x))dx + \int_x \max(\underline{\mu}_{\tilde{A}}(x), \underline{\mu}_{\tilde{B}}(x))dx} \quad (9)$$

Definition 9 The Linguistic Weighted Average (LWA), proposed in [20] is defined as

$$\tilde{Y}_{LWA} = \frac{\sum_{i=1}^{n} \tilde{X}_i \tilde{W}_i}{\sum_{i=1}^{n} \tilde{W}_i} \quad (10)$$

Where $\tilde{X}_i$ and $\tilde{W}_i$, i=1,2,..,n are words modeled by IT2 FSs, $\tilde{Y}_{LWA}$ is also an IT2 FS. It should be noticed that crisp numbers, intervals, and fuzzy sets are the specific kinds of IT2 FSs.

III. FUZZY-BASED TECHNIQUES IN TEACHER'S PERFORMANCE EVALUATION

Most educational institutions have a system for evaluating their teachers' performance. The teacher's performance is very important not only for students but for the educational institution management.

Chiang and Lin [21] presented a method for applying the fuzzy set theory to teaching assessment. Wang and Chen (2008) have used the fuzzy arithmetic operations for the evaluation of high school teachers' performances. They have used fuzzy numbers to denote the fuzzy grades. The fuzzy weights of the criteria are generated from the opinions of the evaluators. They have evaluated the performance of high school teachers flexibly and practically by using the simplified fuzzy number arithmetic operations to calculate the average of fuzzy numbers. O.K. Chaudhari et al., [22] proposed a Fuzzy Expert System for evaluating teachers' overall performance based on fuzzy logic techniques under "uncertain facts" in the decision making process. A suitable fuzzy inference mechanism and associated rule has been discussed. It introduces the principles behind fuzzy logic and illustrates how these principles could be applied by educators to evaluate teachers' performance. This model will help to write the Annual Confidential Reports of all the employees of an organization.

IV. A PER-C BASED FRAMEWORK

In this section, we present a new method for teachers' assessment, where the criteria used for teacher assessment is shown in Tables 1. In this research, six linguistic words are used by the academic evaluators for teacher's performance assessment i.e., very Poor (VP), Poor (P), Medium (M), Good (G), Very Good (VG), and Excellent(E). The evaluation of teaching activity can be defined as the systematic evaluation of teaching performance according to the professional role and contribution required to reach the objectives of the course taking into consideration the institutional context [23]. University or the institutions of higher education do not have uniform standard method for evaluating teachers' performance that covers all factors affecting directly or indirectly the quality of university or the institutes. Hence the fuzzy logic model is proposed to evaluate the teachers' overall performance through his or her involvement in the various sub activity involved in the institute. As mentioned, normally, teacher evaluation at the end of the semester is done anonymously and students are asked to evaluate the teacher from different criteria. In this section, the proposed new methodology for Per-C based method for teachers' assessment is described.

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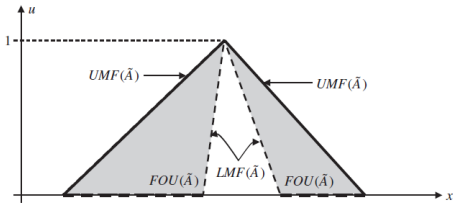

Fig.-2: FOU for an IT2 FS A˜. The FOU is completely described by its lower and upper membership functions [14]

Table-1: The criteria for assessment the performance of teachers

C1	Management of classroom
C2	The knowledge of the teacher in the specialized field and mastery of the subject
C3	Ability to express topics and convey lesson materials
C4	Having a proper lesson plan and continuity of lesson contents
C5	Using new topics and up-to-date resources
C6	Proportion of teaching strategies and methods to the objectives of lessons and exams
C7	How to evaluate and hold exams, timely announcement of grades and review of appeals
C8	Participating students in lesson topics and motivating for further research and study
C9	Attend time and follow the exact class schedule
C10	Attendance at the designated hours for student counseling
C11	Master's social behavior with students and observance of teaching etiquette and mutual respect
C12	Reasonable response to students' suggestions, criticisms and view

Encoder

The encoder converts any linguistic word into IT2FS. This operation is based on the Enhanced Interval Approach (EIA) approach, whereby the EIA codebook can be found in [24]. In this paper, six words i.e., very Poor (VP), Poor (P), Medium (M), Good (G), Very Good (VG), and Excellent(E) are retrieved. The details of these six words (namely linguistic grades) are illustrated in Fig. 3.

Computing-with-words

In the CWW engine, each student's opinions about the teacher re aggregated according to the Eq. (11). Because the weight of the criteria may not be the same, weighting can be considered for each criterion. These weights can also be linguistic. In this study, the weight of all criteria is assumed to be the same.

$$\tilde{y}_r = \frac{\sum_{i=1}^{p} \tilde{X}_{r,i}\, \tilde{w}_i}{\sum_{i=1}^{p} \tilde{w}_i} \qquad (11)$$

where $\tilde{X}_{r,i}$ denotes the linguistic grade from student r given to the specified teacher and W_i indicates weight for criteria i and i denotes the specific criterion (i.e., i = 1, 2, 3, . . ., 12). As an example $\tilde{X}_{2,3}$ is the linguistic grade given

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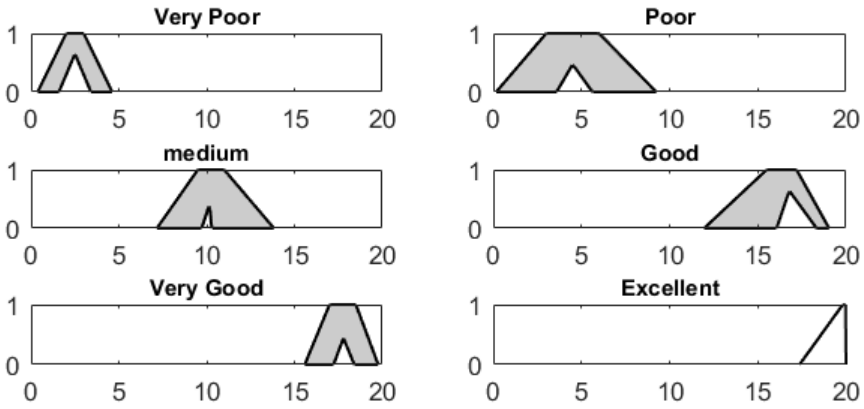

Fig.-3: Linguistic grades very Poor (VP), Poor (P), Medium (M), Good (G), Very Good (VG), and Excellent(E)

to the third specific criterion by Student# 2. Similarly, Eq. (11) is also used to obtain the aggregated results for other students.

The results from all students are aggregated using Eq. (12).

$$\tilde{Y}_R = \frac{\sum_{r\in s} \tilde{y}_r \tilde{w}_i}{\sum_{r\in s} \tilde{w}_i} \qquad (12)$$

Where $\tilde{w}_i$ indicates the weight of student r. In this paper, all students are equally weighted.

Decoder

In this research, the decoder plays two roles. First of all, mapping the aggregated outcomes (represented in IT2FS $\tilde{Y}R$) from CWW to recommendation in term of words and the second is ranking the aggregated outcomes of teachers. The former attempts to map the aggregated outcomes, i.e., $\tilde{Y}_R$, to the words depicted in fig. 3 using the Jaccard similarity indicator [9]. To rank the aggregated outcomes of teachers, we use the average centroid ranking method [19] for ranking IT2 FSs based on their center of centroids which ranks IT2 FSs based on their average centroids.

V. RESULTS AND DISCUSSION

In this section, a real case study is conducted. The proposed Per-C based model was studied and tested with real evaluation data of 21 computer engineering students related to "Data Structure" course at Jahrom University. The results are based on the existing evaluation website available in Table 2. In the current evaluation system, words are converted to crisp numbers and then averaged. For example, in the current system, for the evaluation data of Table 2, a score of 18.45/20 is considered as the overall score.

Table-2: The outcomes using the current evaluation website

	E	VG	G	M	P	VP
C1	15	0	4	1	1	0
C2	14	2	3	1	1	0
C3	15	1	3	0	1	1
C4	15	1	3	0	2	0
C5	12	2	4	1	2	0
C6	15	0	3	2	1	0
C7	14	0	4	1	1	1
C8	13	3	3	1	1	0
C9	15	1	3	1	1	0
C10	14	0	4	1	2	0
C11	16	0	3	1	1	0
C12	15	0	4	1	1	0

The aggregated results for selected teacher were computed using Eq. (11) for each student's assessment. Note that $\tilde{y}_r$ for each student presented in IT2FSs . Finally, the results from each student were aggregated into a final result by using Eq. (12). The weight of each evaluator was the same. The result is depicted in Figure 4. Once the aggregated outcome, i.e., $\tilde{Y}_R$, is obtained, it is mapped to a word using Jaccard similarity [19]. Using the EKM

algorithm [18], the crisp value obtained is 17.382. With these two approaches, it can be concluded that the contribution of teacher is good with a crisp score of 17.382.

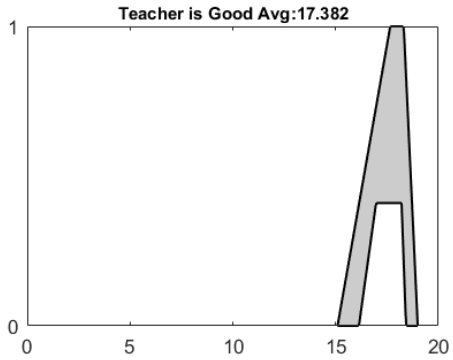

Fig.-4: aggregated result

VI. CONCLUSION

In recent years, some methods have been presented for teachers' performance evaluation based on fuzzy techniques. Nevertheless, the use of Per-C in teachers' performance evaluation is still new. In this paper, we have presented a new method that uses Per-C for teacher evaluation. The results of the proposed approach were compared with the results of the existing evaluation system in the university. The results show that the proposed methodology can be effective in evaluating the performance of teachers and provides reliable results. Furthermore, the use of words in computations eliminates the weaknesses of the previous system in converting words into crisp numbers in evaluation.

In this study, a small population was used to evaluate the method and for simplicity, the weight of all criteria, and students were considered the same. For future work, we will examine the effectiveness of the method with a wider population of students and considering weighted criteria.

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