A Study in Negotiation-based Peer Assessment: Natural Language Applied in Assessment Representation

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Abstract: This study presents a conceptual framework for providing intelligent supports through agent negotiation, fuzzy constraints and natural language processing to enhance the effectiveness of peer assessment. By using fuzzy constraints, it not only provides a flexible marking scheme to deal with the imprecision and uncertainty for the representation of assessment. Additionally, a fuzzy constraint-based negotiation mechanism is employed to coordinate the cognitive differences between students. Through iterative agent negotiation, students can reconcile the differences and reach an agreement on the assessment results. Owing to the difficulty in reading fuzzy sets of assessment results we incorporate the technique of linguistic approximation to translate fuzzy sets into natural language to facilitate students to understand assessment feedback. Experimental results indicated that students were able to acquire more meaningful and readable feedback to reflect upon and revise their work.

Keywords: Peer assessment, linguistic approximation, natural language, agent negotiation

Introduction

Peer assessment supports group learning by motivating students in deep thinking, comparison, discussion and critical judgment of peer work. Numerous researchers have investigated the effectiveness of computer-based peer assessment systems in various learning scenarios [1][2]. In our previous study, we constructed a negotiation-based peer assessment system (NePAS) for providing intelligent supports through agent negotiation and fuzzy constraints to enhance the effectiveness of peer assessment. In this framework, assessments are represented as fuzzy membership functions to deal with the inexactness of marking and its subjective nature. Additionally, a fuzzy constraint-based negotiation mechanism is employed to coordinate the cognitive differences between students. Through iterative agent negotiation, students can reconcile the differences and reach an agreement on the assessment results. The proposed framework can provide more detailed, informed, and make students more inclined to accept the results and to reflect upon and revise their work. However, human are often led to use words in natural language instead of numerical values. Interpretation of fuzzy sets often involves the use of linguistic approximation that assigns a linguistic term to a fuzzy set based on the predefined primary terms, linguistic modifiers and linguistic connectives [3]. This study incorporates the techniques of linguistic approximation and natural language processing to enhance assessment representation. Fuzzy linguistic techniques that can help allow representing qualitative phenomena from a

quantitative approach and even deal with incomplete information [4]. According to the mapping of linguistic approximation and fuzzy sets of assessment results, the graphics of assessment results can be transformed into sentences to express peers' suggestions.

1. Enrichment of Peer Assessment Process

Previous studies reveal that students can have a more in-depth contact with the course material for knowledge interpretation, prolonged interaction between peers for provision of constructive feedback based on multiple observations of performance and opportunity to develop critical reasoning skills and self-directed learning during peer assessment [5][6]. Through a student-involved and interactive process, students' interpretation and reflection can be enhanced, and instructors also can improve their understanding of students' performance by observing students' interaction. However, students may not have the control over the assessment process, and thus they possibly disagree with the assessment rating given by instructors or other peers. Students have difficulties in comprehending how to reflect on their work if assessment results are only given as scores without textual feedback [7]. To alleviate the aforementioned weakness, we have presented a conceptual framework for the enrichment of a peer assessment process as shown in Figure 1.

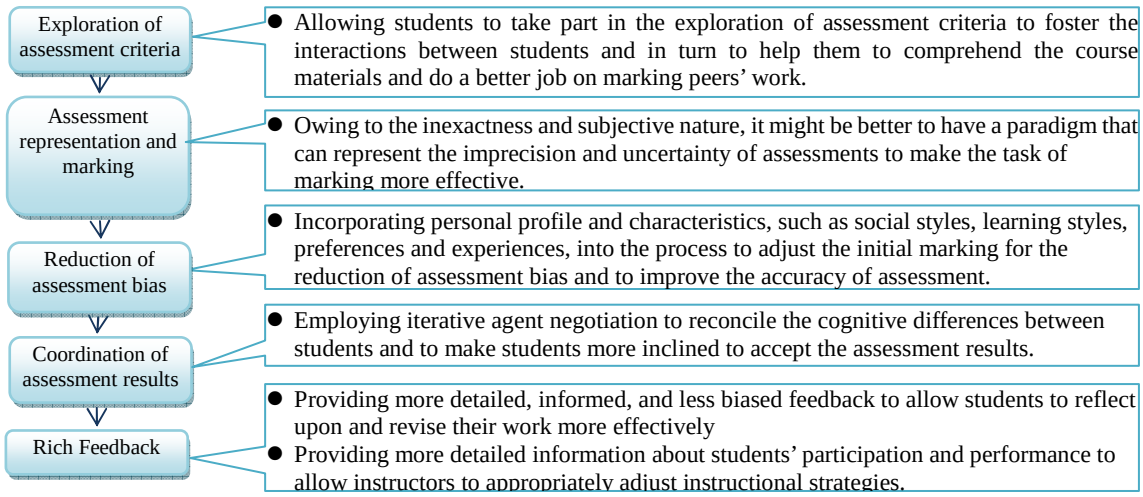

Figure 1. A conceptual framework for the enrichment of a peer assessment process

In this study, we focus on the aspect of rich feedback. Receiving accurate and complete feedback is correlated with effective learning [8]. In the stage of rich feedback, previous proposed method uses defuzzification technique to generate scores to represent assessment results. However, the type of assessment results cannot provide students rich feedback. This study proposes an enhanced framework to incorporate linguistic approximation and natural language processing to produce meaningful representation about assessment results. The enriched peer assessment process enables students to enhance course interpretation, frequently interact with peers, represent their thinking and reflect their work. Through the interactive process and enhancement of assessment representation, assessment accuracy and quality can be improved. The overall process facilitates students in fostering critical thinking skills and reflection as well as promoting meaningful learning.

2. Representation of Assessment in Natural Language

In our previous study, the assessment process and results were represented in graphics and scores. It is difficult to facilitate students to understand peers' assessment and intent of assessment results. Therefore, this study incorporates fuzzy linguistic techniques and natural language processing to represent assessment results in words in order to produce meaningful feedback. Fuzzy linguistic techniques that can help allow representing qualitative phenomena from a quantitative approach and even deal with incomplete information [9]. The linguistic approach is an approximate technique which represents qualitative aspects as linguistic values by means of linguistic variables, that is, variables whose values are not numbers but words or sentences in natural language. The label is a word or sentence belonging to a linguistic term set and the meaning is a fuzzy subset in a universe of discourse. The information processing includes the following three steps:

- Definition of the linguistic term set with its semantic. It consists of establishing the linguistic expression domain used to provide the linguistic performance values according to the different assessment criteria.
- Computation of linguistic approximation. Linguistic approximation can be formalized in the terms of re-translation rules that correspond to the translation rules [11]. The fuzzy membership function of assessment results can be translated into linguistic quantifiers that can be used to represent assessment in natural language.
- Decision of the best representation. It consists of choosing the best semantic according to the linguistic approximation provided.

According to the definition of Zadeh [10], a linguistic variable is characterized by a quintuple (*L*, *H*(*L*), *U*, *G*, *M*) in which *L* is the variable (which is the assessment criteria); *H*(L) (or simply *H*) denotes the term set of *L*, i.e., the set of linguistic values of *L*, with each value being a fuzzy variable denoted generically by *X* and ranging across a universe of discourse *U* which is associated with the base variable u; *G* is a syntactic rule (which usually takes the form of a grammar) for generating the names of values of *L*; and *M* is a semantic rule for associating its meaning with each *L*,*M*(*X*), which is a fuzzy subset of *U*.

In the first step, in order to reduce the complexity of defining a grammar, we use an approach based on an ordered structure to define linguistic terms. A set of seven terms *H* could be given as $H = \{H_0 = None, H_1 = Very\ poor, H_2 = Poor, H_3 = Ordinary, H_4 = good, H_5 = very\ good, H_6 = perfect\}$. The semantic of the linguistic term set is defined by an ordered structure and fuzzy sets represented by triangular and trapezoid membership functions. These membership functions are uniformly distributed. The semantic representation is achieved by four parameters. The first two parameters indicate the interval in which the membership value is 1; the third and fourth parameters indicate the left and right width. For example, $H_0 = None$ = (0, 30, 0, 10),…, $H_3 = Ordinary$ = (60, 60, 10, 10),…, $H_6 = Perfect$ = (90, 100, 10, 0).

In the second step, the problem of linguistic approximation can be defined as mapping from a fuzzy set *X* of assessment results for one assessment criterion into a set of terms *H*. The approximation of fuzzy set H_i and *X* can be defined as follows:

$$\sum Count(H_i/X) = \frac{\sum Count\ (H_i \cap X)}{\sum Count(X)}$$

where $\sum Count(X) = \sum_{j=1}^{N} \mu_{X(j)}$ and *i* represents the number of linguistic terms. A solution of linguistic approximation is a linguistic description *HA* composed of linguistic primary terms *A* and linguistic connectives *c* such that it is most meaningful to describe a possibility distribution of a linguistic variable. For example, a given possibility distribution of a fuzzy set *X* describing the assessment criterion may be linguistically approximated to "Content is good or very good", i.e. $HA(X) \equiv X$ is (A_1 *c* A_2) where $X \equiv Content$, $A_1 \equiv Good$, $A_2 \equiv Very\ good$ and $c \equiv$or. Finally, the best semantic can be represented. The results can be represented as "Content is good or very good" for providing appropriate feedback in natural language.

3. System Realization and Illustrative Example

A walk-through example then is used to illustrate a peer assessment process. First, each student accesses the NePAS through an assessment agent which provides intelligent supports for various assessment activities, including criteria exploration and ranking, characteristics detection, self-assessment, making peers' work and feedback. Coordination agent adopts a fuzzy constraint-based negotiation mechanism to resolve the cognitive differences among the assessors and learner himself. Assessment database includes students' assessment log and coordination results. The coordination agent incorporates the techniques of linguistic approximation to translate the fuzzy sets of negotiation results into natural language. The architecture of coordination agent is shown as Figure 2.

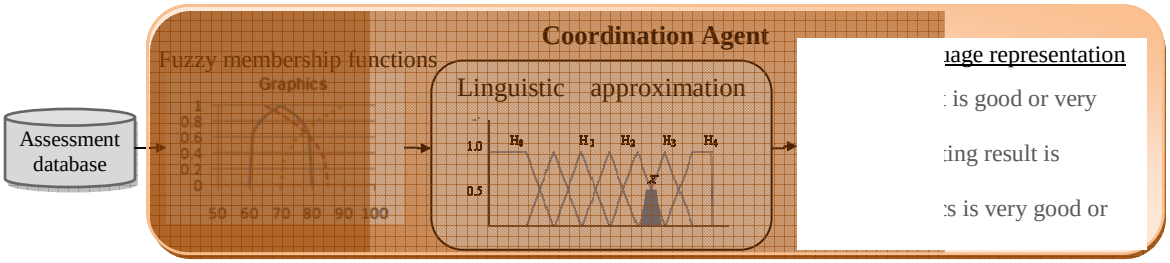

Figure 2. The architecture of natural language representation

During the peer assessment process, students complete and submit their projects to the system, and they then move on to perform peer assessment activities. Assessors select fuzzy membership functions (i.e., triangular, trapezoidal and Gaussian) for each criterion first and then fill out the required (e.g., supports) and optional parameters (e.g., satisfaction degrees). Afterward, a graphical representation of the fuzzy membership function is displayed on the right for reviewing and can be changed literally, if necessary. By using fuzzy membership functions for assessment representation, it provides not only an effective approach for dealing with the uncertainty and impreciseness, but also allows the students to express the confidence of their assessment. A negotiation is automatically performed to coordinate the cognitive differences among students. Agreement is achieved when all participants agree. The communication protocol for agent negotiation is adapted from [11]. The curves indicate the acceptable ranges when students propose their own offers by lowering the threshold. If an overlap exists between acceptable ranges, an agreement can be expected. Otherwise, agents need to revise their assessments prior to a new negotiation process.

Finally, after several rounds of negotiation between agents I, J and K, it has arrived at an agreement on the assessment results of student K's web site design as shown in Figure 3 (solid areas). However, students are difficult to understand the intents of the graphics, and thus we use the technique of linguistic approximation to translate them into natural language to facilitate students to realize assessment feedback. For the assessment criterion "*Content*", the assessment representation in natural language is "*the content is good or very good*". The feedback and the linguistic approximation are represented in Figure 3. At the same time, students can also examine the satisfaction value (0.6, 0.6, 0.7, 0.6) for each criterion. The closer the satisfaction value is to 1, the higher is the acceptance for the assessment results. Therefore, the system can offer rich feedback with two dimensional representation and foster deeper reflection and thinking. Additionally, the system also employs a defuzzification technique to render numerical scores for students' performance.

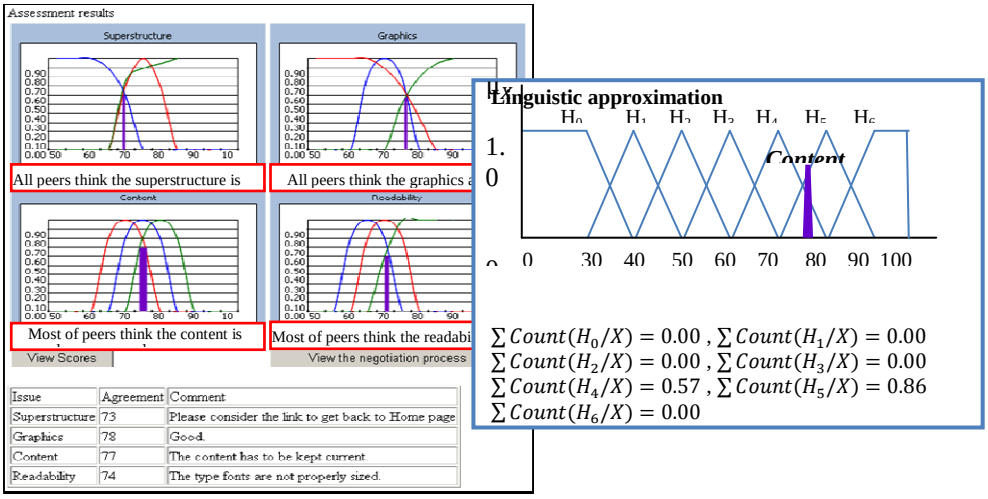

Figure 3. Representation of assessment results and linguistic approximation

4. Conclusions

This study has presented how to use linguistic approximation to represent assessment results in natural language. The difficulty in reading assessment results can be resolved and thus students can understand peers' feedback more inclined to accept the assessment results and to reflect upon their own work. Although the proposed methodology has yielded promising results in promoting the effectiveness of peer assessment, considerable work remains to be done, including further large-scale classroom experiments and system improvement.

References

[1] Lin, S. S., Liu, E. Z. F., Chiu, C. H., & Yuan, S. M. (2001). Web-based peer assessment: attitude and achievement. *IEEE transaction on Education*, *4* (2), pp.211.

[2] Davis, R., & Berrow, T. (1998). An evaluation of the use of computer supported peer review for developing higher-level skills. *Computers and Education*, *30*, pp.111-115.

[3] Kowalczyk, R. (1999). On numerical and linguistic quantification in linguistic approximation, *Proceeding of IEEE Systems*, pp. 326-331.

[4] Cabrerizo, F. J., P´erez, I. J., & Herrera-Viedma, E. (2010). Managing the consensus in group decision making in an unbalanced fuzzy linguistic context with incomplete information, *Knowledge-Based System*, *23*(2), pp. 169–181.

[5] Hattum-Janssen, N. V., & Lourenco, J. M. (2006). Explicitness of criteria in peer assessment processes for first-year engineering students. *European Journal of Engineering Education* , *31* (6), pp. 683–691.

[6] Ballantyne, R., Hughes, K., & Mylonas, A. (2002). Developing procedures for implementing peer assessment in large classes using an action research process. *Assessment & Evaluation in Higher Education* , *27*, pp. 427-441.

[7] Lan, C. H., Graf, S., Lai, K. R., & Kinshuk. (2011). Enrichment of Peer Assessment with Agent Negotiation, *IEEE Transactions on Learning Technologies*, 4, pp.35-46.

[8] Bangert-Drowns, R. L., Kulick, C. L., Kulick, J. A., & Morgan, M. T. (1991). The instructional effect of feedback in test-like events. *Review of Educational Research* , *61*, pp. 213-238.

[9] Herrera, F., & Herrera-Viedma, E. (2000). Linguistic decision analysis: Steps for solving decision problems under linguistic information, *Fuzzy Sets System*, *115*(1), pp. 67–82.

[10] Zadeh, L. A. (1975), The concept of a linguistic variable and its applications to approximate reasoning. *Part I, Inform. Sci. 8*, pp. 199-249.

[11] Lai, K. R., & Lin, M. W. (2004). Modeling agent negotiation via fuzzy constraints in e-business. *Computational Intelligence* , *20*, pp. 624-642.