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Practicality issues in using fuzzy approaches for aggregating students' academic performance

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Abstract

Evaluation of student academic performance is one of the most important parts of the educational process. It has to be done for several important reasons. It also has to provide an evaluation in the form of score or grade that is interpretable by most people especially students, teachers, parents, employers and policy planners. The use of fuzzy approaches to perform student performance evaluation appears very appealing because of the use of natural language in representing the level of performance. However, in spite of such advantages, the existing proposed fuzzy approaches have not yet made any significant impact on the current evaluation systems. This paper presents a brief overview of evaluation of students' performance using fuzzy approaches and discusses the main issues regarding the practicality of using such approaches for aggregating students' academic performance.

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1. Introduction

The rise in the use of computers for assisting student academic performance evaluation has been widely reported in the literature (see for example (McKenna, 2001; Mogey & Watt, 1996)). Various reasons for the use of these new technologies have been highlighted, including to promote learning from feedback, self-assessment and automated assessment systems (Matloobi & Blumenstein, 2007; McKenna, 2001). In general, evaluation of student 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. Currently, arithmetical and statistical methods are the most common techniques that have been used and widely accepted for aggregating information from these assessment components by most educational institutions around the world.

From the literature, it can be observed that the search for alternative and innovative methods to perform student performance evaluation has been identified for many years, and recently several techniques have been proposed. The development of new approaches is also timely as the traditional approaches have been used for very long time

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although there are limitations with these traditional approaches (Rasmani & Shen, 2005). In this work, it is argued that the current method of classifying and grading student academic performance, using arithmetical and statistical techniques, does not necessarily offer the best way to evaluate human acquisition of knowledge and skills. It is expected that reasoning based on fuzzy approaches will provide an alternative way of handling various kinds of imprecise data, which often reflect the way people think and make judgments.

2. Brief Overview of Fuzzy Approaches in Educational Evaluation

Assessment components consist of a wide variety of assessment methods such as series of tests and quizzes, portfolios, formal written examinations, assignments and coursework, observation, etc. Different assessment components reflect different modes of evaluation used to assess student academic performance. The linguistic terms that represent student performance in each assessment component can be represented using predefined fuzzy sets. As there are different kinds of academic performance evaluation, different types of assessment components may be represented using different membership functions. Each of the assessment components could be defined according to the characteristics of the components. For example, 'Achievement in Mathematics' could be different from 'Achievement in English Language'. Thus different kinds of linguistic terms may be used. Furthermore, the characteristic of each linguistic term used also varies according to the relevant standard. Thus, the proposed membership function of each assessment component can be defined according to the criteria of the assessment components.

From the literature, it can be observed that applications of fuzzy approaches cover several different areas in educational systems. Four main areas of applications have been identified; 1) aggregation of students' score, 2) evaluation of instruction carried out by computer, 3) evaluation of educational systems/curriculum, and 4) prediction of ability based on evidence. Of particular interest to the research presented in this paper is the use of fuzzy approaches for the aggregation of student scores, where several techniques have been proposed with the aim to provide alternative techniques to the existing traditional evaluation methods. In (Biswas, 1995; Chen & Lee, 1999; Wang & Chen, 2008), fuzzy techniques have been proposed for aggregation of scores obtained in an answering script. In (Law, 1996), a fuzzy technique has been proposed for grading student's performance based on numerical scores obtained in several assessments. More recent fuzzy techniques for aggregation of students' score have been proposed in (Wang & Chen, 2008) in which fuzzy marks in a student's answer script are represented using type-2 fuzzy set.

In (Carlsson, Fuller, & Fuller, 1997; Fourali, 1994), fuzzy approaches have been proposed to be used for the evaluation of prior educational achievement based on evidence such as academic certificates. In (Kwok, Ma, Vogel, & Zhou, 2001), a fuzzy approach for collaborative assessment has been proposed with the aim to improve on-going teaching and classroom management. A technique based on a neuro-fuzzy approach has also been proposed to predict student performance based on their previous achievement at secondary school level (Al-Hammadi & Milne, 2004). Fuzzy experts' rule-based approaches have also been proposed; for example in (Nolan, 1998), a fuzzy rule-based approach was proposed to be used for classification of student writing samples. Instead of focusing on the development of alternative methods, interesting research has been reported in (Rasmani & Shen, 2005) which proposed the use of a fuzzy rule-based approach as an extended method of student performance evaluation.

3. The Main Issues

While the potential use of fuzzy approaches for educational evaluation have been mentioned repeatedly in the literature (see for example (Johanyak, 2010), it can be observed that the practicality issue of using such techniques never been discussed extensively. This is supported by the fact that many of the proposed methods such as mentioned in the previous section mainly focus on the development of the inference techniques rather than exploring the practicality of using such techniques in a real world situation.

3.1. Types of input values

In line with the general fuzzy approaches, fuzzy techniques used for the evaluation of student performance involve three important tasks: *fuzzification* of input values, the fuzzy inference process and *defuzzification* of fuzzy output values (Zhou, Ma, Turban, & Bolloju, 2002). At the initial stage of evaluation, an evaluator needs to award marks or linguistics terms to represent student performance, depending on the fuzzy techniques that will be used for inference. In cases where numerical values are used, the evaluation can be performed either using crisp values or fuzzy values. The main advantage of using fuzzy marks rather than crisp marks is that this avoids *fuzzification* process whilst at the same time avoiding other disadvantages such as loss of information in the *fuzzification* process. Although awarding fuzzy marks look like a better technique compared to awarding crisp marks, the main question regarding how to awards such marks efficiently still needs to be resolved.

In (Biswas, 1995), a fuzzy grade sheet has been proposed to be used to collect fuzzy marks. The fuzzy grade sheet is a table containing rows for question numbers and columns for awarding marks in term of fuzzy values. In order to facilitate the evaluation process using fuzzy marks, several variations of fuzzy grade sheets have also been proposed (Chen & Lee, 1999; Wang & Chen, 2008). The use of fuzzy grade sheets seems very useful for an evaluator to award fuzzy marks for each assessment components. However, the tasks to award fuzzy marks may not be practical when the number of questions increases or mode of assessment changes, as it may involve awarding too many fuzzy values to evaluate each of the components. This may becomes more critical when a large number of subjects and students have to be evaluated. Additionally, the use of a fuzzy grade sheet to obtain fuzzy marks can be very confusing because the fuzzy marks may not refer to the predefined level of performance.

Besides the disadvantage mentioned above, in (Rasmani & Shahari, 2009), it was discovered that there were great difficulties in awarding marks in the form of fuzzy values. This appeared to be due the type of functions that are normally being used to represent fuzzy membership functions that can be available in the form decreasing, *unimodal* or increasing functions. For example, for a decreasing fuzzy membership function representing linguistic label 'unsatisfactory', higher fuzzy membership values correspond to lower performance, whereas for an increasing function representing 'excellent', the higher the values of fuzzy membership functions correspond to higher performance. This can be even more confusing in the case of *unimodal* functions in which the highest membership values do not represent the lowest or the highest performance. This example shows that awarding fuzzy marks can be very confusing and not quite simple such as the current practice in awarding marks using crisp values.

3.2. Types of output values

The output of the fuzzy inference process can be in the form of fuzzy values or crisp values. In cases where crisp values are needed for the final classification or grade, a *defuzzification* method needs to be employed. The use of crisp output values can be an advantage as these values can be easily interpretable by the user whilst at the same time can also be used for further analysis including traditional statistical analysis. On the other hand, the use of fuzzy values to determine the final classification or grade can be very useful because these values can be used to determine the strength of each classification outcome (Rasmani & Shen, 2005) . However, the use of fuzzy values may create undecided outcomes where the fuzzy membership value for a particular grade can be exactly the same as the fuzzy membership value for another grade. This situation does not normally occur in the case of crisp values. Additionally, these output values may not be able to be utilised for further analysis unless other fuzzy methods are available and can be used for this purpose. Nonetheless, regardless of the type of output used to represent the final outcomes (i.e. fuzzy or crisp, or whether a numerical value or a linguistic label), the output from any fuzzy technique must also be easily interpretable by the user.

3.3. Evaluation using natural language

As has been mentioned earlier, natural language is the normal way to describe student academic performance. Hence, it is expected that the use of natural language (rather than numerical values) will allow more flexibility in

making judgments on students' performance. In this sense, fuzzy approaches seem very promising for the realization of evaluation of student academic performance using natural words rather than numerical values. The evaluator can evaluate student performance using natural language and a proper fuzzy inference mechanism may be used to aggregate student academic performance. An appropriate fuzzy technique that is capable of aggregating information given in the form of natural language is therefore needed. Furthermore, it is also expected that performance evaluation based on natural language will be easier to conduct compared to the traditional systems based on numerical values. This could prove to be very useful for evaluations that involve large numbers of students, where evaluation needs to be carried out in a limited time.

One of the main challenges in using natural language is that no specific fuzzy method is currently available to transform student performance collected entirely in the form of natural language. A possible solution is the use of fuzzy numbers to represent each linguistic term such as used in (Biswas, 1995) or in (Wang & Chen, 2008). The main obstacle in using such fuzzy numbers is the need for an expert in fuzzy sets to create the predefined fuzzy numbers. Besides this, an evaluator needs to understand the theoretical concepts of fuzzy sets and how such sets have been created. Otherwise the whole evaluation process could produce misleading classification outcomes. Remember that the use of natural language is supposed not only to make the evaluation process faster and easier, but also be able to produce valid and reliable evaluation.

3.4. Application to different hierarchical levels in educational evaluation

As mentioned earlier, academic performance evaluation usually consists of several assessment components. Although there are many different modes of evaluation, it can be observed that aggregation processes need to be performed at different hierarchical levels in educational evaluation. Regardless the type of input values, an appropriate inference mechanism is needed to aggregate the data from the assessment components in order to produce a single score representing the overall achievement. For example, to obtain a single score to represent student achievement in a final written examination, p different marks from p different questions will be used. This is followed by aggregation of different scores from different evaluation methods (e.g. assignments, tests and written examinations). The same process will then be repeated at a higher level. Thus, academic performance evaluation usually involves a hierarchical process. Hence, any new fuzzy aggregation approaches should also provide the capability to be used at different hierarchical levels of performance evaluation.

4. Conclusion

This paper has presented a brief overview of the use of fuzzy approaches in educational evaluation, discussed the main issues regarding the practicality of using such approaches and outlined the current challenges. It has briefly described several techniques have been proposed and the potential of such approaches to be used for the aggregation of students' performance have been explored. However, it can be concluded that although fuzzy approaches may be used as the alternative methods, there are many issues regarding the practicality of fuzzy approaches that must be tackled before these approaches can be successfully used. It seems that there is still a long way to go before these approaches will be accepted and implemented in mainstream educational systems. Hence, while focus on the development of suitable fuzzy inference methods for aggregating student score should be further explored, more research on the practicality of using fuzzy approaches for aggregating student score should also be further encouraged. The newly developed fuzzy approaches for aggregating student academic performance should also look into ways of avoiding, or at least reducing, any of the disadvantages mentioned in this paper.

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