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DEVELOPMENT OF A FUZZY-RULE-BASE SYSTEM WITH EDUCATIONAL APPLICATIONS WITH CASE STUDY

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DEVELOPMENT OF A FUZZY-RULE-BASE SYSTEM WITH EDUCATIONAL APPLICATIONS WITH CASE STUDY

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This project is submitted in partial fulfillment of the requirements for the degree of
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For my beloved family and friends.

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ABSTRACT

In criterion-referenced assessment method (CRA), total score for students' work is gather by summing up the scores for each main criterion, where total score is overall mark awarded to student for their performed work e.g. assignment, test, project and etc. CRA is a linear assessment method where total score varies in direct proportion to the scores from each main criterion. A fuzzy inference system (FIS) based assessment model is proposed and developed to allow non-linear relationship between total score and score from each main criterion. FIS based assessment model is constructed with expert knowledge, rules collected from human expert are stored in fuzzy rule base for the use of inference. The number of rules increases exponentially as the number of main criteria increase. As a solution to this issue, a rule reduction system (RRS) is developed. The RRS can pin point a set of important rules, and it is suggested that only important rules is collected. A case study is conducted to evaluate the performance of the developed system. Empirical results show that the FIS based assessment model allow the non-linear relation among total score and the scores from each main criterion to be modeled. Besides, experiments show that the developed RRS can reduce the fuzzy rule significantly.

ABSTRAK

Dalam kaedah penilaian rujukan-kriteria, jumlah skor untuk kerja pelajar diperoleh dengan menambahkan skor dari setiap kriteria utama, di mana jumlah skor adalah keseluruhan markah yang diberi kepada pelajar untuk kerja mereka seperti tugasan, ujian, projek dan sebagainya. Penilaian rujukan-kriteria adalah satu kaedah penilaian linear di mana jumlah skor berkadar terus dengan skor dari setiap kriteria utama. Satu model penilaian berasaskan sistem inferens kabur adalah dicadangkan dan dihasilkan untuk membenarkan hubungan tak linear antara jumlah skor dan skor dari setiap kriteria utama. Model penilaian berasaskan sistem inferens kabur dibina berserta dengan pengetahuan pakar, peraturan yang dikutip daripada pakar disimpan dalam pangkalan peraturan untuk kegunaan inferens. Bilangan peraturan bertambah dengan pesat apabila bilangan kriteria utama meningkat. Untuk menyelesaikan isu ini, sistem pengurangan peraturan telah diperkenalkan. Sistem pengurangan peraturan boleh mengenal pasti peraturan yang penting, dan system ini mengesyorkan bahawa hanya peraturan yang penting sahaja perlu dikutip. Satu kajian kes telah dijalankan untuk menilai prestasi sistem yang telah dibangunkan. Keputusan eksperimen menunjukkan bahawa model penilaian berasaskan sistem inferens kabur yang membenarkan hubungan tak linear antara jumlah skor dan skor dari setiap kriteria utama dapat dibina. Selain itu, eksperimen menunjukkan bahawa sistem pengurangan peraturan boleh mengurangkan peraturan dengan nyata sekali.

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LIST OF ABBREVIATION

CRA	Criterion-Referenced Assessment
FIS	Fuzzy Inference System
FMEA	Failure Mode and Effect Analysis
GDSS	Group Decision Support System
GRRS	Guided Rule Reduction System
IC	Integrated Circuit
NRA	Norm-Referenced Assessment
RRS	Rule Reduction System
SVD	Singular Value Decomposition

CHAPTER 1

INTRODUCTION

1.1 Introduction

Education assessment is an important yet difficult task that would influence students in learning process outcomes (Ma and Zhou, 2000), (Cin and Baba, 2008). Assessment in higher education can be divided into criterion-referenced assessment (CRA) and norm-referenced assessment (NRA). In CRA, students' grades are determined by comparing their achievements with a clearly stated criterion for learning outcomes and clearly stated the standards for particular levels of performance. In NRA, students' grades are awarded based on their ranking within a particular cohort by fitting a ranked list of students' raw scores to a predetermined distribution for awarding grades (Sadler, 2005), (Burton, 2007).

Fuzzy sets theory was introduced by Professor L. A. Zadeh, University of California Berkeley, U.S. in 1965 (Zadeh, 1965). Fuzzy sets theory can be used to represent human's perception and manipulation of information. Human often use fuzzy concept when perceives the outside world. Human brain seems to like to use linguistic hedges like bad, very bad, beautiful, more or less, long, short, etc. to represent the situation or object. This clearly shows that human thinking is able to summarize information into fuzzy sets levels which bear an approximate relation to the primary data. Complex situations are often described in linguistic terms which include the fuzzy denotations (Biswas, 1995).

1.2 Problem Statement

In most cases, student achievement is assessed by tests, assignments or projects (Miller et al., 1998). It is a usually practice to divide tests, assignments or projects to activities/tasks. Scores will be awarded to each activity/task. Nowadays, CRA is used to evaluate student's work by comparing their achievements with a set of stated criteria for learning outcomes and the stated standards for particular levels of performance (Burton, 2007), (Luckett and Sutherland, 2000). In conventional CRA assessment model, total score is obtained by summing up all the sub scores from each activity/task, usually linearly, where total score alters in direct proportion to the sub scores from each activity/task, which is known as a linear assessment method. The score for each activity/task could be weighted according to the importance of each task (Sadler, 2005), (Joughin, 2008).

Let the main criteria for student's project to be evaluated is design skill and presentation skill and full mark for each criterion is 10. Assume one of the students get 9/10 and 6/10 and another student get 6/10 and 9/10 for design skill and presentation skill respectively. By using conventional CRA, both students take the same total score of 15/20 by direct adding the scores for each criterion. However, this may not true in some cases, design skill may has higher importance than presentation skill in that project. FIS based assessment model is introduced, as an alternative to conventional assessment model which allow modeling of nonlinear relationship between total score and the sub scores. In addition, FIS is used in assessment model because it is a framework that allows model to be constructed with expert knowledge.

1.3 Objective

1. To develop a fuzzy inference system based assessment model to evaluate students' lab project.
2. To develop rule reduction system to reduce number of rules in fuzzy rule base.
3. By using Chen and Lee (1999) methods for students' answer scripts evaluation, develop a fuzzy set based assessment program to ease the computation of students' answer scripts.

1.4 Organization

In Chapter 2, fuzzy sets theory, fuzzy membership function and fuzzy inference system (FISs) models, e.g. Mamdani model and Sugeno model FIS are reviewed. A literature on rule reduction and complexity reduction techniques in FIS is presented. A literature on education assessment, with focus in criterion-reference assessment is further presented. At last, a literature on the use of fuzzy techniques in education assessment is reported.

In Chapter 3, background of project, e.g. motivation, problem statements and etc., is presented. A FIS based assessment model and procedure is explained. To further reduce the rules required, a rule reduction method is applied to the FIS based assessment procedure. Chen and Lee (1999) methods for students' answer scripts evaluation is described. Concluding remarks is then presented.

In Chapter 4, assessment results by conventional assessment method and the FIS based assessment method is presented and compared. The results are then analyzed and discussed. Surface plots generated for FIS based assessment method and the conventional assessment method is compared. Results obtained from FIS based assessment model with RRS are presented and compared with FIS assessment model without RRS, the results are analyzed and discussed. Program developed for Chen and Lee (1999) methods for students' answer scripts is discussed.

In Chapter 5, conclusions of the project are presented. Achievement of project towards stated problem is presented. Limitations of project and recommendations on improving project are stated.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

In this chapter, fuzzy sets theory, fuzzy membership function and fuzzy inference system (FISs) models, e.g. Mamdani model and Sugeno model FIS are reviewed. A literature on rule reduction and complexity reduction techniques in FIS is presented. A literature on education assessment, with focus in criterion-reference assessment is further presented. Finally, a literature on the use of fuzzy techniques in education assessment is reported.

2.1 Fuzzy Sets Theory and Fuzzy Membership Function

Fuzzy set theory was introduced as an extension of classical notation of set (Zadeh, 1965). Let X be a universe of discourse with a generic element of X denoted by x. A set A in X is characterized by a membership function $\mu_A(x)$ which associates with each point in X a real number in the interval [0, 1], with the value of $\mu_A(x)$ at x representing the grade of membership of x in A. For classical set, membership function for A can take on only two values 0 and 1 with $\mu_A(x) = 1$ or 0 according as x

does or does not belong to *A,* as in Equation [2.1]. However, for fuzzy set, the grade of membership of x in A is higher when the value of $\mu_A(x)$ is nearer to unity.

$$\mu_A(x) = \begin{cases} 1 \; if \; x \in A \\ 0 \; if x \notin A \end{cases}$$

[2.1]

For example, let X be the universe of discourse of height of human, ranged from 3 feet to 9 feet. Let A be the set of *tall*. In classical set, if the edge between tall and short is 6 feet (Figure 2.1), human taller than 6 feet are considered as tall. Human with the height of 5 feet 11.9 inch are considered as *short*.

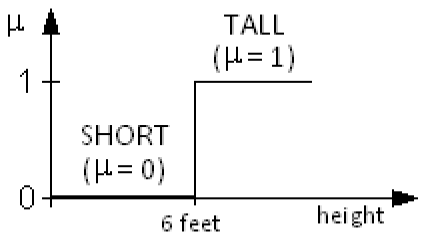

Figure 2.1: Edge between Tall and Short in Classical Set

Figure 2.2 shows a fuzzy membership function of *tall*, as denoted as µ. Height of 7 feet is considered to be tall with membership value of 0.9. Height of 5 feet is considered to be tall with membership value of 0.4.

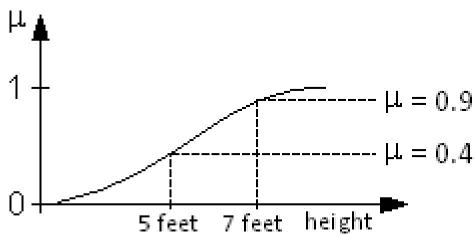

Figure 2.2: Fuzzy Membership Function for Tall

In normal practice, fuzzy membership function is simplified to ease the computation (Nguyen and Walker, 2000). Popular fuzzy membership functions include triangular membership function, trapezoidal membership function and Gaussian membership function.

2.1.1 Triangular Membership Function

Triangular membership function of fuzzy set *A*, $\mu_A(x)$ in *X* is given by Equation [2.2]:

$$\mu_A(x) = \begin{cases} 0, & x < a \\ \frac{x-a}{b-a}, & a \le x \le b \\ \frac{x-c}{b-c}, & b \le x \le c \\ 0, & x > c \end{cases} \quad [2.2]$$

where *a*, *b* and *c* are any real number.

Figure 2.3 shows an example of triangular membership function of set *A* (Satyendar et al, 2008).

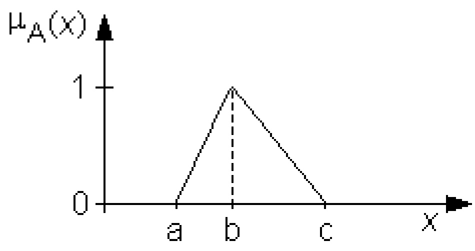

Figure 2.3: An Example of Triangular Membership Function in Set *A*

2.1.2 Trapezoidal Membership Function

Trapezoidal membership function of fuzzy set A, $\mu_A(x)$ in *X,* is given by

$$\mu_A(x) = \begin{cases} 0, & x < a \text{ or } x > d \\ \dfrac{x-a}{b-a}, & a \le x \le b \\ 1, & b \le x \le c \\ \dfrac{x-d}{c-d}, & c \le x \le d \end{cases} \qquad [2.3]$$

where $a < b < c < d$.

Figure 2.4 shows an example of trapezoidal membership function of set *A* (Wang, 1997).

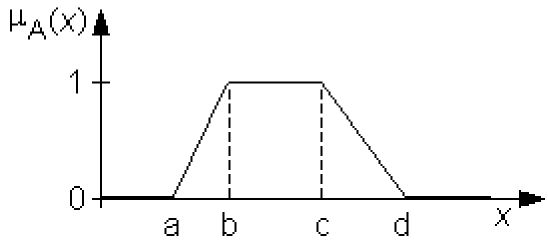

Figure 2.4: An Example of Trapezoidal Membership Function