Fuzzy Modeling for Performance-based Assessment

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Abstract—**Assessment is the most important of all processes in technical education. The high-quality assessment system can increase the students' confidence towards the quality of their training and future employers can have confidence in qualified student. There are many assessment system and practices remain as valid today as they have been. However, new challenge has arisen in this field wherein the traditional approaches to assessment are failing to address. The existing assessment system did not mention about the performance-based assessment that represent a set of strategies for acquisition and application of knowledge, skills, and work habits through the performance of task that are meaningful and engaging to student. This article proposes a performance-based assessment based on fuzzy inference system to characterize student's score information as indicated by the level of their execution, skills and work habits. Here, we perform system identification and parameter estimation of the fuzzy model based on the input data of students' performance. Simulation results verify the performance of our proposed fuzzy assessment model for evaluating students' overall performance. We believe the proposed model will be a reference for education research in seeking authentic measures of student learning through knowledge, skill and work habits.**

Keywords— **fuzzy inference; fuzzification; membership function; Performance-based Assessment;**

I. INTRODUCTION

Fuzzy system is a method that can be applied in as a symbiotic application for many emerging computing disciplines. According to Zadeh, "in contrast to traditional, hard computing, the fuzzy systems tolerant of imprecision, uncertainty, and partial truth" [1]. The fuzzy system allows us to use a language with syntax and local semantics. This can translate the qualitative knowledge about the problem and solve by using fuzzy inference system. The main characteristic of fuzzy system is the robustness of its interpolative reasoning mechanism [2]. In our study, we try to solve the problems of the technical education assessment calculation that usually ill-defined and difficult to model. This is because we are dealing with the human assessment that can be very abstract and subjective [3]. For these cases, almost all existing models are too simple and impractical. Therefore, the use of approximate reasoning system is necessary to handle the imperfect information system [2]. The fuzzy system provides us with a set of flexible computing application to perform this calculation of assessment by using approximate reasoning [2]. In the context of the current interest in measuring teacher's effectiveness, quality of teacher and their teaching is important to distinguish between them [4-5].

Technical academic assessment is the procedure of recording, for the most part in quantifiable terms, information, expertise, states of mind, and convictions. Evaluation can concentrate on the individual learner, the learning group (class, workshop, or other sorted out gathering of students), the organization, or the informative framework in general [4]. Therefore, the suitable calculation method for the technical education assessment is important [6]. The assessment that suitable for technical education is performance-based assessment.

In education, the performance-based approach enables the students to use their knowledge and to apply skills in a realistic situations. Unlike the traditional approach which aim on striving for mastery of

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knowledge and skills, it also measures these in the context of practical tasks. Furthermore, the performance-based education focuses on the process of students go-through while engaged in a task as well as the end product, enabling them to solve problems and to make decisions throughout the learning process. This assessment is an alternative assessment system that can demonstrates the students mastered specific skills and competencies by performing or producing something. The example of performance-based assessment is a group project that require students to apply their knowledge and skills while completing the prescribed task which often call for creativity, critical thinking, analysis, and synthesis.

Evaluation of student performance is one of the most important part in educational process [7]. Therefore, the students' evaluation must be in best possible fairer manner; where as if the process is not properly assessed it will degrade their morals and consequently affect their future prospects and career opportunities.

The use of fuzzy logic theory in the grading system into students' performance evaluation seems a very attractive because it uses logic and mathematics to determine the performance level for each student in more fairly and more intelligent method, as well as accuracy factor in calculating the average marks and classification of the last grade.

II. BACKGROUND STUDIES

In recent years, many articles have been presented for education grading systems by applying the fuzzy set theory [8-15]. There is a very wide scope research for fuzzy math; its basic theory includes fuzzy subsets, fuzzy identification, fuzzy correlation, cluster analysis, fuzzy diagram, fuzzy language, synthetic decision and fuzzy logic [1].

The fuzzy logic is a form of multi-valued logic that allows intermediate values to determine between conventional evaluations such as true-false, yes-no, high-low, and big-small [1]. Notions such as rather tall or very fast can be formulated mathematically and processed by computers in order to apply a more human-like way of thinking. Moreover, in fuzzy system the 'words' or 'sentences' as a part of the regular discussion can be represented as the linguistic variables and come with their linguistic values [13]. These variables speak to the progressive move from high to low, consistent with false and are named fuzzy variables. The utilization of phonetic terms in surveying execution has been the fundamental explanation behind application of the fuzzy system in the process of student execution evaluation [13]. It has been disputed that one of most fitting methods for taking care of different variables that contain free information is to utilize fuzzy system reasoning approach which mirrors the approach for human way of thinking. Fuzzy Logic can be joined into expert system to improve the performance, what's more, unwavering quality of expert system in choice making even amidst instability [13].

Ibrahim Saleh et.al [9], in their study, they proposed a new approach using a fuzzy system in order to assess of students' answer scripts. Their proposed system applied the method of fuzzy which includes (fuzzification, fuzzy inference, and defuzzification) in considering many factors effect on questions such as the difficulty of questions, the complexity and the importance of questions that given to students. Their proposed fuzzy system has many properties such as (objectivity, easy implementation, logical reasoning, and transparency) which offered a useful method to automatically evaluate students' assessment in a more reasonable and fairer way.

J. R. Echauz and G. J. Vachtsevanos [10] , in their study, they proposed a fuzzy logic system for the evaluation of students' learning achievement. They discussed the difficulties related to translating a set of marks/scores into letter-grades. The Fuzzy Grading System uses students' and teachers' performance measures with the aim of modify a set of collectively agreed, a priori fuzzy grades, so as to produce a "fair" mark distribution.

The fuzzy system includes many factors that effect on questions such as: the difficulty of questions, complexity and importance of questions.

III. FUZZY ASSESSMENT MODELING

There are numerous weights of this task, where, this framework is made to facilitate a user in distinguishing student's final grade utilizing the fuzzy system. This system is astounding from the current structure because the estimation and final yield were in light of standards and participation capacity of Fuzzy Inference System (FIS). Whereby, this technique was contrasting with existing framework summation system. The vast majority of college in Malaysia nowadays, utilizing the summation system (non-fuzzy system) amid ascertaining understudy's last checks in term of discovering the final grade of understudies. Microsoft Excel will be their first choice in posting the student's marks and do the summation consequently. Then again, Fuzzy Student's Assessment System is made utilizing Fuzzy Logic procedure, and all the estimation are not by summation while it is by using Mamdani strategy as a part of Fuzzy Inference System. This system will naturally locate the last marks and grade of students after receives the information stacked by lecturers. Additionally, the evaluation will be consequently appear when all the information totally entered. Lecturers can do the correlation between the last yields of student's marks from existing non-fuzzy system and fuzzy system by utilizing this Fuzzy Student's Assessment System.

Fuzzy Assessment System (FAS) was created using MATLAB 7.10.0 (R2010.a). The Fuzzy Logic Toolbox is used to develop the membership function as input and to view the output in the form of a graph. This system able to show the assessment result for students in a semester. The result shows in fuzzy logic interface and the final grade for each assessment grade can directly be identified. The Fuzzy Inferences System used in developing this system is the Mamdani inference system. The Triangular and Trapezoidal Membership Function will be utilized in this system which have proven popular with fuzzy logic system and been used extensively for student academic performance evaluation. This membership function helps in producing the representation of the input data in the form of fuzzy number where this value represent the best assessment criteria.

In this study we construct three sets of fuzzy inference system that consist of three major performance task that enable students to demonstrate their ability to integrate and use knowledge, skills and work habits. The first task is Group Assignment and followed by Quiz. This two task will be integrated to construct the first fuzzy inference system (FIS 1). Next task is Group Projects that will combined with Midterm Exam to determine the second fuzzy inference system (FIS 2). Then both fuzzy inference systems are aggregated together to perform the holistic assessment inference called Output 3. Finally, the Final examination evaluation will be integrated with Output 3 to construct the grade for each student.

The fuzzy sets of the input variables for Carry marks that come from the combination of FIS 1 and FIS2 presented in TABLE I and the membership functions are shown in Fig. 1. Each output variable has four membership functions (two trapezoidal and two triangular) corresponding to Fuzzy Assessment System. The fuzzy sets of the output variables for Quiz provided in TABLE II, and the membership functions shown in Fig. 2.

TABLE I. INPUT VARIABLE 1(CARRY MARKS) IN MEMBERSHIP FUNCTION

Linguistic Variable	Interval
Weak	[0 0 5 15]
Moderate	[12 23 36]
Good	[34 43 55]
Very good	[47 60 70 70]

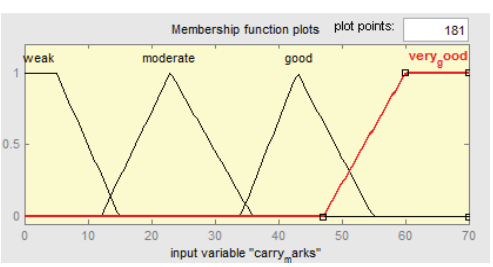

Fig. 1. Membership Function for input variable "carry marks"

TABLE II. OUTPUT VARIABLE IN MEMBERSHIP FUNCTION

Linguistic	Interval
A	[80 90 100 100]
A-	[75 79 84]
B+	[70 74 77]
B	[65 69 72]
B-	[60 64 67]
C+	[55 59 62]
C	[50 54 57]
C-	[47 49 52]
D+	[44 46 48]
D	[40 43 45]
E	[0 0 39 42]

Fig. 2. Membership Function for output variable "gred"

The Linguistic variable in this analysis is in view of an interim that alludes to the level of accomplishment given by expert as indicated in Table I and II. The output performance based on student's final examination result whereby the grade is referring to the level of performance of the student. This is based on one of Malaysia's University grading scale. This project was combined two Fuzzy Inferences System (FIS), to evaluate the final marks of students. Thus, FIS 1 and 2 will be the primary input for FIS 3 while FIS 1 and FIS 2 itself has two inputs for each.

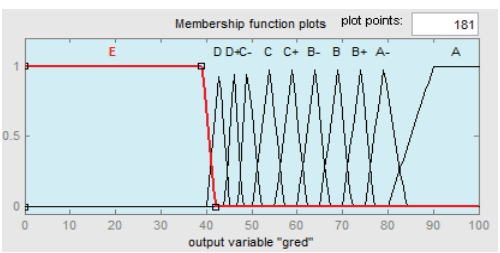

Fig. 3. Fuzzy Classification Model (Design Flow)

As mentioned above, three types of fuzzy set had been joined to determine the final total marks of student, which are:

QUIZ and ASSINGMENT: This FIS 1 contains two input and one output which is Quiz and Assignment as input and Mark_Level as the output.

PROJECT and MIDTERM: This FIS 2 includes two input and one output which is Project and Midterm as input and Marks as the output.

CARRY MARKS and FINAL: This is the final FIS 3 which used to combine both outputs from the above FIS 1 and and FIS 2 then sum up with student's final examination marks. This FIS contains two input and one output which is Carry_Marks (**[QUIZ and ASSINGMENT] + [PROJECT and MIDTERM**) and **FINAL** as input and Grade as the output.

A fuzzy rule portrayed as a conditional statement in the structure: IF x is A, at that point, y is B, where x, and y are linguistic variables. A and B are linguistic value controlled by fuzzy sets on the universe of talk X and Y, separately. Mamdani technique is used in this research, and it operates based on inference mechanism described by the equation.

$$\mu_c(y) = \text{Max}_K\,[\min\,[\mu_A\,(\text{input}(i), \mu_B(\text{input}(j))]\,], \qquad (1)$$

where K = 1, 2, 3, 4… , μ_A and μ_B is the membership function of the input variable. Then $\mu_c(y)$ is the output membership values.
It decides yield enrollment capacity esteem for each governs in dynamic mode. At the point when one standard is dynamic, an AND operation is connected between inputs. All fuzzy rules used AND operation between the input and output. The fuzzy inference process for **CARRY MARKS** score of 17 and **FINAL** score of 7.23 generating *grade value* of 20.9 portrayed in Fig. 4.

The evaluation performance of the final output can be seen by using the surface viewer. Surface Viewer is the place where the result of the performance can be seen inspected in graphical form. Fig. 4 show the grade performance for two inputs (**CARRY MARKS and FINAL**) where the higher value of input will present the greater value for output.

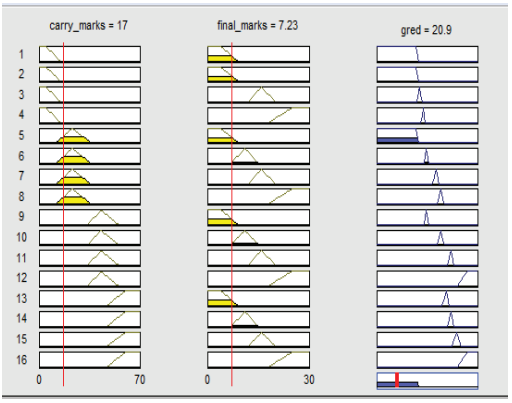

Fig. 4. Rule Viewer of Fuzzy Assessment System

IV. RESULT AND DISCUSSION

Result segment exhibit about the execution of the estimation utilizing a fuzzy system to compute the marks of Quiz and Assignment (FIS 1), Project and Midterm (FIS 2) with Carry Marks and Final Marks (FIS 3). The execution had been represented from the Rules and Membership Function. Accordingly, FIS 1 and FIS 2 yields will be joined to be the input of FIS 3. Fig. 3 demonstrates the combination of three Fuzzy Inference System to construct the final grade for each student.

A. Output Design of Fuzzy Assessment System

Fuzzy Assessment System (FSAS) contain two sides; the left side is for particular lecturer to stack the marks details, view the histogram and the marks list, utilizing fuzzy logic framework, as well, to see the grade evaluated by the fuzzy system. This Fuzzy Expert System will show the outputs into the same page where it produces the marks and graph. Histogram and bar chart will be the outputs in that page, together with the grade 'message box'. Fig. 5 shows the histogram generated from the data loaded by Lecture using the fuzzy logic mark's evaluation system that has been developed over the membership function, rules and coding behind the GUI system. Message box for achieved grade will only appear when user requests it.

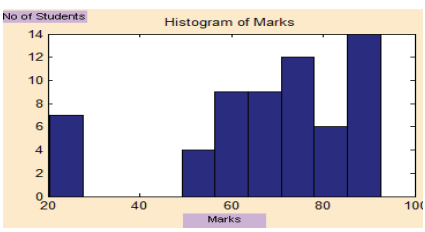

Fig. 5. Fuzzy Student's Assessment System histogram

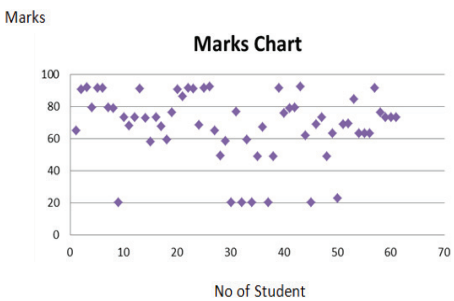

Fig. 6. Fuzzy Student's Assessment mark's output

B. Comparison between Fuzzy System and Non-fuzzy system

Purpose of this Fuzzy Student's Assessment System is to help brilliant students to get the equitably and precisely marks based on their achievement. While the less astute students will get their marks according to their course works and final examination results. Therefore, this system was mainly focusing at final examination marks because it is the accurate method can be used to measure the abilities and intelligence of each student individually.

The fuzzy system assigns higher marks for the students which had performed well during final examination while it will reduce the students' marks if they are unable to achieve well during final examination. Furthermore, this system can estimate whether these students imitate the work of others in producing their tasks. However, besides final examination marks, other coursework marks such as quiz, midterm test, project and assignment marks also very essential to make sure students' performance are consistent and worthy to receive high marks and excellent grade for each subject. However, non-fuzzy system will directly do the marks summations (over 100%) to find the total value without considering the student's eligibility to receive it based on performance in class.

V. CONCLUSION

The paper describes the performance-based assessment system using fuzzy model to characterize student's score information as indicated by the level of their execution, skills and work habits. Here, we perform system identification and parameter estimation of the fuzzy model based on the input data of students' performance. Simulation results verify the performance of our proposed fuzzy assessment model for evaluating students' overall performance. It worth of future exploration to utilize bind systems of Fuzzy Logic and Artificial Neural Networks called Neuro-Fuzzy Systems to assess student performance.

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