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Analysis of Fuzzy Logic Modeling for Student Assessment in E-Learning

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Abstract:- The way of teaching in new normal life is drastically changed around the world including our country. Consequently, the determination of the student's performance is also not simple as in previous conventional education system. The grading of the student cannot be computed not only the result of the exam. Thus, the more criteria have to be considered to determine the student assessment. And, the computation of the student performance is more complicated than the classical way. So, the automatic judgement of student's performance is needed for today's education system. In this paper, the fuzzy logic is modeling for calculation of the performance of the students from the online class. The fuzzy set theory helps the teachers to know easily about the student at the specific course by using the linguistic term. The fuzzy logic toolbox in MATLAB is used to simulate the student's performance judgement system.

Keywords*: Education System, Fuzzy Logic, Student's performance.*

1. Introduction

Since 2019, the coronavirus pandemic makes the changes the classical way of teaching system. During the difficult time, the students want to access the education continuously during the pandemic. At that time, online learning system is being popular among the students and the judgment of the student's performance is consequently changed. Many different ways of theories and computation methods are considered for computing the student's performance. Among them, we use the fuzzy logic for modelling the judgment of the student's performance.

In the studies of the M. Akkur et.al [1], the fuzzy logic is used to decide the performance of the students and they used the theory and practical marks with the other assessments as inputs to the system. According to the other studies, the fuzzy based approach is widely used in the educational system such as the students' achievement evaluating from the answer scripts [2, 3] and the laboratory application [4, 5]. In the study of the Wardoyo et.al [6], they used the fuzzy theory for calculating the students' performance using three types of inputs as fuzzy membership function namely the knowledge, the forum-participation time and attendance. The made some analysis concerned with the fuzzy range of the input membership functions. In the previous works, the fuzzy logic with different type of functions is applied in different studies. Interval Type- Fuzzy logic is applied for the evaluation of the student's grading system to avoid the human judgment and to use the advantage of the fuzzy system with linguistic nature [7, 8]. Gaussian membership function of the fuzzy logic-based calculation of the student's result are mention in the study of [9]. The results comparison of using different fuzzy membership function are presented in the studies of [10] and they preferred to use the Gaussian membership functions. Fuzzy logic-based approaches are very popular in the education field not only for the student's grading system but also for the educational path of the student's interest. In the studies of the G. Agarwal et.al [11] and Alexandra et.al [12], they used the fuzzy logic to make the decision of the higher study field for the students. The inputs to the fuzzy system are the marks of the students in different subject to implement for getting the best future perspective.

2. Fuzzy Logic System

Fuzzy logic is mainly used for this study. There are three stages in the fuzzy logic system. They are the fuzzification, the fuzzy inference engine and defuzzification as in the figure 1. Fuzzy rules generated by the expert drive the fuzzy inference engine. That type of the fuzzy inference system is called as the three-node fuzzy system.

This research is conducted with the online lecture implemented by the LMS Moodle. In this paper, the simulation results of the 20 students are presented [6]. The simulation is implemented via Fuzzy Logic Toolbox in Matlab.

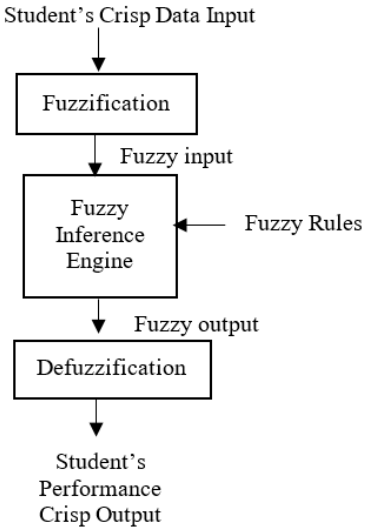

Figure 1. Fuzzy System Implementing the Student's Performance

A. Fuzzification

Triangular membership function is used for fuzzification process of the student's data. The crisp value of the student's data is fuzzified to be usable form of the fuzzy inference system. In this study, three inputs, namely Exam Marks, Assignment Marks and the attendance of the students are used. Fuzzy range for respective input parameters is mention in the following. At every stage of the Fuzzy Inference System, the set range of the function is defined by the linguistic term that is one of the advantages of the fuzzy logic. By using the linguistic term, it provides the user-friendly feature.

The triangular curve is a function of a vector, x, and depends on three scalar parameters *a*, *b*, and *c*, as given by the equation 1.

$$f(x;a,b,c) = \begin{Bmatrix} 0, & x \le a \\ \frac{x-a}{b-a}, & a \le x \le b \\ \frac{c-x}{c-b}, & b \le x \le c \\ 0, & c \le x \end{Bmatrix} \quad \text{Equation 1}$$

The parameters *a* and *c* locate the "feet" of the triangle and the parameter *b* locates the peak.

B. Exam Marks

Like the conventional education system, it has the final examination from which the marks of the students are used as one of the inputs to the system. The given exam marks are 100 and these are ranged as Very Low, Low, Average, High and Very High by linguistic terms as in the figure 2. As an example, when the exam mark of 75 is applied as the red dotted line in the figure 2. In the classical set theory, one element is completely a member of a set from the universe and it is not a member of the other set. According to the fuzzy set theory, the exam mark can be treated in more than one class. So, the exam mark 75 has the membership value from the High and Very High class. The fuzzy value for the High class, the third part of the equation 1 is applied

$(\frac{c-x}{c-b} = \frac{90-75}{90-70} = \frac{15}{20} = 0.75)$. The fuzzy value for the Very High class, the second part of the equation 1 is applied

$(\frac{x-a}{b-a} = \frac{75-70}{90-70} = \frac{5}{20} = 0.25)$.

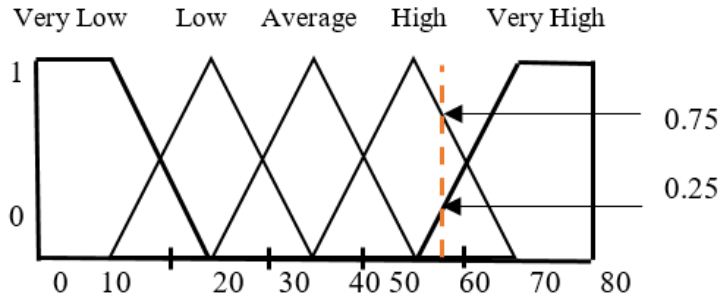

Figure 2. Fuzzification Function of Exam Marks

C. Assignment Marks

Assignment includes the quiz and reports during the school time. It has totally 60 hours lecture periods and the assignment provide every 3 hours of period. Thus, 20 times of the posting the assignment and the given marks of each assignment is assumed as 10 marks. The total 200 assignment marks are divided as four fuzzy range, namely Less, Medium, High and Very High. For the 160 assignment marks, it gets the fuzzy value of 1 that reach the peak at High class as in figure 3.

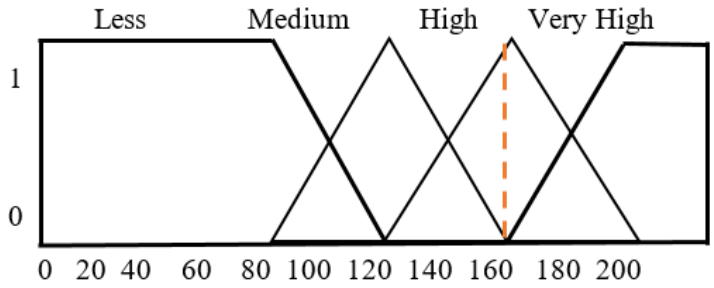

Figure 3. Fuzzification of Assignment Marks

D. Attendance

Counting of the attendance is slightly different from the conventional class. Online class can check the login minutes. For the 60 hours lecture periods, it has 3600 minutes that is divided as five ranges such as Very Less, Less, Medium, High and Very High. For the crisp value of 2475 minutes of the attendance, it gets the fuzzy value of 0.525 and 0.475 in the Medium and High class respectively as in figure 4.

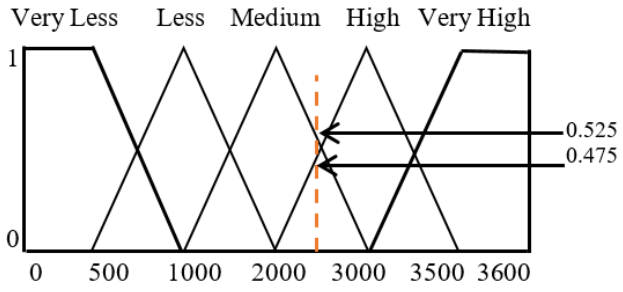

Figure 4. Fuzzification of the Attendance Minutes

3. Fuzzy Inference Rules

There are 100 rules for the fuzzy inference engine based on the 5 range of the exam marks, 4 ranges of the assignment marks and 5 ranges of the attendance. The rules are provided by the experts. One of the advantages of the fuzzy logic approach is that it does not need to make some training like other machine learning technique. Instead that, the rules made by the experts can manage the classification process.

For the above three inputs, the active fuzzy rules are presented as below.

If the Exam Marks is High (0.75) and the Assignment Mark is High (1) and the Attendance Minutes is Medium (0.525) then the Performance is Good (0.525).

If the Exam Marks is High (0.75) and the Assignment Mark is High (1) and the Attendance Minutes is High (0.475) then the Performance is Good (0.475).

If the Exam Marks is Very High (0.25) and the Assignment Mark is High (1) and the Attendance Minutes is Medium (0.525) then the Performance is Good (0.25).

If the Exam Marks is Very High (0.25) and the Assignment Mark is High (1) and the Attendance Minutes is High (0.475) then the Performance is Excellent (0.25).

4. Defuzzification

The achievement of the students is marked as five classes as in figure 5. The fuzzy value is converted to the crisp value by the defuzzification process. The performance of the specific student can be seen not only the linguistic terms but also the marks. The linguistic term led to be easily understood for everybody. According to the above active rules of section 2.2, Defuzzification is computed by the centroid method. And, the performance is resulted as 77.5 that retain in the Good class. The centroid method computed via the fuzzy membership value and their respective class.

$$\frac{(0.525 \times 75) + (0.475 \times 75) + (0.25 \times 75) + (0.25 \times 90)}{0.525 + 0.475 + 0.25 + 0.25} = \frac{116.25}{1.5} = 77.5$$

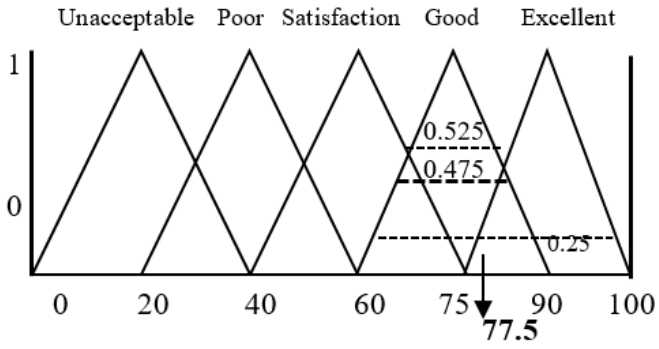

Figure 5. Defuzzification Ranges of the Student's Performance

5. Results and Discussion

In this system, the student's grading system is computed by the way of the fuzzy logic approaches. For the validation of the output of the system, the results are compared with the classical computational results as in table 1. In the classical way, the mean value of the student's data is taken. As in figure 6, the results using the fuzzy logic is getting almost the same one with the classical results. But the fuzzy logic approach can provide the personalization facility. In which, each student can get the individual privileges according to their effort. As shown in table 1, the students can be an excellent one when he or she gets the marks of 90 and above. The student no: 2 get the excellent grade although he gets the same exam marks with the student no: 1. Moreover, the student no: 1 gets the higher assignment marks. That can be proved that the fuzzy logic is adaptable with the calculation of the student's grade because the classical system emphasis on the percentage of the attendance. In the conventional education system, the student must have the 75% of attendance to get the permission for sitting the final exam. For the totally of 3600 minutes, the student needs to attend the class at least 2700 minutes. And the student no: 1 is not fulfilled the 75% of the attendance minutes. In this way, the student no: 1 cannot get the excellent grade. The student no: 2 with the high exam mark, the high assignment marks and the very high attendance rate is classified as the excellent student by the fuzzy logic approach. But the classical computation cannot define the student no: 1 as an excellent grade. Similarly, the student no: 6, 8 and 13 is defined as the

excellent grade by the fuzzy logic approach but it cannot be done by the classical way. The fuzzy logic approach has the advantages to treat each student to get the true grade.

Table 1. Student's Data and Performance

Students no:	Exam Marks	Assignment Marks	Attendance (Minutes)	Results 1 (Fuzzy)	Results 2 (Classic)
001	93.3	200	2461	80.8	87.2
002	93.3	160	3457	90	89.8
003	100	100	227	60	52.1
004	93.3	100	826	60	55.4
005	100	140	2073	77.2	75.9
006	100	160	3088	90	88.6
007	40	100	1071	32.1	39.9
008	100	120	3120	90	82.2
009	93.3	180	1836	55.8	78.1
010	100	100	1820	70.2	66.9
011	80	140	2475	80	72.9
012	100	160	3500	90	92.4
013	100	120	3350	90	84.4
014	100	120	1904	73.7	71
015	100	120	255	60	55.7
016	100	100	1400	65.3	63
017	93.3	100	2553	76.1	71.4
018	100	120	227	60	55.4
019	66.7	140	1199	57.9	56.7
020	100	160	481	60	64.5

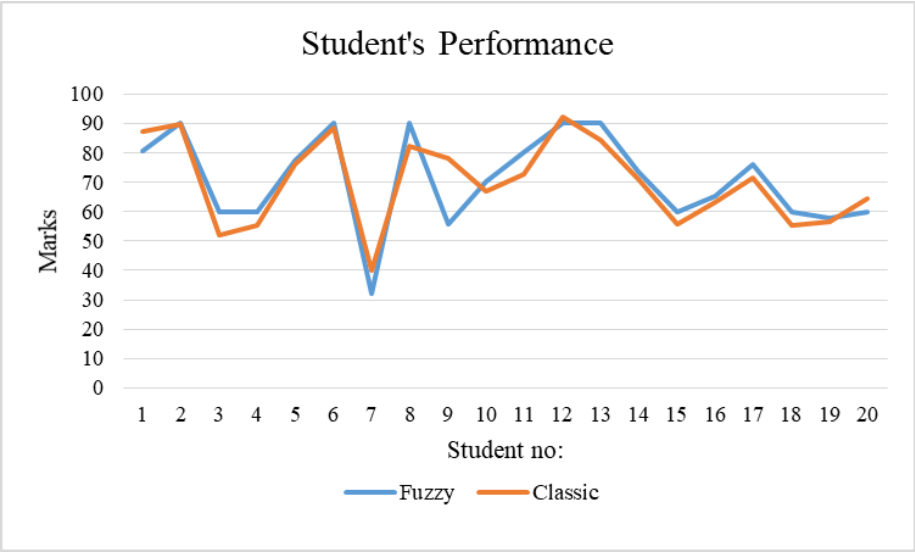

Figure 6. Results Comparison

6. Conclusion

This study implements the student's performance computation system using the Fuzzy logic. The exam marks, assignment marks and the attendance are used as inputs. The output of the system is the student's performance. The Fuzzy logic approach can provide some advantages for computing the student's grade. It can give the individual privileges for the students. In this way, the satisfaction of the students can be provided related with the grade computing method. The results of the system are validated with the classical computation results.

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