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Sugeno Fuzzy Inference Method and MatLab Application Program for Simulation of Student Performance Evaluation in the Elementary Mathematics Learning Process

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ABSTRACT

The purpose of this study is to make a simulation for the assessment of student performance in elementary mathematics learning process by using fuzzy logic to overcome the problem of the assessment process of student performance. Besides that there is no special system that can optimize in providing support for teachers in conducting evaluations that are still manual calculations. One way of determining the calculation of student evaluation results can be facilitated by using the help of Artificial Intelligence (AI) considerations as an optimization. In consideration of the performance evaluation (performance) of these students using fuzzy logic with the sugeno inference system method. This sugeno method is a fuzzy inference method for rules which is represented in the form of IF-THEN, where the system output is not a fuzzy set, but in the form of a linear equation. The criteria used in the assessment of student performance include very unsuccesusful, unsuccessful, average, successful, and very successful. In this simulation the results displayed with manual calculations and MatLab calculations as a comparison of the results of the manual calculation result value of 45 while in the MatLab calculation the result value is 48,5. So it can be concluded that the difference caused by the level of accuracy of the results of the inference rule in manual calculations is less effective and sometimes even a lot of inference rules must be adjusted.

Key words : Sugeno Fuzzy Inference Method, MatLab Program, Student Performance Evaluation, Mathematics Learning Process.

1. INTRODUCTION

The development of human life is currently progressing very rapidly. This development applies to all aspects such as economics, social, politics especially in the field of technology. Along with the progress of information and communication technology plays a very important role in human life. Humans began to use technology such as computerization in helping work and everyday life. Examples in the world of education there are academic information system that can help estimate teachers in processing values and help students control their learning outcomes. Estimates of this value are often found in the fields of artificial intelligence such as fuzzy logic, mathematical techniques from set-theory that can be applied to various forms of decision making including research on techniques and artificial intelligence. At present the technology as above has been developed in the world of education as in all universities in Indonesia. Estimates of the results of this student evaluation are needed and have their own consideration of each parameter. This can be seen from the number of initial inputs from student evaluations.

Student evaluations that occur at this time the teacher must write manually and consider one thing or another to be able to determine the final results of student evaluation. Along with the development of the era found a computerized way that makes it easy for teachers to make decisions. The technology starts from the form of desktop applications to applications that are online. However, the application or technology that has been created is now found weaknesses that can affect the results. There are many factors that influence the results of student evaluations such as the values at the time of the examinations that need to be considered weight. Assessment in education is often a numerical value obtained from the results of teacher evaluations of students. For this reason, evaluation of student evaluations is seen from various supporting criteria. This is because assessment and calculation are the most important part of the education process. The assessment has various methods in conducting evaluations using flows, classical evaluation systems, educational successes or failures because it is based on separation through certain score limits [1], [2]. As an example in the application of student assessment in the laboratory there are 50 students who should be said to be worthy of satisfying grades after learning in the laboratory. In its application not all students can be said to pass, this is because some of these students cannot meet the specified standards. Supported from research [3]-[10] which proposes fuzzy logic to optimize the performance evaluation of the students.

One way to determine the calculation of student evaluation results can be facilitated by using the help of artificial intelligence as an optimization. This consideration is used as one part of computer science that studies how computers can work as well as what humans do or even more. In consideration of student performance evaluation using fuzzy logic [11], [12]. The method used in fuzzy logic in this study is the sugeno inference system method. Fuzzy logic is a methodology of counting with linguistic variables instead of counting with numbers [13]. Fuzzy logic is the process of formulating the mapping from a given input to an output [14]. While the reason for using the fuzzy method is because this concept is easy to understand, flexible, has a high level of tolerance, is able to model complex nonlinear functions, and is based on natural language [15]. On this occasion the author simulates an evaluation evaluation of students using fuzzy logic with the sugeno inference system method. Fuzzy sugeno method is a fuzzy inference method for rules that is represented in the form of IF - THEN, where the output (consequent) of the system is not in the form of a fuzzy set, but in the form of constants or linear equations [16]. The benefit of sugeno-type fuzzy inference system is that it can further integrate with many optimization techniques [17]. In this simulation the results are displayed with the help of MatLab as a calculation [18], [19]. As a comparison, manual calculations will also be carried out related to Sugeno and using pre-existing formulas**.**

2. METHOD

The method used in developing this system is reasoning, which is problem solving by presenting the problem into the knowledge base using logic or formal language (a language that can be understood by computers), while the logic used is fuzzy logic. In the calculation of fuzzy logic for three stages that must be passed, namely: (1) fuzzification; (2) inference engine; and (3) defuzzification [20] - [25].

2.1 Fuzzification

Fuzzification is a process of converting existing or definite values (crips input) into the membership function. At this stage the crips input is the value of each input variable consisting of exam1 (exam value 1) and exam2 (exam value 2) and result (as the value of student performance). Fuzzy set design consisting of several variables in determining the value of student performance is obtained from two variables exam1 and exam2. While the description of the relationship of input and output variables is shown in Figure 1.

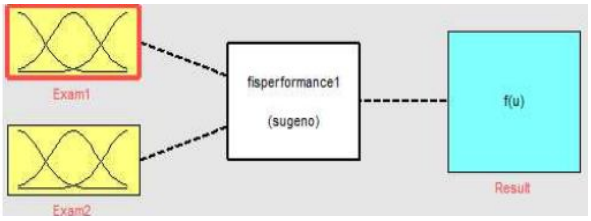

Figure 1: Input and Output Variables using the Sugeno Method

Table 1: Classification of Exam 1 and Exam 2

Variable Linguistik			Interval
Input	Exam 1	VL	(0, 0, 25)
		L	(0, 25, 50)
		A	(25, 50, 75)
		H	(50, 75, 90)
		VH	(75, 90, 100)
	Exam 2	VL	(0, 0, 25)
		L	(0, 25, 50)
		A	(25, 50, 75)
		H	(50, 75, 90)
		VH	(75, 90, 100)
Output	Result	VU	(0, 0, 25)
		U	(0, 25, 50)
		A	(25, 50, 75)
		S	(50, 75, 90)
		VS	(75, 90, 100)

*Note: VL = very low, L = low, A = average, H = high, VH = very high, VU = very unsuccessful, U = unsuccessful, S = successful, VS = very successful.

The formula for determining the value of μ (miu) or the degree of membership of each variable that uses the membership function triangle (triangle) which can be seen in Figure 2.

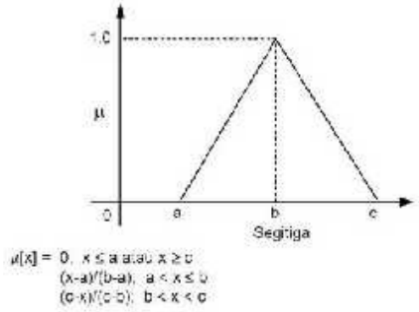

Figure 2: The Formula of Triangle Element Function

The functions element of exam1 and exam2 have the same intervals, so the two exams have the same set of input variables described in Figure 3 and Figure 4.

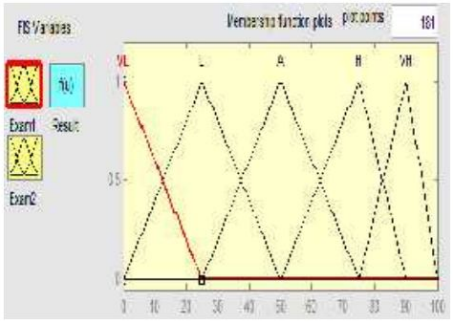

Figure 3: Function Element of Exam 1 based on MatLab Simulation

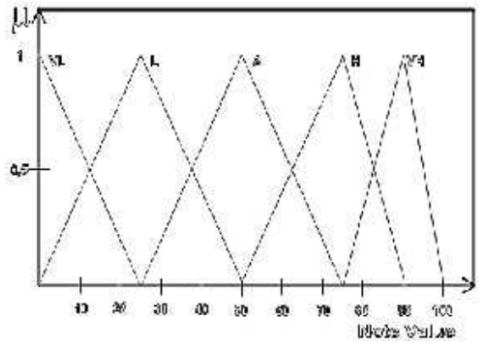

Figure 4: Function element of Exam 1

2.2 Inference Engine

Inference engine in determining the output result (performance value) obtained by students with exam 1 and exam 2. There are 25 rules obtained, as Table II in this system that is used is the MIN method, where fuzzy set solutions are obtained by taking the minimum rule value , then used to modify the fuzzy area, and apply it to the output using AND operators. If all propositions have been evaluated, the output will contain a fuzzy set that reflects the contribution of each proportion. Rules determine the input and output of the membership function that will be in the linguistic inference process and also the rules entitled "IF-THAN"[26]-[27].

Table 2: Inference Engine for Determining the Value of Student Performance

Rule	Output Result (Performance value)
[R1]	IF Exam1 is VL and Exam2 VL THEN Result is VU
[R2]	IF Exam1 is VL and Exam2 L THEN Result is VU
[R3]	IF Exam1 is VL and Exam2 A THEN Result is U
[R4]	IF Exam1 is VL and Exam2 H THEN Result is U
[R5]	IF Exam1 is VL and Exam2 VH THEN Result is A
[R6]	IF Exam1 is L and Exam2 VL THEN Result is VU
[R7]	IF Exam1 is L and Exam2 L THEN Result is U
[R8]	IF Exam1 is L and Exam2 A THEN Result is U
[R9]	IF Exam1 is L and Exam2 H THEN Result is A
[R10]	IF Exam1 is L and Exam2 VH THEN Result is A
[R11]	IF Exam1 is A and Exam2 VL THEN Result is U
[R12]	IF Exam1 is A and Exam2 L THEN Result is U
[R13]	IF Exam1 is A and Exam2 A THEN Result is A
[R14]	IF Exam1 is A and Exam2 H THEN Result is S
[R15]	IF Exam1 is A and Exam2 VH THEN Result is S
[R16]	IF Exam1 is H and Exam2 VL THEN Result is U
[R17]	IF Exam1 is H and Exam2 L THEN Result is A
[R18]	IF Exam1 is H and Exam2 A THEN Result is S
[R19]	IF Exam1 is H and Exam2 H THEN Result is S
[R20]	IF Exam1 is H and Exam2 VH THEN Result is VS
[R21]	IF Exam1 is VH and Exam2 VL THEN Result is U
[R22]	IF Exam1 is VH and Exam2 L THEN Result is A
[R23]	IF Exam1 is VH and Exam2 A THEN Result is S
[R24]	IF Exam1 is VH and Exam2 H THEN Result is S
[R25]	IF Exam1 is VH and Exam2 VH THEN Result is VS

*Note: VL = very low, L = low, A = average, H = high, VH = very high, VU = very unsuccessful, U = unsuccessful, S = successful, VS = very successful.

2.3 Defuzzification

The input from the defuzzification process is a fuzzy set that is obtained from the composition of fuzzy rules, while the output produced is a number in the fuzzy set domain which is the result obtained by students. In this system, sugeno inferencing is used using the defuzzification of the weighted average method calculated by the formula:

$$WA = \frac{\sum_{i=1}^{N} \alpha_i z_i}{\sum_{i=1}^{N} \alpha_i}$$

3. RESULT AND DISCUSSION

2.1 Results

If it is known that a student A takes the first exam (exam 1) gets a score of 40 and on the second exam (exam 2) gets a value of 65. With both the values obtained, the value of student performance will be calculated.

A. Manual Calculation

A.1. Fuzzification

The function element of exam 1 = 40 is shown in Figure 5 below.

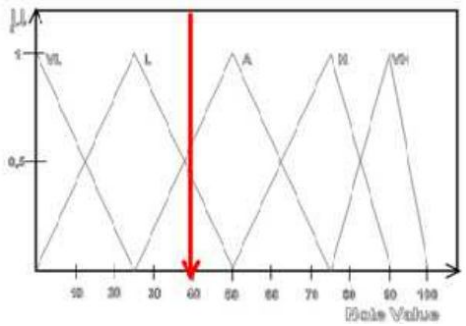

Figure 5: The Function Element of Exam 1 = 40

The calculation of function element for Exam 1 = 40 lies in two fuzzy sets namely Low and Average.

μLow (40) = $(c - x)/(c - b)$
= $(50 - 40)/(50 - 25)$
= $10/25$
= 0,4

μAverage (40) = $(x - a)/(b - a)$
= $(40 - 25)/(50 - 25)$
= $15/25$
= 0,6

The function element of exam 2 = 65 is shown in Figure 6.

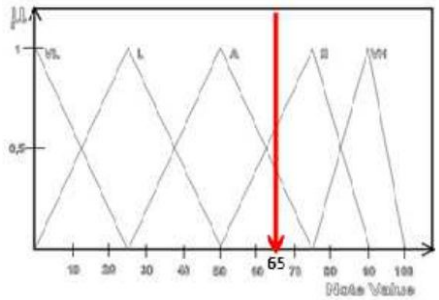

Figure 6: The Function Element of Exam 2 = 65

Table 3: The Active Element Rule

Exam1/ Exam2	VL	L	A	H	VH
VL	VU (R1)	VU (R2)	U (R3)	U (R4)	A (R5)
L	VU (R6)	U (R7)	U (R8)	A (R9)	A (R10)
A	U (R11)	U (R12)	A (R13)	S (R14)	S (R15)
H	U (R16)	A (R17)	S (R18)	S (R19)	VS (R20)
VH	A (R21)	S (R22)	S (R23)	VS (R24)	VS (R25)

Calculation of functions element in Exam 2 = 65 is located in two fuzzy sets, namely Average and High.

μAverage (65) = $(c - x)/(c - b)$
= (75 – 65)/(75– 50)
= 10/25
= 0,4

μHigh (65) = $(x - a)/(b - a)$
= (65 – 50)/(75 – 50)
= 15/25
= 0,6

A.2. Inference Rule

The Inference rule used:

[R8] : IF Exam1 is L and Exam2 A THEN Result is U
[R9] : IF Exam1 is L and Exam2 H THEN Result is A
[R13] : IF Exam1 is A and Exam2 A THEN Result is A
[R14] : IF Exam1 is A and Exam2 H THEN Result is S

From the four fuzzy rules used above, the inference rule used by the conjunction rule (^) by selecting the minimum degree, so that it is obtained.

Search for α predicates and WA values on each rule:

R8 If Exam 1 is L 0,4 and Exam 2 is H 0,4 then is U
α predicate 8 = μ Lower ∩ μ High
= min (μExam1 Lower(40), μExam2 High(65))
= min (0,4; 0,5)
= 0,4
The value of WA8 = 40

R9 If Exam 1 is L 0,4 and Exam 2 is H 0,6 then is A
α predicate 9 = μLower ∩ μ High
= min (μExam1 Lower(40), μExam 2 High(65))
= min (0,4; 0,6)
= 0,4
The value of WA9 = 40

R13 If Exam 1 is A 0,6 and Exam 2 is A 0,4 then is A
α predicate13 = μ Average ∩ μ Average
= min (μExam1 Average(40), μExam2 Average(65))
= min (0,6; 0,4)
= 0,4
The value of WA13 = 65

R14 If Exam 1 is A 0,6 and Exam 2 is H 0,6 then is S
α predicate 14= μ Average ∩ μ High
= min (μExam1 Average(40), μExam2 High(65))
= min (0,6; 0,6)
= 0,6
The value of WA14 = 40

A.3. Defuzzification

For the defuzzification process using a weight average, the average value of student performance is used. From the explanation above, the WA value is obtained, namely:

$$WA = \frac{\sum_{i=1}^{N} \alpha_i z_i}{\sum_{i=1}^{N} \alpha_i}$$

WA = (0,4*40) + (0,4*40) + (0,4*65) + (0,6*65)/ (0,4+0,4+0,4+0,6)
= 81/1,8
= 45

The conclusion obtained by using the Sugeno model for exam 1 = 40 and exam 2 = 65, then the value of student performance is 45.

B. Calculation with MatLab

Program simulation using the MatLab application. The input value is the same as the manually calculated value to find out whether the equation or difference is a manual calculation and calculation with a simulation using MatLab. The MatLab calculation simulation is shown in Figure 7.

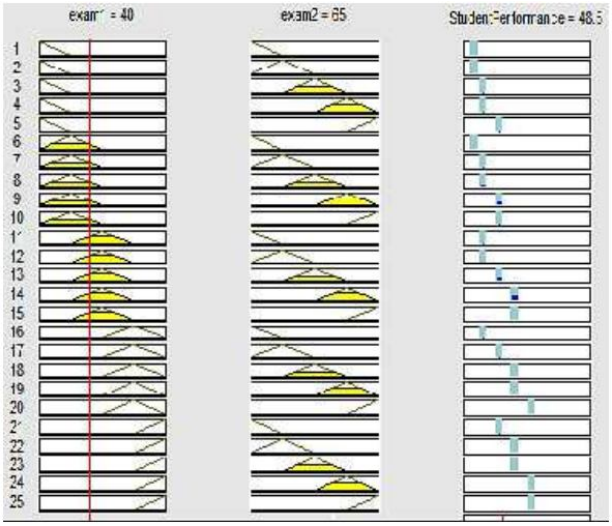

Figure 7: Active Rules and Result Values of Exam Values of 40 and 65

2.2 Discussion

The summary results of the defuzzification of the ten calculations for evaluating student performance using fuzzy logic can be seen in Table 4.

Table 4: Comparison of Defuzzification Results Data

Case	Value		Defuzzification		Difference
	Exam 1	Exam 2	Manual	MatLab	
Case 1	40	65	45	48,5	3,5
Case 2	20	55	25	17,3	7,7
Case 3	70	85	81	95,3	14,3
Case 4	30	89	56,3	58,7	2,4
Case 5	80	52	84,2	80	3,6
Case 6	90	22	63	59	4
Case 7	70	72	86	89	3
Case 8	50	65	59,8	63,1	3,3
Case 9	45	75	70,4	73,6	3,2
Case 10	85	59	85,9	94,7	8,8

Based on Table 4 can be described as follows: (1) the results of the calculation of the first case manual of student performance obtained at 45. While the calculation using MatLab is 48.5, the difference between the two is 3,5; (2) the results of manual calculation of the second case example of student performance are obtained at 25. While the calculation using MatLab is 17.3. The difference between the two is 7.7; (3) the results of manual calculation of the third case performance of student performance are obtained at 81. Whereas the calculation using MatLab is 95.3, the difference between the two is 14.3. The results of the analysis between manual calculations with MatLab show a slightly different difference, this is due to the level of accuracy of the results of the inference rule on manual calculations is not so effective and efficient, even sometimes many inference rules must be adjusted.

4. CONCLUSION

From the explanation above, we can conclude 2 things, they are (1) in determining student performance discussed in this study using the sugeno method with the function of the MIN rule and defuzzification implications using the weight average method, and (2) based on the results of discussion and analysis between manual calculations and Matlab calculations have a slightly different difference, this is because the level of accuracy of the parameter results in manual calculations is not very effective and efficient.

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