

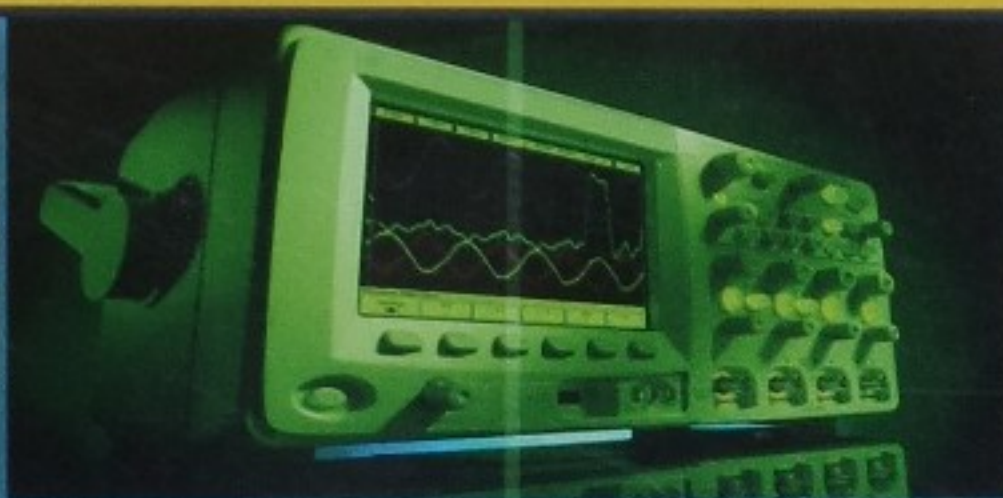
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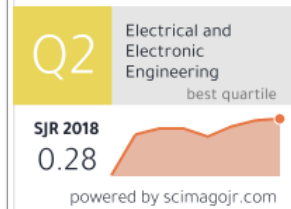
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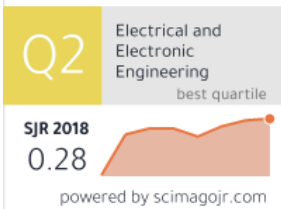
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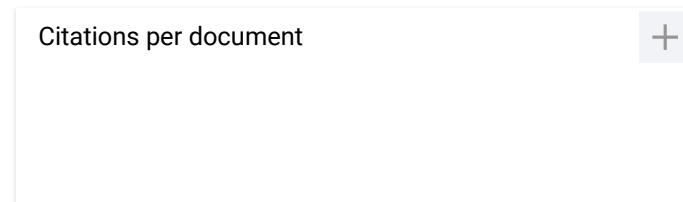
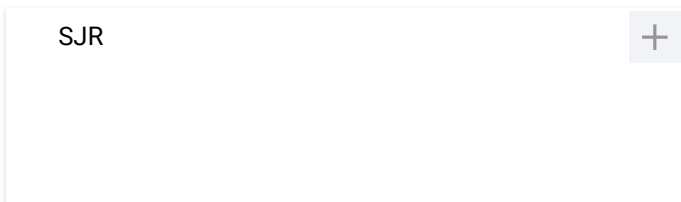
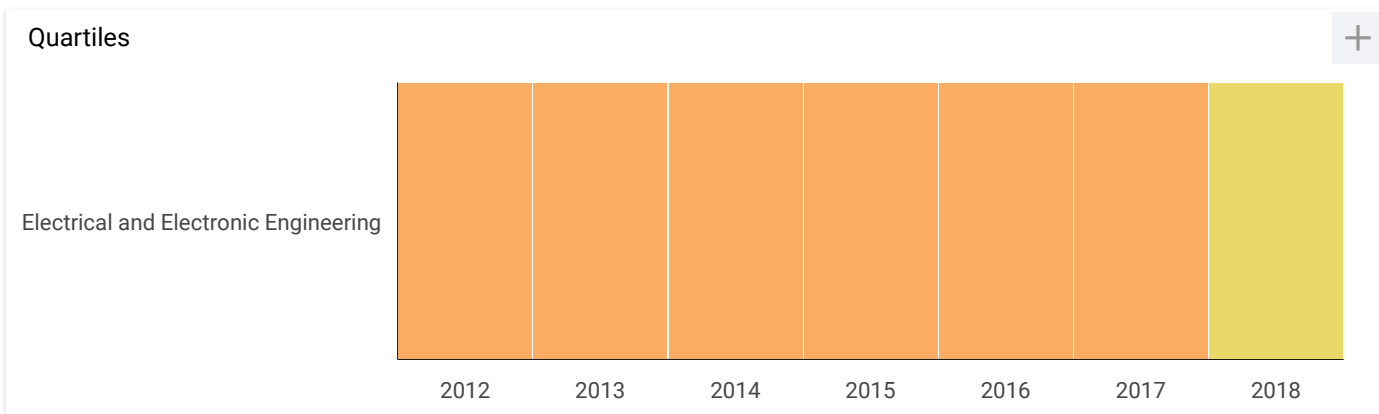
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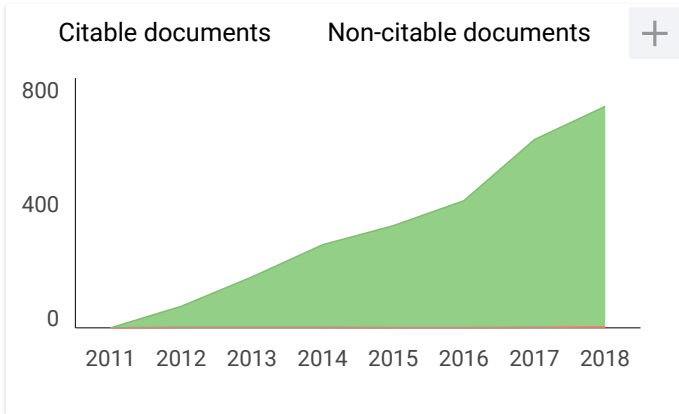
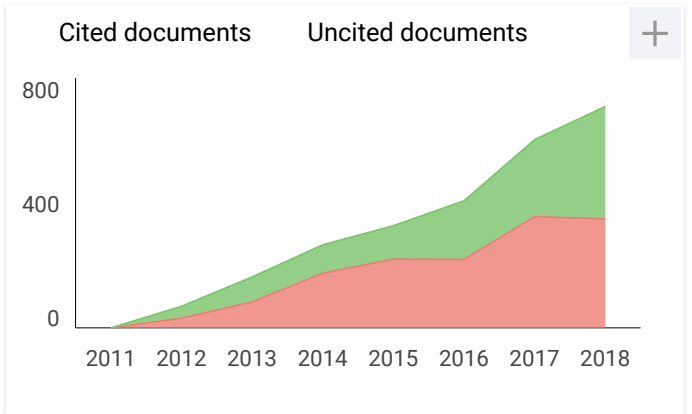
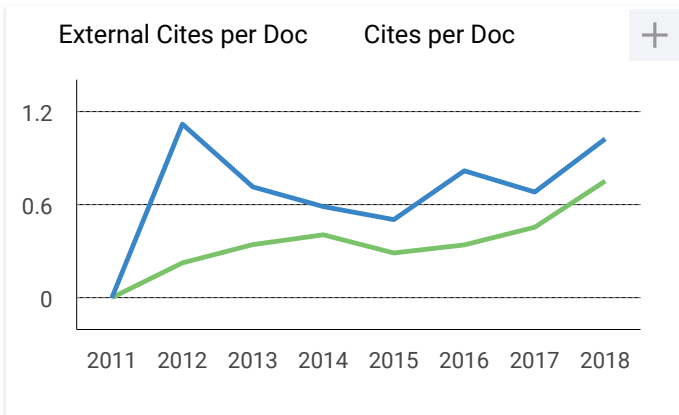
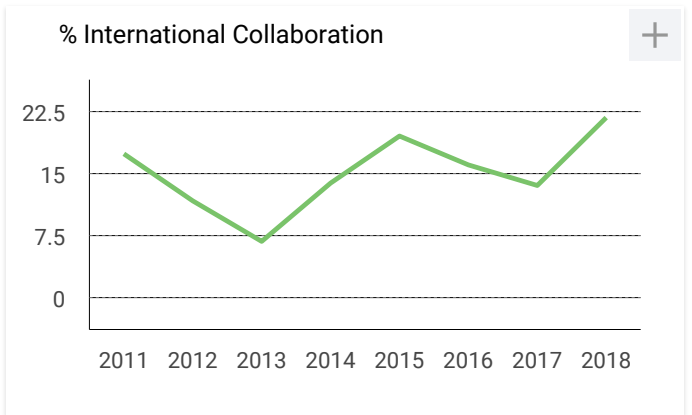
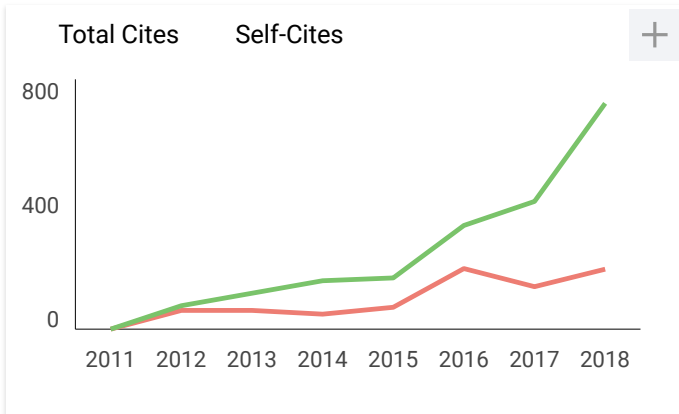
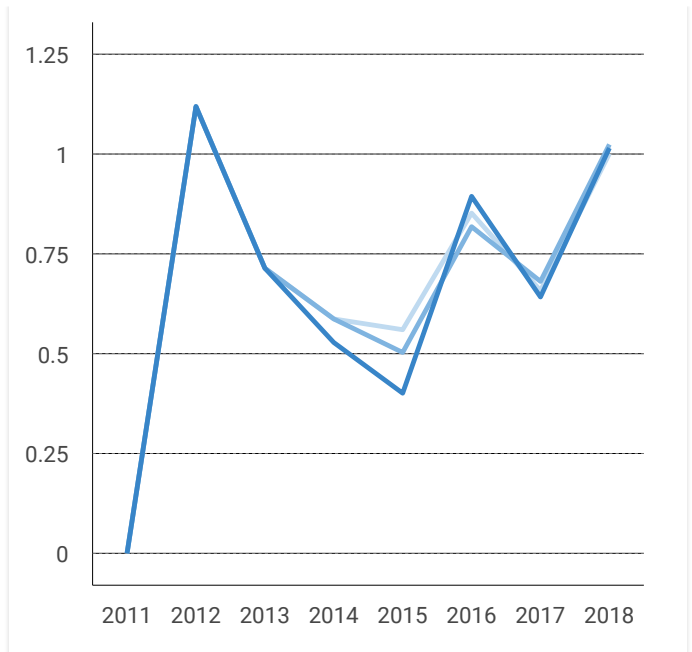
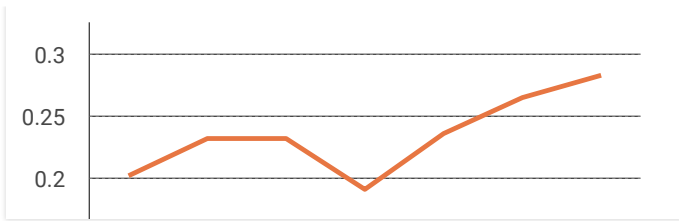
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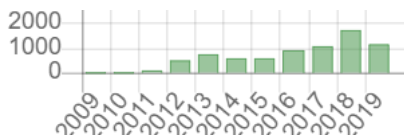
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A Mamdani Fuzzy Model to Choose Eligible Student Entry

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Abstract

This paper presented about study that have been created a new student choosing system by using fuzzy mamdani inference systems method. Fuzzy mamdani is used because it has characteristics such as human perceptions on choosing of students with some specified criteria. The choosing students who want entry to the school have been difficult if it is manually process. With the fuzzy mamdani, the process can be possible completed execute and can be reduced the time of choose. To accomplish the process, the fuzzy variable is created by the national final exam scores, report grade, general competency test, physical test, interview and psychological test. Based on testing 270 data, the fuzzy mamdani has been reached 75.63% accuracy.

Keywords: fuzzy Mamdani inference, choosing, fuzzy variable, membership function

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1. Introduction

The selecting is the process used by an organization to choose from a set of applicants, the person, or persons who best meet the selection criteria for the position available, taking into account current environmental conditions [1]. The selection process of students in a school is one of the stages of new admissions process. In the new admissions process, not all prospective students who apply will be accepted. Therefore, the students who meet the criteria will be selected to be prospective students. The selection is usually based on some specified criteria and process manually. So that, the process of selecting student is take more the time. More over if the parameter which has defined is too many for the process. To help the process, it is necessary to build a system that can determine prospective students selected according to the criteria specified not only cognition criteria but other criteria such as general competency test, physical test, interview and psychological test.

To build the system, we have been defining some fuzzy variables. Fuzzy variable is the set human linguistics that is created by the case. In selection process, we made the fuzzy variable such as national final exam scores, report grade, general competency test, physical test, interview and psychological test.

In the fuzzy term, many fuzzy inference models and the one is fuzzy mamdani inference. Fuzzy mamdani widely used in supporting decision-making as in some studies has been performed which include Muntaha. Mumtaha discusses on the Application of Decision Support System Selecting Candidates for Vocational Students Based Test Results Using Fuzzy Method at SMK Teratai Putih Global 1 Bekasi [2]. Saleh discusses the fuzzy system decision support for the management of breast cancer [3]. Hapsari presents an application of fuzzy Inference system mamdani method for the selection of majors in universities high [4]. Mustafidah and Aryanto presented the system fuzzy inference to predict the achievement of students based on national test scores, academic potential test, and motivation to learn [5]. Mustafidah & Suwarsito explained the prediction achievement of students based on motivation, interest and discipline to use inference system fuzzy [6]. Sumiati and Nuryadhin discussed decision support systems in determining ratings faculty performance with fuzzy database models mamdani [7]. Based on previous studies, the fuzzy mamdani can be used to issue new student selection [2-7], because this method in the calculation process to determine the final

value is based on consideration of each of the criteria that are proposed to specific rules. So, it will get more accurate results in determining the prospective students were selected according to the criteria specified.

In this study has been used fuzzy mamdani inference for the selection of new students by using multiple criteria. Based on a survey that has been collected on 13 schools that made the selection of students and 270 data test, obtained several criteria that include the national final examination middle school used by 9 of the school, the report middle school used by 6 schools, tests of general competence (mathematics, Indonesian, English and science natural) used by 4 schools, physical tests are used by 8 school, the interview is used by 8 school, psychological tests used by 7 schools, vocational competence tests are used by one school, reading and writing test of the Qur'an used by one school.

Based on proposed criteria, the research can be argued that these criteria are not strong influence on the selection of new students. Refer to the previous research; the problem is how much percentage accuracy the fuzzy mamdani model for choosing the student acceptance within parameters that have been proposed. The other problem, what is the parameter that has significantly influence to choose candidature who wants entry to vocation school.

2. Research Method

Fuzzy logic was formerly introduced by Lofti A. Zadeh in 1965. Basic theory of fuzzy logic is fuzzy set theory. Fuzzy language is interpreted fuzzy or vague. Fuzzy logic is a logical development of classical logic. The fundamental difference in fuzzy logic is found in the truth-value range. At the pattern logic value of truth there are only two possibilities, a member of the set or not, true or false, 0 or 1. While on fuzzy logic, the truth value depends on the value of its membership [2]. The fuzzy process can be seen at the Figure 1. Every block has meaning about what the process doing.

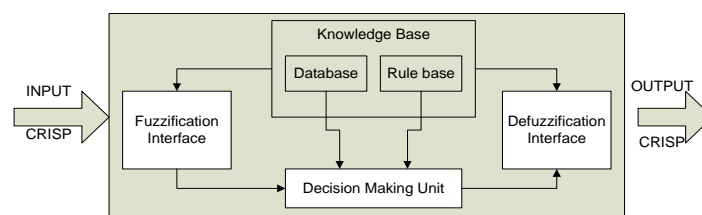


Figure 1. Block Diagram in Fuzzy System Process [11]

Fuzzy mamdani method is one method of fuzzy inference systems. Fuzzy mamdani often referred to as Min-Max method. This method was introduced by Ebrahim Mamdani in 1975. Fuzzy mamdani have characters like human instincts, working under the rules of linguistics and has a fuzzy algorithm that provides an approximation to enter mathematical analysis [2,9]. This research is conducted by Fuzzy Mamdani Method. Fuzzy Mamdani Method is commonly known as Min-Max method. This method was introduced by Ebrahim Mamdani in 1975.

2.1. Determining the Degree of Membership Functions

Determining the degree of membership is the transformation model from crisp value into fuzzy value. The fuzzy fication is setting the value for membership in the fuzzy has a range of values between 0 and 1 [2]. In this stage, the research proposed fuzzy variable and domain value of linguistic. We can be seen on the Table 1, the variable is separated into two parts like input and output variable. The variables have been taken from school perceptions that arrange by the eligibility students who want entry to the vocational school. There are two kinds fuzzy variable such as input and output. Input variable can contain like national grade test, school report, general test, physical test, interview test and psychology test. Meanwhile, output variable just one that determined the pass of entry.

Table 1. Proposed the Fuzzy Variable

Kind of Variable	Fuzzy Variabel
Input	National Grade Test
	School Report
	General Competency Test
	Physical Test
	Interview Test
	Phychology Test
Output	Passed

Furthermore, every operation variable in fuzzy, the value of membership have to domain linguistic value. This idea can be summarized from interview and used human perception. We are pursued every variable have a linguistic domain, like "Low", "Medium", and "High". We can be listed on the Table 2.

Table 2. The Domain of Linguistics Value for Each Fuzzy Variable

<i>variable</i>	<i>Interval of Linguistics value</i>
National Grade Test	Low, Medium, High
School Report	Low, Medium, High
General Competency Test	Low, Medium, High
Physical Test	Minus, Moderate, Good
Interview Test	Minus, Good
Phychology Test	Minus, Good

Refer to the parameter, the straightforward process is mapped the domain value each variable into diagram. We have been choosing diagram that is combine between triangle and trapezoidal. The research is conducted six diagrams for transformation crisp value into fuzzy value. The diagram can be drawn with looking the boundary value for each domain in each variable. Table 3, shows the boundary value for each linguistic at the variable shown. Arrange of values, we have received by average of variables. We divided into three linguistic values such as low, medium, and high. Every linguistic value can arrange by boundary assignment such as bottom value, middle, and top value.

At the Figure 2 shows an example diagram in membership function. We have defined by triangle and trapezoidal diagram. Every diagram was striated for every fuzzy variable which has determined.

Table 3. The Boundary Value of Linguistic for Each Fuzzy Variable

<i>Variable</i>	<i>Linguistic value</i>	<i>Interval value (min, middle, max)</i>
National Grade Test (<i>NGT</i>)	Low	0; 10; 20;
	Medium	15; 22; 29;
	High	25; 35; 40
School Report (<i>Rpt</i>)	Low	0; 55; 65
	Medium	60; 72,5; 85
	High	75; 88; 100
General Competency Test (<i>Cmp</i>)	Low	0; 50; 60
	Medium	55; 67,5; 80
	High	75; 88; 100
Physical Test (<i>Phy</i>)	Minus	0; 50; 60
	Moderate	55; 70; 85
	Good	75; 85; 100;
Interview Test (<i>Intr</i>)	Minus	0; 65; 79
	Good	70; 80; 100
Psychology Test (<i>Psy</i>)	Minus	0; 65; 75
	Good	70s; 75; 100
Passed (<i>Pass</i>)	Not Passed	0; 52; 70
	Passed	60; 75; 100

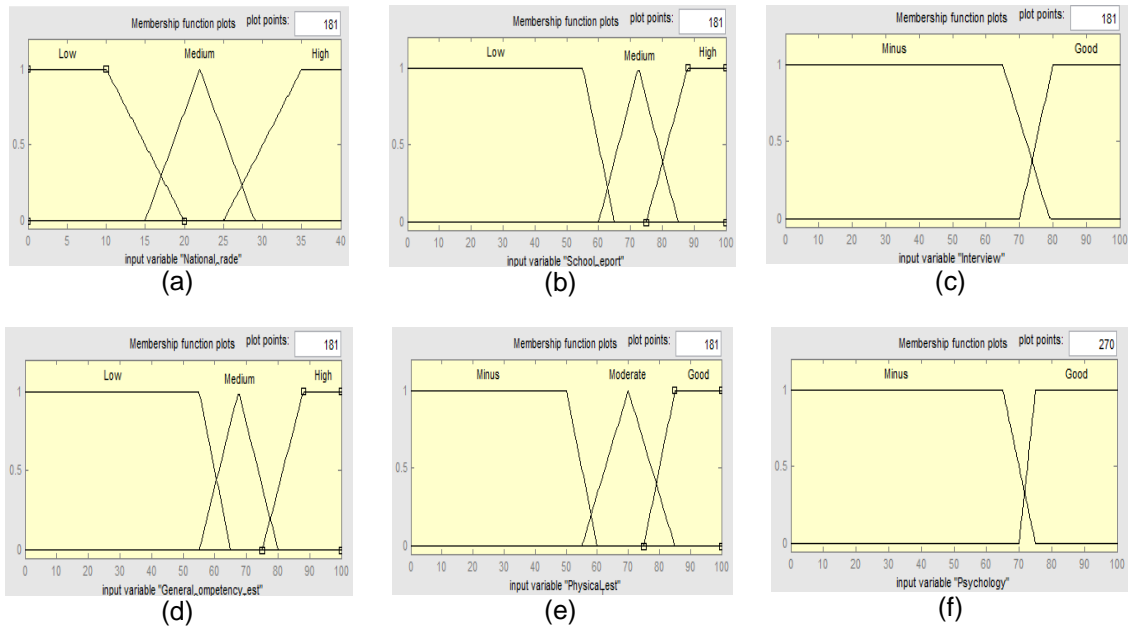


Figure 2. Membership Function (a) National Grade; (b) School Report; (c) General Competency; (d) Physical; (e) Interview; (f) Psychology

To be in line with the goal, we have created the membership function condition. This function can be referred to fuzzy variable and linguistic variable. We defined the variable at the Table 1, 2, and 3. From the Figure 2, we have created every equation for deciding the value of membership. We designed the equation by triangle shape. The equations are shown with the crisp value of membership trough triangle diagram. The set of membership value can be obtained from the boundary for minimum, middle, and maximum value that retrieved from Table 3. In the formula below, we created many functions for transformation crisp value to fuzzy value. It process namely as fuzzification [11].

$$\mu_{Low}[NGT] = \begin{cases} 1; x \leq 10 \\ \frac{(20-x)}{(20-10)}; 10 < x < 20 \\ 0; x \geq 20 \end{cases} \tag{1}$$

$$\mu_{Medium}[NGT] = \begin{cases} 0; x \leq 15, x \geq 29 \\ \frac{(x-15)}{(22-15)}; 15 < x \leq 22 \\ \frac{(29-x)}{(29-22)}; 22 < x < 29 \end{cases} \tag{2}$$

$$\mu_{High}[NGT] = \begin{cases} 0, x \leq 25 \\ \frac{(x-25)}{(35-25)}; 25 < x < 35 \\ 1, x \geq 35 \end{cases} \tag{3}$$

$$\mu_{Low}[Rpt] = \begin{cases} 1; x \leq 55 \\ \frac{(65-x)}{(65-55)}; 55 < x < 65 \\ 0; x \geq 65 \end{cases} \tag{4}$$

$$\mu_{Medium}[Rpt] = \begin{cases} 0; x \leq 60, x \geq 85 \\ \frac{(x-60)}{(72,5-60)}; 60 < x \leq 72,5 \\ \frac{(80-x)}{(80-72,5)}; 72,5 < x < 85 \end{cases} \tag{5}$$

$$\mu_{High}[Rpt] = \begin{cases} 0, & x \leq 75 \\ \frac{(x-75)}{(88-75)}, & 75 < x < 88 \\ 1, & x \geq 88 \end{cases} \tag{6}$$

$$\mu_{minus}[Phy] = \begin{cases} 1; & x \leq 50 \\ \frac{(60-x)}{(60-50)}; & 50 < x < 60 \\ 0; & x \geq 60 \end{cases} \tag{7}$$

$$\mu_{moderate}[Phy] = \begin{cases} 0; & x \leq 55, x \geq 85 \\ \frac{(x-55)}{(70-55)}; & 55 < x \leq 70 \\ \frac{(85-x)}{(85-70)}; & 70 < x < 85 \end{cases} \tag{8}$$

$$\mu_{Good}[Phy] = \begin{cases} 0, & x \leq 75 \\ \frac{(x-75)}{(85-75)}, & 75 < x < 85 \\ 1, & x \geq 85 \end{cases} \tag{9}$$

$$\mu_{minus}[Intr] = \begin{cases} 1; & x \leq 65 \\ \frac{(79-x)}{(79-65)}; & 65 < x < 79 \\ 0; & x \geq 79 \end{cases} \tag{10}$$

$$\mu_{good}[intr] = \begin{cases} 0, & x \leq 70 \\ \frac{(x-70)}{(80-70)}, & 70 < x < 80 \\ 1, & x \geq 80 \end{cases} \tag{11}$$

$$\mu_{minus}[Psy] = \begin{cases} 1; & x \leq 65 \\ \frac{(75-x)}{(75-65)}; & 65 < x < 75 \\ 0; & x \geq 75 \end{cases} \tag{12}$$

$$\mu_{good}[Psy] = \begin{cases} 0, & x \leq 70 \\ \frac{(x-70)}{(75-70)}, & 70 < x < 75 \\ 1, & x \geq 75 \end{cases} \tag{13}$$

2.2. Creating Fuzzy Rules

Fuzzy Inference System (FIS) is also known as rule-based fuzzy systems, fuzzy models, expert systems, or fuzzy associative memory. Fuzzy inference system is the main core of the fuzzy logic system. Fuzzy inference system is formulated appropriate rules are based on the decisions made. It is based on the concept of fuzzy set theory, fuzzy IF-THEN rules, and fuzzy reasoning. Fuzzy inference system is used the rule "IF ... THEN ...", and the other hand is to state the relation between rules, the statement is used "OR" or "AND" to construct the rule needs. At the Table 4, it can be seen that parameter is defined completely. We have designed for each parameter almost 324 fuzzy rules with can be constructed. At the Figure 3, it has shown about rules that pictured in MATLAB [11].

Table 4. An Example of Fuzzy IF-THEN Rules which have taken from Deriving of Membership Function

Rule Number	IF – Then Rule
[1]	IF national grade = low AND school report = low AND competency = low AND physical = minus AND intervie = minus AND psychology = minus THEN passed = not passed
[2]	IF national grade = low AND school report = low AND competency = low AND physical = minus AND intervie = minus AND psychology = good THEN passed = not passed
[3]	IF national grade = low AND school report = low AND competency = low AND physical = minus AND interview = good AND psychology = minus THEN passed = not passed
[4]	IF national grade = low AND school report = low AND competency = low AND physical = minus AND interview = good AND psychology = good THEN passed = not passed

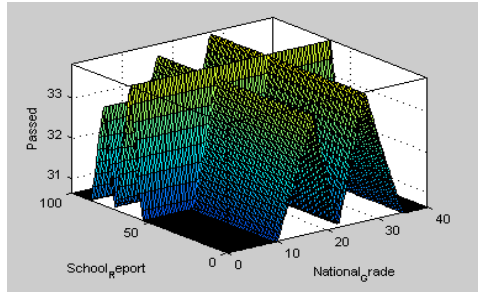


Figure 3. An Example Surface, between School Report and National Grade to Target output “Passed”

2.3. Conducting Operations AND-OR and Mamdani Inference

At the Figure 4, the process has been selected which the rule is matched. We complete the process by combine between rules. We used Max-Min operation to shape the new membership function. We also pictured the AND-OR operation and Mamdani inference with MATLAB [11].

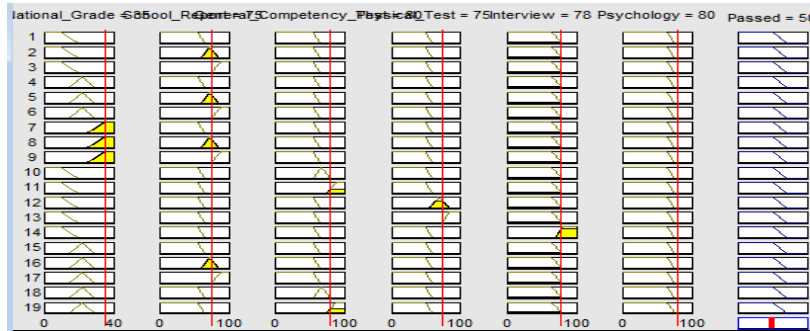


Figure 4. An Example Operation AND-OR in MATLAB

2.4. Perform Fuzzy Inference

The next step from mamdani psdeucode is fuzzy inference [11]. This stage is processed after $\mu[\text{passed}]_{\text{new}}$ calculate. The mamdani inference has given many ways to reach the value. There are many methods to calculate the membership. One of them is clipping methods. Clipping method shows where the area shaped. The process is only mapped the point μ (membership value) into the accepted area. It can be seen at Figure 4. The mapping membership can be done by plot the value into shape. Afterthat, the process has been continuing to calculate the center of gravity that can be seen in Equation (17).

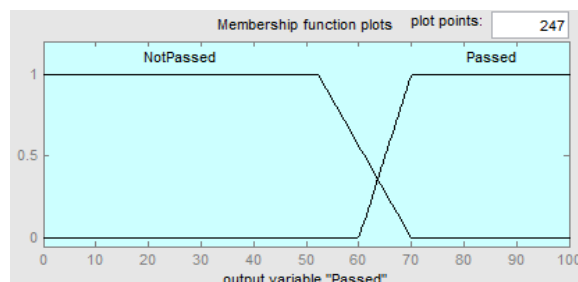


Figure 4. The Diagram Has Been Showing the Area of Student Eligible between Passed and Not Passed

2.5. Determining the Value of Crips (Defuzzification)

The last step of mamdani psedecode is retrieved the crisp value. In one stage before, the process gets the new membership after run the clipping method. It can be seen at the formula number 17. We used center of gravity to transform fuzzy value into crips value. The formula to get the crisp value is named center of gravity (COG). To be change into crisp value, the process is used the formula in (17):

$$COG = \frac{\sum_{j=1}^n z_j \mu(z_j)}{\sum_{j=1}^n \mu(z_j)} \quad (14)$$

3. Results and Analysis

The research is used the data whose taken from 2014. The major of school is informatics major which placed in Tasikmalaya, West Java Indonesia. The amount of data is 270 candidates. From the manual process, we have 126 student who accepted by school. Indeed, if we have been using the fuzzy mamdani system, the passed candidate is only 64 students. At the below, the table 6 has been showing the list of candidature who want entry into the school.

Table 6. An Example Testing Data which Taken From Sample Student Candidate who Wants Entry to the School

ID-Candidate	National Grade	Competency	School report	Physical	Interview	Psychology
071-0002	30,74	83,33	79,84	80,00	85,00	50,0
071-0003	28,21	73,33	79,52	80,00	85,00	80,0
071-0005	31,66	83,33	79,16	70,00	65,00	80,0
071-0006	25,62	63,33	79,04	70,00	65,00	50,0
071-0008	27,67	66,67	77,68	70,00	65,00	80,0
071-0009	27,50	63,33	77,24	80,00	85,00	80,0
071-0011	27,51	66,67	76,28	70,00	65,00	50,0
071-0013	22,97	70,00	75,92	80,00	65,00	80,0
071-0014	24,06	66,67	75,64	80,00	65,00	80,0
071-0015	22,82	56,67	75,56	80,00	65,00	80,0

For the accuracy, the research use formulation has been taken from [10]. Whereas, the formulation is constructed by passed and not passed value. We are referred to Positive value and negative value. The designed passed as positive and not passed is negative value.

$$accuracy = \frac{TP+TN}{TP+ TN+FP+FN} * 100\% \quad (15)$$

Table 7. An Example Running Test of the Model the Testing Data

Id-Candidate	Manual Process (average)	Mamdani Method
071-0002	passed	passed
071-0003	not passed	not passed
071-0005	passed	passed
071-0006	not passed	not passed
071-0008	passed	not passed
071-0009	not passed	not passed
071-0011	not passed	not passed
071-0013	not passed	passed
071-0014	not passed	passed
071-0015	not passed	not passed

The performance result is the comparative value with accepted class as accuracy value. Accuracy is used as a number validity true between fuzzy and real situation. TP is a number student accepted in admission and TN is a number student reject in admission. Meanwhile, FP is a number prediction accepted but false in fuzzy, and FN is a number prediction not accepted but false in fuzzy [10]. The result can be noticed that the mamdani inference has been receipt

75.63% accuracy. It means only 138 students that can full admissions without conditional letter. We are interpreted that not all variable has significantly influence to the admission. This situation, it can be described that mamdani inference just available significant process if the variable has been drawn as a cubic [9]. Too many variables have not guaranteed that the mamdani inference is significantly resulted even in human intuistic. Many factors has triggered for the acceptance, such as behavioral, cancelled admission.

4. Conclusion

Refer to the mamdani process that use the training data, we can be concluded that the validity process only 75.63%. It can be influenced to the process that only accepting the human perception. Therefore, human perception is limited by knowledge. So, it has been creating multi interpretation in the decision. The multiple of value, it can be different for each examiner. Every range in the variable is not directed to the precision value, so it is impact into the process. The other reason is lack of variable, the process just given the variable based on school perception. For the next research, we can add some new variable, like distance, desired, etc

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