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Implementation of fuzzy tsukamoto in employee performance assessment

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ABSTRACT

Employees are one of the important things for the sustainability of a company, because employees are company assets. In addition, employee performance is also something that cannot be ignored because it determines the achievement of company goals. So it is important to monitor employee performance and conduct performance appraisals. With the addition of performance appraisal, the company can determine the provision of rewards, promotions, and punishments. It can be used as a work evaluation stage to improve the quality of work. Employee performance appraisal is based on several predetermined criteria, including responsibility, discipline, and attitude which in the end results in between two linguistic values, namely good or bad. One method for evaluating employee performance is the Tsukamoto fuzzy method. With the Tsukamoto fuzzy method, it is hoped that the assessment can be carried out fairly and measurably.

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1. INTRODUCTION

Human Resources (HR) are humans who work in an organization as a driver of achieving a goal [1]. In a company, employees as an HR are also needed to play an important role. HR performance must always be monitored for the smoothness and achievement of company's goals. One of the efforts that can be done is to conduct employee performance appraisals.

Employee performance appraisal can increase morale and as a form of appreciation in the world of work. According to Istoningtyas (2016), performance appraisal is not only beneficial for the company but also for the employees themselves [2]. Because with the addition of performance appraisal, employees can find out the goals of the company so that they can develop strategies to achieve those goals. However, performance appraisal must be carried out with a good and appropriate method so that the assessed employees can feel satisfied and also guarantee fair treatment. [3].

Several studies have been carried out, including by Sunardi et al., (2019) in his research which states that the application of fuzzy logic is more effective than the SAW method in overcoming the problem of performance evaluation decisions [4]. Therefore, fuzzy logic is widely used in making decisions.

Prabowo et al., (2019) conducted comparative research between the tsukamoto and mamdani methods in determining employee salary bonuses [5]. The study resulted in the MAE value for the Tsukamoto method

of 6.406 and Mamdani method of 8059, and also the MAPE value of the Tsukamoto method of 29,577 and Mamdani of 31,035. From the study that have been carried out, it shows that the Tsukamoto method has a smaller error percentage compared to the Mamdani method.

Andriawan et al., (2014) in his research stated that the system built using the Tsukamoto method was able to process performance appraisals and provide more appropriate solutions to determine the selection of the best employees in certain departments, as well as being more effective and efficient [6]. Basriati et al., (2020) in his research using the Tsukamoto method in optimizing the amount of tofu production, resulted in the truth value of forecasting reaching 98.91%. [7]

Then in a research conducted by Mazenda et al., (2014) stated that the decision support system for determining river water quality with the Tsukamoto fuzzy method has a system performance that is able to run according to functional requirements [8]. This is evidenced by the results of the scenario testing the level of accuracy between the calculation results of the Fuzzy Tsukamoto method and the results of the calculation of river water quality by the STORET method of 90%.

Amalia et al., (2016) also stated in his research on the comparison of the Tsukamoto fuzzy method and the Bayes method to the diagnosis of diabetes mellitus which produces test results with a percentage of confidence value using the Tsukamoto method better than the Bayes method [9].

Based on the description above, employee performance appraisal is important to carry up out for the smoothness of company's goals and this research uses the Tsukamoto fuzzy logic method. The Tsukamoto method is a flexible method and has tolerance for existing data[10]. In addition, the tsukamoto method also has other advantages, including being faster in the computational process, more intuitive, and accepted by many parties [11]. So, it is expected that the fuzzy tsukamoto method is able to analyze employee performance properly and precisely.

2. METHOD

Before performing calculations using the fuzzy inference system, it is necessary to determine the range of criteria values that will be used as employee performance appraisal data. Based on the data obtained, a range of criteria values was made, namely K1 is Responsibility, K2 is Discipline, K3 is Attitude. While K4 is the Work Result which will be the result of the 3 criteria. The following is an explanation of the range of employee performance appraisal scores shown in Table 1.

Table 1. Value Range

Criteria	Range
K1 (Responsibility)	0-100
K2 (Discipline)	0-100
K3 (Attitude)	0-100
K4 (Work result)	0-100

Fuzzy Set

Fuzzy logic was first discovered by professor Lotfi A. Zadeh, from the University of California, in June 1965. Fuzzy logic is a generalization of classical logic which only has two membership values, namely 0 and 1[12]. In fuzzy logic, the truth value of a statement ranges from completely true to completely false [13]. The following is a flowchart of the stages of working on fuzzy logic [14].

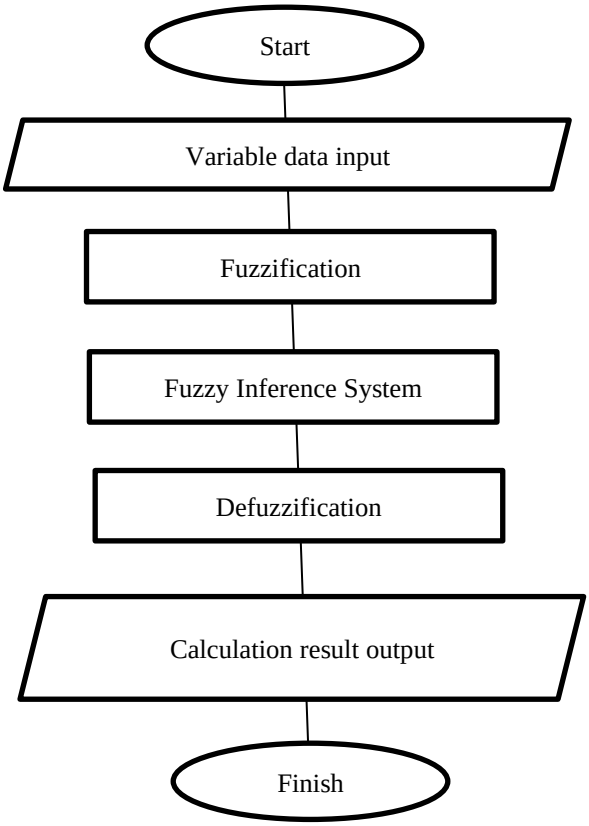


Figure 1. Fuzzy Stage Flowchart

A fuzzy set can be interpreted as a unit that represents a certain state in a fuzzy variable. In this study, a fuzzy set with three linguistic values was used, namely Bad, Good and Very Good. The formation of this fuzzy set is adjusted to the employee input data. Linguistic values are combined with fuzzy sets, each of which has a defined membership function and to construct better mathematical and realtime models [15-16]. Table 2 presents the fuzzy set data and its linguistic values.

Table 2. Fuzzy Set

Variable	Linguistic value
K1	Good
	Bad
K2	Good
	Bad
K3	Good
	Bad
K4	Good
	Bad

Fuzzyfication

The fuzzyfication process is a calculation of the crisp value or the input value into the degree of membership. Calculations in the fuzzyfication process are based on membership function boundaries [17].

a. Fuzzy Set K1

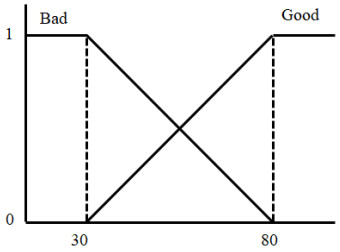


Figure 2. Fuzzy Set K1

The membership degree function of the K1 variable as shown in Figure 2 is defined as follows.
With **Bad** membership degree:

$$\mu Bad(x) = \begin{cases} 1; & x \leq 30 \\ \dfrac{(80-x)}{(80-30)} & 30 \leq x \leq 80 \\ 0; & x \geq 80 \end{cases}$$

With **Good** membership degree:

$$\mu Good(x) = \begin{cases} 0; & x \leq 30 \\ \dfrac{(x-30)}{(80-30)} & 30 \leq x \leq 80 \\ 1; & x \geq 80 \end{cases}$$

b. Fuzzy Set K2

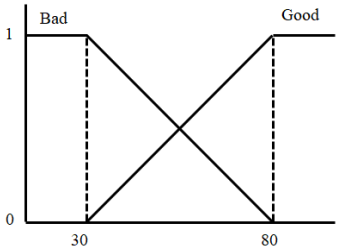


Figure 3. Fuzzy Set K2

The membership degree function of the K2 variable as shown in Figure 3 is defined as follows.
With **Bad** membership degree:

$$\mu Bad(x) = \begin{cases} 1; & x \leq 30 \\ \dfrac{(80-x)}{(80-30)} & 30 \leq x \leq 80 \\ 0; & x \geq 80 \end{cases}$$

With **Good** membership degree:

$$\mu Good(x) = \begin{cases} 0; & x \leq 30 \\ \dfrac{(x-30)}{(80-30)} & 30 \leq x \leq 80 \\ 1; & x \geq 80 \end{cases}$$

c. Fuzzy Set K3

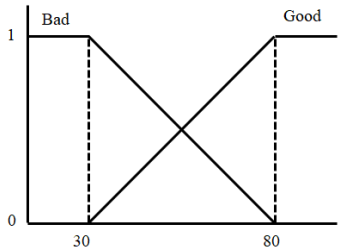


Figure 4. Fuzzy Set K3

The membership degree function of the K3 variable as shown in Figure 4 is defined as follows.
With **Bad** membership degree:

$$\mu Bad(x) = \begin{cases} 1; & x \leq 30 \\ \dfrac{(80-x)}{(80-30)} & 30 \leq x \leq 80 \\ 0; & x \geq 80 \end{cases}$$

With **Good** membership degree:

$$\mu Good(x) = \begin{cases} 0; & x \leq 30 \\ \dfrac{(x-30)}{(80-30)} & 30 \leq x \leq 80 \\ 1; & x \geq 80 \end{cases}$$

d. Fuzzy Set K4

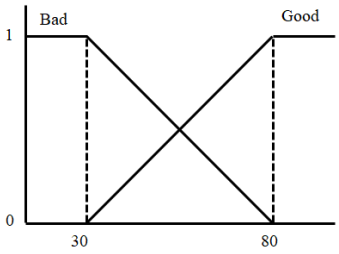


Figure 5. Fuzzy Result Set K4

Fuzzy Inference System

In the fuzzy inference system there is a fuzzy input in the form of crisp values. The crisp value will be calculated based on the rules that have been made to produce a fuzzy quantity called the fuzzification process. The inference system of the Tsukamoto fuzzy method forms a rules based or rule base in the form of "cause and effect" or "if-then". The first step in calculating the Tsukamoto fuzzy method is to create a fuzzy rule. The next step is to calculate the degree of membership according to the rules that have been made. After knowing the value of the degree of membership of each fuzzy rule, the alpha predicate value can be determined by using the fuzzy set operation[17]. The rule-based basis is presented in Table 3 below.

Table 3. Rule Based

Kode	Rules
R1	IF **BAD** RESPONSIBILITY AND **BAD** DISCIPLINE AND **GOOD** ATTITUDE THEN **BAD** WORK RESULTS
R2	IF **BAD** RESPONSIBILITY AND **GOOD** DISCIPLINE AND **BAD** ATTITUDE THEN **BAD** WORK RESULTS
R3	IF **GOOD** RESPONSIBILITY AND **BAD** DISCIPLINE AND **BAD** ATTITUDE THEN **BAD** WORK RESULTS
R4	IF **BAD** RESPONSIBILITY AND **BAD** DISCIPLINE AND **BAD** ATTITUDE THEN **BAD** WORK RESULTS
R5	IF **GOOD** RESPONSIBILITY AND **GOOD** DISCIPLINE AND **BAD** ATTITUDE THEN **GOOD** WORK RESULTS
R6	IF **GOOD** RESPONSIBILITY AND **BAD** DISCIPLINE AND **GOOD** ATTITUDE THEN **GOOD** WORK RESULTS
R7	IF **BAD** RESPONSIBILITY AND **GOOD** DISCIPLINE AND **GOOD** ATTITUDE THEN **GOOD** WORK RESULTS
R8	IF **GOOD** RESPONSIBILITY AND **GOOD** DISCIPLINE AND **GOOD** ATTITUDE THEN **GOOD** WORK RESULTS

Defuzzification

The last step is the defuzzification process which looks for the output value in the form of a crisp (z) value. The method used in this process is the Center Average Defuzzyfier method [18].

$$Z = \frac{\sum \alpha i \ zi}{\sum \alpha i}$$

Note :

Z : Output variables
α_i : α-predikat Nilai value
z_i : Output variable value

With the provisions of the output results show in Table 4 below.

Table 4. Fuzzy Result Output Range [19]

No	Result (K4)	Range
1	Bad	$0 \leq N < 55$
2	Good	$55 \leq N \leq 100$

3. RESULTS AND DISCUSSIONS

Tsukamoto Fuzzy Inference

Tsukamoto fuzzy inference uses MIN, namely by taking the minimum value of the input variable as the output variable.

1. **Input Variable Data**

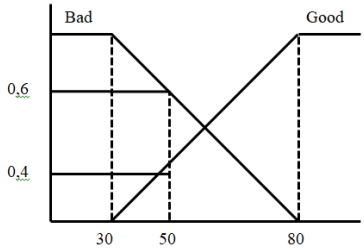
   The following is one of the employee data that will be used as input values for each criterion. The input variables consisting of responsibility, discipline, and attitude are shown in table 5.

Table 5. Employee data

Variabel Input	Nilai Input
K1 (Responsibility)	50
K2 (Discipline)	60
K3 (Attitude)	70

2. Fuzzification

Figure 6 shows responsibility variable membership value.

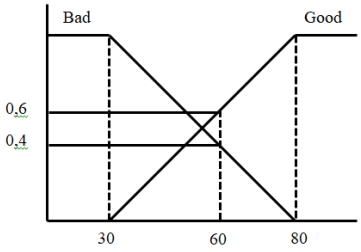


$$\mu Bad(x) = \begin{cases} 1; & x \leq 30 \\ \frac{(80-x)}{(80-30)} & 30 \leq x \leq 80 \\ 0; & x \geq 80 \end{cases}$$

$$\mu Good(x) = \begin{cases} 0; & x \leq 30 \\ \frac{(x-30)}{(80-30)} & 30 \leq x \leq 80 \\ 1; & x \geq 80 \end{cases}$$

Figure 6. Responsibility variable membership value

Discipline variable membership value is presented in Figure 7.

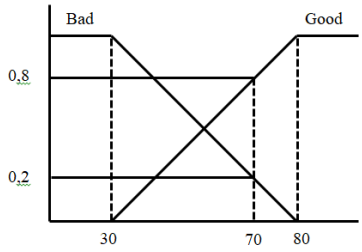


$$\mu Bad(x) = \begin{cases} 1; & x \leq 30 \\ \frac{(80-x)}{(80-30)} & 30 \leq x \leq 80 \\ 0; & x \geq 80 \end{cases}$$

$$\mu Good(x) = \begin{cases} 0; & x \leq 30 \\ \frac{(x-30)}{(80-30)} & 30 \leq x \leq 80 \\ 1; & x \geq 80 \end{cases}$$

Figure 7. Discipline variable membership value

Attitude variable membership value is shown in Figure 8.



$$\mu Bad(x) = \begin{cases} 1; & x \leq 30 \\ \frac{(80-x)}{(80-30)} & 30 \leq x \leq 80 \\ 0; & x \geq 80 \end{cases}$$

$$\mu Good(x) = \begin{cases} 0; & x \leq 30 \\ \frac{(x-30)}{(80-30)} & 30 \leq x \leq 80 \\ 1; & x \geq 80 \end{cases}$$

Figure 8. Attitude variable membership value

3. Fuzzy Inference

The next step is to calculate the antecedent inference ($\alpha_{predicate}$) and the z value for each rule. Table 6 shows 8 rules that must be calculated and work result chart is shown in Figure 9.

Table 6. Result of Rule Base

Rule Base	$\alpha_{predicate}$	Z
R1	0.4	60
R2	0.2	70
R3	0.2	70
R4	0.2	70
R5	0.2	40
R6	0.4	50
R7	0.6	60
R8	0.4	50

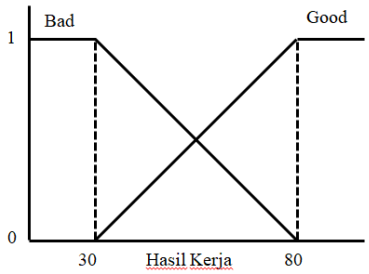


Figure 9. Work Result Chart

4. Defuzzification

The defuzzification equation is as follows.

$$Z = \frac{(\alpha_{pred1}*z1)+(\alpha_{pred2}*z2)+(\alpha_{pred3}*z3)+(\alpha_{pred4}*z4)+(\alpha_{pred5}*z5)+(\alpha_{pred6}*z6)+(\alpha_{pred7}*z7)+(\alpha_{pred8}*z8)}{\alpha_{pred1}+\alpha_{pred2}+\alpha_{pred3}+\alpha_{pred4}+\alpha_{pred5}+\alpha_{pred6}+\alpha_{pred7}+\alpha_{pred8}}$$

$$Z = \frac{(0.4*60)+(0.2*70)+(0.2*70)+(0.2*70)+(0.2*40)+(0.4*50)+(0.6*60)+(0.4*50)}{0.4+0.2+0.2+0.2+0.2+0.4+0.6+0.4}$$

$$Z = 57$$

The results of the employee data input with a responsibility value of 50, a discipline value of 60, and a value of 70 for attitudes resulted in a work output value of 57.

Test Analysis

Data testing is carried out to determine the performance of the system in providing employee performance appraisal results. The data tested amounted to 20 data. The following are the results of testing data using a system of three input variables.

Table 7. Test Assessment

No	Name	K1	K2	K3	Test Assessment	Rating Result
1	Employee1	50	60	70	57	Good
2	Employee 2	65	30	50	55	Good
3	Employee 3	45	60	65	56	Good
4	Employee 4	75	50	70	57	Good
5	Employee 5	40	80	75	62	Good
6	Employee 6	80	70	70	61	Good
7	Employee 7	65	70	60	57	Good
8	Employee 8	75	75	80	68	Good
9	Employee 9	55	40	50	52	Bad
10	Employee 10	50	70	80	55	Good
11	Employee 11	30	40	70	48	Bad
12	Employee 12	40	70	50	52	Bad
13	Employee 13	70	40	45	50	Bad
14	Employee 14	45	40	50	52	Bad
15	Employee 15	75	70	50	57	Good
16	Employee 16	80	50	70	55	Good
17	Employee 17	45	75	80	58	Good
18	Employee 18	80	75	70	62	Good
19	Employee 19	35	50	60	52	Bad
20	Employee 20	60	65	40	57	Good

Based on Table 6. 20 employee performance appraisal data have been tested. The following is the calculation to produce an accuracy value.

4. CONCLUSION

From the results of the research that has been done, it can be concluded that the Tsukamoto fuzzy inference system can be used to determine and assess employee performance. By using the data on responsibility, discipline, and attitude criteria, the results of the assessment are the work results variables so that they can be used as employee performance appraisals. From 20 data test assessment, 14 data rated as good and 6 data rated as bad.

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