The Performance Analysis of Civil Servant using Fuzzy Inference System – Sugeno Method in Department of Population Tomohon

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ABSTRACT
Employee performance assessment is a way to know the quality of work performed by employees. This research was conducted to analyze the performance of existing employees in the Department of Population in Tomohon City by using Fuzzy Inference System Sugeno Method. Fuzzy model used the Sugeno fuzzy model order one. The process by doing substractive clustering to form membership functions and generate cluster centers and sigma, and the clustering of substractive fuzzy inference system will be established to create a rule. Overall analysis and variables is processed by using Matlab R2013a application assistance. In this research, the establishment of rule divided into two, namely staff and managers. Staff have four rules, while managers have five rule.

Keywords
Assesment Performance, Fuzzy Logic, Fuzzy Inference System Sugeno Method.

1. INTRODUCTION
Performance assessment is a way to know the capabilities of each employee in an organization, because assessment of the managers can obtain materials considerations for developing human resources in the organization that he leads. On government agency, Civil Servants is required in organizing the task of government in community service apparatus because they are servant of country and community too. In an effort to improve the quality of performance of an employee, the government issued Government Regulation on Job Achievement Assessment of Civil Servant (Government Regulation No. 46/2011).

Employee performance assessment is very necessary in government agency, as it aims to gives evaluation for employees to improve performance. Assessment system conducted in each department in Tomohon, especially in the Department of Population under Government Regulation on List Of Assessment Work (Government Regulation No. 10/1979). List Of Assessment Work consists of eight (8) elements assessed, which consists of loyalty, achievement, responsibility, devotion, honesty, cooperation, initiative and leadership. Each element of the assessed valuation in the figure. if 91-100 (very good), 76-90 (good), 61-76 (enough), 51-61 (medium) and 50 and below (less). In the reality the objective of this assessment system is still less and just a formality, so that the performance assessment becomes invalid. Assessment system with List Of Assessment Work tended as a formality only and not directly related to what is done by civil servants.

This research was conducted to generate evaluation system of employee performance to became objective. Determination of criteria and sub-criteria assessment based on List Of Assessment Work. The completion of this research using Fuzzy Inference System of Sugeno method order one, which includes fuzzification process, the establishment of the rule, then deffuzikasi and testing..

2. LITERATURE REVIEW
2.1 Research Preview
Research to determine how much laboratory assistants will be accepted at the time of recruitment by using fuzzy inference system sugeno method. This research is done to calculate the total of ideal assistant for a laboratory. The research result is a supporting tool for determine the ideal sum of accepted laboratory assistant in the recruitment process using rules, criterion that already determined such as previous total number of assistant, outgoing assistant and sum of practice participant [1]. Fuzzy inference system sugeno method also is used to predict bottled mineral water production. This research goal is to predict how many production total by applying the fuzzy inference system sugeno method order one based on variables total of demand, total of stock, production machine capability and available production cost [2]. Fuzzy inference system sugeno method to analyze the health, safety, and environment (HSE) in the combustion unit. The research is done to analyze the most suitable event, condition and application pattern for cement industry in determining HSE. The final result is the suitable sugeno method to determine the HSE value. The simulation design on the combustion unit of cement industry is using some membership functions such as trapezium, triangle and gaussian [3].
In this research, the fuzzy inference system with the Sugeno method is used to analyze employee performance assessment based on the variables input of criteria and sub-criteria. The end result is the establishment of the rule of staff and leadership, and also the grading of performance

2.2 Assessment Performance Employee
Performance assessment of civil servants is done periodically. The performance grading goal is to oversee the end result of civil servant in doing his duty and also to see the shortage and the excess of civil servant in doing his duty. The performance grading result is used as consideration material in the coaching of public officer, such as promotion, the appointment of position, education and training, also award give away. The performance grading of civil servant is based on Government Regulation No. 10 year 1979. The components graded are: loyalty, work in progress, responsibilities, compliance, honesty, cooperation, initiative and leadership. Each component graded has sub-components. The grade for implementation of work is stated in words and numbers below: [4]

verry good = 91 - 100

good = 76-90
enough = 61-75
medium = 51-60
less = 50 and below

2.3 Fuzzy Logic

Fuzzy logic is a logic that has fuzzy value or vagueness between right and wrong. In theoretical fuzzy logic, a value can be right and wrong at the same time. But how big is the "right" and "wrong" of the value is dependent on membership weight that it has [5]. Fuzzy logic is a method of problem solving that is very robust with a variety applications embedded and information processing. Fuzzy provides a simple way to infer from vague, ambiguous and imprecise information. [6]. Fuzzy logic is a way to map the input into an output space. Fuzzy logic use a kind of word term to describe the value of a variable. Fuzzy logic work by using degree of membership of a value and then used to determine the expected result based on determined specification. [7].

2.4 Fuzzy Inference System (FIS) Sugeno Method

Fuzzy inference system is a popular methodology to implement fuzzy logic. Fuzzy inference system is one of the most famous applications of fuzzy logic and fuzzy set theory [8].

Sugeno method is introduced by Takagi-Sugeno Kang in the year 1985, so it also called TSK method. The system output (consequence) of Sugeno method is not in form of fuzzy sets but a constant or linear equation. According to Cox (1994), TSK method has two forms:

1. Sugeno model order zero

The form in general:

IF (x_1 is A_1)o(x_2 is A_2)o(x_3 is A_3)o...o(x_N is A_N) THEN z=k

Where A_i is the i-the fuzzy set as the antecedence and *k* is a clear constant as the consequence.

2. Sugeno model order one

The general form is :

IF (x_1 is A_1) o...o (x_N is A_N) THEN $z=p_1*x_1+...+p_N*x_N+q$

Where A*i* is the i-th fuzzy set as antecedence and p*i* is the i-th firm constant and *q* also is a contant in the consequence.

The defuzzification process is done by calculating the average value. In this research the membership function for Sugeno model ordo one is using Gaussian bell membership function and the equation is : [9]

$$f(x,\sigma,c) = e^{\frac{-(x-c)^2}{2\sigma^2}} \quad \text{..... (1)}$$

2.5 Subtractive Clustering

Substractive Clustering based on the size of potential (density) of data points in some space. The basic concept ofsubstractive clusteringis determining the area within variable that has highest potential compared to other data point. A data point which has highest neighbor will become a cluster center, after subtracted with its density. The algorithm will chose other point that has highest neighbor to become the next cluster center. This process will iterate until all data points is tested.. If there are *N* data : X_1, X_2,...,X_n and we state that the data is already normalized, the density of point Xk can be calculated using equation:

$$D_k = \sum_{j=1}^{N} Exp\left(-\frac{\left\| X_k - X_j \right\|}{(r/2)^2} \right) \text{..... (2)}$$

Where $||X_k-X_j||$ is the distance between X_k and X_j, and *r* is positive constant known as radius. After calculating the density of each points, then the point that has the highest density is chosen as cluster center.Then, other point's density surrounding the chosen point will be subtracted using equation:

$$D_k = D_k - D_{C1} * \exp\left(-\frac{\left\| X_k - X_{C1} \right\|}{(r_b/2)^2} \right) \text{..... (3)}$$

Where r_b is a positive constant. The result of substractive clustering is a cluster center matrix (C) and sigma (σ) that will be used in Gaussian bell membership function. [10]

2.6 Establishment of Fuzzy Inference System with Subtractive Clustering

The design of fuzzy inference system based on the clustering result for Sugeno Method order one. Beforehand, we separate the input variables from output variables. For example, the number of input variable is m, and the output variable is i, the rules can be formed as followed lists:

[R1] IF (x_1 is A_{ll}) o (x_2 is A_{12}) o...o (x_n is A_{lm}) THEN ($z= k_{l\ l}x_l+...+ k_{l\ m}x_m + k_{l0}$)

[R2] IF (x_1 is $A_{2\ l}$) o (x_2 is A_{22}) o...o (x_n is $A_{2\ m}$) THEN ($z= k_{2\ l}x_l+...+ k_{2\ m}x_m + k_{20}$)

...

[Rn] IF (x_1 is A_{ll}) o (x_2 is A_{12}) o...o (x_n is A_{lm}) THEN ($z= k_{l\ l}x_l+...+ k_{l\ m}x_m + k_{l\ 0}$)

where :

- $A_{ij}$is the i-th rule and j-th variable of fuzzy sets as the antecedence
- $K_{ij}$is the coefficient of the fuzzy output equation for i-th rule and j-th (i=1,2,...,r; j=1,2,...,m), and k_{10} is the constant for the fuzzy output equation for i-th rule
- "o"-sign is used as the operator of the antecedence (in this research, it's a product operator)

The number of rules created will the same as the cluster formed on previous step. For example, if the clustering process produce 5 cluster center, the fuzzy inference system rules will also have 5 rules. [9]

3. METODOLOGY RESEARCH

In this research there are steps that will be done:

1. Problem identification, i.e. determining the criterion and sub-criteria that will be used to grade
2. Data gathering. In this step, manager grade it's staff based on the criterion and sub-criteria that already determined.
3. Data processing that include:
   - Fuzzification process which is: creating fuzzy set for each input variable and output variable. In this step we use subtractive clustering to get the membership function (MF) needed.
   - Rule base forming by combining some input variable. We complete the steps by carrying clustering product into next step which is creating the consequence equation of the fuzzy rule base.
   - The affirmation by defuzzification method using weighted average to get final Z value of the employee grade

4. RESULTS AND ANALYSIS

4.1 Determination of Criteria and Sub Criteria

Grading criteria used is based on List Of Assessment Work grading that currently used in Department of Population when grading it's officer. The grading criteria can be seen at Table 1.

Table 1. Criteria of List Of Assessment Work Grading

No	Grading Criteria
1.	Loyalty
2.	Achievement
3.	Responsibility
4.	Devotion
5.	Honesty
6.	Cooperation
7.	Initiative
8.	Leadership

Each criteria or grading component on List Of Assessment Work has sub-criteria based on Government Regulation No. 10 year 1979. These sub-criteria can be seen at Table 2

Table 2. Sub-criteria of List Of Assessment Work Grading

Criteria	Sub-Criteria
Loyalty	Never doubt the truth of Pancasila in words, attitudes, behavior and deeds.
	Highly honor the country and the government, always accentuate the country prominence above the self prominence, someone, or group.
	Try to deepen the knowledge about Pancasila and Constitution of the Republic of Indonesia 1945, and always try to learn the state policy, government politics, and the government plans in order to do their work effectively and efficiently.
	Not involved as sympathizer or member of group that try to change or betray Pancasila dan UUD 1945.
	Not deliver languages or sentences or do something that can change or betray Pancasila, UUD 1945, the country, and government.
Achievement	Have skills in doing his/her duties.
	Have experience in their field or other field that correspond with the duties.
	Mean to do his/her duties and without considering time.
	Do his/ her duties effectively and efficiently.
	The work result extend the standard work, in quality and quantity.
Responsibility	Always finish their duties well and on time.
	Always in the work place in any condition.
	Always accentuate the official prominence more than self prominence, someone, or group.
	Never blame to others for the mistakes made.
	Never doubt the truth of Pancasila in words, attitudes, behavior and deeds.
	Brave to endure the risks made or the things done.
	Brave to endure the risks made or the things done.
Devotion	Obey the constitution and the civil laws applied.
	Obey well the civil order that given by the head authorized.
	Obey the work time provision.
	Give best service as their fields.
	Behave politely.
Honesty	Do their duties sincerely.
	Not misapply authority.
	Report the work results to the head appropriately.
Cooperation	Know deeply others duty that correspond with his/her duty.
	Appreciate others opinion.
	Can adjust his/her opinion with others, if they are true.
	Want to consider and accept good opinion from others.
	Always able to cooperate with others as the time and duty scheduled.
	Always ready to accept the decision made even though not agree.
Initiative	Without waiting direction and order from the head, make own decision or do something needed in doing his/her duty as long as not contradict with the head general policy.
	Try to find new work procedures to obtain efficiency and maximum results.
	Give advice that considered good and useful for the head, asked or not asked that correspond with the duty.
Leadership	Master the entirely of duties
	Make decision well and quickly
	Give opinion clearly to others
	Able to decide the priority well
	Act firmly and not take sides
	Give good examples
	Try to bring up and develop cooperation
	Know the ability and the limitation of subordinates
	Try to arouse spirit and activate the subordinates in doing their duties
	Pay attention to the chance and support the development of subordinates
	Want to consider the subordinates advices

4.2 The Analysis by using Fuzzy Inference System Using Sugeno method

In this research, there are two steps that need to be done. First, subtractive clustering and then second, building fuzzy inference system using fuzzy subtractive clustering. The first step is needed to build the membership function (antecedence part of the rule) where the second step's goal is to build Z part of the rule (consequence) using least squared method.

4.2.1 *Subtractive Clustering*

In the subtractive clustering, we need to input which data that need to be clustered. Data is taken from list of assessment work grading. (see table 3)

Table 3. List Of Assessment Work Grading

No	C1	C2	C3	C4	C5	C6	C7	Cr
1	76,4	53,67	60,43	54,2	53	54,17	56,33	58,6
2	53,6	55,17	68,71	54,2	53,33	54,17	56	57,34
3	76,4	56,67	65,28	56,6	55	54,33	52,67	60,31
4	76,2	54,17	59	63,6	54,33	53,67	54	59,54
5	90	73	73	73,2	72,67	72,5	72	75,26
6	90,2	72,17	72,14	74,6	73,67	73	73,67	75,48
7	90,4	70,67	70,71	75,2	78,67	70,83	75	75,23
8	90,4	70,83	70,14	73,4	78,67	70,83	75	74,88
9	90,4	70,83	70,28	73,8	78,67	71,5	74,67	75,05
10	73	47	48,71	43,2	44,67	44,67	44,67	49,714
11	66	51,5	47,85	48,8	46,67	43,17	44,67	50,02
12	66	51,5	43,85	51,4	45,67	43,33	44,67	49,54
13	73	47	49	47,6	46,67	43,17	44,67	50,31
14	73	46,5	49	46,2	43,67	44,33	44,67	49,97
15	87,8	71,67	70,28	75	78,67	74,5	74,67	76,08
16	83	73,33	72,86	76	75,67	76,67	75,67	76,17
17	87,4	75,33	78,57	72,8	74,67	80,83	77	78,09
18	91	77,33	81,57	78,8	75,67	79	84,33	81,10
19	82,6	77,5	76	77,2	76,33	81,33	77	78,28
20	90,4	92,17	92,57	91,8	89,67	92,5	88,33	91,06
21	89	91	92,14	88,8	91	91	94,33	91,04
22	90,6	91,67	92	92,2	90,33	92,17	90,67	91,38
23	90,6	91	91,57	91,2	90	93	90	91,05
24	91,6	89	92,14	92,2	91	91,33	91	91,18

We define some constant parameter for subtractive clustering, i.e. radius, squash factor, accept ratio, reject ratio, minX, maxX as such:

Jari-jari = 0.3
sqshFactor = 1.25
acceptRatio = 0.5
rejectRatio = 0.15
minX = 0 0 0 0 0 0 0 0
maxX = 100 100 100 100 100 100 100 100

Next, we normalize the input data:

$$X_{ij} = \frac{X_{ij} - XMin_j}{XMax_j - XMin_j}, i = 1,2,\ldots,n; j = 1,2,\ldots,m \quad .....(4)$$

Normalized input data :

0.7640 0.5367 0.6043 0.5420 0.5300 0.5417 0.5633 0.5860
0.5360 0.5517 0.6871 0.5420 0.5333 0.5467 0.5600 0.5734
0.7640 0.5667 0.6529 0.5660 0.5500 0.5433 0.5267 0.6031
0.7620 0.5417 0.5900 0.6360 0.5433 0.5367 0.5400 0.5954
0.9000 0.7300 0.7300 0.7320 0.7267 0.7250 0.7200 0.7526
0.9020 0.7217 0.7214 0.7460 0.7367 0.7300 0.7367 0.7549
0.9040 0.7067 0.7071 0.7520 0.7867 0.7083 0.7500 0.7523
0.9040 0.7083 0.7014 0.7340 0.7867 0.7083 0.7500 0.7489
0.9040 0.7083 0.7029 0.7380 0.7867 0.7150 0.7467 0.7506
0.7300 0.4700 0.4871 0.4320 0.4467 0.4467 0.4467 0.4971
0.6600 0.5150 0.4786 0.4880 0.4667 0.4317 0.4467 0.5003
0.6600 0.5150 0.4386 0.5140 0.4567 0.4333 0.4467 0.4954
0.7300 0.4700 0.4900 0.4760 0.4667 0.4317 0.4467 0.5031
0.7300 0.4650 0.4900 0.4620 0.4367 0.4433 0.4467 0.4997
0.8780 0.7167 0.7029 0.7500 0.7867 0.7450 0.7467 0.7608
0.8300 0.7333 0.7286 0.7600 0.7567 0.7667 0.7567 0.7617
0.8740 0.7533 0.7857 0.7280 0.7467 0.8083 0.7700 0.7809
0.9100 0.7733 0.8157 0.7880 0.7567 0.7900 0.8433 0.8110
0.8260 0.7750 0.7600 0.7720 0.7633 0.8133 0.7700 0.7828
0.9040 0.9217 0.9257 0.9180 0.8967 0.9250 0.8833 0.9106
0.8900 0.9100 0.9214 0.8880 0.9100 0.9100 0.9433 0.9104
0.9060 0.9167 0.9200 0.9220 0.9033 0.9217 0.9067 0.9138
0.9060 0.9100 0.9157 0.9120 0.9000 0.9300 0.9000 0.9105
0.9160 0.8900 0.9214 0.9220 0.9100 0.9133 0.9100 0.9118

Next, we calculate the first potential (density) of each data point and choose the highest density (potential) by using the equation (2). Density result : (see Table. 4)

Table 4. Point Of Data Potential

1	2	3	4	5	6	7	8
2.7399	1.2254	2.5945	2.4571	6.7421	7.2475	6.9547	6.8704
9	**10**	**11**	**12**	**13**	**14**	**15**	**16**
7.0147	4.0299	4.0204	3.6160	4.3069	4.2177	7.3455	6.7209
17	**18**	**19**	**20**	**21**	**22**	**23**	**24**
5.6734	3.5981	5.1795	4.6581	4.4109	4.8047	4.7963	4.6968

From the above matrix, we can see that the highest density is on data point 15 which is 7.3455. Therefore, the 15-th data point is chosen as cluster center.

After we choose the highest potential (density) then we loop the process. In this research, there are 4 loops. Iteration stops at the fourth loop because there are no data point that have potential to be cluster center. Iteration will be stop when the ratio <reject ratio. The iteration process will produce number of cluster, cluster center and sigma.

Equation for cluster center:

$$Center_{ij} = Center_{ij} * (XMax_j - XMin_j) + XMin_j \quad ..... (5)$$

Equation for cluster sigma :

$$\sigma_j = r_j * (X\max_j - XMin_j) / \sqrt{8} \quad ..... (6)$$

As the end result on the fourth iteration with radius=0.3; accept ratio = 0.5; reject ratio=0.15; squash factor = 1,25; minX =[0 0 0 0 0 0 0 0] and maxX = [100 100 100 100 100 100 100 100]; we got four cluster which has center (C):

87.80 71.67 70.28 75.00 78.67 74.50 74.67 76.08
90.60 91.67 92.00 92.20 90.33 92.17 90.67 91.38
73.00 47.00 49.00 47.60 46.67 43.17 44.67 50.31
76.40 56.67 65.28 56.60 55.00 54.33 52.67 60.31

and sigma (σ) :

10.61 10.61 10.60 10.61 10.61 10.61 10.61 10.61

4.2.2 *Establish a Fuzzy Inference System with Subtractive Clustering*

Next step is to complete the consequence part of the fuzzy rule using sugeno method order one. We take the cluster center and sigma from previous step as such:

$$C = \begin{pmatrix} 87.8000 & 71.6667 & 70.2857 & 75.0000 & 78.6667 & 74.5000 & 74.5000 & 74.5000 \\ 90.6000 & 91.6667 & 92.0000 & 92.2000 & 90.3333 & 92.1667 & 90.6667 & 91.3762 \\ 73.0000 & 47.0000 & 49.0000 & 47.6000 & 46.6667 & 43.1667 & 44.6667 & 50.3143 \\ 76.4000 & 47.0000 & 65.2857 & 56.6000 & 55.0000 & 54.3333 & 52.6667 & 60.3143 \end{pmatrix}$$

$$\sigma = (10.6066\ 10.6066\ 10.6066\ 10.6066\ 10.6066\ 10.6066\ 10.6066\ 10.6066)$$

The equation is solved based on the resulting cluster thus we can obtain Z equation for each rule as the output. The process is by calculating degree of membership for each data point and then normalize until we get U matrix. The matrix U is obtained by using the equation:

$$d_{ij}^k = X_{ij} * \mu_{ki} \text{ dan } d^k{}_{i(m+1)} = \mu_{ki} \quad ..... (7)$$

Normalization process is calculated by dividing d^k_{ij} and $d^k_{i(j+1)}$against total degree of membership of data point *i* on cluster *k*:

$$d_{ij}^k = \frac{d_{ij}^k}{\sum_{k=1}^{r} \mu_{ki}} \quad ..... (8)$$

$$d_{i(m+1)}^k = \frac{d_{i(m+1)}^k}{\sum_{k=1}^{r} \mu_{ki}} \quad ..... (9)$$

The solution is below:
Rule number 1
Degree of membership for each data point on rule (cluster) 1

10.6315
14.4915
9.6414
9.5617
0.2859
0.1683
0.0957
0.1048
0.0795
23.3337
22.1209
22.6566
21.9427
22.9776
0
0.2139
0.6607
1.3638
0.6940
8.1675
8.2424
8.3529
8.0131
7.9587

We got U matrix:
Only column 1- 8 printed, column 11-32 is 0

0.0018	0.0013	0.0015	0.0013	0.0013	0.0013	0.0014	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0050	0.0037	0.0042	0.0037	0.0036	0.0035	0.0034	0.0001
0.0054	0.0038	0.0042	0.0045	0.0038	0.0038	0.0038	0.0001
67.6178	54.8455	54.8455	54.9958	54.5951	54.4699	54.0942	0.7513
76.2275	60.9877	60.9675	63.0441	62.2553	61.6919	62.2553	0.8451
82.1473	64.2155	64.2587	68.3349	71.4851	64.3669	68.1532	0.9087
81.4019	63.7828	63.1610	66.0940	70.8364	63.7828	67.5347	0.9005
83.4889	65.4181	64.9123	68.1580	72.6526	66.0338	68.9584	0.9235
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
87.8000	71.6667	70.2857	75.0000	78.6667	74.5000	74.6667	1.0000
67.0175	59.2123	58.8278	61.3654	61.0963	61.9037	61.0963	0.8074
45.1421	38.9097	40.5821	37.6012	38.5653	41.7504	39.7705	0.5165
23.2678	19.7733	20.8570	20.1483	19.3472	20.1995	21.5632	0.2557
41.2659	38.7180	37.9686	38.5681	38.1351	40.6331	38.4682	0.4996
0.0256	0.0262	0.0263	0.0260	0.0254	0.0262	0.0251	0.0003
0.0234	0.0240	0.0243	0.0234	0.0240	0.0240	0.0248	0.0003
0.0214	0.0216	0.0217	0.0217	0.0213	0.0217	0.0214	0.0002
0.0300	0.0301	0.0303	0.0302	0.0298	0.0308	0.0298	0,0003
0.0320	0.0311	0.0322	0.0322	0.0318	0.0319	0.0318	0.0003

The next process is the same for each rule (cluster) up to rule #4 to obtain final normalized U matrix. The z vector as the output vector is in form of:

$$Z = [z_1 \;\; z_2 \;\; ... \;\; z_n]^T$$

From vector k, matrix U and vector z are then formed this linear equation:

$$U*k = z$$

The above equation is used to find output coefficient value for each rule for each variables (k_{ij}, i=1,2,...,r; and j=1,2,...,m+1). Matrix U is not a square matrix, that's why we use least squared method to solve the above equation.

This is normalized U matrix:

Column 1- 10

0.0021	0.0015	0.0017	0.0015	0.0015	0.0015	0.0016	0.0000	0.0000	0.0000
0.0003	0.0003	0.0004	0.0003	0.0003	0.0003	0.0003	0.0000	0.0000	0.0000
0.0048	0.0035	0.0041	0.0035	0.0034	0.0034	0.0033	0.0001	0.0000	0.0000
0.0077	0.0055	0.0059	0.0064	0.0055	0.0054	0.0054	0.0001	0.0000	0.0000
89.9506	72.9599	72.9599	73.1598	72.6267	72.4602	71.9604	0.9995	0.0098	0.0079
90.1672	72.1404	72.1166	74.5729	73.6399	72.9735	73.6399	0.9996	0.0135	0.0108
90.3786	70.6499	70.6975	75.1822	78.6480	70.8166	74.9822	0.9998	0.0126	0.0098
90.3793	70.8171	70.1268	73.3832	78.6486	70.8171	74.9828	0.9998	0.0088	0.0069
90.3793	70.8171	70.2696	73.7831	78.6487	71.4836	74.6496	0.9998	0.0102	0.0080
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
87.7736	71.6451	70.2646	74.9775	78.6430	74.4776	74.6442	0.9997	0.0207	0.0169
82.9414	73.2816	72.8057	75.9464	75.6133	76.6126	75.6133	0.9993	0.0530	0.0468
87.0553	75.0362	78.2615	72.5129	74.3722	80.5145	76.6963	0.9961	0.3430	0.2957
85.4608	72.6260	76.6062	74.0034	71.0608	74.1912	79.1999	0.9391	5.5391	4.7072
81.9533	76.8932	75.4050	76.5956	75.7357	80.6965	76.3971	0.9922	0.6460	0.6061
0.0264	0.0269	0.0271	0.0268	0.0262	0.0270	0.0258	0.0003	90.3736	92.1397
0.0267	0.0273	0.0277	0.0267	0.0273	0.0273	0.0283	0.0003	88.973	90.9727
0.0213	0.0216	0.0217	0.0217	0.0213	0.0217	0.0214	0.0002	90.5787	91.6451
0.0304	0.0305	0.0307	0.0306	0.0302	0.0312	0.0302	0.0003	90.5696	90.9695
0.0334	0.0324	0.0336	0.0336	0.0332	0.0333	0.0332	0.0004	91.5666	88.9676

Column 11-Column 20

0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	8.3653	5.8762	6.6166	5.9346
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	3.1140	3.2050	3.9921	3.1489
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	3.1309	2.3222	2.6755	2.3195
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	5.4612	3.8821	4.2285	4.5582
0.0079	0.0079	0.0079	0.0079	0.0078	0.0001	0.0000	0.0000	0.0000	0.0000
0.0108	0.0112	0.0111	0.0110	0.0111	0.0002	0.0000	0.0000	0.0000	0.0000
0.0098	0.0104	0.0109	0.0098	0.0104	0.0001	0.0000	0.0000	0.0000	0.0000
0.0068	0.0071	0.0077	0.0069	0.0073	0.0001	0.0000	0.0000	0.0000	0.0000
0.0079	0.0083	0.0089	0.0081	0.0084	0.0001	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	70.9524	45.6817	47.3479	41.9883
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	63.0073	49.1648	45.6871	46.5872
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	64.0191	49.9543	42.5409	49.8573
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	70.0082	45.0738	46.9918	45.6492
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	70.6745	45.0187	47.4390	44.7282
0.0166	0.0177	0.0185	0.0176	0.0176	0.0002	0.0000	0.0000	0.0000	0.0000
0.0465	0.0485	0.0483	0.0490	0.0483	0.0006	0.0000	0.0000	0.0000	0.0000
0.3084	0.2857	0.2930	0.3172	0.3022	0.0039	0.0000	0.0000	0.0000	0.0000
4.9652	4.7965	4.6058	4.8087	5.1333	0.0609	0.0000	0.0000	0.0000	0.0000
0.5944	0.6038	0.5970	0.6361	0.6022	0.0078	0.0000	0.0000	0.0000	0.0000
92.5444	91.7732	89.6405	92.4730	88.3075	0.9997	0.0000	0.0000	0.0000	0.0000
92.1152	88.7733	90.9727	90.9727	94.3050	0.9997	0.0000	0.0000	0.0000	0.0000
91.9783	92.1783	90.3120	92.1449	90.6453	0.9998	0.0000	0.0000	0.0000	0.0000
91.5407	91.1694	89.9698	92.9688	89.9698	0.9997	0.0000	0.0000	0.0000	0.0000
92.1093	92.1664	90.9668	91.3001	90.9668	0.9996	0.0000	0.0000	0.0000	0.0000

Column 21-Column 30

5.8032	5.9309	6.1682	0.1095	68.0325	47.7890	53.8103	48.2639	47.1954	48.2342
3.0985	3.1760	3.2534	0.0581	50.4857	51.9613	64.7218	51.0508	50.2345	51.4904
2.2539	2.2266	2.1583	0.0410	73.2643	54.3409	62.6062	54.2770	52.7426	52.1033
3.8940	3.8463	3.8702	0.0717	70.7311	50.2791	54.7656	59.0354	50.4338	49.8150
0.0000	0.0000	0.0000	0.0000	0.0397	0.0322	0.0322	0.0323	0.0320	0.0320
0.0000	0.0000	0.0000	0.0000	0.0192	0.0154	0.0154	0.0159	0.0157	0.0156
0.0000	0.0000	0.0000	0.0000	0.0089	0.0069	0.0069	0.0074	0.0077	0.0069
0.0000	0.0000	0.0000	0.0000	0.0119	0.0093	0.0092	0.0097	0.0104	0.0093
0.0000	0.0000	0.0000	0.0000	0.0105	0.0082	0.0082	0.0086	0.0091	0.0083
43.4138	43.4138	43.4138	0.9720	2.0476	1.3183	1.3664	1.2117	1.2528	1.2528
44.5506	41.2093	42.6413	0.9547	2.9927	2.3352	2.1700	2.2128	2.1160	1.9573
44.2961	42.0328	43.3261	0.9700	1.9809	1.5457	1.3163	1.5427	1.3706	1.3006
44.7541	41.3976	42.8361	0.9590	2.9918	1.9262	2.0082	1.9508	1.9126	1.7691
42.2756	42.9210	43.2437	0.9681	2.3255	1.4813	1.5610	1.4718	1.3911	1.4123
0.0000	0.0000	0.0000	0.0000	0.0057	0.0047	0.0046	0.0049	0.0051	0.0048
0.0000	0.0000	0.0000	0.0000	0.0056	0.0049	0.0049	0.0051	0.0051	0.0051
0.0000	0.0000	0.0000	0.0000	0.0017	0.0015	0.0015	0.0014	0.0014	0.0016
0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
0.0000	0.0000	0.0000	0.0000	0.0007	0.0006	0.0006	0.0006	0.0006	0.0007
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Column 31-Column 32

50.1636	0.8905
52.7463	0.9419
50.5051	0.9590
50.1244	0.9282
0.0317	0.0004
0.0157	0.0002
0.0073	0.0001
0.0099	0.0001
0.0087	0.0001
1.2528	0.0280
2.0254	0.0453
1.3406	0.0300
1.8306	0.0410
1.4229	0.0319
0.0049	0.0001
0.0051	0.0001
0.0015	0.0000
0.0001	0.0000
0.0006	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000
0.0000	0.0000

Using least squared method, we can get the following k coefficients:

0.6313	2.2082	-0.0399	0.5428	0.5829	0.2715	0.3723	-267.8862
-238.3828	-217.6611	317.4616	199.0879	-426.9637	190.2301	166.7087	0
0.2478	0.3535	0.2015	0.1209	-0.0003	0	0	0
0.1857	0	0.3690	0.2013	0	0	0.2032	0

From the *k* coefficients matrix above, we can build Z part for each rule, so that:

$Z_1 =$ 0,6313X_1+ 2,2082X_2+(-0,0399X_3) + 0,5428X_4 + 0,5829X_5 + 0,2715X_6 0,3723X_7 +(-267,8862)

$Z_2 =$ -238,3828 X_1+ (-217,6611X2) + 317,4616 X_3 + 199,0879X_4 + (-426,9637X_5) + 190,2301X_6 + 166,7087X_7 + 0

$Z_3 =$ 0,2478X_1+ 0,3535X2 + 0,2015X_3 + 0,1209X_4 + (-0,0003X_5) + 0X_6 + 0X_7 +0

$Z_4 =$ 0,1857X_1+ 0X2 + 0,3690X_3 + 0,2103X_4 + 0X_5 + 0X_6 + 0,2032X_7 +0

The above process is the calculation process for staff, the same process is performed for building Z part for manager's rule until we obtain the k coefficients matrix below:

0,66605743	-0,04975054	0	0,27951477	0	0	0	0 0
0	0,46211815	0	0	0	0	0,16290604	0 0
0	0	0	0,203285960	0	0,79504179	0	0 0
0,58525386	0	0	0,31827622	0	0	0	0 0
0,6602402	0	0	0	0	0	0	0 0

And thus, we produce these Z equations:

$Z_1 =$ 0,66605743X_1+ (-0,04975054X_2)+(0X_3) + 0,27951477X_4 + 0X_5 + 0X_6 + 0X_7 +0X_8+

$Z_2 =$ 0X_1+ 0,46211815X2 + 0X_3 + 0X_4 + 0X_5 + 0X_6 + 0,16290604X_7 + 0X_8+0X_9

$Z_3 =$ 0X_1+ 0X2 + 0X_3 + 0,20328596X_4 + 0X_5 + 0X_6 + 0,79504179X_7 +0X_8+0X_9

$Z_4 =$ 0,58525386X_1+ 0X2 + 0X_3 + 0,31827622X_4 + 0X_5 + 0X_6 + 0X_7 +0X_8+0X_9

$Z_5 =$ 0,6602402X_1+ 0X2 + 0X_3 + 0X_4 + 0X_5 + 0X_6 + 0X_7 +0X_8++0X_9

As we can see, there are differences between staff's rules and Manager's rules, which is, there are four rules for staff, where the rules for manager is five.

4.2.3 *Establishment of Rule*

In this research, the rules is categorized into two parts: for staff and for manager. Staff has 4 rules where manager has 5 rules. The following lists are rules for staff:

[R1] IF(C1 is in1cluster1) and (C2 is in2cluster1) and (C3 is in3cluster1) and (C4 is in4cluster1) and (C5 is in5cluster1) and (C6 is in6cluster1) and (C7 is in7cluster1) THEN (out is Z1)

[R2] IF(C1 is in1cluster2) and (C2 is in2cluster2) and (C3 is in3cluster2) and (C4 is in4cluster2) and (C5 is in5cluster2) and (C6 is in6cluster2) and (C7 is in7cluster2) THEN (out is Z2)

[R3] IF(C1 is in1cluster3) and (C2 is in2cluster3) and (C3 is in3cluster3) and (C4 is in4cluster3) and (C5 is in5cluster3) and (C6 is in6cluster3) and (C7 is in7cluster3) THEN (out is Z3)

[R4] IF(C1 is in1cluster4) and (C2 is in2cluster4) and (C3 is in3cluster4) and (C4 is in4cluster4) and (C5 is in5cluster4) and (C6 is in6cluster4) and (C7 is in7cluster4) THEN (out is Z4)

These are rules for Managers:

[R1] IF(C1 is in1cluster1) and (C2 is in2cluster1) and (C3 is in3cluster1) and (C4 is in4cluster1) and (C5 is in5cluster1) and (C6 is in6cluster1) and (C7 is in7cluster1) and (C8 is in8cluster5) THEN (out is Z1)

[R2] IF(C1 is in1cluster2) and (C2 is in2cluster2) and (C3 is in3cluster2) and (C4 is in4cluster2) and (C5 is in5cluster2) and (C6 is in6cluster2) and (C7 is in7cluster2) and (C8 is in8cluster5) THEN (out is Z2)

[R3] IF(C1 is in1cluster3) and (C2 is in2cluster3) and (C3 is in3cluster3) and (C4 is in4cluster3) and (C5 is in5cluster3) and (C6 is in6cluster3) and (C7 is in7cluster3) and (C8 is in8cluster5) THEN (out is Z3)

[R4] IF(C1 is in1cluster4) and (C2 is in2cluster4) and (C3 is in3cluster4) and (C4 is in4cluster4) and (C5 is in5cluster4) and (C6 is in6cluster4) and (C7 is in7cluster4) and (C8 is in8cluster5) THEN (out is Z4)

[R5] IF(C1 is in1cluster5) and (C2 is in2cluster5) and (C3 is in3cluster5) and (C4 is in4cluster5) and (C5 is in5cluster5) and (C6 is in6cluster5) and (C7 is in7cluster5) and (C8 is in8cluster5) THEN (out is Z5)

After we form both rules for staff and manager, we must put these rules on test then compare it to existing List Of Assessment Work. Beforehand, we must calculate z and alpha-predicate for each rule. Both values will be used on defuzzification process using weighted average method as seen on this equation:

$$Z = \frac{\alpha_1 z_1 + \alpha_2 z_2 + ... + \alpha_n z_n}{\alpha_1 + \alpha_2 + ... + \alpha_n} .....(10)$$

In the following part, we will take one example each from performance grading and fuzzy calculation process for staff and manager. (see Table. 5 and Table. 6)

Table 5. Staff's average grade for each category

Cr	1	2	3	4	5	6	7
Nilai	72,6	69,3	68,2	67,7	67,3	68,1	69,5

Table 6. Manager's average grade for each category

Cr	1	2	3	4	5	6	7	8
Nilai	90,5	73,4	71,9	73,8	73,3	72,7	72,5	72,6

From the table above, we must calculate z and alpha-predicate value for each rule. Alpha-predicate can be obtained by multiplication all **μ**values. The **μ**values are degree of membership values that calculated using equation (1). On the next following tables, we can observe the value of *z* and alpha-predicate for each rules: (see Table. 7 – Table 14)

Table 7. Z1 value for Staff

Cr	X	k	k*x
1	72,6	0,63128469	45,8312683
2	69,3	2,20819958	153,028231
3	68,2	-0,03988665	-2,72026967
4	67,7	0,54278458	36,7465158
5	67,3	0,58286514	39,2268239
6	68,1	0,27145815	18,4863003
7	69,5	0,37231617	25,8759741
8		-267,886207	-267,8862069
		Z1	48,58863647

Table 8. Degree of membership each criteria for [R1]

Cr	X	σ	c	μ
1	72,6	10,6066017	87,8	0,3581353
2	69,3	10,6066017	71,6666667	0,97541347
3	68,2	10,6066017	70,2857143	0,98085147
4	67,7	10,6066017	75	0,78911403
5	67,3	10,6066017	78,6666667	0,56313992
6	68,1	10,6066017	74,5	0,83356429
7	69,5	10,6066017	74,6666667	0,88812571
			α –predikat	0,11272201

Based on the both tables above, z value for [R1] and alpha-predicate value for [R1] for staff is 316.474743 and 0.11272201

Table 9. Z2 value for Staff

Cr	x	k	k*x
1	72,6	-238,382787	-17306,5903
2	69,3	-217,661065	-15083,9118
3	68,2	317,461632	21650,8833
4	67,7	199,08788	13478,2495
5	67,3	-426,963742	-28734,6598
6	68,1	190,230082	12954,6686
7	69,5	166,708676	11586,253
8		0	0
		Z2	-1455,10755

Table 10. Degree of membership each criteria for [R2]

Cr	X	σ	c	μ
1	72,6	10,6066017	90,6	0,23692776
2	69,3	10,6066017	91,6666667	0,10823913
3	68,2	10,6066017	92	0,08066011
4	67,7	10,6066017	92,2	0,06940629
5	67,3	10,6066017	90,3333333	0,09461579
6	68,1	10,6066017	92,1666667	0,07621157
7	69,5	10,6066017	90,6666667	0,13652677
			α -predikat	1,4134E-07

The z value and alpha-predicate value for [R2] are -1455.10755 and 1.4134E-07.

Table 11. Z3 value for Staff

Cr	x	k	k*x
1	72,6	0,24777168	17,9882241
2	69,3	0,35348861	24,4967605
3	68,2	0,20150532	13,7426631
4	67,7	0,12091489	8,18593773
5	67,3	-0,00033536	-0,02256952
6	68,1	0	0
7	69,5	0	0
8		0	0
		Z3	64,3910159

Table 12. Degree of membership each criteria for [R3]

Cr	X	σ	c	μ
1	72,6	10,6066017	73	0,99928914
2	69,3	10,6066017	47	0,10968115
3	68,2	10,6066017	49	0,19429066
4	67,7	10,6066017	47,6	0,16602781
5	67,3	10,6066017	46,6666667	0,15074689
6	68,1	10,6066017	43,1666667	0,06310327
7	69,5	10,6066017	44,6666667	0,06451457
			α -predikat	2,1698E-06

The z value and alpha-predicate value for [R3] are 64.3910159 and 2.1698E-06.

Table 13. Z4 value for Staff

Cr	x	k	k*x
1	72,6	0,18574589	13,4851516
2	69,3	0	0
3	68,2	0,36900176	25,16592
4	67,7	0,20131865	13,6292725
5	67,3	0	0
6	68,1	0	0
7	69,5	0,20317791	14,1208651
8		0	0
		Z4	66,4012091

Table 14. Degree of membership each criteria for[R4]

Cr	X	σ	c	μ
1	72,6	10,6066017	76,4	0,93783826
2	69,3	10,6066017	56,6666667	0,49196964
3	68,2	10,6066017	65,2857143	0,9629566
4	67,7	10,6066017	56,6	0,57833615
5	67,3	10,6066017	55	0,51048195
6	68,1	10,6066017	54,3333333	0,43071182
7	69,5	10,6066017	52,6666667	0,28382918
			α -predikat	0,01603532

The z value and alpha-predicate value for [R2] are 66.4012091 and 0.01603532.

Using the same method, we can compute z and alpha-predicate value for Manager's rules (see Table. 15 – Table. 24).

Table 15. Z1 value for Manager

Cr	X	k	k*x
1	90,5	0,66605743	60,2781977
2	73,4	-0,0497505	-3,6516895
3	71,9	0	0
4	73,8	0,27951477	20,6281904
5	73,3	0	0
6	72,7	0	0
7	72,5	0	0
8	72,6	0	0
9		0	0
		Z1	77,2546985

Table 16. Degree of membership each criteria for [R1]

Cr	X	σ	c	μ
1	90,5	0,10606602	90	1,49453E-05
2	73,4	3,65927759	76,5	0,698485043
3	71,9	4,10627009	74,8571429	0,771583645
4	73,8	3,7335238	75,8	0,866337904
5	73,3	3,74766594	75	0,902231998
6	72,7	3,8890873	76	0,697676326
7	72,5	4,20728535	75	0,838164242
8	72,6	3,95336973	76,2727273	0,649513605
			α -predikat	2,39124E-06

The z value and alpha-predicate value for manager's [R1] are 77.2546985 and 2.39124E-06.

Table 17. Z2 value for Manager

Cr	x	k	k*x
1	90,5	90,5	0
2	73,4	73,4	0,462118148
3	71,9	71,9	0
4	73,8	73,8	0
5	73,3	73,3	0
6	72,7	72,7	0
7	72,5	72,5	0,16290604
8	72,6	72,6	0,375344744
9			0
		Z2	72,98018841

Table 18. Degree of membership each criteria for [R2]

Cr	X	σ	c	μ
1	90,5	0,10606602	90,4	0,64118039
2	73,4	3,65927759	90,5	1,8116E-05
3	71,9	4,10627009	90,4285714	3,7911E-05
4	73,8	3,7335238	90,6	4,0107E-05
5	73,3	3,74766594	91	1,4331E-05
6	72,7	3,8890873	90,6666667	2,3206E-05
7	72,5	4,20728535	90,6666667	8,9421E-05
8	72,6	3,95336973	90,4545455	3,7229E-05
			α -predikat	1,9554E-32

The z value and alpha-predicate value for manager's [R1] are 72.98018841 and 1.9554E-32.

Table 19. Z3 value for Manager

Cr	x	K	k*x
1	90,5	0	0
2	73,4	0	0
3	71,9	0	0
4	73,8	0,20328596	15,00250417
5	73,3	0	0
6	72,7	0	0
7	72,5	0,79504179	57,64053012
8	72,6	0	0
9		0	0
		Z3	72,6430343

Table 20. Degree of membership each criteria for [R3]

Cr	X	σ	c	μ
1	90,5	0,10606602	91	1,4945E-05
2	73,4	3,65927759	90,6666667	1,4628E-05
3	71,9	4,10627009	90,4285714	3,7911E-05
4	73,8	3,7335238	91	2,4624E-05
5	73,3	3,74766594	91	1,4331E-05
6	72,7	3,8890873	91	1,5561E-05
7	72,5	4,20728535	91	6,3314E-05
8	72,6	3,95336973	90,9090909	2,2004E-05
			α -predikat	6,3405E-38

For [R3] z3 value is 72.6430343 and alpha-predicate is 6.3405E-38.

Table 21. Z4 value forManager

Cr	x	K	k*x
1	90,5	0,58525386	52,96547418
2	73,4	0	0
3	71,9	0	0
4	73,8	0,31827622	23,48878504
5	73,3	0	0
6	72,7	0	0
7	72,5	0	0
8	72,6	0	0
9		0	0
		Z4	76,45425922

Table 22. Degree of membership each criteria for [R4]

Cr	X	σ	c	μ
1	90,5	0,10606602	90,4	0,64118039
2	73,4	3,65927759	76	0,77691736
3	71,9	4,10627009	75,1428571	0,73209929
4	73,8	3,7335238	77,2	0,66056619
5	73,3	3,74766594	74,3333333	0,96270068
6	72,7	3,8890873	75,5	0,77168908
7	72,5	4,20728535	75	0,83816424
8	72,6	3,95336973	76,6363636	0,5937995
			α -predikat	0,08907257

Based on the above table, z value for [R4] is 6.454259922 with alpha-predicate 0.08907257.

Table 23. Z5 value for Manager

Cr	x	K	k*x
1	90,5	0,6602402	59,75173831
2	73,4	0	0
3	71,9	0	0
4	73,8	0	0
5	73,3	0	0
6	72,7	0	0
7	72,5	0	0
8	72,6	0	0
9		0	0
		Z5	59,75173831

Table 24. Degree of membership each criteria for [R5]

Cr	X	σ	c	μ
1	90,5	0,10606602	90,4	0,64118039
2	73,4	3,65927759	56,1666667	1,527E-05
3	71,9	4,10627009	52,5714286	1,5443E-05
4	73,8	3,7335238	56,2	1,4945E-05
5	73,3	3,74766594	55,6666667	1,5585E-05
6	72,7	3,8890873	54,3333333	1,4353E-05
7	72,5	4,20728535	52,6666667	1,4945E-05
8	72,6	3,95336973	54	1,5607E-05
			α -predikat	1,179E-34

The z value for [R5] is 59.75173831with alpha-predicate 1.179E-34.

After we got all of z value and alpha-predicate value for each rule for staff and manager, we can use equation (10) to find final grade (Z) for each staff and manager. We take one example from staff grading:

$$Z = \frac{\begin{array}{l}0{,}11272201 * 48{,}58863647 + 1{,}4134E-07 * (-1455{,}1075) \\ + 2{,}1698E-06 * 64{,}3910159 + 0{,}01603532 * 66{,}4012091\end{array}}{0{,}1127220+{,}4134 + E-07 + 2{,}1698E-06 + 0{,}01603532}$$

$$Z = 50{,}8055732$$

The next after we got final Z value is to describe this value in the same manner as List Of Assessment Work ranging, so, that staff is in the range "Medium". Using the same method, we grade other staff and compare all the result with List Of Assessment Work.

This one is an example for manager grading using defuzzification.

$$Z = \frac{\begin{array}{l}2{,}39124E-06 * 77{,}2546985 + 1{,}9554E-32 * 72{,}98018841 + 6{,}3405E-38 \\ * 72{,}6430343 + 0{,}08907257 * 76{,}45425922 * +1{,}179E-34 * 59{,}7513831\end{array}}{2{,}39124E-06 + 1{,}9554E-32 + 6{,}3405E-38 + 0{,}08907257 + 1{,}179E-34}$$

$$Z = 76{,}4542807$$

Based on the Z value and applied to List Of Assessment Work ranging, the manager is in the range of "Good". We use the same method for other manager and compare it with existing List Of Assessment Work grading system.

Table 23. Comparison between Fuzzy Inference Systems with List Of Assessment Work

No	C1	C2	C3	C4	C5	C6	C7	C8	List Of Assessment Work Grade	Fuzzy Grade	Fuzzy Description	List Of Assessment Work Description
1	76,4	53,67	60,42	54,2	53	54,16	56,33	0	58,6	58,6	medium	medium
2	76,4	56,67	65,28	56,6	55	54,33	52,67	0	60	60.31	medium	medium
3	90	73	73	73,2	72,67	72,5	72	0	75,25	75,27	medium	medium
4	90,4	56,16	52,57	56,2	55,67	54,33	52,67	0	59,68	58,41	medium	medium
5	91	90,67	90,42	91	91	91	91	90,9	90,84	90,84	verry good	verry good
6	90,4	90,5	90,42	90,6	91	90,67	90,67	90,45	90,54	90,57	verry good	verry good
7	90,4	90	90,14	91,4	90,67	90,67	92,33	90,63	90,65	90,68	verry good	verry good
8	90,8	89,83	91,28	89,4	90	90,83	91	90,63	90,52	90,52	verry good	verry good

Based on the above table, we can see how fuzzy inference system we built compared to List Of Assessment Work. Grading using proposed fuzzy inference system has almost the same result as List Of Assessment Work where the description from fuzzy inference system compared to List Of Assessment Work is 100% the same. This shows us that Fuzzy Inference System using sugeno method can be applied for staff performance grading.

5. CONCLUSION

Based on the discussed result above we can conclude that fuzzy inference system using sugeno method order one can be applied into employee performance assessment system of

Departement of Population in Tomohon City. Performance grading would be objective because for each criterion there are more sub-criteria that should be graded until we got averaged graded for the criteria. Rule modeling is separated into two parts, i.e. for staff and manager. For staff, there are four rules where for manager, there are five rules.

There should be further research using the same model and method to achieve higher result using more data sample. In the future research, ones should build more complex system using mode variable category.

6. REFERENCES

[1] Ramdhani Indra, Imam Syaifuddin Rifkan, Noviana Endarsari, Sheila Nurul Huda. 2012. "Fuzzy Inference System dengan Metode Sugeno untuk Penentuan Banyaknya Asisten Laboratorium yang Diterima pada Saat Rekrutmen". Seminar Nasional Aplikasi Teknologi Informasi (SNATI). Yogyakarta. ISSN: 1907-5022.

[2] Suwandi, Mohammad Isa Irawan, Imam Mukhlash. 2011. "Aplikasi Sistem Inferensi Fuzzy Metode Sugeno dalam Memperkirakan Produksi Air Mineral dalam Kemasan". Prosiding Seminar Nasional Penelitian, Pendidikan dan Penerapan MIPA, Fakultas MIPA. Universitas Negeri Yogyakarta.

[3] Pradana Revina Saptya Kusuma, Imam Abadi. 2013. "Analisis Health untuk Pekerja, Safety, dan Environment (HSE) berbasis Logika Fuzzy pada Unit Pembakaran (Preheater-Rotary Kiln-Cooler) Studi Kasus Industri

Semen". Jurnal Tesis. Institut Teknologi Sepuluh November.

[4] Badan Kepegawaian Negara. 2010 "Penilaian Kinerja PNS".http://www.bkn.go.id/in/peraturan/pedoman/pedoman-penilaian-pns.html.

[5] Triayudi Agung, Nazori AZ. 2012. "Analisa Sistem Penilaian Kinerja Guru Menggunakan Fuzzy Inference System Mamdani: Studi Kasus UPT Dinas Pendidikan Kec. Penengahan Lampung Selatan". Jurnal TICOM. Vol. 1 No. 1. ISSN: 2302-3252.

[6] Rusmiari, Darma-Putra, Arya-Sasmita. 2013. Fuzzy Logic Method for Evaluation of Difficulty Level of Exam and Student Graduation. IJCSI International Journal of Computer Science Issues. Vol. 10. Issue 2. No. 2. ISSN:1694-0784.

[7] Kusumadewi Sri, Idham Guswaludin. 2005. Fuzzy Multi-Criteria Decision Making. Media Informatika. Vol. 1. Juni 2005. 25-38. ISSN: 0854-4743.

[8] Abdullah Lazim, Mohd Nordin Abd Rahman. 2012. Employee Likelihood of Purchasing Health Insurance using Fuzzy Inference System. IJCSI International Journal of Computer Science Issues. Vol. 9. Issue 1. No. 2. ISSN:1694-0814.

[9] Kusumadewi Sri, Hari Purnomo. 2010. "Aplikasi Logika Fuzzy untuk Pendukung Keputusan Edisi ke-2". Graha Ilmu. Yogyakarta.

[10] Laksono Heru Dibyo, Muhammad Hafuzzy inference system. 2013. "Aplikasi Fuzzy Clustering dengan menggunakan Algoritma Substractive Clustering untuk Perkiraan Kebutuhan Energi Listrik Jangka Panjang di Provinsi Sumatera Barat dari Tahun 2012-2021". Jurnal Teknologi Informasi & Pendidikan. Vol. 6. No.2. ISSN:2086-4981