Application of Tsukamoto's Fuzzy Inference System in Determination of concentration for students' thesis topics

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Application of Tsukamoto's Fuzzy Inference System in Determination of concentration for students' thesis topics

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Abstract
The IBI Darmajaya master's informatics engineering study program has two concentrations, namely Software Engineering and Information Systems. The concentration is used as a guide for students to take the thesis topic. The determination of the thesis topic that so far has only been based on students' interest in the existing concentration, not based on their expertise. The variables used in determining concentration for the thesis topic are course values, interests, and motivation. This study aims to produce a fuzzy system that can help students in the selection of concentrations for the determination of the topic of the thesis. The method used in this study is the Tsukamoto fuzzy inference system method with 256 rules for a concentration of Software Engineering and 64 rules for a concentration of Information Systems. Based on testing the data of students who do not have concentration, the results obtained are that students are advised to take the concentration of the information system because it has the highest value of 70.6753 compared to the concentration of Software Engineering which has a value of 70.2391.

Keywords: Concentrations, thesis topic, Fuzzy system

INTRODUCTION

The selection of concentration has a very important role in determining the topic of the thesis that students will take.The selection of concentration allows the student to be able to develop the ability that has become better again by studying in-depth of a certain subject according to their interests. This will impact on the topic of the thesis that student will take.

The selection of student interest which has been done by the study program is based on the number of students who take a particular interest at that time (Yulmaini, 2011). The knowledge for the selection of student interest really exists in the head of a department and academic supervisor of the student, but the knowledge is unknown by the student, so there is a possibility of student not selection their interest well (Lukas, Meiliayana, & Simson, 2009). Both of these research input variables used are the values of courses, so it is necessary to do the next research by adding input variables of interest and motivation.

Interest is the tendency in individuals to be attracted to something object or like something object (Djamarah & Bahri, 2008). Interest is basically the acceptance of a relationship between oneself and something outside of oneself. The stronger or closer the relationship the greater the interest. While motivation is a number of processes that are internal or external to an individual that causes enthusiasm and precise attitude, in this case carrying out certain activities (Winardi, 2002).

There are several factors that influence the motivation of students in the choice of concentration in the management department of the faculty of economics at Jember University, namely friend factor, lecturer factor, interest factor, and ability factor. So based on this, knowing the interest and motivation in selecting student concentration in determining the thesis topic that existed in students early can help students develop their abilities so that they will be more focused on developing their abilities (Yaqin, 2013).

Department of Master of Informatics Engineering Graduate Program IBI Darmajaya has two concentrations that students can use to determine the topic of thesis. The concentrations are Software Engineering and Information Systems. During this time, the determination of student thesis topic only based on student interest to a concentration that is not based on the expertise it has. While the method used so far is conventionally by regression analysis of the factors that influence the selection of concentration, where the determination of interest-based on the exact approach by using statistical methods. Therefore, attempted to compare the performance of conventional methods of regression analysis with the intelligent system method, in this case, is fuzzy logic. The reason for the use of fuzzy logic because this logic can tolerate uncertain values and based on reasoning using an approach to the uncertainty that compiles numeric variables, linguistic variables, and rules. Regression analysis is used to measure the interest and motivation of students in the selection of concentration while the result of interest and motivation measurement will be used as an input variable in the fuzzy method.

Based on the explanation from the above background, then the problem is "how the application of fuzzy logic in the selection of student concentration for the determination of the thesis topic". The purpose of this study is to produce a system that can assist students in the selection of concentration for the determination of thesis topics by using fuzzy logic. While the benefits of this research are to assist students in the selection of concentration for the determination of the thesis topic and to know the effect of the number of variables used in the selection of student concentration.

LITERATURE REVIEW

Fuzzy Logic

Fuzzy logic is a method used to map input space into an output space (Kusumadewi & Purnomo, 2010). Fuzzy logic is an extension of the many logical values derived from the formation of fuzzy sets and fuzzy relations as a tool (Bojadziev & Bojadziev, 2007).

Universe of speech

The universe of speech is the entire problem space from the smallest value to the largest value. The universe of speech is monotonous upward. For example, the temperature of the universe is 100-360.

Crisp Association

The crisp set is the set that distinguishes members and non-members with clear boundaries (Suyanto, 2007). This set is symbolized by uppercase letters (A, B, P, etc.), members (elements) of the set are symbolized by lowercase letters (a, b, x, y, etc.). The crisp set has only 2 membership values (μ), namely (Kusumadewi & Purnomo, 2010).
one (1) value, if an item is a member of a set, or;
zero (0) value, if an item is not a member in a set.

Fuzzy Variable

Variables of fuzzy are the variables that will be discussed in a fuzzy system. For example, temperature, age, height, and others.

Fuzzy Set

Fuzzy sets are sets that will be discussed on a variable in a fuzzy system. For example, Temperature: Cold, Cool, Warm, H Age: Young, Paraya, Old, Height: Low, High, etc. The fuzzy set has two attributes, namely:

Linguistics, namely the naming of a group that represents a certain state or condition using natural language. For example, YOUNG, PAROBAYA, OLD; Linguistic variables are variables that have the value of words or sentences in natural or intelligent languages (Bojadz & Bojadziev, 2007).

Numerical, which is a value (number) that indicates the size of a variable. For example, 40, 25, 20, etc.

Fuzzy Set Domain

The fuzzy set domain is the whole value in the universe of conversation. The domain is a set of real numbers that rise (increase) monotonically from left to right. Domain values can be either positive or negative numbers.

Membership Function

A membership function is a curve that shows the mapping of data input points into membership values (often also called degrees of membership) that have intervals from 0 to 1. One way that can be used to obtain membership values is through a approach function (Kusumadewi & Purnomo, 2010). Some membership functions that are often used in the real world, namely: (Suyanto, 2007)

a. Triangle function

This function has one x value which has a membership degree equal to 1, that is when x = b. However, the values around b have a degree of membership that drops quite sharply (away 1). Graphs and mathematical notation of the triangle function as shown in Figure 1.

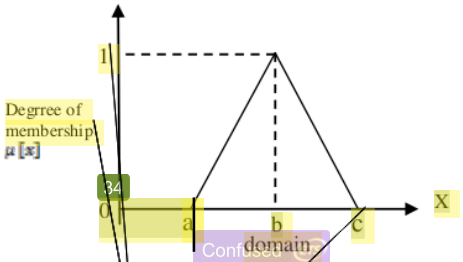

Figure 1. Triangle function (Suyanto, 2007)

Membership Function:

$$\mu(x) = \begin{cases} 0; & x \le a \text{ or } x \ge c \\ (x-a)/(b-a); & a \le x \le b \\ (c-x)/(c-b); & b \le x \le c \end{cases}$$

Where x is the variable will find, a is the lower limit, b is the middle limit, and c is the upper limit.

b. Trapezoidal Function

This function has several x values that have a membership level equal to 1, when b x ≤ c. However, the degree of membership for a <x <b and c <x ≤ d has the same characteristics as triangle function. Graphs and mathematical notation of the trapezoidal function as shown in Figure 2.

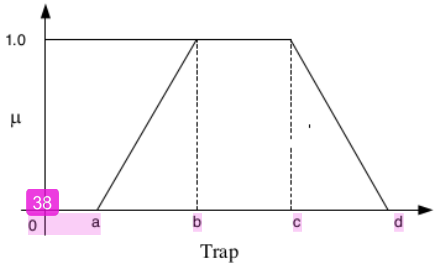

Figure 2. Trapezoidal Function (Suyanto, 2007)

Membership Function :

$$\mu(x) = \begin{cases} 0; & x \le a \text{ or } x \ge d \\ (x-a)/(b-a); & a \le x \le b \\ 1; & b \le x \le c \\ (d-x)/(d-c); & c \le x \le d \end{cases}$$

Where x is the variable to look for, variable a is the lower limit, b and c are the middle limit, and d is the upper limit.

Fuzzy Inference System (FIS)

The main motivation for fuzzy logic theory is to map an input space into an output space using IF-THEN rules. Mapping is done in a Fuzzy Inference System (Fuzzy Inference System / FIS) also call fuzzy inference engine is a system that can evaluate all the rules simultaneously to produce conclusions and the order of rules can be arbitrary (Naba, 2009). Therefore, all the rul or rules must be defined first before building a FIS that will be used to interpret a rule. Several type of FIS are known, namely Mamdani, Sugeno and Tsukamoto (Naba, 2009). A complete fuzzy rule-based system consists of three main components: fuzzification, inference, and defuzz tion.

Fuzzification changes the input whose truth value is certain (crisp put) into the form of fuzzy input, which is a linguistic value whose semantics are determined based on a certain membership function (μ). Inference makes reasoning using fuzzy input and fuzzy rules that have been determined t oduce fuzzy output. Whereas defuzzification changes fuzzy output to crisp value based on the specified membership function (μ).

Tsukamoto Method

Tsukamoto's method every consequent to IF-THEN rules must be represented by a fuzzy set with a monotonous membership function. As a result, the output of the inference results from each rule is given explicitly (crisp) based on α-predicate (fire strength). The final results are obtained using weighted averages (Kusumadewi & Purnomo, 2010).

Suppose there are input variables, namely x and y, and one output variable, z. The variable x is divided into 2 sets, namely A1 and A2, the variable y is divided into 2 sets too, namely B1 and B2, while the output variable Z is divided into 2 sets namely C1 and C2. Of course the set C1 and C2 must be a monotonous set. Then 2 rules as follows:

IF x is A_1 **and** y is B_2 **THEN** z is C_1

IF x is A_2 **and** y is B_1 **THEN** z is C_2

α-predicate for the first and second rules, respectively α1 and α2, then the value of Z1 is obtained in the first rule, and Z2 in the second rule. Finally, by using a weighted rule, the final output (Z value) is obtained with the following formula:

$$Z = \frac{\alpha_1 Z_1 + \alpha_2 Z_2}{\alpha_1 + \alpha_2}$$

The block diagram of the inference process with the Tsukamoto method can be seen in Figure 3.

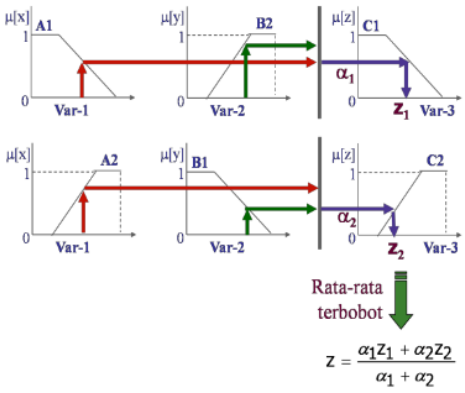

Figure 3. Block diagram of the inference process with the Ttsukamoto method (Kusumadewi & Purnomo, 2010)

There are several steps needed to get the output, including:

a. Formation of Input variables, fuzzy sets, and fuzzy outputs
   Input variables and output variables are divided into one or more fuzzy sets
b. Degree of membership
   Determine the degree of membership based on fuzzy input and sets
c. Fuzzy operator application
   At this stage determine the α-predicate rule with the MIN function implication and then determine the value of Z for each rule.
d. Affirmation (defuzzy)
   The defuzzification used is a weighted average.

Interest

Interest is a settled tendency to pay attention to and remember some activities (Djamarah & Bahri, 2008). Someone interested in the activity will pay attention to the activity consistently with pleasure. Therefore the interest then begins to provide an existing attraction or there is a pleasant experience with these things. Someone interested in an activity will pay attention to that activity consistently with a sense of pleasure because it comes from within someone who is based on feelings of love and the absence of coercion from outside parties. In other words, interest is a feeling of preferability and sense of attachment to a thing or activity, without being forced. According to (Yaqin, 2013) interest is the tendency of individuals to focus attention on feelings of preferability and sense of attraction towards an object or situation in this case is the choice of concentration.

There are several indicators of interest in learning, which are as follows (Yaqin, 2013):

1. Feelings of pleasure. A student who has a feeling of pleasure or likes the lesson then he has absolutely no feeling of being forced to study the field.
2. Student Interest. Related to the motive that drives students to tend to feel attracted to people, objects, activities, or can be an effective experience that is stimulated by the activity itself.
3. Student Attention. Attention is the concentration or activity of the soul towards observation and understanding, leaving aside others from it. Students who have an interest in a particular object will naturally pay attention to that object.
4. Student Involvement. A person's interest in an object causes the person to be happy and interested in doing or doing the activities of the object.

METHOD

This research uses data from postgraduate students who have taken a thesis and will take a thesis in the form of course scores and questionnaire data (interest and motivation). The sample data used in this study was 37 students. Questionnaire data is taken by distributing questionnaires to postgraduate students.

Research methods

The technique of applying the method used in developing the fuzzy system in the selection of student concentration for the determination of the thesis topic in this research is using the Fuzzy Inference System (FIS) Tsukomoto method. This method can be described in Fuzzy system architecture. The architecture of this FIS-Tsukamoto system can be seen in Figure 4.

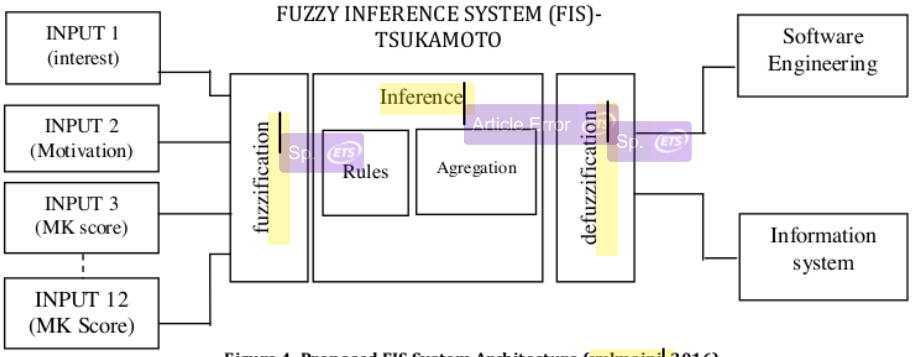

Figure 4. Proposed FIS System Architecture (yulmaini 2016)

The selection of student concentration for the determination of the topic of the thesis is influenced by the values of the courses that have been taken, 14 input variables are required are the values of the courses related to the concentration of the thesis topic, the value of interest, and the value of motivation. Variable input consists of Computer Network and Data Communication (JK) Management, Software Engineering and System Analysis Design (PL), Database Management (BD), Strategic Information System Planning (PS), Project Management of Information Technology (MP), Image Processing (PC), Artificial Intelligence (KB), Internet and Web Programming (IP), Software Quality Assurance (PK), Algorithm Analysis and Design (AP), Information System Audit (AS), Decision Support System (SP) Interests (MT), and Motivation (MS). The required input will fill the size of the range and choose the type of membership function as well as the required parameters. Data processing is done by determining input variables and output variables and determining the universe of speech. The next step is to form a fuzzy set. Determination of variables and universes of speech from the results of data collection can be obtained in Table 3. And the fuzzy set is shown in Table 4.

Table 3. Determination of Variables and Discussion Universe

Function	Name of variable	universe of speech	Explaination
Input	Value MK [1:12]	[0 – 100]	Value of MK :
	Value Interest [13]		
	Value of Motivation[14]		
Output	Group of Concentration [1:2]	[0 – 100]	Concentration 1 (KRP) : Concentration of Software Engineering Concentration 2 (KSI): Information Systems Concentration

Table 4. Fuzzy set

Function	Variable	Name of Fuzzy Set /linguistic	Symbol	Range	Domain
Input	Value MK [1:12]	High	Ti	0 - 100	50 – 100
		Low	Re		0 – 80
	Value of Interest [13]	High	Tn	0 - 100	50 – 100
		Low	Rn		0 – 80
	Value of motivation [14]				
Output	Group of concentration [1:3]	Hight	Tn	0 - 100	50 – 100
		Low	Rn		0 – 80

Membership Function Design

In this research, we purpose membership function design; the design of membership functions in this study has a universe of talks from 0 to 100 for the variables of course values based on Benchmark Reference (PAP) (2010). The reason for determining the discovery of the universe of talks from 0 to 100 is that each lecturer has different judgments depending on the class condition.

Membership Function Variable Input Values Subject (MK) with the universe of speech (0 - 100)

Represents the value variable of the course used the membership function representation of the left shoulder for the LOW fuzzy set and right shoulder for the HIGH fuzzy set. This function is to end an area and there are some points that have a membership value of 1.

HIGH with domains (50-100) and right Trapezoid membership functions.

$$\mu_{HIGH}(x) = \begin{cases} 1; & x \geq 80 \\ \frac{x-50}{30}; & 50 \leq x \leq 80 \\ 0; & x \leq 50 \end{cases}$$

LOW with domain (0 - 80) and left trapezoid membership functions.

$$\mu_{LOW(x)} = \begin{cases} 1; & x \le 50 \\ \frac{80-x}{30}; & 50 \le x \le 80 \\ 0; & x \ge 80 \end{cases}$$

Membership Function Variable Input Values motivation (MT) with the universe of speech (0 - 100)
The interest value variable represents the membership function of the left shoulder representation for the LOW fuzzy set and the right shoulder for the HIGH fuzzy set. This function is to end an area and there are several points that have a membership value of 1.
HIGH with domain (50-100) and right Trapezoid membership function.

$$\mu_{HIGH\ (x)} = \begin{cases} 1; & x \ge 80 \\ \frac{x-50}{30}; & 50 \le x \le 80 \\ 0; & x \le 50 \end{cases}$$

LOW with domains (0 - 80) and left Trapezoid membership function.

$$\mu_{LOW(x)} = \begin{cases} 1; & x \le 50 \\ \frac{80-x}{30}; & 50 \le x \le 80 \\ 0; & x \ge 80 \end{cases}$$

Membership Function Input Variable Motivation Value (MS) with the universe of conversation (0 - 100)
Representing the motivational value variable is used as the left shoulder representation function for the LOW fuzzy set and the right shoulder for the HIGH fuzzy set. This function is to end an area and several points have a membership value of 1.
HIGH with domain (50-100) and right Trapezoid membership function.

$$\mu_{HIGH\ (x)} = \begin{cases} 1; & x \ge 80 \\ \frac{x-50}{30}; & 50 \le x \le 80 \\ 0; & x \le 50 \end{cases}$$

LOW with domains (0 - 80) and left Trapezoid membership function.

$$\mu_{LOW(x)} = \begin{cases} 1; & x \le 50 \\ \frac{80-x}{30}; & 50 \le x \le 80 \\ 0; & x \ge 80 \end{cases}$$

Membership Function Variable Output Group Concentration with Universe Discussion (0 - 100)
The concentration group for the thesis topic is the concentration of software engineering and information systems. It represents the concentration group variable used the left shoulder representation membership function for the LOW fuzzy set and the right shoulder for the HIGH fuzzy set, where this function is to terminate an area and some points have a membership value of 1.
HIGH with domains (50-100) and right Trapezoid membership functions.

$$\mu_{HIGH\ (z)} = \begin{cases} 1; & z \ge 80 \\ \frac{z-50}{30}; & 50 \le z \le 80 \\ 0; & z \le 50 \end{cases}$$

LOW with domain (0 - 80) and left trapezoid membership function.

$$\mu_{LOW(z)} = \begin{cases} 1; & z \le 50 \\ \frac{80-z}{30}; & 50 \le z \le 80 \\ 0; & z \ge 80 \end{cases}$$

Design of Fuzzy Rules
The design of the Fuzzy Rule's in this study is based on the mapping of the subject value associated with each topic thesis concentration. There are several foundations in the formation of fuzzy rules are as follows:
Basic course (MD) is a course that is in all concentrations of a thesis topic that is JK, PL, BD, PS, MP, PC, KB, and IP. One of the MD course grades can below to meet one of the concentration groups.
Core Courses (MI) is the core course of each of the thesis topic concentration of PK, AP, AS, and SP courses. MI course grades should not be Low to produce High concentration groups.

Problem Solving Process of Student Concentration Election
The process of solving the problem of student concentration selection to determine the topic of this thesis using the FIS-Tsukamoto method. The process flow of problem-solving with this method can be seen in Figure 6.

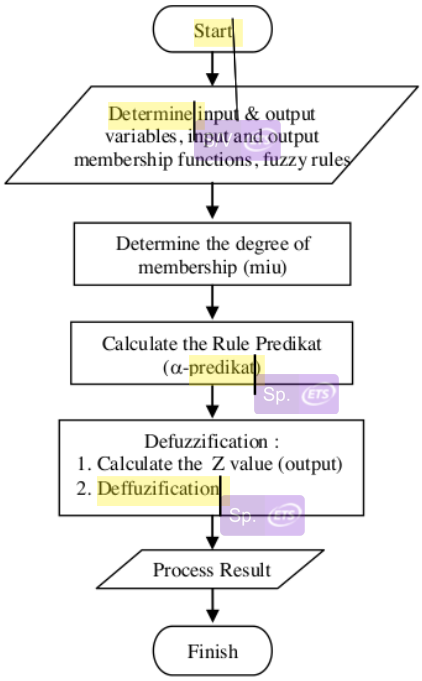

Figure 6. FIS-Tsukamoto Method Problem Solving Flow

RESULT AND DISCUSSION

Results Usage of fuzzy logic

The results obtained in this study are the selection of student interest in the selection of concentration for the determination of the thesis topic by using fuzzy logic that is the Fuzzy Inference System (FIS) method, Tsukamoto. The result of the fuzzy logic process is an alternative problem-solving in the selection of student concentration for the determination of the topic of the thesis. The input variables of this system consist of 14 namely the values of subjects, motivation, and interest while the 3 output variables are student concentration groups.

Fuzzy System View

The FIS method view is used to perform the process in the FIS method. The user enters the data of course values then will be processed to produce the suggested interest for the student concerned.

The FIS method used in this study is Tsukamoto. Stages needed to get output, including :

Step One: Determine Input Variables, Outputs, Membership Functions, and Fuzzy Rules

Determination of input variables based on table 2. and output variables based on table 3. Determine membership functions based on equations 4 through equation 11. The membership function used is the left Trapezoid for Low, Right Trapezoid for High and the Triangle for medium.

Step Two: Determine the degree of membership (Miu) course values.

Determination of the degree of membership based on 1 data not a sample of student course values. The determination of the degree of membership is based on non-sample data input variables. The formation of the degree of membership is based on the input variables, namely the group of course values based on table 3 and the design of the membership function according to equations 1 through 6 in the previous chapter. The results of determining the degree of membership or μ(Miu) for each course value.

Third step: Determine α-predicate

Determine the α-value predicate based on the degree of membership or μ (Miu) for each course value and fuzzy rules that have been designed in table 3. The implication function used is Min, which takes the lowest value from the fuzzy set of input variables based on the fuzzy rules of each final project specialization group (the lowest of the fuzzy rules). Twelve (12) examples of predicate determination results for the PPP Concentration are as follows:

1	Rule	1	0.547
2	Rule	2	0.3
3	Rule	3	0.1567
4	Rule	4	0.1567
5	Rule	5	0.45
6	Rule	6	0.3
7	Rule	7	0
8	Rule	8	0.1567
9	Rule	9	0.1567
10	Rule	10	0.1567
11	Rule	….	…..
12	Rule	256	0

Twelve (12) examples of the results of determining the α--predicate for KSI Concentration areas as follows:

1	Rule	1	0.550
2	Rule	2	0.35
3	Rule	3	0.1933
4	Rule	4	0.1567
5	Rule	5	0.1567
6	Rule	6	0.1567
7	Rule	7	0.1567
8	Rule	8	0.1567
9	Rule	9	0.45
10	Rule	10	0.35
11	Rule	…..	.....
12	Rule	64	0.157

Step Four: Determine the Z Value (output / PM)
Determine the Z value for each specialization group Z value specialization group rules, the design of the fi assignment specialization group membership functions in equation (4.4), equation (4.5), equation (4.6), and fuzzy output rules for each specialization of the final project. The results of determining the Z value (output) of the KRP concentration for each fuzzy rule are as follows:

1	Rule	1	66.4
2	Rule	2	59
3	Rule	3	54.7
4	Rule	4	54.7
5	Rule	5	63.5
6	Rule	6	59
7	Rule	7	80
8	Rule	8	54.7
9	Rule	9	75.3
10	Rule	10	75.3
11	Rule	…..	.....
12	Rule	256	80

The results of determining the value of Z (output) KSI concentration for each fuzzy rule areas follows:

1	Rule	1	66.5
2	Rule	2	69.5
3	Rule	3	74.2
4	Rule	4	55.8
5	Rule	5	75.3
6	Rule	6	75.3
7	Rule	7	54.10
8	Rule	8	75.3
9	Rule	9	66.5
10	Rule	10	60.5
11	Rule	……	….

12	Rule	64	75.3

Step Five: Defuzzification process

The defuzzification process used in this study is a weighted average, where the determination is based on the Z value for each fuzzy group specialization rule. The value of Z is obtained from Σ (α-predicate$_{rule}$ (KK Group) * Z$_{rule}$(KK-Group)) / Σ (α-predicate$_{rule}$), where Z is a weighted rule and α is a fire straight. The defuzzification process of the two concentrations is as follows:

The concentration of the PPP is 70,2391.

The KSI concentration is 70.6753.

CONCLUSION

Based on the discussion that has been described in the previous chapters, it is taken some conclusions that the fuzzy system made used in the selection of student concentration to determine the topic of this new thesis to the design stage of the method and system. A fuzzy system using the FIS-Tsukamoto method will produce output based on a fuzzy rule designed.

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