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PROCEEDINGS

In Cooperations With :

Hosted by :
Faculty of Engineering and Faculty of Computer Science,
Bandar Lampung University (UBL), Indonesia

2nd ICETD 2013

THE SECOND INTERNATIONAL CONFERENCE ON ENGINEERING AND TECHNOLOGY DEVELOPMENT

28 -30 January 2013
Bandar Lampung University (UBL)
Lampung, Indonesia

PROCEEDINGS

Organized by:

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PREFACE

The Activities of the International Conference is in line and very appropriate with the vision and mission of Bandar Lampung University (UBL) to promote training and education as well as research in these areas.

On behalf of the Second International Conference on Engineering and Technology Development (2nd ICETD 2013) organizing committee, we are very pleased with the very good response especially from the keynote speaker and from the participans. It is noteworthy to point out that about 80 technical papers were received for this conference.

The participants of the conference come from many well known universities, among others : University Kebangsaan Malaysia – Malaysia, APTIKOM – Indonesia, Institut Teknologi sepuluh November – Indonesia, Surya Institute – Indonesia, International Islamic University – Malaysia, STMIK Mitra Lampung – lampung, Bandung Institut of Technology – Bandung, Lecture of The Malahayati University, B2TP – BPPT Researcher – lampung, Starch Technology Center – Lampung, Universitas Islam Indonesia – Indonesia, Politeknik Negeri Malang – Malang,University of Kitakyushu – Japan, Gadjah Mada University – Indonesia, Universitas Malahayati – Lampung, Lampung University – lampung, Starch Technology Center – Lampung, Universitas Riau – Riau, Hasanuddin University – Indonesia, Diponegoro University – Indonesia, King Abdulaziz University – Saudi Arabia, Parahyangan Catholic University – Indonesia , National Taiwan University– Taiwan, Surakarta Christian University – Indonesia, Sugijapranata Catholic University – Indonesia, Semarang University – Indonesia, University of Brawijaya – Indonesia, PPKIA Tarakanita Rahmawati – Indonesia, Kyushu University, Fukuoka – Japan, Science and Technology Beijing – China, Institut Teknologi Sepuluh Nopember – Surabaya, Researcher of Starch Technology Center, Universitas Muhammadiyah Metro – Metro, National University of Malaysia – Malaysia.

I would like to express my deepest gratitude to the International Advisory Board members, sponsor and also to all keynote speakers and all participants. I am also gratefull to all organizing committee and all of the reviewers who contribute to the high standard of the conference. Also I would like to express my deepest gratitude to the Rector of Bandar Lampung University (UBL) who give us endless support to these activities, so that the conference can be administrated on time

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IMPLEMENTATION OF FUZZY INFERENCE SYSTEM WITH TSUKAMOTO METHOD FOR STUDY PROGRAMME SELECTION

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Abstract - *Deciding study programme is crucial because any fault in making the decision will affect students' learning motivation, length of study period which exceeds the standard, and the students' failure. With a methodical selection of study programme, each student is expected to focus on his interest and capability more. Fuzzy Inference System (FIS) with Tsukamoto method can be applied to support the settlement. In the method, output is obtained with four stages, namely the formation of fuzzy sets, the establishment of rules, the application of implicated functions, and defuzzification. The purpose of this study is to apply FIS with Tsukamoto method to the decision of study programme which fits prospective students' interest and capability. Moreover, the input variables involve Interview Scores, Scores of Informatics Engineering, Scores of Information Systems and Scores of Written Tests. Output variables are the students' interest either in the Department of Informatics Engeenering or the Department of Information System.*

Keywords: *Study Program, Tsukamoto Method, Students*

I. INTRODUCTION

Problem solving, nowadays, requires a decision supporting system with science, technique and methodology. Every person must have problems and meet several unavoidable options. Problems in decision makings are also experienced by students who are continuing their education to a higher level. Many things have to be considered in deciding what study program will be taken. Most people prefer a study programme which is easy to deal with and potential in the job market, regardless of their interest and ability. In fact, the opinion needs to reconsider because deciding study programme is very crucial. Faults in making the decision significantly affect the students' future. One obvious impact is that the students do not enjoy the learning process and fail in their study (Selfina-Pare, 2010, p1).

University is an institution of higher education and research which offers academic degrees in a range of fields. A university generally provides undergraduate and postgraduate programmes involving faculties with various study programmes. The Faculty of Computer Science (FIK) is one of faculties in Bandar Lampung University (UBL). The faculty has two optional study programmes, which are Informatics Engineering and Information Systems. To become a new student in the faculty, some requirements need to meet, namely a copy of academic certificates, a copy of academic reports, a copy of academic transcripts, photographs, following a written test and interview.

Hitherto, in the faculty, the selection of study programme relies on the prospective students. The method has various weaknesses. From the faculty, there is no thorough approach which is applied in the study-programme selection, no standard indicators determining what study programme most fits the students' interest and capability, and no aid or supporting software used to help the decision making.

Additionally, from the students' viewpoint, less information and knowledge regarding the optional study programmes are other weak points. The selection of inappropriate study programme can influence their learning process. If there is a mistake in settling on study programme, learning motivation and length of study period will poorly affected. Fuzzy Inference System (FIS) is an approach which can be applied to aid the decision making and to resolve the issues.

In FIS, there are three methods, which are *Tsukamoto*, *Mamdani* and *Sugeno*. In Tsukamoto method, each consequence of IF-Then rules has to be represented with a *fuzzy* set with monotonous membership functions. Accordingly, the output of the interference of each rule is explicitly given (*crisp*) based on α-predicate (*fire strength*). The end result is obtained by using a weighted average. In *Mamdani* method, input and output variables are divided into one or more *fuzzy* set(s). Consequently, the output of the interference of each rule uses the Max (maximum) method and the Additive (sum) method. The end result is numbers in the domain of the *fuzzy* set, where the data is processed by using some *defuzzification* methods on the composition rules to get the output. Conversely, in *Sugeno* method, which is similar to *Mamdani* method, the output (consequence) system is not a *fuzzy* set, but a constants or a linear equation. In this study, the writer applied Tsukamoto method because the inference process of study program selections for the Department of Informatics Engineering and the Department of Information Systems is monotonous scores (in accordance with Tsukamoto method).

By FIS with Tsukamoto method, which involves *fuzzyfication*, inference, and *defuzzyfication*, the selection process of study program becomes more accurate. The end result is obtained by using a weighted average. The main factors influencing the study program selection as input variables are interview scores (NW), scores of Informatics Engineering (NTI), scores of Information Systems (NSI) and test scores (NT). Output variables consist of study programmes, namely Informatics Engineering (TI) and Information Systems (SI). With the decision supporting system based on FIS with Tsukamoto method, the choice of study program more agrees with the future students' interests and ability.

II. LITERATURE REVIEW

2.1 Fuzzy Logic

Prof. Lotfi A. Zadeh states that *fuzzy logic* is associated with the principles of formal reasoning on unconditional things or approximate reasoning. However, the *fuzzy*-set theory does not replace the theory of probabilities. In the *fuzzy*-set theory, the most influential component is membership functions.

There are several reasons why *fuzzy logic* is used (Kusumadwi, Purnomo, 2010, p2), as follows:

a. The concept of *fuzzy logic* is easy to understand. The mathematical concept

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underlying *fuzzy* reasoning is vastly simple and easy to work out.

b. *Fuzzy logic* is very flexible. It means that *Fuzzy logic* can adapt to variation and vagueness coming with problems.
c. *Fuzzy logic* can tolerate inaccurate data.
d. *Fuzzy logic* can model complex nonlinear functions.
e. *Fuzzy logic* can be directly constructed and applied in line with experts' experiences without training.
f. *Fuzzy logic* can be used in conventional control systems.
g. *Fuzzy logic* is based on natural languages.

2.2 Concept of *Fuzzy* Set

Fuzzy logic was born in line with imprecise natural phenomenon, which is reviewed from people's perspectives - in which no condition or statement is exactly right or wrong. Prof. Lotfi A. Zadeh suggests that the concept of *true* or *false* in Boolean logic cannot represent uncertain statements between the statements of *true* or *false* - similar to the real world. To represent the uncertainty values between the true or false, Prof. Lotfi A. Zadeh suggests that *fuzzy set* is a class of objects with a united series of membership grades. A set is characterised by functions, which gives each object a membership grade from 0 to 1. Ideas of inclusion, union, intersection, complement, relations and convexity are given to the set; and various properties of these ideas, in the context of *fuzzy set*, are constructed. Particularly, a hypothesis of convex *fuzzy* sets is proved without dashed fuzzy sets.

Fuzzy set has two attributes (Maria Bojadziev& George Bojadziev 2006, P43-45), as follows:

a. Linguistics is a naming of a group which stands for a particular condition with natural language, such as: very less, less and fair.
b. Numeric is a value (number) indcating a size of variables, such as: 45, 46, or 59.

2.3 *Fuzzy* System

Some details need to understand in making sense of *fuzzy* system (Kusumadwi, Purnomo, 2010, p6-p7), as follows:

a. *Fuzzy* variables are addressed variables in a fuzzy system.
b. *Fuzzy* sets are a group representing a particular condition in a variable
c. Universe sets are overall values which are allowed to operate in a fuzzy variable. They are a set of real numbers which monotonically increase from left to right. Their values can be positive or negative numbers.
d. Domain is overall values which are allowable in a universe set and can be operated in a fuzzy set. Similar to universe sets, domain is a set of real numbers which monotonically increase from left to right. Their values can be positive or negative numbers.

Membership function is a curve showing a point mapping –points of inputting data into membership values (often called membership grades), whose interval is between 0 and 1 (Kusumadwi, Purnomo, 2010, p8-p23). One method applied to obtain the membership grades is the function approach. There are several functions that can be used.

a. *Linear Representation* is a mapping input into their grades of membership described as a straight line. It is the simplest form and an excellent option to approach vague concepts. There are two circumstances of linear *fuzzy* set, as follows:
   1. Increasing Linear Representation is a set increase started from a domain value, whose membership grade is

0, moving to the right – to domain values with higher grades of membership.
2. Decreasing Linear Representations is the opposite. A straight line is begun with a domain values with the highest grade of membership on the left, then going down to domain values with lower grades of membership.
3. Triangle Curve Representation is a combination of 2 linear lines, shown in the figure below.
4. Shoulder-Shaped Curve Representation is an area located in the middle - between variables represented in a triangle, on the right and the left going up and down, an example can be seen in the following figure:

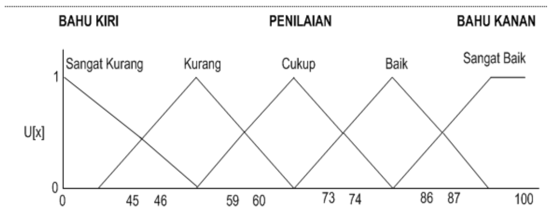


Figure 2

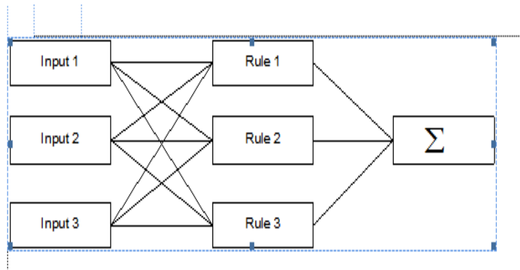
Shoulder-Shaped Curve Representation

2.4 *Fuzzy*-Rule Based Systems

Linguistic variable is a numerical interval with linguistic values, which is defined by its membership functions. The *fuzzy*-rule based system consists of three main components: *fuzzyfication*, inference and *deffuzzification*.

1. *Fuzzyfication* is a value mapping process of crisp-inputs coming from the system (non-*fuzzy* scales) controlled into a *fuzzy* set along with its membership functions. The *fuzzy* set is *fuzzy* inputs being processed in the next *fuzzical* process. To change crisp inputs into *fuzzy* inputs requires determining membership functions for each crisp input, then a *fuzzyfication* process will take crisp inputs and compare them with the existing membership functions to generate values of fuzzy inputs (Siler, James, 2005: p49).
2. Inference is a proceeded relationship between values of crisp input and values of crisp output, which are expected by particular rules. These rules will determine the system's response towards various conditions of setting points and disruptions in the system. The used rules are *IF-THEN*.
3. *Deffuzification* is a stage where min values (α 1, α 2 .. n α) are defined, then finding the value of z1 (approximate values), calculating crisp values, and outputs (Kusumadwi, Purnomo, 2010, p37). The stage is illustrated below.

$$Z = \frac{((\alpha1*z1)+(\alpha2*z2)+(\alpha3*z3)+(\alpha4*z4)+(\alpha5*z5)+(\alpha6*z6)+(\alpha n*zn))}{\alpha1+\alpha2+\alpha3+\alpha4+\alpha5+\alpha6+\alpha n}$$



Picture 2.7

Processes on Fuzzy Logic

2.5 *Fuzzy* Operators

Zadeh's basic types for *fuzzy* set operations are similar to a conventional

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set. Some operations are specifically defined to combine and modify fuzzy sets. Membership values are the result of two-set operations called *firestrength* α-predicates. There are three basic operators suggested by Zadeh, namely: AND operators (operators associated with intersectional operations on α-predicate sets as the result of the AND operators obtained by taking the smallest membership value among elements of the set.

$$\mu_{A \cap B} = \min(\mu_A[x], \mu_B[y]).$$

2.6 Implicative Function

Each proposition on *fuzzy* principles is corresponding to a *fuzzy* relation. The general form of the applied rules in the implicative function is as follows:

IF x is A THEN y is B

X and *y* are scalar. A and B are fuzzy sets. Proposition following *if* is called *antecedent*. Proposition following THEN is called *consequence*. The propositions can be extended by *fuzzy* operators, as follows:

IF (x1 is A1) o (x2 is A2) o (x3 is A3) o ...... o (xN is AN) THEN is B

o is an operator (i.e OR or AND). In general, there are two implicative functions (Sri KusumaDewi, 2004, p28), as follows:

a. Min (minimum) is a function which cuts outputs of a fuzzy set.
b. Dot (product) is a function scaling outputs of a fuzzy set. The figure below illustrates an application of dot function.

2.7 Operators and Hedges in Linguistics

Basically, a *fuzzy* set is a correspondence of a linguistic value (such as: HIGH) and a linguistic variable (such as: height). Hedge is a sort of words strengthening or weakening a linguistic value, such as: more, less, very, fair, and much. For example, a fuzzy set has 3 hedges, 'very', 'quite' and 'not very'. The hedge ‘very’ can be formed with a concentration operation. The hedge ‘quite’ is formed by a dilation operation. The hedge 'not very' is formed by a complement of the concentration operation 'very'. *Fuzzy* hedges can be defined differently regarding certain uses and needs.

a. Hedge: VERY. For example, if there is a membership of the *fuzzy* set HIGH, the relationship of membership functions is from HIGH to very HIGH. The equation is as follows:

$$\mu_{TINGGI}[x] \geq \mu_{SANGATTINGGI}[X]$$

By the concentration operations, the following is obtained:

$$\mu_{SANGAT} A[X] = (\mu_a[X])^2$$

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b. Hedge: QUITE. It is used for the *fuzzy* set HIGH. The relationship of membership functions is from HIGH to quite HIGH. It is formulated as follows:

$$\mu_{TINGGI}\left[X\right] \leq \mu_{AGAKTIGGI}\left[X\right]$$

By the dilation operations, the following is obtained:

$$\mu_{TINGGI}\left[X\right] \leq \mu_{AGAKTIGGI}\left[X\right]$$

In general, the hedge 'quite' is formulated as follows:

$$\mu_{TINGGI}\left[X\right] \leq \mu_{AGAKTIGGI}\left[X\right]$$

2.8 Fuzzy Inference System (Method Tsukamoto)

In Tsukamoto method, each consequence of the *IF-Then* rules must be represented by a fuzzy set with monotonous membership function. Consequently, the interference outputs of each rule are crisply presented in line with α-predicate (*firestrength*). The end result is obtained by a weighted average.

For example, there are two input variables – variable 1 (x) and variable 2 (y) – and one output variable – variable 3 (z). The variable 1 is divided into two sets, namely A1 and A2. The variable 2 is divided into two sets, namely B1 and B2. The variable 3 is divided into two sets, namely C1 and C2 (C1 and C2 must be monotonous). Two rules are used as follows:

[R1] IF (x is A1) AND (y is B2) THEN (z is C1)

[R2] IF (x is A2) AND (y is B2) THEN (z is C2)

First, membership functions of each *fuzzy* set of each rule is the set A1, B2 and C1 from the *fuzzy* rules [R1]; and the set A2, B1 and C2 from the *fuzzy* rules [R2]. *Fuzzy* rules R1 and R2 can be represented in Figure 2.11 to obtain a crisp value Z.

Because, in Tsukamoto method, the used set operation is a conjunction (AND), the membership values of antecedents from the *fuzzy* rule [R1] is a portion of the membership value A1 from Var-1 with the membership value B1 from Var-2. According to the theory of set operations, on the equation 2.7, the value of antecedent memberships from the conjunction operation (AND) of the *fuzzy* rules [R1] is the minimum value between the membership value A1 from Var-1 and the membership value B1 from Var-2. Likewise, the membership values of antecedents from the *fuzzy* rules [R2] are the minimum value between the membership value A2 from Var-1and the membership value B1 from Var-2.

Subsequently, the membership values of antecedents from the *fuzzy* rules [R1] and [R2], called α1 and α2. Then, the value α1 and α2 are substituted into the set of membership functions C1 and C2 in line with the *fuzzy* rules [R1] and [R2] to obtain the value z1 and z2, which are the values z (approximate values) for the *fuzzy* rules [R1] and [R2]. To obtain crisp

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output values/ the fixed value Z requires changing the input (*fuzzy* sets), which is obtained from the composition of the fuzzy rules into a number in the domain of the *fuzzy* sets. This method is called the *defuzzification* method (affirmation). The *defuzzification* methods used in Tsukamoto method is Centre Average Defuzzyfier formulated in a equation.

III. RESEARCH METHODS

3.1 Analysis of Needs

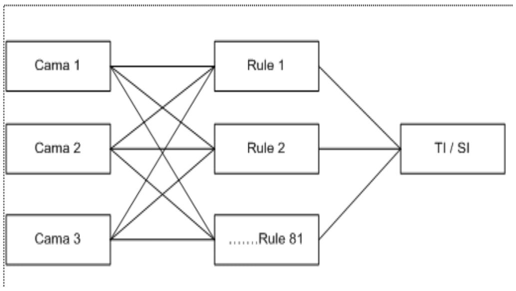
The study will be conducted in several stages illustrated in Figure 4. In the first stage, it begins with determining input and output characters from the dataset of prospective students, then *fuzzyfication* is formulated, after conducting inferences with making rules, calculating *defuzzification* of each input variable and the calculating results of *defuzzification* (specifying crisp outputs).

Table 1
Criteria of Input and Output Variables

Kriteria	Keterangan	Fungsi
NW	Nilai Wawacara	Variabel Input
NTI	Nilai Test	Variabel Input
NSI	Nilai Test	Variabel Input
NTest	Nilai Test	Variabel Input
SI	Prodi Sistem Informasi	Variabel Output
TI	Prodi Teknik Informatika	Variabel Output

Table 2
Required Data Attributes

Kasus	Prodi Awal	NW (a)	NTI (b)	NSI (c)	NTest (d)
1	SI	87	76	68	47
2	SI	76	77	77	55
3	SI	76	79	77	51
4	SI	76	66	82	47
5	SI	75	77	81	48
6	SI	60	70	83	62
7	SI	87	87	79	45
8	SI	83	78	82	52
9	SI	68	78	88	47
10	SI	88	78	79	47
11	SI	85	81	79	87
12	SI	74	64	70	50
13	SI	78	68	74	48
14	SI	76	65	80	60
15	SI	73	80	80	50
16	TI	79	66	72	61



Picture 3.2

FIS Process Determination Prodi

3.2 Data Analysis Techniques

A technique of data analysis is the category process of data sequence, organizing it into a pattern, category and description of the basic unit. In this study to apply fuzzy Inference System for determining the program of study, it is required to have data analysis with the following results:

a. Data transformation
Before analyzing the data, the data value is transformed into a single value. Math scores are obtained from the average value of the value of mathematics at the time of class xi and xii. The scores of TI in the Report cards are obtained for the average value of exact sciences lesson, while scores from report cards for SI are obtained from the average scores of non-exact lesson during class xi and xii. To the following, this formula is used:

$$NTI = \frac{matematika + Nilai\ Raport\ TI}{2}$$

$$NSI = \frac{matematika + Nilai\ Raport\ SI}{2}$$

b. Formation of fuzzy sets (*fuzzification*)
At this stage, Fuzzy Inference System takes input and determines the degree of membership in all fuzzy sets using

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membership functions. Degree of membership functions used in each fuzzy variable is determined based on the circumstances at the Faculty of Computer Science of Bandar Lampung University. Membership function (u) for every fuzzy set has the interval from 0 to 1. A value of 1 indicates absolute membership (100%), while a value of 0 indicates no membership (0%) in the fuzzy set. Table 3.2 below shows the universe of discourse in the fuzzy sets. Range of values that exist in the universe of discourse derived from the value of min, average, and maximum of the database of UBL Marketing Department on Faculty of Computer Science.

Fungsi	Variabel	Notasi	Semesta Pembicaraan
Input	NW	a	[40-90]
	NTI	b	[50-90]
	NSI	c	[50-90]
	NTest	d	[40-90]
Output	TI	e	[40-90]
	SI	f	[40-90]

Table 3
Universe Sets

The following table illustrates fuzzy inputs which affect the selection of study programmes.

Table 4
Inputs of Fuzzy Sets

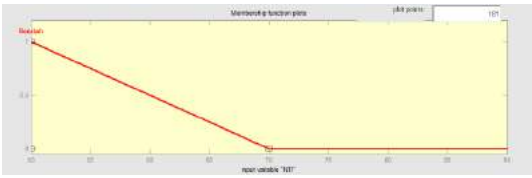
Variabel		Himpunan *Input Fuzzy*		Domain
Nama	Notasi	Nama	Notasi	
NW	a	Rendah	r	[40-65]
		Sedang	s	[52.5-77.5]
		Tinggi	t	[65-90]
NTI	b	Rendah	r	[50-70]
		Sedang	s	[60-80]
		Tinggi	t	[70-90]
NSI	c	Rendah	r	[50-70]
		Sedang	s	[60-80]
		Tinggi	t	[70-90]
NTest	d	Rendah	r	[40-65]
		Sedang	s	[52.5-77.5]
		Tinggi	t	[65-90]

Each fuzzy set considers the maximum and minimum values of each variable. The used value in this method is the minimum value. Each variable consists of three fuzzy sets, namely: low, medium, and high.

a. Fuzzy Sets of Informatics Engineering Scores (NTI)

The degree of linear membership functions decreases. Figure 5 represents the fuzzy sets *low*. The degree of the membership function *low* from the variable NTI is as follows:

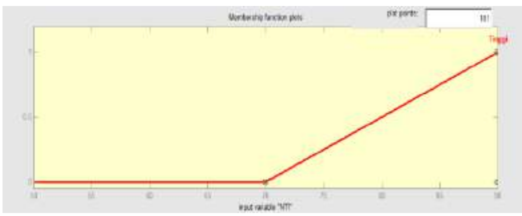
$$\mu r(b) = \begin{cases} 1; \ \frac{70-b}{20} & 50 \leq b \leq 70 \\ 0; & b \geq 70 \end{cases}$$



Picture 3.7
Fuzzy set Low for NTI

The degree of triangular membership function (Figure 7) is used to represent the fuzzy sets “medium”. The degree of membership functions from the variable NTI are defined in the equation below:

$$\mu s(b) = \begin{cases} 1; \ \frac{80-b}{80-70}; & b \leq 60 \\ \frac{b-60}{70-60}; & 60 \leq b \leq 70 \\ 0; & b \leq 60 \ atau \ b \geq 80 \end{cases}$$



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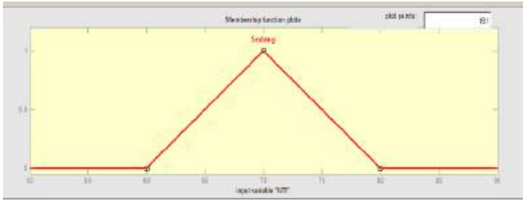


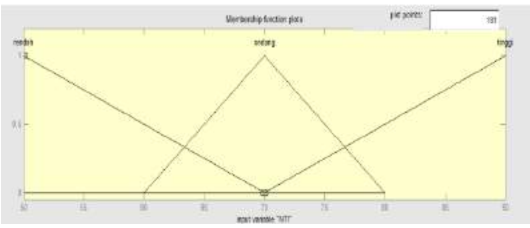
Picture 3.8
Fuzzy Medium set for NTI

The degree of linear membership climbed. Figure 8 is used for *fuzzy* sets *high*. The degree of membership function for the variables NTI is defined below:

$$\mu t(b) = \begin{cases} 0; & b \leq 70 \\ \frac{b-70}{90-70}; & 70 \leq b \leq 90 \\ 1; & b \geq 90 \end{cases}$$

Picture 3.9
Fuzzy high set for NTI

The shoulder-shaped curve is a representation of the result combination from the degree of the decreasing linear of membership functions, the triangle and the increasing linear (Figure 8).



Picture 3.10
Fuzzy set for the Value of Information

c. Application of function of Implication and making inference rules
Application of function of implication in the study uses the method of minimum to combine any degree of membership of each *if then* rules that are made and expressed in a degree of truth (α). Rules derived from the combination of 3 fuzzy sets and 4 input variables, result in 81 rules in Table 3.6. Here is an example of the use of inference rules and the use of function of implication on the determination of the program of study.

[2] **JIKA** NTes Tinggi **DAN** NW Tinggi **DAN** NTI Tinggi **DAN** NSI Sedang **MAKA** TI Tinggi, SI Sedang.

$\alpha_1 = \mu_{NTes}Tinggi \cap {}_{NW}Tinggi \cap {}_{NTI}Tinggi \cap {}_{NSI}Sedang$

[40] **JIKA** NTes Sedang **DAN** NW Sedang **DAN** NTI Sedang **DAN** NSI Tinggi **MAKA** TI Sedang, SI Tinggi.

$\alpha_{40} = \mu_{NTes}Sedang \cap {}_{NW}Sedang \cap {}_{NTI}Sedang \cap {}_{NSI}Tinggi$

[80] **JIKA** NTes Rendah **DAN** NW Rendah **DAN** NTI Rendah **DAN** NSI Sedang **THEN** TI Rendah, SI Sedang.

$\alpha_{40} = \mu_{NTes}Rendah \cap {}_{NW}Rendah \cap {}_{NTI}Rendah \cap {}_{NSI}Sedang$

d. Defuzzification Method
After all the scores of the variables are included, the results would be obtained from defuzzification in the form of the specified crisp scores. At this stage it is specified min value (α1, α2 .. α n), then find the value of z1 = z max - α 1 (zmax-zmin), after that to calculate the value of crisps. The next step is to calculate the output, as follows:

The scores of defuzzification are analyzed. If the entered scores in TI are greater than the scores of SI then new students enter the TI course and vice versa.

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e. Examples of calculation in Tsukamoto Fuzzy Inference System Method. Below is an example of where the data will be calculated by the method of Tsukamoto Fuzzy Inference System. The example of the case is taken and modified from the data of prospective students.

FIS calculation in the first stage is to find the degree of membership of each variable from example in case 16

1. Interview Score (NW = 79)
   Fuzzy set *high*

   $\mu_a(79) = (79-65)/25 = 0.56$
2. Scores of Informatics Engineering (NTI=66)
   Fuzzy set *low*
   $\mu_a(66) = (70-66)/20 = 0.20$
   Fuzzy set *medium*
   $\mu_a(66) = (66-60)/10 = 0.60$
3. Score of Information System (NSI=72)
   Fuzzy set *medium*
   $\mu_a(72) = (70-68)/20 = 1.2$
   Fuzzy set *high*
   $\mu_a(72) = (68-60)/10 = 0.10$
4. Test Score (NTest=61)
   Fuzzy set *low*
   $\mu_a(61) = (65-61)/25 = 0.16$
   Fuzzy set *medium*
   $\mu_a(61) = (61-52,5)/12,5 = 0.68$

FIS calculation in the second stage is to apply the implications for the function to get an output modification of each fuzzy area of any rule that applies. Implication function that is used is: Min method (α -cut). Rule which is affected by the value of the output membership degree of TI is rule 32, rule 59 and rule that is affected by the value of the output membership degree of SI is rule 31, rule 3, rule 34, rule 58, rule 61 and rule 62.

Rule 31

JIKA NW Tinggi **DAN** NTI Sedang **DAN** NSI Tinggi **DAN** NTest Sedang **MAKA** TI Sedang, SI Tinggi

$\alpha_{31} = \mu_{NW}Tinggi \cap {}_{NTI}Sedang \cap {}_{NSI}Tinggi \cap \mu_{NTes}Sedang$

$= \min(0.56;0.6;0.10;0.68)$

$= 0.10$

Lihat himpunan Program Studi SI Tinggi, $(90-f)/15=0.10 \rightarrow Z_{31} = 88.5$

After the involved rule is idenfitied, the next step is calculating the value of crips to produce outputs, as follows:

$$TI = \frac{(\alpha 32 * z32) + (\alpha 59 * z59)}{\alpha 32 + \alpha 59}$$

$$TI = \frac{(0.56 * 71.7) + (0.16 * 68.7)}{0.56 + 0.16}$$

$$TI = \frac{51.14}{0.72}$$

$$TI = 71.03$$

Hasil Output Program Studi Teknik Informatika (TI) adalah 71.03.

$$SI = \frac{(\alpha 31 * z31) + (\alpha 34 * z34) + (\alpha 35 * z35) + (\alpha 58 * z58) + (\alpha 61 * z61) + (\alpha 62 * z62)}{\alpha 31 + \alpha 34 + \alpha 35 + \alpha 58\alpha + \alpha 61 + \alpha 62}$$

$$SI = \frac{(0.10 * 88.5) + (0.10 * 88.5) + (0.20 * 69) + (0.10 * 88.5) + (0.10 * 88.5) + (0.16 * 68.7)}{0.10 + 0.10 + 0.20 + 0.10 + 0.10 + 0.16}$$

$$SI = \frac{60.19}{0.76}$$

$$SI = 79.20$$

Information System (SI) is 79.20

The final step is to compare the value of TI crisp with the value of SI crisp. Of crisp values that have been calculated with Tsukamoto Fuzzy Inference System method in this case, the crisp value of SI

= 79.20 is greater than the crisp value of TI = 71.03. Therefore prospective students should enter the study program of SI (System Information)

IV. IMPLEMENTATION

After all the process of Tsukamoto FIS method is complete. The next stage is to compare the result of the calculation of TI scores and SI scores to get the output. The numbers that exist are in Table 4.6. Output Study Program is the number resulting from the inference test.

Program for recommendations that best suits the interests and abilities of new students come from regulations set by the Faculty of Computer Science University of Bandar Lampung. The provisions of this Program are: if the scores of TI are greater than SI, then they go to TI course, vice versa if the SI scores are greater than the TI program.

Tabel 4.6

Output Program Studi

NO	P_0	Prodi		Minat	Status
		TI	SI		
1	TI	76.9	0.0	TI	SESUAI
2	SI	85.6	77.4	TI	TIDAK SESUAI
3	TI	79.1	84.8	SI	TIDAK SESUAI
4	SI	0.0	83.4	SI	SESUAI
5	SI	84.8	82.7	TI	TIDAK SESUAI
6	SI	0.0	83.8	SI	SESUAI
7	SI	79.9	0.0	TI	TIDAK SESUAI
8	TI	84.0	82.2	TI	SESUAI
9	TI	85.0	80.5	TI	SESUAI
10	TI	78.7	83.3	SI	TIDAK SESUAI
11	TI	82.4	0.0	TI	SESUAI
12	TI	70.4	69.8	TI	SESUAI
13	SI	0.0	76.3	SI	SESUAI
14	TI	70.4	80.6	SI	TIDAK SESUAI
15	SI	83.6	77.1	TI	TIDAK SESUAI
16	SI	0.0	75.2	SI	SESUAI
17	SI	83.4	76.7	TI	TIDAK SESUAI
18	SI	83.3	79.8	TI	TIDAK SESUAI
19	TI	84.7	0.0	TI	SESUAI
20	TI	78.5	82.5	SI	TIDAK SESUAI
21	TI	70.1	80.9	SI	TIDAK SESUAI
22	TI	79.2	87.0	SI	TIDAK SESUAI
23	TI	78.3	87.0	SI	TIDAK SESUAI
24	SI	85.0	84.9	TI	TIDAK SESUAI
25	TI	79.9	87.3	SI	TIDAK SESUAI
26	SI	0.0	84.6	SI	SESUAI
27	SI	84.2	0.0	TI	TIDAK SESUAI
28	SI	87.0	82.2	TI	TIDAK SESUAI

V. CONCLUSION

Based on research done by the application of FIS Tsukamoto method, it can be concluded that: FIS Tsukamoto method can be used for the determination of the program of study. With the implementation of FIS Tsukamoto method, this can simplify the Faculty of Computer Science of Bandar Lampung University particularly in marketing unit in giving the recommendation to potential new students in determining the course that best suits with their interests and abilities. The stages in the process Tsukamoto Fuzzy Inference System method namely:

a. Formation of fuzzy sets (fuzzification). At this stage, it is to find a membership value for each fuzzy set of each variable (input of crisp). By combining all fuzzy sets, it is found of 81 fuzzy rules.
b. Fuzzy rule-making (inference). At this stage, it is to search for antecedent membership values (α) and the estimated value of the most appropriate course (x) of each rule by using the membership function of each fuzzy set.

The determination of output (defuzzification) At this stage, the crisp output value is in the form of the most appropriate course (Z) by altering the input crisps namely: fuzzy sets derived from the composition of fuzzy rules into a fuzzy set of numbers in the domain of the fuzzy sets.

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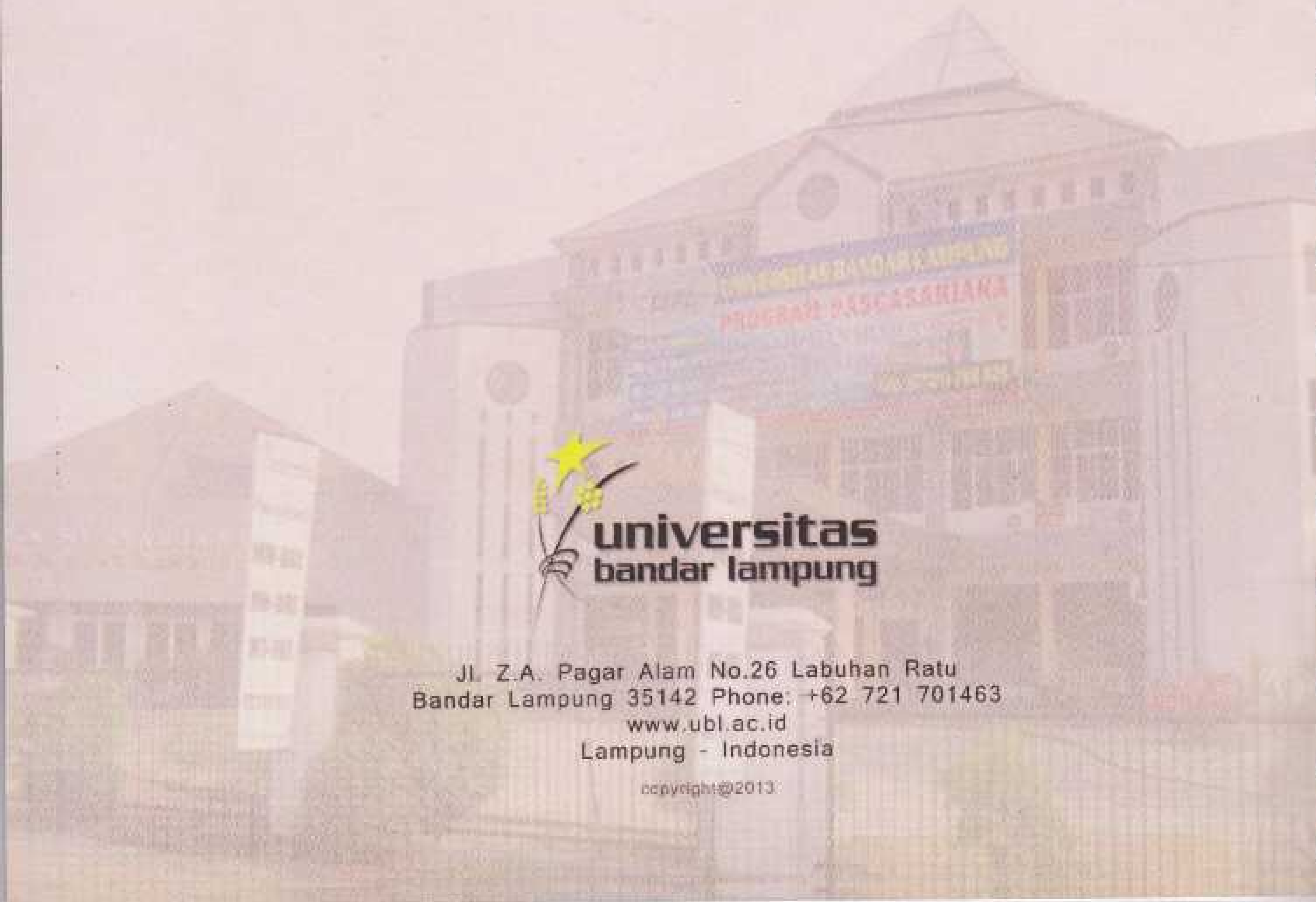

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