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An Application of Mamdani in Selecting Majors in Higher Education

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***Abstract*—The election for a right major at university will make a big difference because students should choose a major that suits their basic skills and talent preference. A research case uses a sample from various majors in state university in Indonesia. There are 29 majors available. Therefore, interest score, talent score, and basic ability score become a consideration matter in choosing the right major for them. The implementation of this system uses PHP programming language and MySQL database which based on the web. This research uses sample data of SMAN (state high school) 1 on Kutowinangun, Kebumen. It is including self-data, interest score, talent score, and basic skill score. This research uses a fuzzy inference system using Mamdani method. Mamdani method works based on linguistic principle and has a fuzzy algorithm which supply approximation to be entered by mathematic analysis. Data are processed through the calculation phase of fuzzy and result given by the system is a recommendation of a major suggested to be taken by the student. This system shows a recommendation of a major that suits the student. This system also gives information about universities which provide recommended major. This system is hope to help students in choosing their major.**

Keywords-fuzzy; inference; Mamdani; decision making

I. INTRODUCTION

A human being is always faced with several choices. The right decision making will be very influence his future. A decision is an activity that is taken over a problem. A decision is resulted from a selection process among several alternative actions that exist to achieve a predetermined goal.

Decision-making problems are also experienced by students of SMAN 1 Kutowinangun Kebumen in determining the selection of majors in education. Lack of information about majors and the unknown on their own interests, talents and abilities among students has made students choose their majors based solely on parents' choices, follow friends, or just choose arbitrarily. The incorrect chosen majors may make the students experience difficulties because feel unable to take classes and feel misguided. Moreover, the student goes through college with laziness and lack of seriousness.

Therefore, a system is necessary, which can help students solve problems in determining the majors that suits their interests, talents, and abilities. This system should provide more than one choice that meets certain criteria. One method that proper to this case is fuzzy inference system. Furthermore, fuzzy inference system with Mamdani method best suited to human instincts, works based on linguistic rules and has a fuzzy algorithm that provides an approximation to enter mathematical analysis. Mamdani method is more suitable for the case in this study, because the input received from humans (not machines) and the expected output in the form of fuzzy sets is not a constant or a linear equation. The results of the decision are based on the value of the calculation results that meet, the value of an interest in the major, the value of certain talents and the value of basic abilities that support certain selected majors in the choices that meet the requirements.

An example of a previous research is an application of a decision support system that help students in choosing aptitude testing and report card grades using Item Response Theory Three-Parameter and AHP (case study at the University of Bengkulu). Students are faced with choices which are science and social studies majors [1]. It is different with our research that has variables interests, talents and basic abilities. Our research also uses Mamdani method for the inference system method.

Other previous research is an implementation of a selection of appropriate majors for students who are going to college with the Nearest Neighbor Method. Variables used are report cards, interests and aptitude tests of the students concerned [2]. The differences with our research are on the inference method and variables used.

The last previous research given here is an application of an expert systems to help students choose majors in college. The system developed was inspired by Rule-Based Systems and Ripple Down Rules. This system organizes the basis of rules in a special structure so that it eases the development of knowledge base. The search for matched knowledge and the dynamic of the system could be obtained by employing the special structure [3].

II. FUZZY LOGIC CONCEPT

Fuzzy logic is an appropriate way to map an input space into an output space. The fuzzy logic model works by using the degree of membership of value, then used to determine the desired results, based on predetermined rules [4]. The process of fuzzy logic is a process based on a knowledge base or rule basis, while the fuzzy logic rules consist of an IF-THEN statement in a membership function.

A. Crisp Set and Fuzzy Set

A crisp set has values of an item x in a set A, which is often written with μA [x]. It has 2 choices, namely:

1) One (1), which means that an item becomes a member in a set, or

2) Zero (0), which means that an item does not belong to a set.

On the other hand, a fuzzy set the membership value are in the range 0 to 1. The fuzzy set has 2 attributes, namely:

1) Linguistics, naming a group that represents a certain condition by using natural language, such as young, middle-aged, old.

2) Numerical, which is a value (number) that shows the size of a variable, such as 40, 25, 50 and so on.

B. Membership function

The membership function is a curve that shows the mapping of input data points into their membership values (often also called the membership degree) which has an interval between 0 and 1. One way that can be used to get membership value is through a function approach. Several functions can be used, including:

1) Linear representation

In linear representation, mapping inputs into degrees of membership is described as a straight line. This form is the simplest and is a good choice to approach a concept that is not clear.

There are 2 linear fuzzy sets. First, the increase in a set starts at the domain value that has zero membership degree [0] moves to the right towards the value of the domain that has a higher degree of membership, as shown in Figure 1.

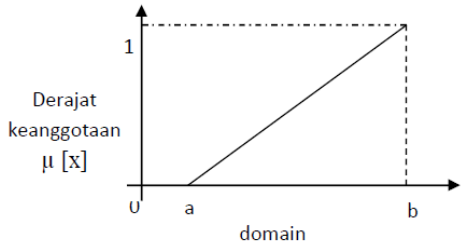

Figure 1. Linear Representation Rises

Membership function is shown in Equation 1:

$$\mu[x] = \begin{cases} 0; & x \le a \\ (x-a)/(b-a); & a \le x \le b \\ 1; & x \ge b \end{cases} \quad (1)$$

Second, is the first inverse. The straight line starts from the value of the domain with the highest degree of membership on the left side, then moves down to the value of the domain that has a lower degree of membership. It is shown in Figure 2.

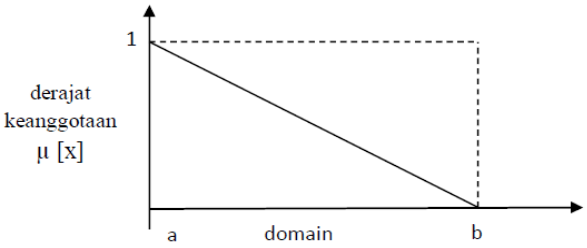

Figure 2. Linear Representation Goes Down

Membership function is shown in Equation 2:

$$\mu[x] = \begin{cases} (b-x)/(b-a); & a \le x \le b \\ 0; & x \ge b \end{cases} \quad (2)$$

2) Representation of Triangle Curves

The triangle curve is a combination of 2 lines (linear) as shown in Figure 3.

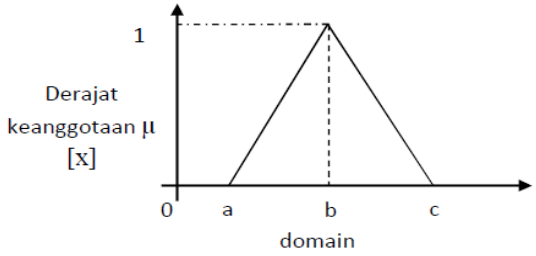

Figure 3. Triangle Curve

Membership function is shown in Equation 3:

$$\mu[x] = \begin{cases} 0; & a \text{ or } x \ge c \\ (x-a)/(b-a); & a \le x \le b \\ (c-x)/(c-b); & b \le x \le c \end{cases} \quad (3)$$

3) Representation of the Trapezoidal Curve

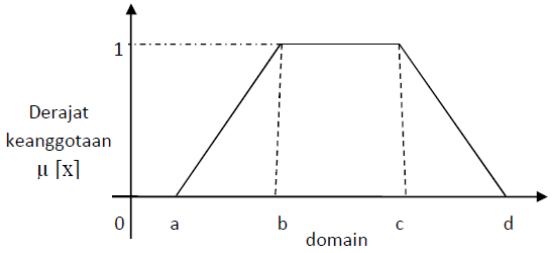

Figure 4. Trapezoidal Curve

Trapezoidal curves, as shown in Figure 4, are basically like triangle shapes, it is just that some points have membership value 1. Membership function is shown in Equation 4:

$$\mu[x] = \begin{cases} 0; & x \le a \text{ or } x \ge d \\ (x-a)/(b-a); & a \le x \le b \\ 1; & b \le x \le c \\ (d-x)/(d-c); & c \le x \le d \end{cases} \quad (4)$$

4) Representation of Shoulder Shape Curves

The area located in the middle of a variable represented in the form of a triangle, on the right and left side will rise and fall. But sometimes one side of the variable does not change. The fuzzy set "shoulder", not a triangle, is used to terminate a variable in a fuzzy area. The left shoulder moves from right to wrong, so the right shoulder moves from wrong to true. Figure 5 shows the temperature varies with the shoulder area.

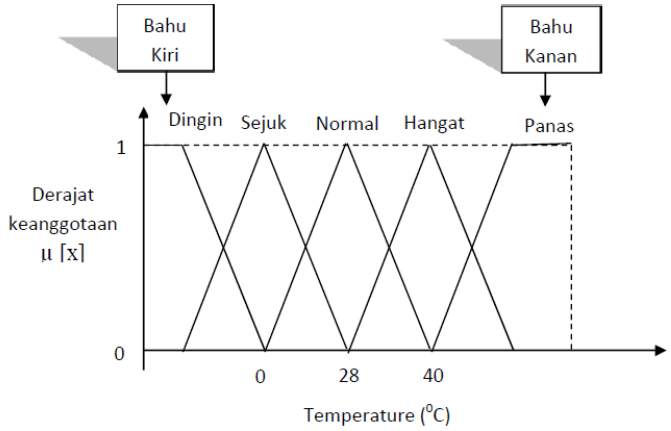

Figure 5. Area 'shoulder' on variable temperature

C. Zadeh Basic Operators for Fuzzy Set Operations

Like conventional sets, there are several operations specifically defined to combine and modify fuzzy sets. The value of membership as a result of 2 set operations is often known as fire strength or α-predicate. There are 3 basic operators created by Zadeh [4].

1) AND Operator

This operator is related to the intersection operation of the set. α- predicate as the result of operation with AND operator is obtained by taking the smallest membership value between elements in the relevant sets. It is shown in Equation 5.

$$\mu A \P B = \min(\mu A[x], \mu B[y]) \quad (5)$$

2) OR Operator

This operator is related to the union operation on the set. α- the predicate as the result of operations with an OR operator is obtained by taking the largest membership value between the elements in the concerned set. It is shown in Equation 6.

$$\mu A \vee B = \max(\mu A[x], \mu B[y]) \quad (6)$$

3) NOT Operator

This operator is related to complement operations in the set. α- the predicate as the result of operations with the NOT operator is obtained by subtracting the membership value of the element in the corresponding set from 1. It is shown in Equation 7.

$$\mu A' = 1 - \mu A[x] \quad (7)$$

III. FUZZY INFERENCE SYSTEM

Fuzzy inference system also called a fuzzy inference engine is a system that can do reasoning with the same principle as humans doing reasoning with their instincts [6]. The input given for the system of fuzzy inference system is a certain number and the output produced must also be a certain number.

The rules in linguistic language can be used as meticulous inputs must be converted first, then do reasoning based on rules and convert the results of reasoning into meticulous output.

A. Tsukamoto Method

In the Tsukamoto method, every consequence of 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 result is obtained using a weighted average.

B. Mamdani Method

The Mamdani method is often known as the Max-Min method. This method was introduced by Ebrahim Mamdani in 1975. To obtain output, it takes 4 stages:

1) Formation of fuzzy sets

In the Mamdani method, both input variables and output variables are divided into one or more fuzzy sets.

2) Application function implications

In the Mamdani method, the implication function used is Min.

3) Composition of rules

Unlike monotonous reasoning, if the system consists of several rules, then the inference is obtained from a collection and correlation between rules.

4) Defuzzyfication

The input from the defuzzyfication process is a fuzzy set that is obtained from the composition of fuzzy rules, while the output produced is a number in the fuzzy set domain.

C. Sugeno Method

Reasoning with the Sugeno method is almost the same as Mamdani reasoning, but the output (consequent) of the system is not in the form of a fuzzy set but in the form of constants or linear equations. This method was introduced by Takagi-Sugeno Kang in 1985.

IV. REQUIREMENT ANALYSIS

A. System Requirements Analysis

Development of an application must go through a Developing Life Cycle System. System analysis and design is the first step and must be done before entering into the implementation phase. This chapter contains an explanation of the stages in the analysis, design and implementation of the fuzzy inference application system Mamdani method that will be created.

B. Data Requirements Analysis

The research carried out requires several data including student data, department data, interest test scores, talent data test value data, and basic ability test score data. The value of the activities considered in the interest test, aptitude test, and basic ability test, for each major, has been consulted with a psychologist, Drs.H.Saeri Tri Kusumo, M.Si., the tests that are processed become the best decision-making factors based on grades which are obtained.

1) Value of interest test

Interest is a desire of a student to pursue a particular major, but in psychology test institutes of interest can be tested through interest tests, there are ten types of activities in interest tests namely [4]:

a) Outdoor activities (ODR).
b) Activities related to machinery and mechanical devices (MECH).
c) Activities related to numbers (COMP).
d) Activities in fact finding and problem solving (SCIE).
e) Activities meet and influence others (PERS).
f) Creative arts and hands-on activities (ART).
g) Reading-writing or relating to books (LITR).
h) Music activities, singing and music viewing (MUS).
i) Community service and help activities (SOS).
j) Service activities in office administration (CLER).

2) Value of Aptitude Test

Talent tests can reveal the extent of the tendency of student talents in certain fields. This aptitude test is a measure of the ability of expressions and in a narrower sense is the ability that handles numerical relations, abstract and symbolic relationships. It can be ascertained that this test includes a variety of abilities that are very important for measuring a combination of one's abilities. There are eight activities in the aptitude test, namely [5]:

a) Verbal Ability (KV).
b) Non-verbal ability (KNV).
c) Mastery of accounting and number (N).
d) Mastery of language (A).
e) Mastery of general knowledge (C).
f) Mastery of mathematical foundations (M).
g) Mastery/perception of space (P).

h) Mastery of the basics of engineering and mechanics (T).

3) Basic Ability Test Scores

Basic ability tests can reveal the extent of students' ability in the learning process at the next level. There are three activities in the basic ability test, namely [5]:

a) Intelligence, general thinking skills (IQ).
b) Emotional intelligence (E).
c) Spiritual Intelligence (S).

V. IMPLEMENTATION

A. Majors Module

A major module can be selected if the user acts as an admin by entering using a valid username and password. This module is for managing major data, admin can edit, add, and delete majors' data. It is shown in Figure 6.

Figure 6. Majors Module

B. User Management Module

The management user module is used to manage admin data and data of students of SMAN 1 Kutowinangun who will use this application. Admin can change the admin username and password through the manage admin password submenu in the user management menu. It is shown in Figure 7.

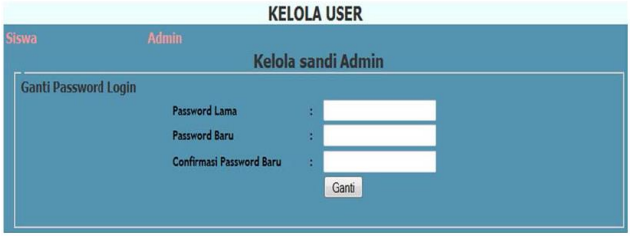

Figure 7. Data Admin Module

Admin can add student data through the student menu on the added submenu, admin can search and edit student data through the search/edit submenu to find student data, by entering nisn or other data as keywords in the search, after the student to be edited the data is found The admin can directly edit and save it. The student data form looks like Figure 8:

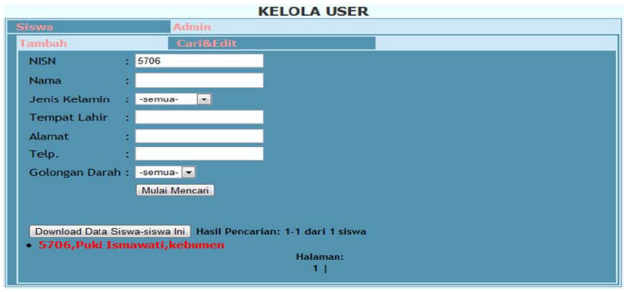

Figure 8. Student Data Module

C. The Module Scores Interest Tests

This module is to show the value of the results of each activity in the student interest test. Admin can search students through the search form with the keyword. Admin can add, edit, delete student data and activity name data in interest tests, admin can also download data on student interest. It is shown in Figure 9.

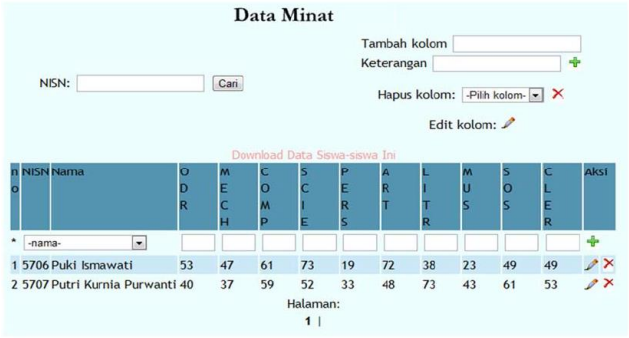

Figure 9. The Module Scores Interest Tests

D. Talent Test Score Module

This module is to show the results of each activity in the student aptitude test. Admin can search students through the search form with the keyword. Admin can add, edit, delete student data and activity name data in aptitude tests, admin can also download student talent data. It is shown in Figure 10.

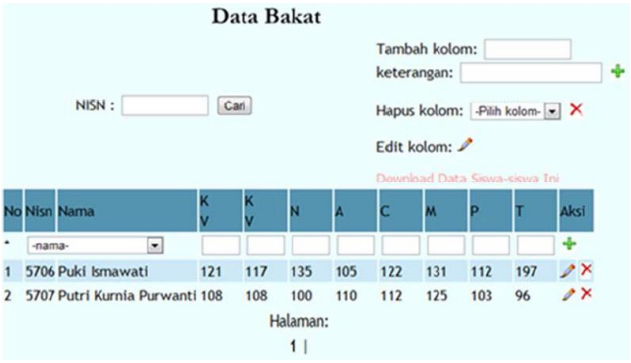

Figure 10. Talent Test Score Module

E. Basic Ability Test Value Module

This module is to show the value of the results of each activity in the student's basic ability test. Admin can search students through the search form with the keyword. Admin can add, edit, delete student data and activity name data in basic ability tests, admin can also download data values of students' basic abilities. It is shown in Figure 11.

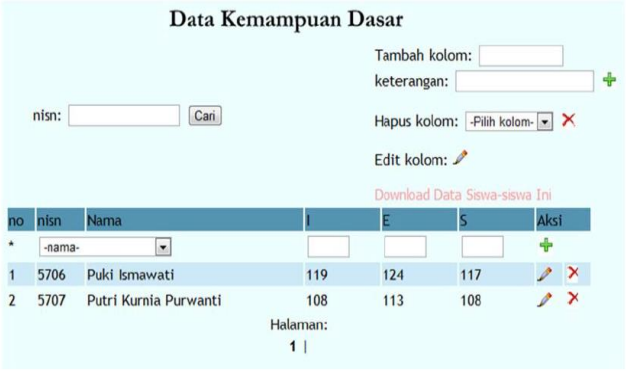

Figure 11. Basic Ability Test Value Module

F. Module managing function values

The function value management module is used to store the domain of membership functions of each fuzzy variable, namely interest variables, talent variables, and basic ability variables, the graph consists of three parts namely left linear, triangle and right linear, each of which has three domain values, admin can edit the function value data, for the graph will change according to the input number. It is shown in Figure 12.

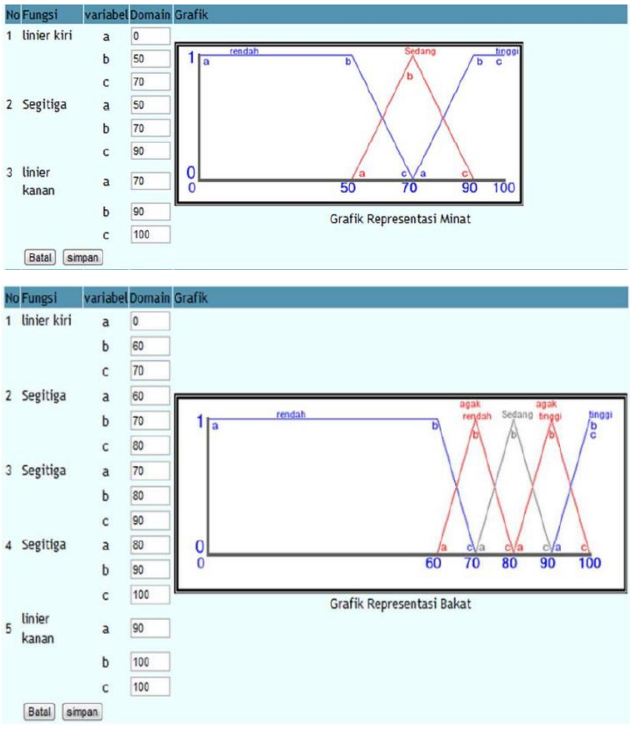

Figure 12. Module Managing Function Values

G. Report Module

The report module displays the decisions of the recommended majors according to the interest of the interest test, the aptitude test score and the student basic ability test score, containing the name of the recommended course for each student, from the first choice recommendation, the second choice recommendation, and the third choice recommendation. It is shown in Figure 13.

Figure 13. Decision Module

The results of the report that can be seen by students when printing documents is as shown in Figure 14.

Figure 14. Report of decision

H. Student's page decision module

This module is viewed from the student menu, displays the decisions of the recommended majors according to the value of interest tests, aptitude test scores and student basic ability test scores, containing the name of the recommended department, the name of the university that has the department and the university website. It is shown in Figure 15.

Figure 15. Student's page decision report

VI. Conclusion

Based on the activities during the design and implementation of the process of making a fuzzy inference application for the department selection system in higher education using the Mamdani method, the following conclusions can be drawn:

1) The major's selection application developed can help in choosing a department in higher education with the best possible outcomes because each calculation is obtained from the results of interest scores, talent scores, and students' basic abilities.

2) This research produces an online system and is dynamic fuzzy which can help students determine their majors in college.

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