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Decision Support System (DSS) for New Student Admissions and Majors by Using Simple Additive Weigthing (SAW) and Fuzzy Tsukomoto at SMA Negeri 1 Kalirejo

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Abstract

Decision support system (DSS) is an information system that helps managers with unique strategic decisions (non-recurring) or a system that provides a means that allows managers to develop information, so that it is appropriate to support the decisions they are making. In this study, the SAW method was used to select student admissions and the Fuzzy Tsukamoto method was used to specialize students. This research is to select and organize specializations so that the school can easily select students and students are not organized in the wrong in specializations. The results of the student selection test using the SAW method, it selected 281 students from 325 students who registered. By using the Fuzzy Tsukamoto method, there were 19 of 281 selected students who were placed in the wrong major. Through a decision support system using the Simple Additive Weighting (SAW) method, criteria are needed to be considered in the selection of new student admissions at SMA 1 Kalirejo. The criteria that have been determined by the school are zoning, non-zoning, and independent.

Keywords: SAW, fuzzy tsukamoto, DSS.

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1. Introduction

The development of technology is increasing rapidly. It cannot be denied that technology is a secondary need for its users. So far technology has also been applied to several fields including in the education sector that makes it easier for users to carry out the selection process for new student admissions (PPDB). The author is interested in the development of technology to apply it in the PPDB education sector. Lately PPDB is getting bigger and more difficult for the selection committee (Arta et al., 2017) .

PPDB is an important decision-making issue because the selection of quality new students can improve school performance. Selection of new student admissions is a decision making with various criteria that have been determined by the school (Ismal, 2021) . Decision making whether or not prospective students are accepted is determined by criteria such as SKHU scores, report cards, and school zoning. However, the school is quite difficult in determining whether prospective students pass or not because the number of applicants is very large, which is around 500 people to be recruited to only 281 prospective students (PSB committee data). Thus, it can cause subjective elements, take a long time, and produce data on students who pass or not pass less accurate. Therefore, to help solve this problem, the author uses the SAW method in the selection process for new student admissions.

As for the new prospective students who have been selected, the school also finds it difficult to determine which students will enter class IPA1, IPA2, IPA3, IPA4 or IPS1, IPS2, IPS3, and IPS 4. For this reason, the author uses the fuzzy tsukamoto method in determining student class.

Jayanti & Hartati (2012) examined the decision support system for selecting adult choir members using the fuzzy Mamdani method. They concluded that by testing the two linguistic data used, it would help increase the number of participants' scores because the data range used was quite long, namely linguistics whose letters were colored blue, making it possible to increase the participant's score to a higher calculation result (Jayanti & Hartati, 2012) . However, this study has not applied fuzzy Tsukamoto and Simple Additive Weighting (SAW) to PPDB.

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Fuzzy logic is a method to represent the uncertainty that accompanies received data or information as a result of data processing (Jacquin & Shamseldin, 2009) . Ambiguous parameters can be easily represented and decisions made based on Fuzzy rules using the Fuzzy Inference System (FIS) (Yudaningtyas & Pramono, 2014)

FIS, especially the Tsukamoto method, has been widely used in several studies with a relatively low error rate. FIS has more accurate results than the conventional linear regression model (Jacquin & Shamseldin, 2009) . The advantage of the Tsukamoto Fuzzy method is that the ranking decision-making process will select the best alternative from a number of alternatives and the assessment will be more precise because it is based on having tolerance for inappropriate data. Tsukamoto's Fuzzy logic is able to model several complex nonlinear functions and has better usability than other techniques (Kusumadewi & Suharto, 2010) .

In this study, Fuzzy logic was used to support PPDB decisions, while the Simple Additive Weighting (SAW) method was used to rank students and at the same time place their majors in science or social studies. The use of the method in this study aims to produce optimal values in the decision-making process and can create prototypes of new methods that can be used in further research.

This system also aims to apply the rules run by the school in terms of determining majors for students. These regulations are made to really select the right majors for students. in this case the selection process for the placement of majors must be in accordance with the criteria and calculations of the report card value parameters and academic potential test scores. This does not mean that the placement process for majors is not based on previous calculations and selection processes. With this decision-making system, it will facilitate the work of the new student admissions committee in carrying out the selection process to the placement process for majors without disappointing students who really have potential in the field of majors. Based on the background of the problem above, the following problems can be identified:

a. SMA Negeri 1 Kalirejo does not yet have a special system in the selection of new student admissions and majors,
b. SMA Negeri 1 Kalirejo has criteria in the selection of admissions and majors for new students including zoning, non-zoning and independent pathways.

Based on the identification of the problems described above, a problem formulation is taken, namely:

a. How is the application of the Simple Additive Weighting (SAW) method to conduct the selection process for new student admissions?
b. How is the Tsukamoto fuzzy method applied to the direct placement process?

Based on the formulation of the problem above, the problem limits can be given as follows:

a. The decision support system made is a decision support system that only helps provide alternative admissions and majors for new students.
b. The decision support system for the selection of admissions and majors is made using the Microsoft Office Excel 2007 program.

The purpose of this study is to apply the concept of a Decision Support System at SMA Negeri 1 Kalirejoin in the selection process for new student admissions and majors using Fuzzy Tsukamoto and Simple Additive Weighting (SAW).

The benefit of this research is to simplify decision making to determine new students at SMAN 1 Kalirejo. Applying the Tsukamoto fFuzzy method and the Simple Additive Wighting (SAW) method are intended to support decision-making to assist schools in providing alternatives for new student admissions and determining science and social studies majors.

2. Theoretical Basic

Decision Support Systems were first introduced in the early 1970s by Michael S. Scott with the term Management Decision System which is a computer-based system that helps decision making by utilizing data and models to solve unstructured problems (Magdalena, 2012) .

The most commonly used definition of DSS today is from Ralph H. Sprague, Jr., "A Framework For The Development Of Decision Support Systems" 1980 namely: Interactive Computer Based Systems That Help Decision-Making Personnel Use Data And Models To Solve Unstructured Problems. An unstructured problem is a non-routine DSS object (Akbar, 2020) .

At a higher managerial level, more solutions are needed for problems that are not programmed/structured. Unstructured means (among others) it is not routine and appears suddenly when needed (ad-hoc). The decision making procedure is not known for certain, so it requires a simulation method (what-if) and the experience of an expert (expert).

Thus, Decision Support Systems (DSS) are information systems that help managers with unique (non-recurring) strategic decisions that are relatively unstructured or systems that provide a means that enable managers to develop information in such a way that it satisfies the decisions making .

From some of the definitions above, it can be said that the Decision Support System is a specific information system intended to assist managers in making decisions related to semi-structured and unstructured issues. This system has the facility to generate various alternatives that can be used interactively by the user. This computer-based system is designed to increase the effectiveness of decision-making in solving semi-structured and unstructured problems.

2.1. Characteristics of Decision Support Systems

Some characteristics of decision support systems (Sheldon et al., 2005) are:

a. Decision support systems can assist decision-making in solving problems, especially in semi-structured situations by including human assessment and computerized information.
b. It provides support for all managerial levels.
c. Decision support systems increases the effectiveness of decision making.
d. Decision support systems provides support for individuals and groups.
e. It is adaptable and flexible because users can add, remove, modify or rearrange basic elements to solve other similar problems.

2.2. Decision Support System Components

The initial definition of a decision support system shows it as a system intended to support managerial decision makers in semi-structured decision situations. Decision support systems are intended for decisions that require judgment or on decisions that cannot be supported by algorithms (practical steps in problem solving). The decision support system has three main subsystems, namely the database management subsystem, the model base management subsystem, and the dialogue organizer software subsystem (K. Suryadi & Ramdhani, 2000) . In Figure 1, it can be seen the components of the decision support system and the relationship between each component. Users of the decision support system have an active role in running the decision support system, which is indicated by the line of two arrows.

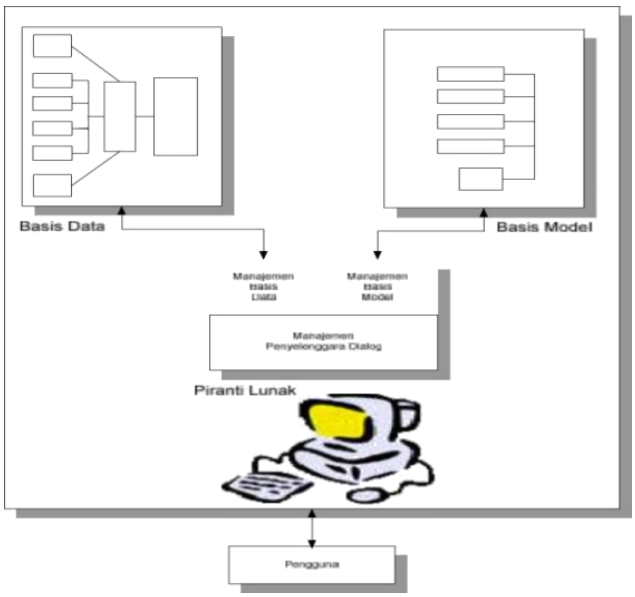

Figure 1. Decision Support System Components (in Indonesia)

2.3. Database Management Subsystem

There are some differences between databases for DSS and non-DSS. First, data sources for DSS are richer than non-DSS where data must come from outside and from within because the decision-making process, especially at the top management level, relies heavily on external data sources, such as economic data (K. Suryadi & Ramdhani, 2000) .

Another difference is the process of taking and extracting data from very large data sources. In this case the required capabilities of database management can be summarized as follows (K. Suryadi & Ramdhani, 2000) :

a. The ability to combine various data variations through data retrieval and extraction.
b. The ability to add data sources quickly and easily.
c. The ability to draw logical data structures according to the user's understanding so that the user can know what is available and determine the need for addition and subtraction.
d. The ability to handle data personally so that users can try various alternatives for personnel considerations.
e. The ability to manage various data variations.

2.4. Model Base Management Subsystem

One of the advantages of DSS is the ability to integrate data access and decision models. This can be done by adding decision models to the information system that uses a database as a mechanism for integration and communication between models (K. Suryadi & Ramdhani, 2000) .

One of the problems with models is that modeling is often tied to a model structure that assumes the right inputs and the right output modes. Meanwhile, the model tends to be insufficient because of the difficulty in developing an integrated model to handle a set of interdependent decisions. The way to deal with this problem is to use a collection of separate models, where each model is used to deal with a different part of the problem at hand (K. Suryadi & Ramdhani, 2000) .

The capabilities of the model base subsystem include:

a. Ability to create new models quickly and easily.
b. Ability to access and integrate decision models.
c. Ability to manage the model base with analogous management functions and database management (such as mechanisms for saving, creating dialogs, linking and accessing models).

2.5. Dialog Management Subsystem

The flexibility and strength of DSS characteristics arise from the ability to interact between the system and the user, which is called the dialogue subsystem. Bennett defines users, terminals, and software systems as components of the dialogue system (H. Suryadi, 2010) . He divided the subsystem into three parts namely:

a. Action language includes what the user can use to communicate with the system. This includes options such as keyboards, touch panels, joysticks, voice commands and so on.
b. Display or presentation language including what the user must know. The display language includes options such as printer, display screen, graphics, color, plotter, sound output and so on.
c. Knowledge base includes what the user should know. The knowledge base includes what the user must know in order to use the system effectively. The knowledge base can be in the user's mind, on reference cards or instructions, in manuals and so on.

2.6. Decision Support System Development

According to Simon, the decision-making process includes three main phases namely intelligence, design, and criteria or choices. He then added a fourth phase of believe implementation (Sheldon et al., 2005) .

2.6.1. Intelligence Phase

Intelligence in decision making includes environmental scanning, either periodically or continuously. Intelligence includes a variety of activities that emphasize the identification of problem situations or opportunities. The stages in the intelligence phase include problem identification (opportunities), problem classification, and problem ownership (Sakti & PUTRI, 2007) .

2.6.2. Design Phase

The design phase includes discovering or developing and analyzing possible actions to take. This includes understanding the problems and test feasible solutions. The stages in the intelligence phase include choosing a principle of choice, developing (generating) alternatives, and measuring the final result. (Anjarwati & Kuncoro, 2016).

2.6.3. Choice Phase

Choice is a critical decision-making act. The choice phase is the phase where a real decision is made and a commitment is made to follow a certain course of action. The boundary between the choice and design phases is often not clear because certain activities can be performed during both phases and because people can frequently return from the choice activity to the design activity. (Fatmawati et al., 2017) .

For example, one can generate new alternatives while evaluating existing alternatives. The choice phase includes searching, evaluating, and recommending an appropriate solution for the model. A solution to a model is a specific set of values for the decision variables in an alternative that has been selected.

2.6.4. Implementation Phase

In essence, the implementation of a proposed solution to a problem is the initiation of something new or the introduction of change. The definition of implementation is a bit complicated because implementation is a long process and involves unclear boundaries (RAHMATIKA, nd) . In short, implementation means making a recommended solution work, not requiring the implementation of a computer system.

2.7. Multi Criteria Decision Making (MCDM)

Multi Criteria Decision Making (MCDM) is a method of decision making to determine the best alternative from a number of alternatives based on certain criteria. Criteria are usually in the form of measures, rules or standards used in decision making. MCDM is used to assess or select the best alternative from a number of alternatives (Kusumadewi & Suharto, 2010).

Several methods can be used to solve MCDM (Multi Criteria Decision Making) problems including:

a. Simple Additive Weighting Method (SAW)
b. Weighted Products (WP)
c. ELECTR
d. Technique for Order Preference by Similarity to Deal Solution (TOPSIS)
e. Analytic Hierarchy Process (AHP)

The methods used in this research are Simple Additive Weighting Method (SAW) and TOPSIS (Technique for Order Preference by Similarity to Deal Solution).

2.8. Simple Additive Weighting (SAW)

The Simple Additive Weighting (SAW) method is often also known as the weighted addition method. The basic concept of the SAW method is to find the weighted sum of the performance ratings for each. The method used to obtain data is by observing the object of research and systematically recording an idea under investigation. The activities carried out are direct observations of the new student assessment process (Liesnaningsih et al., 2020) . The literature study is done by finding sources from books on the Simple Additive Weiighting (SAW) method and books on decision support systems. The SAW method requires the process of normalizing the decision matrix (X) to a scale that can be compared with all existing alternative ratings (Wati & Mayasari, 2017) . Given the following equation

Information :

rij = normalized performance rating value xij = attribute value of each criterion Max xij = largest value of each criterion Min xij = smallest value of each criterion Where rij is the normalized performance rating of alternative Ai on attribute Cj; i=1,2,...,m and j=1,2,...,n. The preference value for each alternative (Vi) is given the following formula:

$$v_i = \sum_{j=1}^{n} w_j r_{ij}$$

Information :

Vi = rank for each alternative wj = weighted value of each criterion rij = value of normalized performance rating A greater value of Vi indicates that alternative Ai is preferred.

2.9. Fuzzy Logic

The starting point of the modern concept of uncertainty is a paper made by Lofti A Zadeh, in which Zadeh introduces a theory that has objects from fuzzy sets that have imprecise constraints and membership in fuzzy sets, and not in true logic form or false (false), but expressed in degrees (degrees). This concept is called Fuzziness and the theory is called Fuzzy Set Theory (Charolina, 2017) .

Fuzziness can be defined as fuzzy logic regarding the semantics of an event, phenomenon or statement itself. Often found in statements made by someone, evaluation and a decision. As an example:

a. The warehouse manager tells the production manager how much inventory is at the end of this week, then the production manager will determine the number of goods that must be produced tomorrow.
b. Restaurant waiters provide services to guests, then guests will give appropriate tips on whether or not the services provided.
c. You tell me how cool the room you want, I will adjust the rotation of the fan in this room.

There are several reasons why people use fuzzy logic, among others:

a. The concept of fuzzy logic is easy to understand. The mathematical concepts underlying fuzzy reasoning are very simple and easy to understand.
b. Fuzzy logic is very flexible.
c. Fuzzy logic has tolerance for inappropriate data.
d. Fuzzy logic is able to model very complex nonlinear functions.
e. Fuzzy logic can build and apply the experiences of experts directly without having to go through the training process.
f. Fuzzy logic can work with conventional control techniques.
g. Fuzzy logic is based on natural language.

2.10. Difference Between Fuzzy Set and Crisp Set

In a definite set (crisp) the membership value of an item x in a set A, which is often written as A[x], has 2 possibilities, namely:

- One (1), which means that an item belongs to a set, or
- Zero (0), which means that an item is not a member of a set.

Example :

Suppose the age variable is divided into 3 categories, namely:

YOUNG age < 35 years old

Middle-Aged 35 age 55 years old

Old > 55 years old

Graphical membership value, YOUNG set, MIDDLE-AGED, and This OLD can be seen in Figure 2.

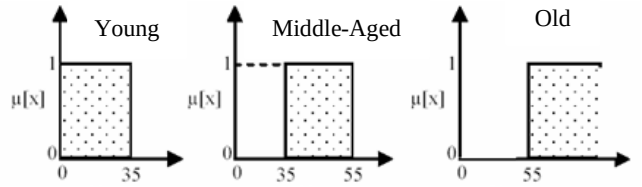

Figure 2. Young, Middle-aged, and Old Associations

In Figure 2, it can be explained that:

- If a person is 34 years old, then he is said to be

  Young (μYoung[34] = 1);
- If a person is 35 years old, then he is said to be

  Not Young(μYoung[35] = 0);
- If a person is 35 years and less than 1 day old, then he is said to be

  Not Middle-Aged (μmiddle-Aged[35 years – 1 day] = 0).

Based on the example above, it can be said that the use of the crisp set to express age is very unfair, the slightest change in a value results in significant category differences.

Fuzzy set is used to anticipate this. A person can fall into 2 different groups, Young And Middle-Aged, Middle-aged and Old, etc. How big its existence in the set can be seen in the value of its membership. Figure 3. shows the fuzzy set for the age variable.

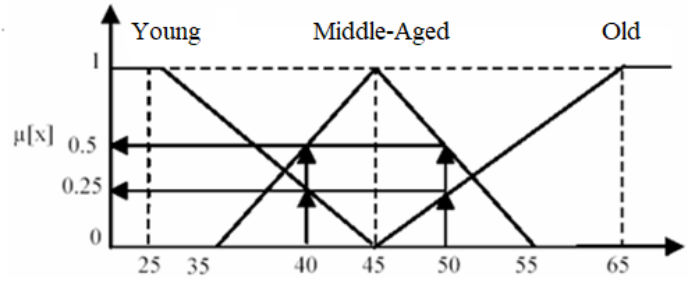

Figure 3. Fuzzy set for age variable

In Figure 3, it can be seen that:

- A person who is 40 years old is included in the YOUNG set with YOUNG[40]=0.25; but he is also included in the set Middle-aged with Middle-aged[40]=0.5.
- A person who is 50 years old, is included in the YOUNG set with OLD[40]=0.25; but he is also included in the set Middle-aged with Middle-aged[50]=0.5.

If in the crisp set, the membership value has only 2 possibilities, namely 0 or 1, in the fuzzy set the membership value lies in the range 0 to 1. If x has a fuzzy membership value A[x]=0 it means that x is not a member of set A, thus Also if x has a fuzzy membership value A[x]=1 it means that x becomes a full member of set A.

2.11. Some Things to Know in a Fuzzy System

There are several things that need to be known in understanding the fuzzy system, namely:

a. Fuzzy Variables

Fuzzy variable is a variable that will be discussed in a fuzzy system. Example: age, temperature, demand, etc.

b. Fuzzy Set

Fuzzy set is a group that represents a certain condition in a fuzzy variable.

Example :

- Age variable, divided into 3 fuzzy sets, namely: YOUNG, MIDDLE-AGED, and Old.
- Temperature variable, divided into 5 fuzzy sets, namely: COLD, COOL, NORMAL, WARM, and HOT (Figure 4).

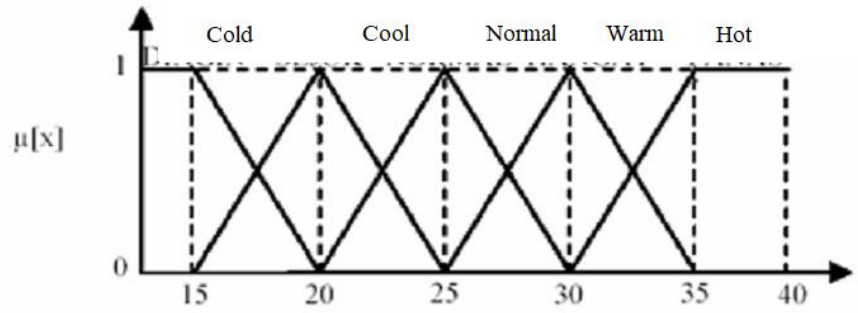

Figure 4. Fuzzy Set on the temperature variable

Fuzzy set has 2 attributes, namely:

a. Linguistics, naming a group that represents a certain situation or condition using natural language, such as: YOUNG, MIDDLE-AGED, Old.
b. Numeric, a value (number) that indicates the size of a variable such as: 40, 25, 50, etc.

c. Universe of Conversation

The universe of speech is the entire value that is allowed to operate in a fuzzy variable. The universe of speech is a set of real numbers that always increase monotonically from left to right. The value of the universe of speech can be a positive or negative number. Sometimes the value of the universe of this conversation is not limited to its upper limit.

Example:

- The universe of speech for the age variable: [0 +∞].
- Universe talks for temperature variable: [0 40].

d. Domain

The domain of the fuzzy set is the entire value that is allowed in the universe of talk and may be operated in a fuzzy set. As with the universe of speech, the domain is a set of real numbers that always increases monotonically from left to right. Domain values can be positive or negative numbers.

Fuzzy set domain example:

- YOUNG = [0, 45]
- MIDDLE-AGED = [35, 55]
- OLD = [45, +∞]
- COLD = [0, 20]
- COOL = [15, 25]
- NORMAL = [20, 30]
- WARM = [25, 35]
- HOT = [30, 40]

2.12. Membership Functions

The membership function (membership function) is a curve that shows the mapping of data input points into their membership values (often also referred to as membership degrees) which has an interval between 0 to 1. One way that can be used to get the membership value is through function approach. There are several functions that can be used:

a. Linear Representation

In a linear representation, the input mapping to its membership degree is represented as a straight line. This form is the simplest and is a good choice for approaching a concept that is less clear. There are 2 states of linear fuzzy sets, namely:

1) Ascending Linear Representation

The increase in the set starts at the domain value which has a membership degree of zero (0) moves to the right towards the domain value which has a higher membership degree.

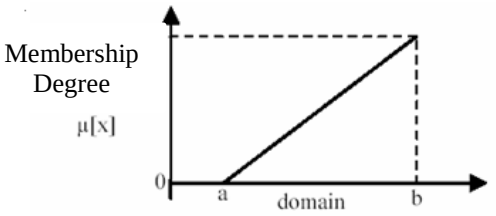

Figure 5. Linear Representation Ascending

Membership function:

$$\mu(x) = \begin{cases} 0, & x \le a \\ \frac{x-a}{b-a}, & a \le x \le b \\ 1, & x = b \end{cases}$$

2) Descending Linear Representation

A descending linear representation is the opposite of an ascending linear one. The straight line starts from the domain value with the highest degree of membership on the left side, then moves down to the domain value with the lower degree of membership (Figure 6).

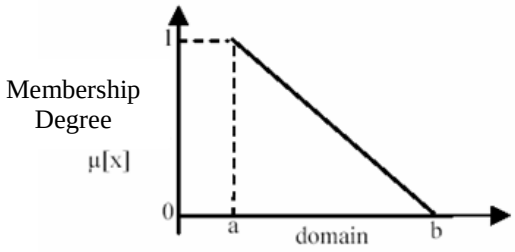

Figure 6. Descending Linear Representation

Membership function:

$$\mu(x) = \begin{cases} \frac{b-x}{b-a}, & a \le x \le b \\ 0, & x \ge b \end{cases}$$

b. Triangle Curve Representation

The triangular curve is basically a combination of 2 linear lines as shown in Figure 7.

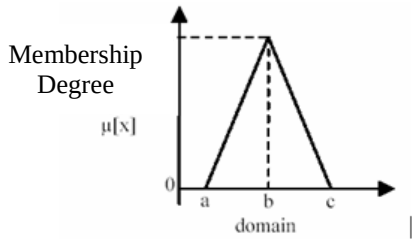

Figure 7. Triangle Curve Representation

Membership function:

$$\mu(x) = \begin{cases} 0, & x \leq a \; atau \; x \geq c \\ \frac{x-a}{b-a}, & a \leq x \leq b \\ \frac{c-x}{c-b}, & b \leq x \leq c \end{cases}$$

c. Trapezoidal Curve Representation

The trapezoidal curve is basically like a triangle shape, except that there are some points that have a membership value of 1 (Figure 8.).

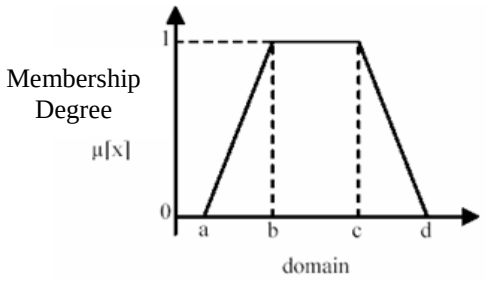

Figure 8. Trapezoidal Curve Representation

Membership function:

$$\mu(x) = \begin{cases} 0, & x \leq a \; atau \; x \geq d \\ \frac{x-a}{b-a}, & a \leq x \leq b \\ 1, & b \leq x \leq c \\ \frac{d-x}{d-c}, & c \leq x \leq d \end{cases}$$

d. Shoulder Shape Curve Representation

The area located in the middle of a variable represented in the form of a triangle, on the right and left sides will rise and fall (eg: COLD moves to COOL moves to WARM and moves to HOT). But sometimes one side of the variable does not change. For example, if it has reached HOT conditions, the increase in temperature will still be in HOT conditions. Fuzzy set 'shoulder', not triangle, is used to terminate a variable of a fuzzy region. The left shoulder moves from right to left, while the right shoulder moves from left to right. Figure 9 shows the TEMPERATURE variable with the shoulder area.

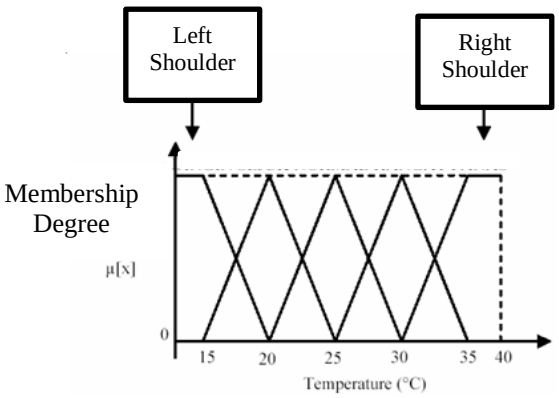

Figure 9. The 'shoulder' area of the Temperature variable

e. S-Curve Representation

The S-curve has a non-linear increase or decrease in value. There are two representations of the S-curve, namely the Growth and Representation curves. The S-curve is defined using 3 parameters, namely: zero membership value (α), complete membership value (γ), and inflection or crossover point (β) which is a point that has a 50% true domain.

1) Representation of the S-Curve of Growth

The Growth S-curve will move from the leftmost side with a membership value of zero (0) to the far right side with a membership value of one (1). Its membership function will rest on 50% of its membership value which is often called the inflection point (Figure 10).

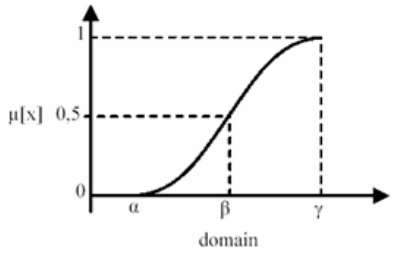

Figure 10. Characteristics of the S-curve function: Growth

Membership function:

$$\mu(x) = S(x;\alpha,\beta,\gamma) = \begin{cases} 0; & x < \alpha \\ 2\left(\frac{x-\alpha}{\gamma-\alpha}\right)^2; & \alpha \le x \le \beta \\ 1 - 2\left(\frac{\gamma-x}{\gamma-\alpha}\right)^2; & \beta \le x \le \gamma \\ 1; & x > \gamma \end{cases}$$

2) Representation of the S-Curve Of Description

The S-Curve Of Depreciation is the opposite of the S-Curve Of Growth. The membership value will move from the left side with a membership value of one (1) to the right side with a membership value of zero (0). Like (Figure 11).

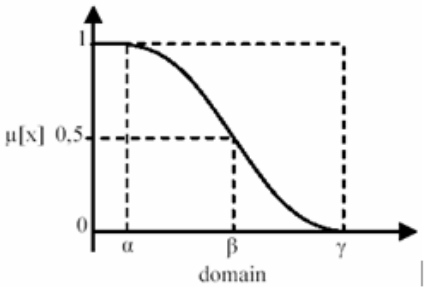

Figure 11. Characteristics of the S-Shrinkage curve function

Membership function:

$$\mu(x) = S(x;\alpha,\beta,\gamma) = \begin{cases} 1; & x < \alpha \\ 1 - 2\left(\frac{x-\alpha}{\gamma-\alpha}\right)^2; & \alpha \le x \le \beta \\ 2\left(\frac{\gamma-x}{\gamma-\alpha}\right)^2; & \beta \le x \le \gamma \\ 0; & x > \gamma \end{cases}$$

f. Bell Curve Representation

To represent fuzzy sets, a bell curve is usually used. The bell shape curve is divided into 3 classes, namely: curve, BETA, and GAUSS. The difference between these three curves lies in the gradient.

1) Curve

The curve is bell-shaped with membership degree 1 located at the center with the domain (γ), and the width of the curve (β). As shown in (Figure 12.)

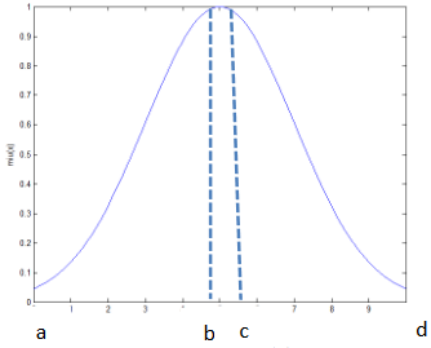

Figure 12. Functional characteristics of the curve

Membership function:

$$\Pi(x:a,b,c,d) = \begin{cases} 0; & x \le a \\ 2\left(\frac{x-a}{b-a}\right)^2; & a < x \le \frac{a+b}{2} \\ 1 - 2\left(\frac{x-b}{b-a}\right)^2; & \frac{a+b}{2} < x < b \\ 1 & b \le x \le c \\ 1 - 2\left(\frac{x-c}{d-c}\right)^2; & c < x < \frac{c+d}{2} \\ 2\left(\frac{x-d}{d-c}\right)^2; & \frac{c+d}{2} < x \le d \\ 0; & x \ge d. \end{cases}$$

2) BETA curve

Like the -Curve, the BETA curve is also bell-shaped but more dense. This curve is defined by 2 parameters, namely the value in the domain indicating the center of the curve with the domain(γ), and half the width of the curve (β). As shown in (Figure 13)

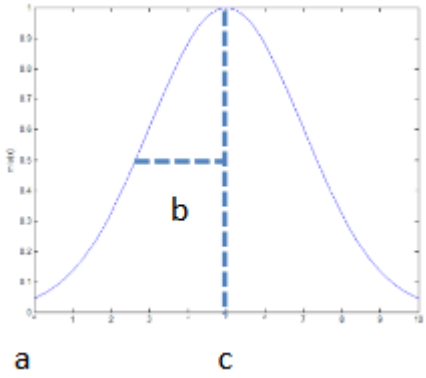

Figure 13. Functional characteristics of the BETA curve

Membership function:

$$B(x; a, b, c) = \frac{1}{1+\left|\frac{x-c}{a}\right|^{2b}}$$

One of the striking differences of the BETA-Curve from the -Curve is that the membership function will approach zero only if the value of (β) is very large.

3) GAUSS Curve

The GAUSS curve uses (γ) to represent the value of the domain at the center of the curve, and (k) to denote the width curve (Figure 14).

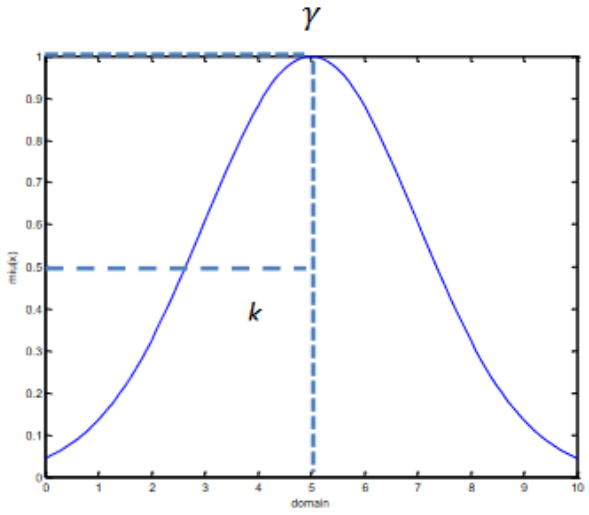

Figure 14. Functional characteristics of the GAUSS curve

Membership function:

$$f(x; \gamma, k) = e^{\frac{-(x-k)^2}{2\gamma^2}}$$

2.13. Basic Zadeh Operators for Fuzzy Set Operations

As with conventional sets, there are several operations that are specifically defined for combining and modifying fuzzy sets. The membership value as a result of the operation of 2 sets is often known as the fire strength or - predicate.

There are 3 basic operators created by Zadeh, namely:

1. AND operator

   This operator deals with the intersection operation on sets. - predicate. As a result of the operation with the AND operator, it is obtained by taking the smallest membership value between elements in the sets in question.

   $A \cap B = \min(\mu A[x], B[y])$

2. OR . operator

   This operator deals with the union operation on the set. - the predicate as the result of the operation with the OR operator is obtained by taking the largest membership value between elements in the sets in question.

   $AUB = \max(\mu A[x], B[y])$

3. NOT operator

   This operator is related to the complement operation on set. -predicate as result of operation with operator NOT obtained by subtracting the element's membership value on the set in question dr 1.

3. Materials and Methods

3.1. Research Flow

The flow of research analysis is carried out based on the problems that will be handled by the system, where the research steps are described in Figure 15.

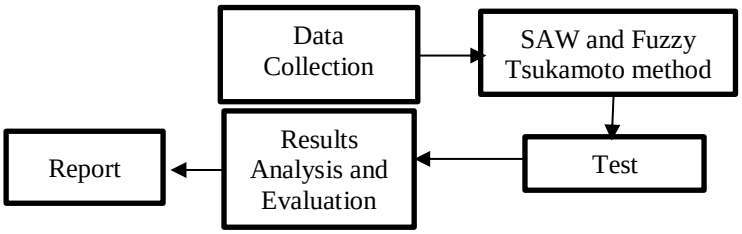

Figure 15. The Flow Chart

3.2. Research Methods

The research method is a series of activities that will provide an overview of the steps in carrying out this research, starting from conducting research to processing data to be presented. (Haryono, 2020) . In this study, the steps that the author will take include research design, types and methods of data collection and methods of approach and system development.

3.3. Research Design

Research design is needed to improve the current information system (Nugroho, 2016). A system analysis is needed that aims to achieve the following goals:

a. The system design must be useful, easy to understand and later easy to use
b. System design must be effective and efficient to support tasks that are not performed by computers.
c. The system design must be able to prepare a detailed design of each component of the information system. To achieve the above objectives, a structured analysis is carried out, namely as follows:
   1) Design System Model Development, the use of structured techniques involving the development of models for both existing systems and new systems.
   2) Design Output i.e. during the design phase, the detailed content and format of the system output should be defined.

3) Code Design (Coding),a code must be designed in such a way that the identification and data retrieval process can run efficiently.
4) Input Design. There are two types of input in a computer-based system, namely Batch input and On-line input. Batch input approach is a traditional transaction data collection method for data processing by computer. On-line input approach means that data collection is directly connected to a computer.
5) Database Design (File) which includes designing a database. There are obstacles that often occur, including data applications. To avoid this problem, a normalization technique is needed. Normalization is a process of elaborating a document that has a problem which is then broken down into a relationship data structure in the form of a 2-dimensional table.

3.4. Types and Methods of Data Collection

The type of data that the author uses are primary data and secondary data and the data collection method that the author uses is by combining the types of primary data and secondary data. Where the data will support the goals and objectives of the research.

3.5. Primary Data Source

The primary data collection method that the author uses is in three ways, including:

a. Interviews, namely direct dialogue with the head of the section or employees regarding the History and Organizational Structure, as well as the procedures for the admission process for new students at SMA Negeri 1 Kalirejo.
b. Observation, observing directly the process of new student admissions to obtain a clear picture of the new student admissions information system at SMA Negeri 1 Kalirejo.
c. Feasibility Study, conducting observations or research on the current system at the new student admissions department.

3.6. Secondary Data Source

Secondary data collection methods were taken from company data, books, modules, lecture notes and from the internet related to the new student admissions information system.

3.7. Approach Method and System Development

A good information system is a system that can provide results as expected by the designer and owner. To produce a good system, the compilers use a method of approach and system development. Things that must be considered in system development in order to produce a good system and can complete the information that will be needed, it is necessary to use system design methods to be made.

3.8. System Approach Method

The system approach method is one way of solving problems that begins with the identification of a number of needs, so as to produce an operation of the system that is considered effective.The approach method that I use for this research is a data-oriented approach, namely structured analysis and design.

3.9. System Development Method

The development of information systems that are realized with the help of computers goes through a stage called system analysis and design. Systems analysis and design is the improvement of the performance of an organization with the aim of improving procedures and better methods.

Information development means the process of planning, developing and implementing an information system in such a way that the information system exists. One of the information system development models used by the author is the system development cycle model, often also called SDLC (System Development Life Cycle), which is a collection of activities from the analysis of designers and users of information systems that are carried out to be developed and implemented.

The system development process with the system development cycle model passes through several stages, from the system being planned to the system being implemented. The stages are as follows:

a. Feasibility Study, carried out to collect data from the current system
b. System Analysis, carried out to better understand user needs for the system

c. System Design, implemented to meet the need for a system that has been obtained from system analysis
d. System Implementation, carried out to conduct trials before the new system is operated
e. System Maintenance, carried out to keep the system operating normally and to anticipate new system deficiencies.

4. Result and Disscusion

SMA Negeri 1 Kalirejo is located on Jl. Raya Sridadi, Kalirejo Subdistrict, Central Lampung Regency has 779 students from various regions of Central Lampung. SMA Negeri 1 Kalirejo is a pretty good and favorite school in Kalirejo sub-district. This is because SMA Negeri 1 Kalirejo has many proud achievements in both academic and non-academic fields.

In the non-academic field, SMA Negeri 1 Kalirejo has never been absent from participating in championships such as Scouts, Drum Band and others. This can be seen from the hundreds of trophies neatly arranged in the cupboard. These trophies are proof of the greatness of the SMA Negeri 1 Kalirejo school in the non-academic field.

In the academic field, SMA Negeri 1 Kalirejo also has various achievements that are no less proud. The school always sends representatives to participate in the Olympics at the City, Provincial and National levels.

The success of SMA Negeri 1 Kalirejo in academic and non-academic fields is because it is supported by qualified teaching staff, students with a variety of good and fun methods.

4.1. SAW and Fuzzy Tsukamoto Test Results

a. Determine Criteria and Weights

In the SAW method, there are criteria needed to determine who will be selected to be accepted at SMA Negeri 1 Kalirejo. The criteria are assessed based on Zoning, Non Zoning and Independent.

b. Determine Input and Output Variables

Table 1. Determine Input and Output Variables

Input variable / criteria	Output/Alternative Variables	Output
Zoning Non Zoning Independent	Name of Prospective Students of SMA Negeri 1 Kalirejo	Students Accepted

c. SAW Architecture and Fuzzy Tsukamoto

At this stage the alternative is prospective students of SMA Negeri 1 Kalirejo, while for the criteria consisting of Zoning, Non Zoning and Independent then calculations are carried out using the SAW method so as to produce accepted student output and student majors.

Figure 16 is an architectural view of the SAW and Fuzzy Tsukamoto methods.

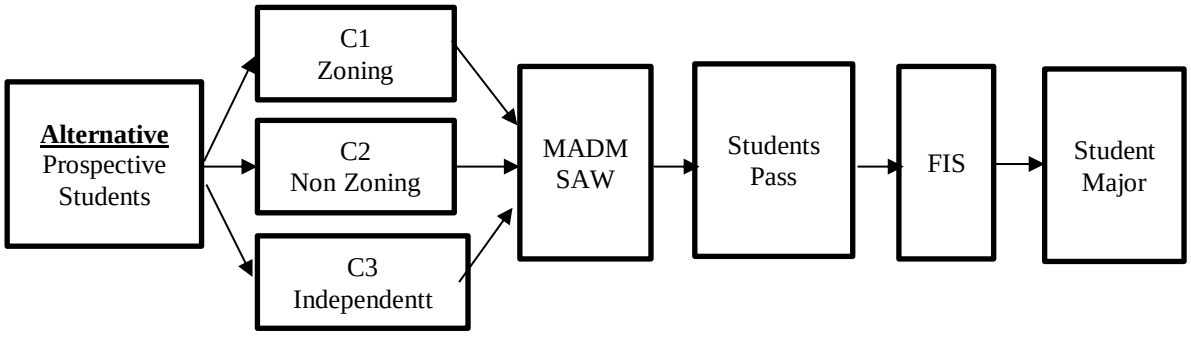

Figure 16. Architecture of SAW and FIS

d. SAW Method Test

The SAW test is carried out to select students who will be accepted at SMA Negeri 1 Kalirejo.

a. Determine the Range for each criterion, here is a table display of the Range for each criterion:

1. Zoning Range

The zoning range is determined based on the distance from the student's residence to the school, the closer the distance, the greater the value. The Table 2 is the zoning range table.

Table 2. C1 Zoning Range (Benefits)

0-3000m	5
3001-6000	4
6001-9000	3
9001-12000	2
1201-1500	1

2. Non Zoning Range

Non-zoning range is determined based on the son of the teaching staff, students who are outside the area but live in the vicinity of the school location, academic and non-academic scores. The Table 3 is a table of Non Zoning.

Table 3. C2 Non Zoning (Benefits)

CAR	5
outside the area	4
Academic	3
Non-Academic	2

3. Independent Range

The independent range is determined based on the student's academic grades, the ability of parents and the results of interviews. The Table 4 is a standalone table view.

Table 4. Independent C3 (Cost)

Academic	5
Parents' ability	3
Interview	1

Determine the weight for the most important

C1= 60% = 0.6
C2= 25% = 0.25
C3= 15% = 0.15

The next step is to determine the criteria that will be used as a reference.

4. Criteria Table

Based on tables 2 to 4, it can be determined the criteria that are used as a reference in student selection. The Table 5 is a table display of student criteria.

Table 5. Criteria

Alternative	Criteria		
	C1	C2	C3
Rizky Silfiana Princess	5	3	5
Ade Imroatul Hsanah	5	3	5
Devi Muti'ah	5	3	3
Niken Seviana	5	3	5
Beautiful Valentine's Day	4	3	3

From the table 5, the values obtained from the range of zoning, non-zoning and independent are obtained. And Max/Min is obtained from the benefits and costs of each criterion.

The next step is to perform Matrix Normalization.

Table 6. Normalization

Max	Max	Min
5	5	1
1	0.6	0.2
1	0.6	0.2
1	0.6	0.333333
1	0.6	0.2

Normalization results are obtained from the results for example Criterion C1 = 5 and divided by 5 (the divisor of 5 is obtained from the Max benefit of criteria C1). The next step is the Student Selection Process with 281 accepted students. The Table 7 is a student selection table.

Table 7. Selection Table

1	0.6	0.15	0.03	0.78
2	0.6	0.15	0.03	0.78
3	0.6	0.15	0.05	0.8
4	0.6	0.15	0.03	0.78
5	0.48	0.15	0.05	0.68

The value of the table above is obtained, for example, from multiplying the weight of C1 which is 0.6 times the table of normalization results from C1. After the selection process is carried out, the next step is sorting with excel from the largest to the smallest. The results can be seen in the table 8.

Table 8. Accepted student results

9	Mohamad Ricki A.	0.6	0.15	0.15	0.9	1
25	Nanda Arum Rahmawati	0.6	0.15	0.15	0.9	2
60	Putut Water Langga	0.6	0.15	0.15	0.9	3
77	Ayesha Anindya Ls	0.6	0.15	0.15	0.9	4
117	Alda Novitasari	0.6	0.15	0.15	0.9	5

After selecting student admissions, then selecting the majors with fuzzy tsukamoto.

From the information generated from the V-class center (Matlab) in the last iteration, the interest group can be determined.

$$V=\begin{pmatrix} 72{,}0635 & 76{,}3067 & 71{,}5032 \\ 73{,}5371 & 74{,}7951 & 79{,}7301 \\ 80{,}0742 & 75{,}0224 & 74{,}4123 \end{pmatrix}$$

Suppose the highest score on the average group of specialization subjects is used as the basis for determining specialization, then:

1. In the first cluster (first row), the highest score is in the second column (IPS interest) so that the first cluster is identified as a social studies specialization group.
2. In the second cluster (third row), the highest score is in the first column (IPA specialization), so the third cluster is identified as a science specialization group. Before the Fuzzy Inference System was built, the existing data values were transformed into one value. The formula used was:

   NIPA = mathematical value+2×physics value+2×chemical value+2×biological value

   NIPS = mathematical value+2×economic value+2×geographical value+2×sociological value

   To build a Fuzzy Inference System we need a talk universe.

Table 9. UniverseTalk

Function	Variable	Notation	Universe Pemtalk	Information
Input	NIPA	A	[55-100]	The value of the subject IPA
	NIPS	B	[55-100]	The value of studying social studies
	IQ	C	[90-130]	Value i te s IQ
	Interest	D	[0-100]	Interest rate in IPA
	Capacity	E	[0-480]	Capacity s for all classes
Output	IPA	F	[0-1]	Go to class IPA
	IPS	G	[0-1]	Sign in to IPS class

4.2. Construction FIS

The steps in the Mamdani method to get the crisp value are the formation of fuzzy sets (fuzzification), determination of rules, application of functions, inference of rules and confirmation (defuzzification).

Table 10. Fuzzy Input Set

Variable		**Set n Fuzzy Inputs**		**Domain**
Notation Name		Notation Name		
NIPA	A	Low	r	[55,70]
		Normal	n	[65.85]
		Height	t	[75,100]
NIPS	B	Low	r	[55,70]
		Normal	n	[65.85]
		Height	t	[75,100]
IQ	C	Normal	b	[90,110]
		Smart	c	[98,120]
		very smart	sc	[115,130]

Interest	D	not interested	tm	[0.50]
		normal	n	[10.90]
		interest	m	[50,100]
Capacity	E	IPA	a	[0.320]
		IPS	s	[250,480]

Table 11. FuzzyOutput Set

Variable		**Set n Fuzzy Inputs**		**Domain**
Notation Name		Notation Name		
I PA	f	low	r	[0,0.4]
		being	s	[0.1,0.9]
		height	t	[0.6,1]
IPS	g	low	r	[0,0.4]
		being	s	[0.1,0.9]
		height	t	[0.6,1]

Based on table 11 (the tendency of students in certain specialization groups), the following data is presented on the specializations that have been carried out and the results of specialization / clustering using Fuzzy Tsukamoto.

Table 12. Results of Selected Specializations and Results of Specializations Generated by Fis Tsukamoto

Student	Average Value of Specialization Subjects Before Specialization / Major (Class X)		Interest	Average Value of Specialization Subjects After Specialization / Major		
	IPA	IPS	The selected	FIS	Class XI	Class XII
1	72.2	74.8	IPA	IPA	75.5	74.2
2	74.9	76.5	IPS	IPS	77	75.5
3	77.5	70.6	IPA	IPA	75.5	78
4	68.1	77.1	IPS	IPS	72	74.5
5	76.6	71.3	IPA	IPA	72.8	71.5

Determination of accuracy results is based on the provision that if the value of the chosen specialization is greater than the standard of the Completeness Ideal Criteria (KKM), which is greater than or equal to 70, the specialization carried out by the FIS algorithm is considered ACCURATE, whereas if the value of the chosen specialization is smaller than the KKM then The specialization performed by Tsukamoto's FIS algorithm is considered NOT ACCURATE. The accuracy of the results of interest carried out by the Tsukamoto FIS algorithm is presented in table 13.

Table 13. Accuracy of Tsukamoto FIS Algorithm Interesting Results

Student Clustering / Specialization Results FIS >= 70 accurate below 70 inaccurate for FIS Results

Student	Clustering Results/Specialization		FIS >= 70 accurate below 70 inaccurate for FIS	Result
	The selected	FIS	Score	
1	IPA	IPA	75.5	Accurate
2	IPS	IPS	77	Accurate
3	IPA	IPA	75.5	Accurate
4	IPS	IPS	72	Accurate
5	IPA	IPA	72.8	Accurate

In table 13 it can be seen that the inaccurate results were 19 students out of 281 students in determining majors (complete data can be seen in the Appendix). So that it can be seen in the selection of majors interest there are 19 students who are not right in choosing interests using the Tsukammoto FIS algorithm.

5. Conclusion

Based on the result and discussion, we conclude that:

a. Through a decision support system using the Simple additive weighting (SAW) method, criteria are needed to be considered in the selection of new student admissions at SMA 1 Kalirejo. The criteria that have been determined by the school are zoning, non-zoning and independent
b. Prospective students who passed the selection of new students at SMA 1 Kalirejo through a decision support system using the Simple Additive Weighting (SAW) method were 281 students out of 352 students who registered.
c. From the results of testing the Fuzzy C-Means (FCM) algorithm in determining majors in high school on 281 student data samples tested in this study, it shows that the Tsukamoto FIS Algorithm is able to do majors with 19 students who are not right in taking majors.

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