Fuzzy Logic Implementation Using The Tsukamoto Method As A Decision Support System In Scholarship Acceptance

Sukenda, S.T., M.T.[1], Yan Puspitarani[2], Ari Purno Wahyu[3], Benny Yustim[4], Sunjana[5]

[1]Department of Informatics, Faculty of Engineering, Widyatama University Cikutra Street No. 204A Bandung
[2]Department of Informatics, Faculty of Engineering, Widyatama University Cikutra Street No. 204A Bandung
[3]Department of Informatics, Faculty of Engineering, Widyatama University Cikutra Street No. 204A Bandung
[4]Department of Informatics, Faculty of Engineering, Widyatama University Cikutra Street No. 204A Bandung
[5]Department of Informatics, Faculty of Engineering, Widyatama University Cikutra Street No. 204A Bandung
[1]kenda@widyatama.ac.id, [2]yan.puspitarani@widyatama.ac.id, [3]ari.purno@widyatama.ac.id,
[4]byustim@widyatama.ac.id, [5]sunjana@widyatama.ac.id

Abstract - Scholarships are a supporting factor for students. In the process of determining who receives the scholarship we need a decision-making process is subjective, with the criteria some students who have the ability or value that is not so different. With the existence of a system that supports decision making in determining who is entitled to a scholarship. This system is supported by the Tsukamoto fuzzy logic method which is based on data or human resources rules with criteria that have been determined by a group of people. Therefore, the results of this process will be given to students based on existing decisions.

Keywords : Scholarship, Decision Support System, and Tsukamoto Fuzzy Logic

1. Background

Scholarship is a form of financial assistance given to individuals whose purpose is to be used in the educational process that is taken. Every educational institution, especially at universities or high schools, will offer many scholarships to students. These scholarships come from the government or from the private sector who collaborate with the university. To determine the acceptance of the scholarship, it must be in accordance with predetermined criteria or rules. General criteria that are usually required to receive scholarships are assessed in terms of academic achievement index (GPA), family economic condition, organizational activeness during education, distance from home to campus, and others. Every time there is a scholarship announcement there will be a lot of students who will take part in it and not all scholarship applications are accepted, so a decision support system is needed that can help provide recommendations for scholarship recipients.

The problem that often arises in the provision of scholarships is the difficulty in determining each student who is eligible for a scholarship because of the limited quota provided and the number of students applying for scholarships is the main difficulty for certain universities.

By knowing the problems that often occur in each university, there is an idea that can be built as a decision support system in scholarship acceptance using an appropriate and applicable method in solving scholarship acceptance problems. Based on the existing background, an explanation of the scholarship acceptance system can be explained.

2. Basis of theory

a. Decision Support System

A decision support system is a system that is able to provide a problem solving and communication skills for problems with semi-structured and unstructured settlement conditions. With the aim of providing information that provides predictions and directs information users to make better decisions.
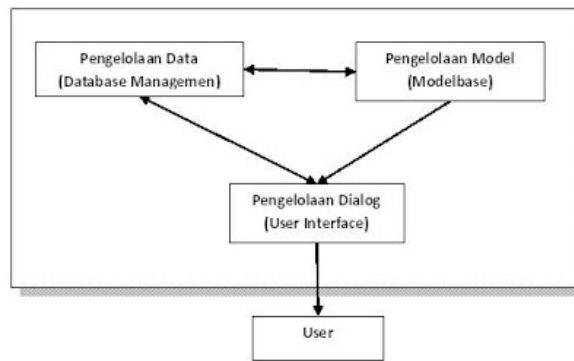
Figure 2.1 Components of a Decision Support System (DSS)

b.   Fuzzy Logic

The fuzzy set is based on the idea of extending the range of characteristic functions such that the function will cover real numbers in the interval [0,1]. Its membership value indicates that an item in the universe is not only at 0 or 1, but also a value that lies between it. In other words, the truth value of an item is not only true or false. A value of 0 indicates false, a value of 1 indicates true and there are still values that lie between true and false. There are several things that need to be known in understanding fuzzy systems :

•   Fuzzy variables. Is a variable to be discussed in a fuzzy system, for example: age, temperature, demand and so on.

•   Fuzzy sets. Is a group that represents a certain condition or condition in a fuzzy variable, for example: - The age variable is divided into 3 fuzzy sets: young, middle, old.

Fuzzy logic is an alternative to various existing systems in decision making because fuzzy logic has the following advantages :

➢   Fuzzy logic has a very simple concept so it is easy to understand.
➢   Fuzzy logic is very flexible, meaning that it is able to adapt to changes and uncertainties.
➢   Fuzzy logic tolerates imprecise data.
➢   Fuzzy logic is able to systematize very complex non-linear functions.
➢   Fuzzy logic can apply the experience or knowledge of experts.

In general, fuzzy has four stages in solving problems, namely :
o   *Fuzzyfication*
o   *Inference*
o   Composition
o   *Defuzzification*

c.   Tsukamoto Method Fuzzy Logic

According to Kusumadewi (2010: 31; Jovic, 2018; Armijos, 2019; Bae & Han, 2019; Birhan, 2019; Aras, 2019; Maake & Tranos, 2019; Erol & Velioglu, 2019) the Tsukamoto method is an extension of monotonous reasoning. In the Tsukamoto method, each consequence of the IF-Then rule must be presented with a fuzzy set with a monotonous membership function. As a result, the inference output of each rule is given crisp based on the α-predicate (fire strength). The final result is obtained using weighted averages.

According to Sutojo (2011: 233), in general, the shape of Tsukamoto's fuzzy model is:
    If (X IS A) and (Y IS B) Then (Z IS C)
Where A, B, and C are fuzzy sets.
Suppose the following 2 rules are known,
    IF (x is A_1) AND (y is B_1) Then (z is C_1), IF (x is A_2) AND (y is B_2) Then (z is C_2)
In inferencing, Tsukamoto's method uses the following stages.
o   *Fuzzyfication*
o   Establishment of a Fuzzy knowledge base (rules in the form of IF ... THEN)
o   Inference Engine, Using the MIN implication function to get the α-predicate value of each rule ($\alpha 1, \alpha 1, \alpha 1,\dots \alpha n$).
o   Defuzzyfication, Using the average method (Average).

$$z^* = \frac{\sum \alpha i \, z1}{\sum \alpha i}$$

Figure 2.3 averaging method

d.   Research Methods

In building a decision support system that will clearly solve the problem, data collection techniques are used to obtain information about the object of the research problem, in the form of :

• Observation techniques, namely direct observation at the research site of the object that will be used as a source of research data used by the author by collecting data.

• Interview technique, which is to hold questions and answers directly with the parties related to the problem of the object of research to obtain accurate information.

• Literature techniques, to obtain theoretical studies as a theoretical basis in analyzing the design of an ongoing system.

3.   Result and discussion

The application of the Tsukamoto method is used to determine which students are eligible for scholarships based on criteria in terms of the Grade Point Average (GPA), the economic condition of the family and the distance between the student's house and campus. So, a fuzzyfication method, rule formation, inference engine and defuzzyfication were implemented.

a.   Fuzzyfication

At this stage, the division process will be carried out into three linguistic variables using variable functions that will be determined according to the criteria in order to get the results of student decisions that deserve a scholarship. And following the fuzzyfication according to the criteria will be described.

1.   Assessment of the cumulative grade point average (GPA)

The GPA criteria will be divided into 3 sets that will represent each student's GPA score, namely: low GPA, medium GPA and high GPA.
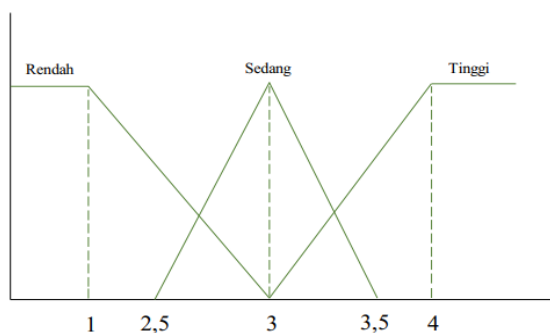

Figure 5.1 The membership function of the GPA variable

$$\mu IPK\_Rendah(x) = \begin{cases} 1; & x \leq 1 \\ \dfrac{3-x}{2,5}; & 1 \leq x \leq 3 \\ 0; & x \geq 3 \end{cases}$$

$$\mu IPK\_Sedang(x) = \begin{cases} 0; & x \leq 2,5 \; atau \geq 3,5 \\ \dfrac{x-2,5}{1}; & 2,5 \leq x \leq 3 \\ \dfrac{3,5-x}{1}; & 3 \leq x \leq 3,5 \end{cases}$$

$$\mu IPK\_Tinggi(x) = \begin{cases} 0; & x \le 3 \\ \dfrac{x-3}{2,5}; & 3 \le x \le 4 \\ 1; & x \ge 4 \end{cases}$$

2. **The distance from the student's house to the campus**

In determining the distance from the student house to the campus, it is divided into 3 groups, namely: short distance, short distance and long distance. As for this assessment, it is based on the farthest distance from campus to home based on google maps (km) and according to the image below.
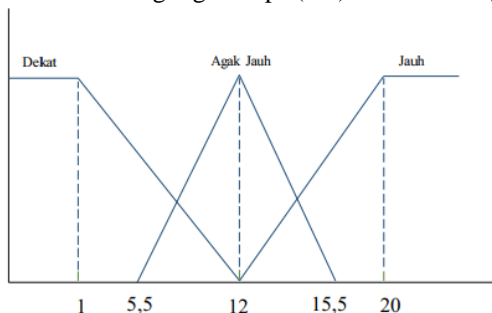

Figure 5.2 The membership function for the variable distance between the student's house and the campus.

$$\mu J\_Dekat(x) = \begin{cases} 1; & x \le 1 \\ \dfrac{12-x}{11}; & 1 \le x \le 12 \\ 0; & x \ge 12 \end{cases}$$

$$\mu J\_Agak\_Jauh(x) = \begin{cases} 0; & 5,5 \le x \; atau \ge 15,5 \\ \dfrac{x-12,5}{12,5}; & 5,5 \le x \le 12 \\ \dfrac{15,5-x}{5,5}; & 12 \le x \le 15,5 \end{cases}$$

$$\mu J\_Jauh(x) = \begin{cases} 0; & x \le 12 \\ \dfrac{x-12}{12}; & 12 \le x \le 20 \\ 1; & x \ge 20 \end{cases}$$

3. **Family Economic Situation**

In determining the economic condition of the student family applying for scholarships, it will be divided into 3 groups, namely : underprivileged economic conditions (TM), moderately well-off economic conditions (AM), poor economic conditions (M) On this criterion, students applying for scholarships must attach a parent's salary slip from the company or income statement from the local RT / RW. Following is the membership function of the variable family economic condition.
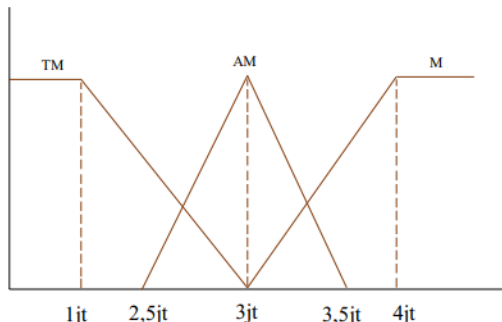

Figure 5.3 Membership Function of Family Economic Condition Variables

$$\mu KE\_TM(x) = \begin{cases} 1; & x \leq 1.000.000 \\ \dfrac{3.000.000 - x}{1.000.000}; & 1.000.000 \leq x \leq 3.000.000 \\ 0; & x \geq 3.000.000 \end{cases}$$

$$\mu KE\_AM(x) = \begin{cases} 0; & x \leq 2.500.000 \; atau \geq 3.500.000 \\ \dfrac{x - 2.500.000}{1.500.000}; & 2.500.000 \leq x \leq 3.000.000 \\ \dfrac{3.500.000 - x}{1.500.000}; & 3.000.000 \leq x \leq 3.500.000 \end{cases}$$

$$\mu KE\_M(x) = \begin{cases} 0; & x \leq 3.000.000 \\ \dfrac{x - 3.000.000}{1.000.000}; & 3.000.000 \leq x \leq 4.000.000 \\ 1; & x \geq 4.000.000 \end{cases}$$

b.   Rule or Composition

Table 5.1 Rules for admission of scholarships

1	[R1]	IF GPA = Low AND J = Near AND KE = No_Mampu THEN did not get a scholarship
2	[R2]	IF GPA = Low AND J = Close AND KE = Somewhat_Mampu THEN did not get a scholarship
3	[R3]	IF GPA = Low AND J = Close AND KE = Capable THEN doesn't get a scholarship
4	[R4]	IF GPA = Moderate AND J = Somewhat far AND KE = No_ able THEN gets a scholarship
5	[R5]	IF GPA = Medium AND J = Somewhat_distant AND KE = Somewhat_Ableful THEN doesn't get a scholarship
6	[R6]	IF GPA = Medium AND J = Somewhat_Jauh AND KE = Able THEN doesn't get a scholarship
7	**[R7]**	IF GPA = High AND J = Far AND KE = No_ able THEN gets a scholarship
8	[R8]	IF GPA = Low AND J = Near AND KE = No_Mampu THEN did not get a scholarship
9	[R9]	IF GPA = High AND J = Far AND KE = Able THEN does not get a scholarship
10	[R10]	IF GPA = Low AND J = Somewhat_distant AND KE = No_Ableful THEN does not get a scholarship
11	[R11]	IF GPA = Low AND J = Somewhat_distant AND KE = Somewhat_Ableful THEN doesn't get a scholarship
12	[R12]	IF GPA = Low AND J = Somewhat_Jauh AND KE = Able THEN does not get a scholarship

13	[R13]	IF GPA = Low AND J = Far AND KE = No_ able THEN doesn't get a scholarship
14	[R14]	IF GPA = Low AND J = Far AND KE = Somewhat-able THEN doesn't get a scholarship
15	[R15]	IF GPA = Low AND J = Far AND KE = Able to earn THEN cannot get a scholarship
16	**[R16]**	IF GPA = Medium AND J = Close AND KE = No_Mampu THEN didn't get a scholarship
17	[R17]	IF GPA = Medium AND J = Near AND KE = Somewhat_Mampu THEN didn't get a scholarship
18	[R18]	IF GPA = Medium AND J = Near AND KE = Able THEN doesn't get a scholarship
19	**[R19]**	IF GPA = Medium AND J = Far AND KE = No_Able to THEN can't get a scholarship
20	[R20]	IF GPA = Medium AND J = Far AND TO = Somewhat_Mampu THEN did not get a scholarship
21	[R21]	IF GPA = Average AND J = Far AND KE = Able THEN doesn't get a scholarship
22	**[R22]**	IF GPA = High AND J = Close AND KE = No_Mampu THEN get a scholarship
23	[R23]	IF GPA = High AND J = Near AND KE = Somewhat_Mampu THEN did not get a scholarship
24	[R24]	IF GPA = High AND J = Close AND KE = Capable THEN does not get a scholarship
25	**[R25]**	IF GPA = High AND J = Somewhat_distant AND KE = No_ able THEN gets a scholarship
26	[R26]	IF GPA = High AND J = Somewhat_distant AND KE = Somewhat_Ableful THEN does not get a scholarship
27	[R27]	IF GPA = High AND J = Somewhat_Jauh AND KE = Able THEN does not get a scholarship

c. Inference Engine

At the inference engine stage, in determining the students who pass the scholarship awarded by the university, they will apply the MIN function to each rule used in the decision support system with its implication function.

d. Defuzzyficationi

At the defuzzyfication stage, in determining the qualification for students to get scholarships, calculations can be made based on the formation of rules so that later the results of the names of students who receive the scholarship will be obtained.

Table 5.2 Defuzzyfication Results

No	NPM	Name	GPA	Far	To	Information
1	0801	Rian A	3,5	2,1	2,6 million	No scholarship
2	0802	Bandi S	2,9	4,1	3,2 million	No scholarship
3	0803	Valya W	3,1	13,8	1,95 million	Get a scholarship
4	0805	Gracia M	3,2	5,7	2,4 million	Get a scholarship

4. Conclusion

1. The implementation of fuzzy logic in this decision support system can determine who receives the scholarship. This system uses the Tsukamoto fuzzy logic method through predetermined criteria, namely: the cumulative grade point average (GPA), the distance from the student's house to the campus and the economic condition of the student's family. The output received from the system is in the form of information about who has received the scholarship.
2. This system will produce a decision on the names of students who pass the selection and get scholarships.
3. This system will produce a decision on the names of students who pass the selection and get scholarships.
4. Problem solving and finding decisions are very appropriate using fuzzy logic with the Tsukamoto method because it can produce efficient output and make work easier and the results look more tangible.

Reference

1. Aras, A. (2019). The Effect of Mobbing Levels Experienced by Music Teachers on Organizational Commitment and Job Satisfaction. Eurasian Journal of Educational Research, 84, 29-56.
2. Armijos-Bravo, G. (2019). Inequidades socioeconómicas en el uso de cuidados paliativos en Europa. Cuadernos de Economía, 42(118).
3. Birhan, A. T. (2019). Review of Corpus Linguistics for Vocabulary: A Guide for Research. Eurasian Journal of Applied Linguistics, 5(3), 543-545.
4. Bae, Y., & Han, S. (2019). Academic Engagement and Learning Outcomes of the Student Experience in the Research University: Construct Validation of the Instrument. Educational Sciences: Theory & Practice, 19(3).
5. Kusumadewi, Sri (2003). *Artificial Intelligence* (Teknik dan Aplikasinya). Edisi Pertama. Penerbit Graha Ilmu, Jakarta.
6. Jović, D. (2018). Accession to the European Union and perception of external actors in the Western Balkans. Croatian International Relations Review, 24(83), 6-32.
7. Kusumadewi, S, dan Purnomo, H, 2010. Aplikasi Logika *Fuzzy* Sistem Penduku Pendukung Keputusan. Graha Ilmu. Yogyakarta.
8. Wang, W., Tian, G., Zhang, T., Jabarullah, N. H., Li, F., Fathollahi-Fard, A. M., ... & Li, Z. (2021). Scheme selection of design for disassembly (DFD) based on sustainability: A novel hybrid of interval 2-tuple linguistic intuitionistic fuzzy numbers and regret theory. *Journal of Cleaner Production*, 281, 124724.
9. Lumbung Pustaka Universitas Negeri Yogyakarta.http://eprints.uny.ac.id/43552/2/BAB%20II.pdf
10. Wikipedia. Beasiswa. https://id.wikipedia.org/wiki/Beasiswa
11. Maake, B. M., & Tranos, Z. U. V. A. (2019). A Serendipitous Research Paper Recommender System. International Journal of Business and Management Studies, 11(1), 39-53.
12. Erol, İ., & Velioğlu, M. N. (2019). An Investigation Into Sustainable Supply Chain Management Practices In A Developing Country. International Journal Of Ebusiness And Egovernment Studies, 11(2), 104-118.