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The implementation of mamdani fuzzy logic in determining student concentration in computer engineering program

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ABSTRACT

The selection of a concentration is a crucial stage for students in the Computer Engineering program at Universitas Negeri Makassar before entering the 5th semester. Every student is required to choose one concentration in the fields of networking, embedded systems, or intelligent systems. This concentration selection process has a significant impact on academic activities and future career prospects. However, many students face difficulties in determining a concentration that aligns with their abilities and interests. This can have a negative impact on their academic achievements and career prospects. To address this issue, this research proposes a method that utilizes Mamdani fuzzy logic to assist students in selecting a concentration that suits their interests and aptitude. The approach involves collecting data through questionnaires given to students who have completed the 4th semester of the Computer Engineering program. The collected data is then processed using the Mamdani fuzzy logic concept within the MATLAB environment to generate concentration values for each field. The research findings demonstrate the effectiveness of Mamdani fuzzy logic in determining students' concentrations in networking, embedded systems, and intelligent systems, with an accuracy rate of 66.66%. By utilizing appropriate linguistic variables, students' levels of interest and capabilities in each field can be accurately represented. This study provides valuable guidance for students and the university in identifying concentration fields that align with students' interests and abilities, thereby enhancing the effectiveness of education in the Computer Engineering program at Universitas Negeri Makassar.

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1. INTRODUCTION

The computer engineering program is one of the study programs in the Department of Informatics and Computer Science at University of Makassar [1]. The computer engineering program requires every student entering the 5th semester to choose one of the available concentrations such as embedded systems, smart system and networks.

The determination of concentration is an essential part in students' academic journey, this process is not easy and has a significant impact through the academic process in the future [2]. Many students are still uncertain about their talents, interest, and abilities [3]. Therefore, students need to carefully evaluate their talents to avoid mistakes in choosing their desired concentration [4].

In some cases, students choose concentrations that do not match their abilities, which can affect their academic performance and career prospects [5]. Therefore, an efficient method is required to help students choose the right concentration [6].

In a study conducted by Priska et.al., which discussed the implementation of the Fuzzy Inference System (FIS) with the Sugeono method in determining concentrations for high school students at SMP Bakti 17 Jakarta who have recently graduated. However, this research did not consider student's interests and talents [7].

In a study conducted by Amalia et.al., the Fuzzy C-Means algorithm was used as an analytical method. Based on th research results, it was found that the Fuzzy C-Means algorithm achieved an average accuracy rate of 78.39%. However, the process of determining the number of clusters according to the desired number of departments, so it cannot ensure the ideal number of clusters, and the accuracy of grouping cannot be measured [8].

In a study conducted by Dio Setiawan et al., which discussed the determination of study programs in the Faculty of Science and Technology at the University of Muhammadiyah East Kalimantan using the Fuzzy Inference System with the Tsukamoto method. In this study, the accuracy level using the Tsukamoto method reached 87.72% out of 57 data samples. However, this study only included three inputs variables, such as Mathematics, English and Indonesian [9].

Based on the above explanation, the researcher conducted a study on the application of the Mamdani method of Fuzzy Inference System (FIS) in determining student concentrations in the field of networks, embedded system and smart systems. The Mamdani method has advantages in dealing with data uncertainty and complexity [10]. According to research conducted by Ardiansyah et al. the accuracy rate using the Mamdani method reached 80% [11]. This research aims to help students in determining concentrations that match their abilities.

2. METHOD

This step involves gathering information about a problem [12] that occurs in the Computer Engineering program at University of Makassar. The identified problem is how to determine concentrations that align with the abilities if Computer Engineering students. Research flowchart can be seen in Figure 1.

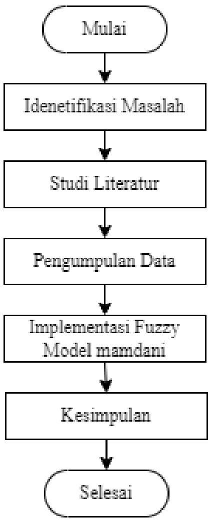

Figure 1. Research flowchart
(Source: Research, 2023)

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2.1 Problem Identification

This was done by collecting information about a problem [13] that occurred in the Computer Engineering study program, Makassar State University. The problem identified is how to determine a concentration that suits the abilities of Computer Engineering Study Program students.

2.2 Literature Review

The literature review is conducted by collecting information related to identified problems [14]. Subsequently, the gathered literature is screened to determine which sources will be used in the research. Literature sources may come from journals, articles, or other sources that address data related to the problem [15].

2.3 Data Collection

In this step, data is collected through the completion of questionnaires by Computer Engineering students who have chosen concentrations [16]. The purpose of filling out these questionnaires is to gather information about the grades in courses related to the fields of embedded systems, smart systems and networks. The collected data serves as test data as well as material for evaluation and decision-making [17] in the selection of concentrations for students. The compiled data can be seen in Table 1 below:

Table 1. Students' data

Initial Name	Computer Network	*IoT*	Artificial Intelligence	GPA	Last Education	Concentration
Zat	3	4	3.25	3.7	SMK	Embedded
Zmash	3	4	4	4	SMA	Smart System
Ais	4	4	4	3.8	SMK	Embedded
SBL	3.75	4	3.75	3.87	SMK	Embedded
Cokya	4	4	4	3.87	SMK	Network
Alm	3	3	3	3.7	SMA	Network
Arini	4	4	4	4	SMK	Smart System
Accang	4	4	4	4	SMA	Embedded
Jal	3	3	3	3	SMA	Embedded
Aul	4	4	4	4	SMA	Embedded
A	3.75	4	4	3.8	SMK	Embedded
G	3	3	3	3.82	SMA	Smart System
NI	3.25	3.75	4	3.6	SMA	Smart System
I	4	4	4	3.6	SMA	Network
M	4	4	3.75	3.65	SMA	Network

2.4 Implementation of Fuzzy Mamdani Method

In this step, a fuzzy set is formed for input and output variables based on the acquired data [18]. This fuzzy set serves to depict the uncertainty or membership of a value in the input and output variables. From these fuzzy sets, rules are formulated connecting the input and output variables [19]. These rules are used to make decisions or perform inference based on the given input values. The final step is defuzzification. Defuzzification is the process of converting the fuzzy set values of the output variable into precise sets or concrete values. The goal of defuzzification is to obtain results that are clearer and more understandable [20].

2.5 Conclution

This stage is carried out to draw conclusions regarding the research results on the determination of student concentration in embedded systems, smart system and computer networks.

3. RESULTS AND DISCUSSIONS

3.1 Fuzzification

In this research, there are five input variables consisting of GPA, Artificial Intelligence score, IoT score, Computer Network score, and graduate status, while the output variable is concentration. Based on these variables, a fuzzy set is formed, which can be seen in Table 2 below:

Table 2. Input and output variables

Input /Output	Variable Name	Fuzzy Sets	Range
		Low	(0 - 2.5)
	Artificial Intelligent	Medium	(2 - 4)
		High	(3.5 - 5)
		Low	(0 - 2.5)
	IoT	Medium	(2 - 4)
		High	(3.5 - 5)
		Low	(0 - 2.5)
Input	Computer Network	Medium	(2 - 4)
		High	(3.5 - 5)
		Low	(0 - 2)
	GPA	Medium	(1.5 - 3.5)
		High	(3 - 5)
		Sederajat	(0.5 - 1.5)
	Last Education	SMA	(1.5 - 2.5)
		SMK	(2.5 - 3.5)
		Network	(50 - 75)
Output	Concentration	Smart System	(75 - 85)
		Embeded	(85 -100)

(Source: Research, 2023)

Below shows a curve that represents the membership function of the artificial intelligence value input variable as seen in the illustration in Figure 2.

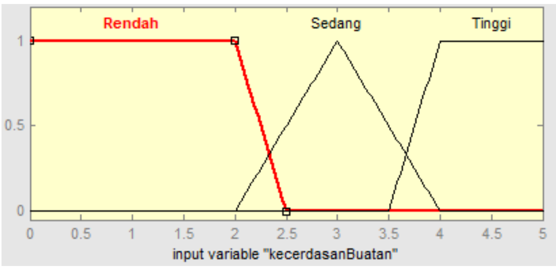

Figure 2. Artificial Intelligence variable Membership Function
(Source: Research, 2023)

The input variable artificial intelligence score can form three groups of fuzzy sets, namely low, medium, and high. The fuzzy sets of the input variable can be seen in the equations below:

$$\mu Low(X) = \begin{cases} 1 ; X \leq 2 \\ \frac{2.5 - X}{2.5 - 2} ; 0.5 \leq X \leq 2.5 \\ 0 ; X \geq 2.5 \end{cases} \quad (1)$$

$$\mu Medium(X) = \begin{cases} 1 ; X \leq 2 \ atau \ X \geq 4 \\ \frac{X - 2}{3 - 2} ; 2 \leq X \leq 4 \\ \frac{4 - X}{4 - 3} ; 3 \leq X \geq 4 \end{cases} \quad (2)$$

.

$$\mu High(X) = \begin{cases} 0 \;; X \leq 3.5 \\ \frac{X-3.5}{4-3.5} \;; 3.5 \leq X \leq 4 \\ 1; X \geq 4 \end{cases} \quad (3)$$

Below is the curve representing the membership function of the input variable IoT score as shown in Figure 3.

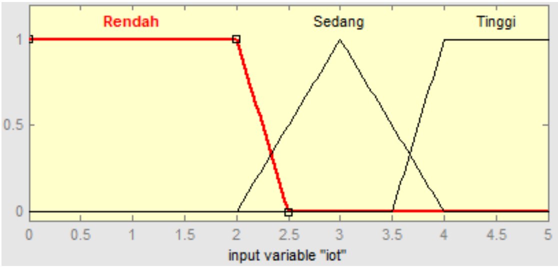

Figure 3. IoT Membership Function
(Source: Research, 2023)

The input variable IoT score can form three fuzzy groups, namely low, medium and high. The fuzzy sets of the input variable can be seen in the equation below:

$$\mu Low(X) = \begin{cases} 1 \;; X \leq 2 \\ \frac{2.5-X}{2.5-2} \;; 0.5 \leq X \leq 2.5 \\ 0; X \geq 2.5 \end{cases} \quad (4)$$

$$\mu Medium(X) = \begin{cases} 1 \;; X \leq 2 \; atau \; X \geq 4 \\ \frac{X-2}{3-2} \;; 2 \leq X \leq 4 \\ \frac{4-X}{4-3} \;; 3 \leq X \geq 4 \end{cases} \quad (5)$$

$$\mu High(X) = \begin{cases} 0 \;; X \leq 3.5 \\ \frac{X-3.5}{4-3.5} \;; 3.5 \leq X \leq 4 \\ 1; X \geq 4 \end{cases} \quad (6)$$

Below is the curve representing the membership function of the input variable Computer Network score as shown in Figure 4.

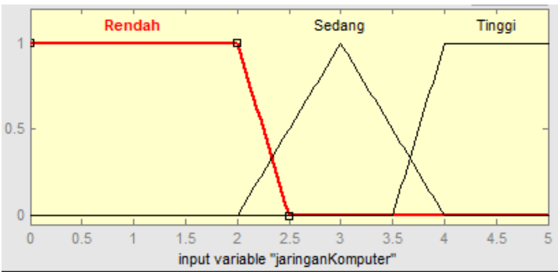

Figure 4. Computer Network Membership Functions
(Source: Research, 2023)

The input variable Computer Network score can form three groups of fuzzy sets, namely low, medium and high. The fuzzy sets of the input variable can be seen in the equations below:

$$\mu Low(X) = \begin{cases} 1 \;; X \leq 2 \\ \frac{2.5-X}{2.5-2} \;; 0.5 \leq X \leq 2.5 \\ 0; X \geq 2.5 \end{cases} \quad (7)$$

$$\mu Medium(X) = \begin{cases} 1\,; X \leq 2 \text{ atau } X \geq 4 \\ \dfrac{X-2}{3-2}\,; 2 \leq X \leq 4 \\ \dfrac{4-X}{4-3}\,; 3 \leq X \geq 4 \end{cases} \quad (8)$$

$$\mu High(X) = \begin{cases} 0\,; X \leq 3.5 \\ \dfrac{X-3.5}{4-3.5}\,; 3.5 \leq X \leq 4 \\ 1; X \geq 4 \end{cases} \quad (9)$$

Below is the curve representing the membership function of the input variable GPA score as shown in Figure 5.

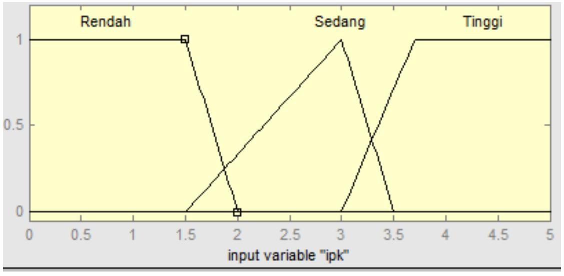

Figure 5. IPK Membership Functions
(Source: Research, 2023)

The input variable GPA score can form three groups of fuzzy sets, namely low, medium and high. The fuzzy sets of the input variable can be seen in the equations below:

$$\mu Low(X) = \begin{cases} 1\,; X \leq 1.5 \\ \dfrac{2-X}{2-1.5}\,; 1.5 \leq X \leq 2 \\ 0; X \geq 2 \end{cases} \quad (10)$$

$$\mu Medium(X) = \begin{cases} 0\,; X \leq 1.5 \text{ atau } X \geq 3.5 \\ \dfrac{X-1.5}{3-1.5}\,; 1.5 \leq X \leq 3 \\ \dfrac{3.5-X}{3.5-3}\,; 3 \leq X \geq 3.5 \end{cases} \quad (11)$$

$$\mu High(X) = \begin{cases} 1\,; X \geq 3.7 \\ \dfrac{3.7-X}{3.7-3}\,; 3 \leq X \leq 5 \\ 0; X \leq 3 \end{cases} \quad (12)$$

Below is the curve representing the membership function of the input variable graduate status as shown in Figure 6.

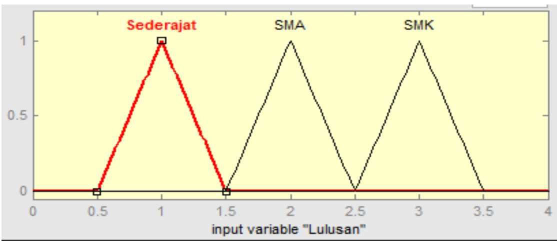

Figure 6. Graduate Membership Functions
(Source: Research, 2023)

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In the input variable graduate status can form three groups of fuzzy sets, namely equivalent, high school graduate and vocational school graduate. The fuzzy sets of the input variable can be seen in the mathematical expressions below:

$$\mu Sederajat\ (X) = \begin{cases} 0\ ; X \leq 0.5\ atau\ X \geq 1.5 \\ \frac{X - 0.5}{1 - 0.5}\ ; 0.5 \leq X \leq 1.5 \\ \frac{1.5 - X}{1.5 - 1}\ ; 1 \leq X \geq 1.5 \end{cases} \quad (13)$$

$$\mu SMA\ (X) = \begin{cases} 0\ ; X \leq 1.5\ atau\ X \geq 2.5 \\ \frac{X - 1.5}{2 - 1.5}\ ; 1.5 \leq X \leq 2 \\ \frac{2.5 - X}{2.5 - 2}\ ; 2 \leq X \geq 2.5 \end{cases} \quad (14)$$

$$\mu SMK(X) = \begin{cases} 0\ ; X \leq 2.5\ atau\ X \geq 3.5 \\ \frac{X - 2.5}{3 - 2.5}\ ; 2.5 \leq X \leq 3.5 \\ \frac{3.5 - X}{3.5 - 3}\ ; 3 \leq X \geq 3.5 \end{cases} \quad (14)$$

In the input variable concentration, three fuzzy groups can be formed, such as network, embedded and smart system. The fuzzy sets of the output variable can be seen in the equations below:

$$\mu Network(X) = \begin{cases} 1\ ; X \leq 70 \\ \frac{75 - X}{75 - 70}\ ; 70 \leq X \leq 75 \\ 0; \geq 75 \end{cases} \quad (16)$$

$$\mu EmbeddedX) = \begin{cases} 0\ ; X \leq 75\ atau\ X \geq 85 \\ \frac{X - 75}{80 - 75}\ ; 75 \leq X \leq 80 \\ \frac{85 - X}{85 - 80}\ ; 80 \leq X \geq 85 \end{cases} \quad (17)$$

$$\mu SistemCerdass(X) = \begin{cases} 0\ ; X \leq 85 \\ \frac{X - 85}{90 - 85}\ ; 85 \leq X \leq 100 \\ 1; X \geq 90 \end{cases} \quad (18)$$

3.2 Rule Formation

This step is a forming logic rules of fuzzy that indicates the connection between input variables and output variables. It uses an operator called operator AND to combine the input rule and indicates the connection between input and output in an IF-THEN format. Input and output variables can be seen in Figure 7.

Aturan		Jaringan Komputer		IoT		Kecerdasan Buatan		IPK		Lulusan		Konsentrasi
R1		Sedang		Tinggi		Sedang		Tinggi		SMK		Embedded
R2		Sedang		Tinggi		Tinggi		Tinggi		SMA		Sistem Cerdas
R3		Tinggi		Tinggi		Tinggi		Tinggi		SMK		Embedded
R4		Tinggi		Tinggi		Tinggi		Sedang		SMA		Jaringan
R5		Tinggi		Tinggi		Tinggi		Tinggi		SMK		Jaringan
R6		Tinggi		Tinggi		Sedang		Sedang		SMK		Jaringan
R7		Sedang		Tinggi		Sedang		Tinggi		SMK		Embedded
R8		Sedang		Tinggi		Sedang		Tinggi		SMA		Embedded
R9		Sedang		Tinggi		Tinggi		Sedang		SMA		Sistem Cerdas
R10		Sedang		Tinggi		Tinggi		Tinggi		SMA		Sistem Cerdas
R11	AND	Tinggi	AND	Sedang	AND	Tinggi	AND	Sedang	AND	SMK	THEN	Jaringan
R12		Tinggi		Sedang		Tinggi		Tinggi		SMA		Sistem Cerdas
R13		Tinggi		Tinggi		Tinggi		Sedang		SMA		Sistem Cerdas
R14		Tinggi		Tinggi		Tinggi		Sedang		SMK		Sistem Cerdas
R15		Sedang		Sedang		Sedang		Sedang		SMK		Jaringan
R16		Sedang		Sedang		Sedang		Tinggi		SMA		Sistem Cerdas
R17		Tinggi		Tinggi		Sedang		Sedang		SMA		Embedded
R18		Tinggi		Tinggi		Sedang		Sedang		SMK		Embedded
R19		Tinggi		Sedang		Sedang		Tinggi		SMK		Jaringan
R20		Sedang		Tinggi		Tinggi		Sedang		SMA		Sistem Cerdas
R21		Sedang		Tinggi		Tinggi		Sedang		SMK		Embedded

Figure 7. Input and Output variables
(Source: Research, 2023)

3.3 Inference

The inference method in the Mamdani is the steps of making decision or drawing conclusion in accordance with the fuzzy rules specified in Table 4. This method aims to transform fuzzy input into fuzzy output using fuzzy rules. The inference method in the Mamdani metod allows us to combine domain knowledge that is ambiguous or uncertain into a system that can provide more accurate decisions. By using the fuzzy rules, this method allows the model to represent the level of uncertainty or information deficiency in the system.

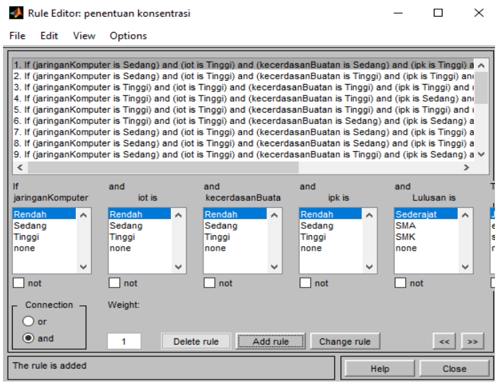

Figure 8. Rule editor
(Source: Research, 2023)

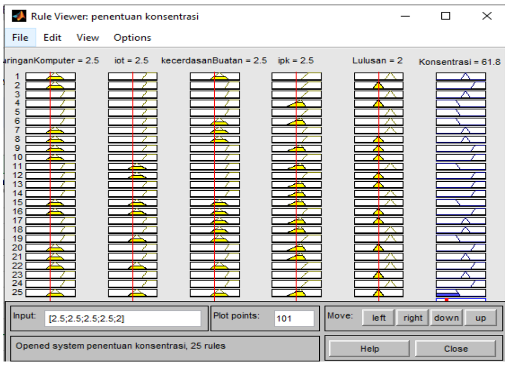

Figure 9. Inference results for input values in the FIS program
(Source: Research, 2023)

3.4 Defuzzification

Defuzzificaton is a step in the fuzzy system that aims to convert the result of the fuzzy output through fuzzy set using the function of membership into certain score. This is important in practical applications because most cases require concrete or certain score in applying the decision making or action.

In the defuzzification process, the membership function graph is used to determine the boundaries of the fuzzy output. There are three linguistic values to determine the concentration conditions, as shown in Figure 10:

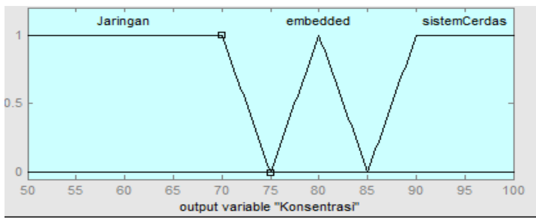

Figure 10. Fuzzy output membership function
(Source: Research, 2023)

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Figure 11. Fuzzy Design for Selecting Student Concentration
(Source: Research, 2023)

In Figure 9 above, the result of selecting student concentrations using the GUI MATLAB is displayed. On the left side, there is an input configuration where values can be entered based on the data obtained earlier. On the right side is for obtaining the output value. The results of inputting the previously obtained data can be seen in Figure 12.

Nama	Jaringan Komputer	Io T	Kecerdasan Buatan	IPK	Lulusan	Nilai	Hasil	Sesuai / Tidak sesuai	Konsentr asi
Zet	3	4	3.25	3.7	SMK	80	Embedd ed	Ya	Embedde d
Zmuh	3	4	4	4	SMA	93.79 41	Sistem Cerdas	Ya	Sistem Cerdas
Ais	4	4	4	3.8	SMK	80	Embedd ed	Ya	Embedde d
SBL	3.75	4	3.75	3.87	SMK	80	Embedd ed	Ya	Embedde d
Cahya	4	4	4	3.87	SMK	80	Embedd ed	Tidak	Jaringan
Alm	3	3	3	3.7	SMA	75	Jaringan	Ya	Jaringan
Aeini	4	4	4	4	SMK	80	Embedd ed	tidak	Sistem Cerdas
Accan g	4	4	4	4	SMA	80	Embedd ed	ya	Embedde d
Jal	3	3	3	3	SMA	61.17 03	Jaringan	tidak	Embedde d
Aul	4	4	4	4	SMA	80	Embedd ed	ya	Embedde d
A	3.75	4	4	3.8	SMK	80	Embedd ed	Ya	Embedde d
G	3	3	3	3.82	SMA	93.79 41	Sistem Cerdas	ya	Sistem Cerdas
NI	3.25	3.7 5	4	3.6	SMA	93.23 21	Sistem Cerdas	ya	Sistem Cerdas
I	4	4	4	3.6	SMA	73	Jaringan	Ya	Jaringan
M	4	4	3.75	3.65	SMA	74.9	Jaringan	Ya	Jaringan

Figure 12. Input and output variables

In Table 4 above, calculations can be performed to obtain error values and accuracy values. The result of FIS Mamdani is then made between the obtained data and the data from the created system.

Total amount of data = 15
The amount of data does not match = 3
Jumlah data sesui = 12

$$\text{Error value} = \frac{\textit{The amount of data does not matc}}{\text{Total amount of data}} \text{x } 100\% \quad (19)$$

= 3/15 x 100% = 0.3333 x 100%
= 20%

$$\text{Accuracy Value} = \frac{\textit{The amount of data is appropriate}}{\textit{Total amount of data}} \text{x}100\% \quad (20)$$

= 12/15 x 100% = 0.8 x 100%
= 80%

The results show that the FIS Mamdani provides an accuracy rate of 80%, indicating that 80% of the FIS Mamdani predictions match the study programs accepted by Computer Engineering students at Makassar State University. However, there is a 20% discrepancy between the FIS Mamdani results and the actual study program. The error value represents the percentage of errors between the FIS Mamdani results and the actual study program.

4. CONCLUSION

From the research results, it can be concluded that the Fuzzy Inference System (FIS)with Mamdani method can be used to determine student concentrations in the networking field, embedded sytem and smart system in the Computer Engineering program in University of Makassar. This method can help students who have difficulties in selecting the appropriate concentration based on their abilities. The accuracy of this method reaches 80%.

The implementation of decision support system based on Mamdani FIS is expected to significantly contribute to the students, higher education institutions, and the industry. Students can avoid mistakes in selecting concentrations that potentially hinder their academic progress and career. Higher education institutions will have students who are more committed and suitable for the offered programs, thereby it can increase the graduation rates and the institution's reputation. Meanwhile, the industry will also benefit from graduates who are well-prepared and aligned with the needs of the job market.

However, it is important to notice that despite the accuracy rate achieving 80%, the system is still potentially to have further improvement. Developing the model with more data and a wide range of concentration can enhance the performance of the system. In addition, other factors like personal interest, career goals and technological development may affect the students' choice. With the support and further development, the decision support system based on Mamdani FIS has the potential to make significant progress and contribute to the brighter education world and student's career.

REFERENCES

[1] R. T. Mangesa, M. S. Lamada, and A. Khaerunnisa, "Analisis Faktor yang Mempengaruhi Keputusan Mahasiswa Dalam Pemilihan Mata Kuliah Konsentrasi di Program Studi Pendidikan Teknik Informatika dan Komputer Universitas Negeri Makassar," vol. 1, no. 3, pp. 1–4, 2022.

[2] N. L. G. P. Suwirmayanti and I. G. A. D. Saryanti, "undhirab,+Journal+manager,+69++Suwirmayanti+(519-526)," *SINTESA*, vol. 2, 2019.

[3] Tira Nur Fitria, "Bimbingan Karir Bagi Lulusan Mahasiswa: Pelatihan Mencari Lowongan Pekerjaan, Menulis Surat Lamaran Pekerjaan dan Mendesain CV Menarik," *J. Entrep. Community Innov.*, vol. 1, no. 1, pp. 9–15, 2022, doi: 10.33476/jeci.v1i1.15.

[4] P. Subekti, T. D. Andini, and M. Islamiyah, "Sistem Penentuan Konsentrasi Jurusan Bagi Mahasiswa Informatika Menggunakan Metode K-Means Di Institut Asia Malang," *J. Manaj. Inform.*, vol. 12, no. 1, pp. 25–39, Mar. 2022, doi: 10.34010/jamika.v12i1.6452.

[5] A. Setiawan and A. Artanti, "Komparasi Metode Elimination Et Choix Traduisant La Realite (Electre) dan K-NN Similarity dalam Sistem Pendukung Keputusan Pemilihan Konsentrasi Jurusan …," *InfoTekJar J. Nas. Inform. dan …*, vol. 2, 2021.

[6] M. Farid, S. Wibowo, N. F. Puspitasari, and B. Satya, "PENERAPAN DATA MINING DAN ALGORITMA NAÏVE BAYES UNTUK METODE KLASIFIKASI Abstraksi Pendahuluan Tinjauan Pustaka Metode Penelitian," vol. 3, no. 2, 2022.

[7] L. N. Prastika *et al.*, "Pemodelan Metode Fuzzy Sugeno Untuk Penentuan Jurusan Sma Pada Siswa Smp Di Smp Bakti 17 Jakarta," *Semin. Nas. Mhs. Ilmu Komput. dan Apl.*, pp. 785–798, 2020.

[8] K. R. Amalia, F. Rizki, and A. Setiawan, "SISTEM PENDUKUNG KEPUTUSAN PENENTUAN JURUSAN DI SMA YADIKA NATAR DENGAN ALGORITMA FUZZY C-MEANS," *Aisyah J. Informatics Electr. Eng.*, vol. 1, no, pp. 18–23, 2019.

[9] D. Setiyawan, A. Arbansyah, and A. J. Latipah, "FUZZY INFERENCE SYSTEM METODE TSUKAMOTO UNTUK PENENTUAN PROGRAM STUDI FAKULTAS SAINS DAN TEKNOLOGI DI UNIVERSITAS MUHAMMADIYAH KALIMANTAN TIMUR," *JIKO (Jurnal Inform. dan Komputer)*, vol. 7, no. 1, p. 23, Feb. 2023, doi: 10.26798/jiko.v7i1.657.

[10] V. Issue, M. Asman, D. H. Gutama, D. P. Wijaya, and A. Pramuntadi, "JUTIN : Jurnal Teknik Industri Terintegrasi Perancangan Sistem Prediksi Pembelian Stok Masker dengan Metode Fuzzy Mamdani (Studi Kasus : Ud Masker Murah Jogja)," vol. 6, no. 3, pp. 685–695, 2023.

[11] Y. R. Ardiansyah, L. A. Syamsul, and I. Akbar, "SISTEM PENGAMBILAN KEPUTUSAN UNTUK PEMILIHAN BIDANG KEAHLIAN BAGI MAHASISWA TEKNIK ELEKTRO UNIVERSITAS MATARAM MENGGUNAKAN LOGIKA FUZZY MAMDANI BERTINGKAT Decision Making System for Determining Student Expertise Area in Electrical Engineering University o," 2021.

[12] T. Triyah and C. Anggraini, "Pengaruh Komunikasi Strategi CSR Dan Stakeholder Management

.

Terhadap Corporate Branding PT. Pertamina Ft Bandung Group," *eProceedings …*, vol. 10, no. 1, pp. 493–504, 2023.

[13] M. R. Aprillya and U. Chasanah, "Sistem Pendukung Keputusan Identifikasi Daerah Rawan Kekeringan dengan Metode Fuzzy Analytical Hierarchy Process (Studi Kasus: Kabupaten Lamongan)," *J. CoSciTech (Computer Sci. Inf. Technol.*, vol. 3, no. 2, pp. 159–167, 2022, doi: 10.37859/coscitech.v3i2.3983.

[14] A. M. Abidin, "Penerapan Teori Belajar Behaviorisme dalam Pembelajaran (Studi Pada Anak)," *An Nisa'*, vol. 15, no. 1, pp. 1–8, 2022.

[15] R. Ilham and H. Fryonanda, "Perancangan Prediksi Produksi Teh Menggunakan Metode Fuzzy Tsukamoto Berbasis Web," *JITSI J. Ilm. Teknol. Sist. Inf.*, vol. 4, no. 1, pp. 16–22, 2023.

[16] K. Muflihunna, "Penerapan Metode Fuzzy Mamdani dan Metode Fuzzy Sugeno dalam Penentuan Jumlah Produksi," 2022.

[17] C. H. Nufus, I. Prihantoro, and P. D. M. H. Karti, "Jurnal Ilmu Nutrisi dan Teknologi Pakan," vol. 20, no. 1, pp. 7–13, 2022.

[18] G. Silalahi, "Model Optimasi Himpunan Fuzzy Untuk Menentukan Harga Jual Optimal Pada Daging Sapi," vol. 3, pp. 3263–3275, 2023.

[19] M. Sovina and F. A. Harahap, "Penentuan Status Gizi Dengan Indeks Massa Tubuh (IMT) Menggunakan Logika Fuzzy Determination of Nutritional Status With Body Mass Index (BMI) Using Fuzzy Logic," *InfoSys J.*, vol. 7, no. 1, pp. 105–116, 2022.

[20] M. M. F. Fatori, "Aplikasi IoT Pada Sistem Kontrol dan Monitoring Tanaman Hidroponik," *J. Pendidik. Sains dan Komput.*, vol. 2, no. 02, pp. 350–356, Oct. 2022, doi: 10.47709/jpsk.v2i02.1746.