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Decision Support System for Single Tuition Scholarship Awardees in Higher Education Using Mamdani Fuzzy Inference

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Abstract
Universitas Madura implements the Single Tuition Fee (UKT) scholarship program in the Informatics department. The current UKT scholarship selection system uses a traditional model that is still not effective, causing obstacles such as inflexibility in registration time. The print-out documents are vulnerable to damage or loss and difficulty searching when it required. The criteria in the current system consisted of a minimum Grade Point Average (GPA) of 3, a letter of family condition, and also student status in semesters 3 to 7. The three criteria are not enough to determine a scholarship candidate. The recruitment process involves only the Head of the Study Program (Kaprodi). The Informatics study program still has many candidates applying for scholarships reaching around 280%. This research proposes a Decision Support System (DSS) using Fuzzy Mamdani with six criteria, including GPA, Achievement, Parents' Income, Parents' Dependents, Semester, and History of not receiving scholarships with the aim of overcoming these problems. The results show that the performance of the proposed SPK is very good, it is shown by the MAPE value of less than 10% and more efficient time than the current system. This system has also been in accordance with the required functions through the black test.
Keywords: Decision Support System, DSS, Fuzzy, Mamdani, scholarship.

1. Introduction
Universitas Madura, located in Pamekasan Regency, East Java Province, Indonesia, has a Single Tuition Tuition (UKT) scholarship program. This UKT scholarship program is opened at the beginning of every semester for all Study Programs (Prodi), including the Informatics Study Program. Each period for each study program is given a quota of 25. However, enthusiasts from the Informatics Study Program usually reach approximately 280% of the quota provided or approximately 70 applicants. In its implementation, the selection process is carried out manually, where data is collected in hardcopy form, which allows data to be prone to loss and damage and has limited time for registration. The criteria for UKT scholarship recipients in the old system were based on a Grade Point Average (GPA) of at least 3, a certificate of indigency from the village, and students who had taken semesters 3 to 7.

Meanwhile, only one human resource was involved in this process, namely the head of the study program of the study program he leads. The time given by the university from closing the registration period until the final announcement of UKT scholarship recipients is a month. The impact of the selection process is that the selection process becomes less effective and efficient. Because many applicants potentially have the same values and conditions for the three specified criteria. If it is only based on GPA ranking, many applicants can have the same GPA value. It will also be unfair if it is based on earlier registration time. Because there could be more critical conditions to take into consideration. Apart from the GPA score criteria, the applicant's achievement criteria can also be considered, whether the applicant has provincial, national, or international level achievements (Sari et al., 2018). The criteria for a certificate of incapacity can be changed to criteria for parental income and criteria for parental dependents (Aflahin et al., 2023; Putriani et al., 2022; Sari et al., 2018). Apart from the semester criteria (Khasanah & Rofiah, 2019), the criteria for

a history of not receiving a scholarship can also be considered so that UKT scholarship recipients are more evenly distributed (Kirom et al., 2012).

The same problems related to the manual selection system for UKT scholarship recipients have been researched, including 1) Salendah et al. (2022) proposed a system using web-based Fuzzy Tsukamoto with criteria for scholarship recipients based on the number of UKTs, the GPA obtained by the student, and the amount of income from the student's parents; 2) Aldisa et al. (2022) proposed a Decision Support System (DSS) with 7 (seven) criteria (GPA, percentage of attendance, organizational activity, semester, achievement, parent's dependents, parent's income), weighted using Rank Order Centroid (ROC), then comparing performance between Multi-Objective Optimization based on Ratio Analysis (MOORA) and Simple Additive Weighting (SAW). The results of research by Aldisa et al. (2022) show that SAW has a higher preference value than MOORA; 3) Kusnaidi et al. (2022) proposed applying K-Means to determine UKT assistance priorities based on parental employment, home ownership status, and parental income; 4) Andrea & Nursobah (2022) proposed applying K-Medoids to determine UKT assistance priorities. The criteria used in Andrea & Nursobah (2022) research are the same as Kusnaidi et al. (2022); 5) Cahya et al. (2022) also proposed applying K-Means to determine prospective UKT scholarship recipients based on father's job, mother's job, the combined income of both parents, and some family members covered; 6) Fitriani (2018) proposed SPK as a solution for receiving scholarships for students using Fuzzy Mamdani based on GPA, semester, parental income, parental allowance, age, and certificate. Meanwhile, research related to the application of Fuzzy Mamdani in SPK was also carried out by Saputra et al. (2021) in the Academic Achievement Improvement (PPA) scholarship selection process at Muhammadiyah Pontianak, West Kalimantan Province, Indonesia.

Of the 7 (seven) studies that have been presented, there are three approaches commonly used in SPK, namely: 1) Multi-Criteria Decision-Making (MCDM), 2) Clustering in data mining, and 3) Fuzzy. MOORA and SAW are commonly used methods based on Multi-Criteria Decision-Making (MCDM) (Ameri et al., 2018; Pérez-Domínguez et al., 2018). MCDM and clustering algorithms in data mining face difficulties in collecting often uncertain data (Baydas & Pamucar, 2022; Raju et al., 2008). Handling uncertainty can be done using fuzzy sets (Raju et al., 2008; Shoaip et al., 2019). Meanwhile, Bede and Rudas in (Shoaip et al., 2019) stated that the Mamdani approach in many studies is better than the Takagi-Sugeno-Kang (TSK) model in solving real problems. In their research, Sonalitha et al. (2019) stated that Fuzzy Mamdani provided better performance than Fuzzy Tsukamoto with a Mean Absolute Percentage Error (MAPE) value of 6.49%.

In this research, an SPK is proposed based on six criteria, namely 1) Cumulative Achievement Index (GPA); 2) Parent's income; 3) Dependent parents; 4) Semester; 5) Achievement; and 6) History of not having received a scholarship. The six criteria have uncertain problems. For example, the income of the applicant's parents may vary, so uncertain concepts such as “low”, “medium”, or “high” are necessary. This research aims to overcome existing problems so that UKT scholarships can be enjoyed by students equally, fairly, and with the same opportunities, not dominated by certain students. Therefore, to achieve the goal, the method proposed in this research is to use Fuzzy Mamdani, which can handle uncertainty problems.

2. Literature Review

Anam dan Santoso (2018) conducted research by comparing the performance of the C4.5 algorithm with Naive Bayes in the case of selecting scholarship recipients based on semester, GPA, co-/extra-curricular achievements, parents' income, electricity costs, and number of parents' dependents. Semester attributes, GPA, and co/extra-curricular achievements are of binomial type. Meanwhile, the attributes of parents' income, electricity costs, and number of parents' dependents are polynomial types. The data used was 164. Based on test results using 10-fold cross-validation, C4.5's performance was better than Naive Bayes's, with an accuracy value of 96.4%.

Musthafa et al. (2015) conducted research by comparing the C.45 and AHP-TOPSIS algorithms in the scholarship recipient selection process based on 12 variables. AHP-TOPSIS combines the Analytical Hierarchy Process (AHP) with the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). The twelve (12) variables include 1) Father's income; 2) Mother's income; 3) Father's education; 4) Father's occupation; 5) Dependent parents; 6) National exam average; 7) Average report card score; 8) Academic achievement; 9) Non-academic achievements; 10) House area; 11) Land and building tax; and 12) Electricity account. The data used was 975, of which 45.33% was training data and 54.67% was test data. Based on the test results, it was found that C4.5 was better than AHP-TOPSIS, with an average value of 91.5% accuracy, 87% precision, and 89.5% recall.

Setiawan (2021) proposed the Fuzzy TOPSIS algorithm for a scholarship recommendation system based on semester, age, GPA, extracurricular, academic, non-academic, employment, and marital status. The data used in this research was 1,000 registrants. The performance of the proposed algorithm gets an average accuracy value of 77.60% in approximately 3 minutes.

Munawaroh et al. (2019) proposed Fuzzy Mamdani by defuzzification using the centroid method to determine scholarship recipients based on average report card grades, parents' income, and dependents. Adawiah dan Ruliah (2013) proposed SPK for selecting Fuzzy Mamdani-based scholarship recipients based on parents' income, parents' dependents, Achievement Index (GPA), semester, age, and achievements. Fuzzy Mamdani performs better than AHP based on the Fuzzy Mamdani accuracy value of 85.7% (Adawiah & Ruliah, 2013).

3. Methods

The method for building SPK for UKT scholarship recipients using Fuzzy Mamdani in this research includes several stages illustrated in Fig. 1.

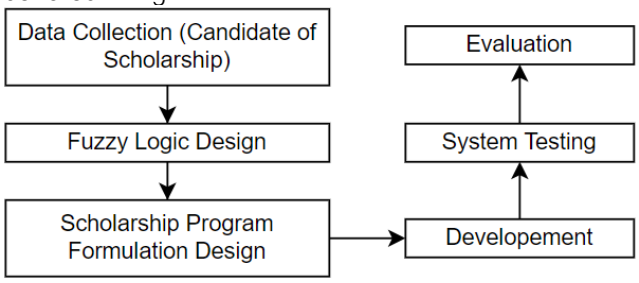

Fig. 1. Research methodology.

Table 1
Variabel himpunan.

Function	Input Variable	Fuzzy Set	Domain
Input	Grade Poin Average (GPA)	Low	0 – 3
		Medium	2.75 – 3.5
		High	3.25 – 4
	Parent's income	Low	500,000 – 1,000,000
		Medium	750,000 – 2,750,000
		High	2,500,000 – 3,500,000
	Parent's dependents	Few	1 – 3
		Many	3 – 6
	Semester	Medium	0 – 7
		High	6 – 10
	Achievement	Province	1 – 30
		National	20 – 70
		International	50 – 100
	Scholarship Awardee	No	0.25
		Yes	1
Output	Decision	Not Recommended	0 – 50
		Recommended	50 – 100

3.1. Data collection

At this stage, a literature review was first carried out referring to the method used by Fitriani (2018) to obtain criteria for selecting the proposed UKT scholarship recipients, where initially only three criteria became six criteria which would be used as input variables in Fuzzy Mamdani, such as in Table 1. The data used in this research was taken from the Universitas Madura Informatics Study Program for the 2022/2023 odd semester academic year. Data was collected from 70 registrants.

3.2. Fuzzy logic design

At this stage, the Fuzzy logic design was carried out referring to Fitriani's research (2018), in this research, the focus was on Mamdani, which has four stages, according to Kartika et al. in (Saputra et al., 2021) and (Parjono & Witanti, 2021), namely:

1) Formation of Fuzzy sets (Fuzzification)
   At this stage, Fuzzy variables and Fuzzy sets are defined. Input and output variables are divided into two or more Fuzzy sets. This research has 6 (six) input variables and 1 (one) output variable, as illustrated in Table 1. The membership function in this study uses trapezoidal and triangular curve

representations to determine member point values (Gorianto et al., 2020; Parjono & Witanti, 2021). With these curves, a defined area can be applied along the boundary of each domain.

a) Membership function of the GPA value variable

In Table 1 and Fig. 2, the GPA value variable has three fuzzy sets: low, medium, and high.

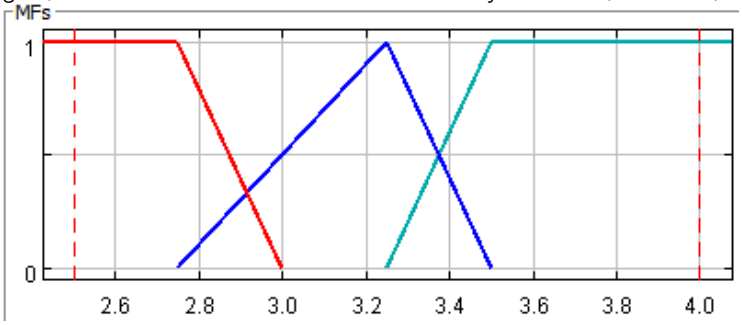

Fig. 2. GPA value variable membership function.

$$\mu GPA_{low(x)} = \begin{cases} 1\,;0 \le x \le 2.5 \\ \frac{x-2.5}{3-2.5} \quad ;2.5 < x \le 3 \\ 0\,;x \ge 3 \end{cases} \tag{1}$$

$$\mu GPA_{medium(x)} = \begin{cases} \frac{x-3.25}{3.25-2.75}\,;2.75 \le x \le 3.25 \\ \frac{x-3.25}{3.5-3.25}\,;3.25 < x \le 3.5 \\ 0\,;x \ge 3.5 \end{cases} \tag{2}$$

$$\mu GPA_{high(x)} = \begin{cases} 0\,;x \le 3.25 \\ \frac{x-3.25}{4-3.25};3.25 < x \le 4 \\ 1\,;\ x = 4 \end{cases} \tag{3}$$

b) Membership function of the parent income variable

In Table 1 and Fig. 3, the parental income variables have 3 fuzzy sets, namely low, medium and high.

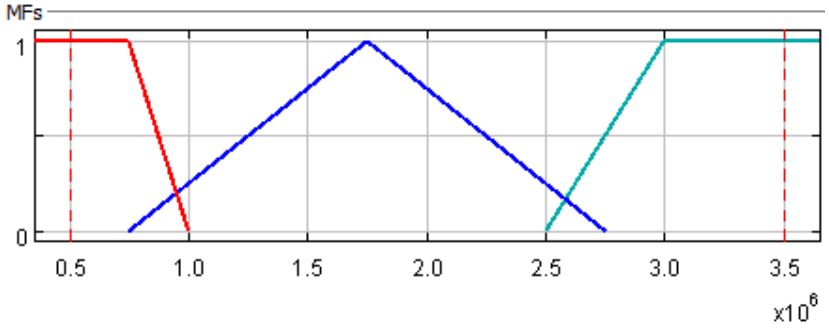

Fig. 3. Membership function of parental income variable.

$$\mu Income_{low(x)} = \begin{cases} 1\,;0 \le x \le 500{,}000 \\ \frac{x-500{,}000}{1{,}000{,}000-500{,}000} \quad ;500{,}000 < x \le 1{,}000{,}000 \\ 0\,;x \ge 1000{,}000 \end{cases} \tag{4}$$

$$\mu Income_{medium(x)} = \begin{cases} \frac{x-750{,}000}{1{,}750{,}000-750{,}000}\,;750{,}000 \le x < 1{,}750{,}000 \\ \frac{x-1{,}750{,}000}{2{,}750{,}000-1{,}750{,}000}\,;1{,}750{,}000 < x \le 2{,}750{,}000 \\ 0\,;x \ge 2{,}750{,}000 \end{cases} \tag{5}$$

$$\mu Income_{high(x)} = \begin{cases} 0\,;x \le 2{,}500{,}000 \\ \frac{x-2{,}750{,}000}{3{,}500{,}000-2{,}500{,}000};2{,}500{,}000 < x < 3{,}500{,}000 \\ 1\,;\ x \ge 3{,}500{,}000 \end{cases} \tag{6}$$

c) Membership function of dependent parent variables
Table 1d and Fig. 4, show that the dependent parent variable has 2 Fuzzy sets: few and many.

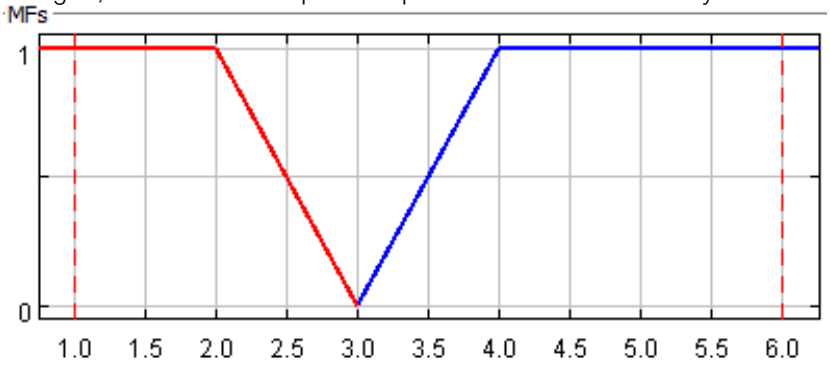

Fig. 4. Parental dependent variable membership function.

$$\mu Dependents_{few(x)} = \begin{cases} 1\,; 0 \le x \le 1 \\ \frac{3-x}{3-2} \quad ; 2 \le x \le 3 \\ 0\,; x \ge 3 \end{cases} \tag{7}$$

$$\mu Dependents_{many(x)} = \begin{cases} 0\,; x \le 3 \\ \frac{x-3}{6-4}; 4 \le x \le 6 \\ 1\,;\ x \ge 6 \end{cases} \tag{8}$$

d) Semester variable membership function
In Table 1 and Fig. 5, the semester variable has 2 Fuzzy sets: medium and high.

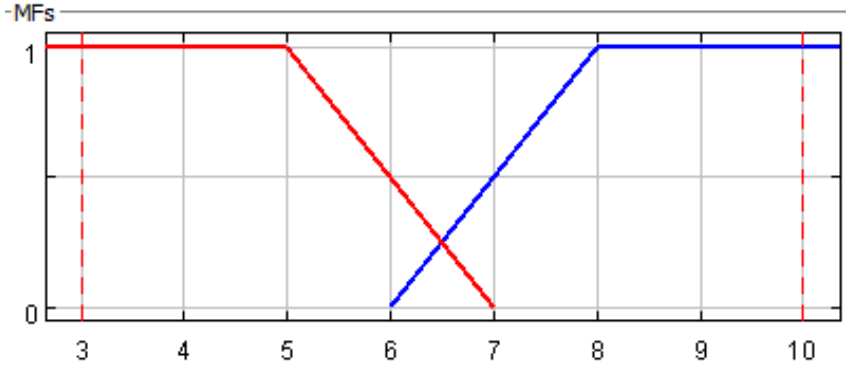

Fig. 5. Semester variable membership function.

$$\mu Semester_{medium(x)} = \begin{cases} 1\,; x \le 3 \\ \frac{x-3}{7-3} \quad ; 3 < x \le 7 \\ 0\,; x \ge 7 \end{cases} \tag{9}$$

$$\mu Semester_{high(x)} = \begin{cases} 0\,; x \le 6 \\ \frac{x-6}{10-6}; 6 < x \le 10 \\ 1\,;\ x \ge 10 \end{cases} \tag{10}$$

e) Membership function of the achievement variable
In Table 1 and Fig. 6, the achievement variables have three fuzzy sets, namely provincial, national, and international.

$$\mu Achievement_{province}(x) = \begin{cases} 1; 1 \le x \le 15 \\ \frac{x-15}{30-15} = 15 \le x < 30 \\ 0; x > 30 \end{cases} \tag{11}$$

$$\mu Achievement_{national}(x) = \begin{cases} \frac{x-20}{35-20}; 20 \le x \le 35 \\ \frac{x-35}{70-35} = 35 \le x < 70 \\ 0; x > 70 \end{cases} \tag{12}$$

$$\mu Achievement_{international}(x) = \begin{cases} 0; x \leq 50 \\ \frac{x-50}{100-50} = 50 \leq x < 100 \\ 1; x \geq 100 \end{cases} \quad (13)$$

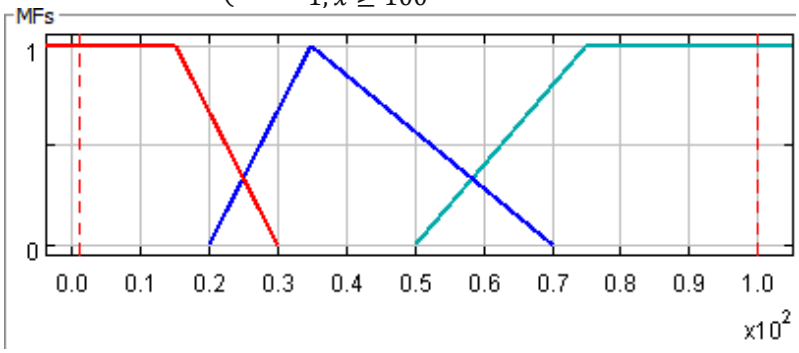

Fig. 6. Membership function of the achievement variable.

f) The variable membership function has not received a scholarship
In Table 1 and Fig. 7, the variables for not receiving a scholarship have 2 Fuzzy sets, namely not yet and received. The membership function for the variable receiving scholarships used is presented in Eq. (14).

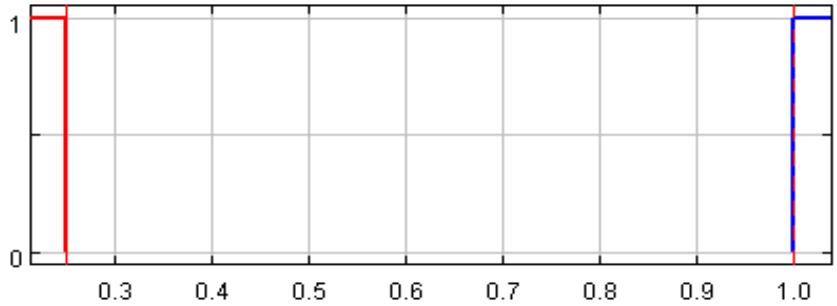

Fig. 7. The variable membership function has not received a scholarship.

$$\mu ScholarshipAwardee(x) = \begin{cases} 1\,; x = No \\ 0.25\,; x = Yes \end{cases} \quad (14)$$

g) Decision variable membership function
In Table 1 and Fig. 8, the decision variables are output variables with 2 Fuzzy sets, namely, not recommended and recommended. The decision variable membership function used is presented in Eq. (15).

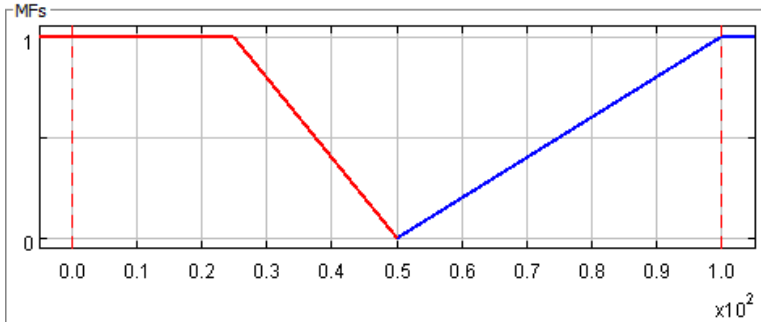

Fig. 8. Decision variable membership function.

$$\mu Decision_{not\ recommended(z)} = \begin{cases} 1; z \leq 25 \\ \frac{z-25}{50-25}; 25 < z \leq 50 \\ 0;\ x \leq 50 \end{cases} \quad (15)$$

$$\mu Decision_{recommended(z)} = \begin{cases} 0\,; z \leq 50 \\ \frac{100-z}{100-50}\,; 50 < z \leq 100 \\ 1\,; x \geq 100 \end{cases} \quad (16)$$

2) Apply the implication function
Previously, at the Fuzzy logic creation stage, rules were created based on the criteria that had been provided. There are 150 rules used in this research which were obtained by calculating based on actual data (calculated data) adjusted to the conditions of the membership function in Eq. (1) to Eq. (14). From the explanation Eq. (1) to Eq. (14) a certain number of rules will be obtained according to the actual data conditions, which are then searched for the implicit value (MIN) (Parjono & Witanti, 2021; Saputra et al., 2021).

3) Composition of rules (Rules)
At this stage the rule configuration is carried out using the MAX method as presented in Eq. (19) (Parjono & Witanti, 2021), where $\mu_{sf}(x_i)$ is the membership value of the Fuzzy solution up to the *i*-iteration rule. $\mu_{kf}(x_i)$ is the Fuzzy consequent membership value up to-i. This method is related to the OR or (union) operator.

$$\mu_{sf}(x_i) = max(\mu_{sf}(x_i), \mu_{kf}(x_i)) \quad (17)$$

4) Defuzzification
The input of the defuzzification process is a Fuzzy set obtained from the composition of Fuzzy rules, while the resulting output is a number in the Fuzzy set domain. In this research, the defuzzification method used is the centroid method (Saputra et al., 2021). This method was chosen because the defuzzification value will move smoothly, so that changes to a fuzzy set will also occur smoothly, and are easier to calculate. In this research, the crisp Z value is determined by dividing the area into three parts, namely D1, D2 and D3 based on research by Febriany (2016), as illustrated in Fig. 9, where the corresponding regions are areas A1, A2, and A3; and the moments of the corresponding member values are moments M1, M2, and M3.

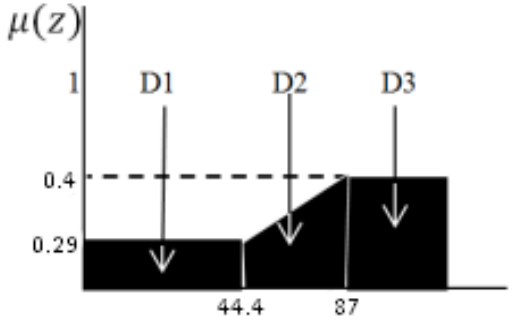

Fig. 9. Defuzzification process.

Determining the moment or M for each area uses Eq. (18).

$$M = \int_a^b \mu_A(x) x \, dx \quad (18)$$

Determining the area or A for each area uses Eq. (19).

$$A = \int_a^b \mu_A(x) \, dx \quad (19)$$

Based on these calculations, Z or the center of the Fuzzy region, is obtained by applying Eq. (20).

$$Z = \frac{\int_z^b \mu_A(x) x \, dx}{\int_a^b \mu_A(x) \, dx} \quad (20)$$

3.3. Design system

The flowchart, database, Data Flow Diagram (DFD), and user interface of the proposed SPK system are designed at this stage. The flowchart is illustrated in Fig. 10, where the first thing to do is enter student data into the system: personal data (number and name), GPA, parents' income, parents' dependents, semester, achievements, and not yet receiving a scholarship. Each input variable (GPA, income, etc.) is divided into a Fuzzy set with a membership function. For example, a GPA can have “low,” “medium,” and “high” sets. The Fuzzy rule implication function is applied to the Fuzzy set that has been formed. The system rule composition combines the implication results of all the rules using the Fuzzy AND logic operation, producing a combined Fuzzy set as a Fuzzy decision representation. Defuzzification of the system changes the combined Fuzzy set into crisp values using the centroid method, thereby producing concrete decision values. The output produced by the system is based on the crisp value of the defuzzification results in the form of a decision whether the student is recommended or not recommended to receive a scholarship.

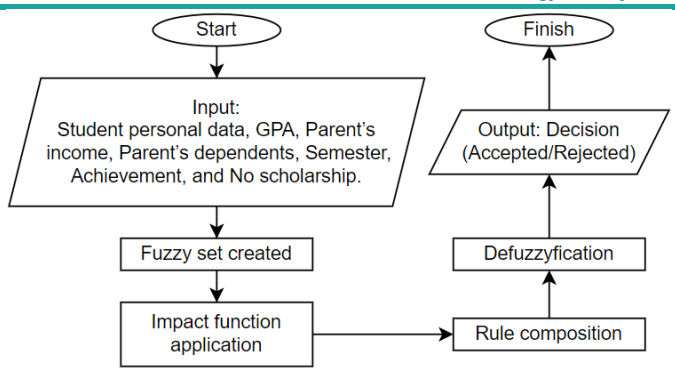

Fig. 10. Flowchart system.

The database design consists of four tables. These tables include admin, period, student, and decision tables. The admin table is a table used to store admin data such as usernames and passwords. The period table is used to store period data in the system. The student data table is a table used to store student data. The Mamdani method uses the decision data table to store data from student data calculations.

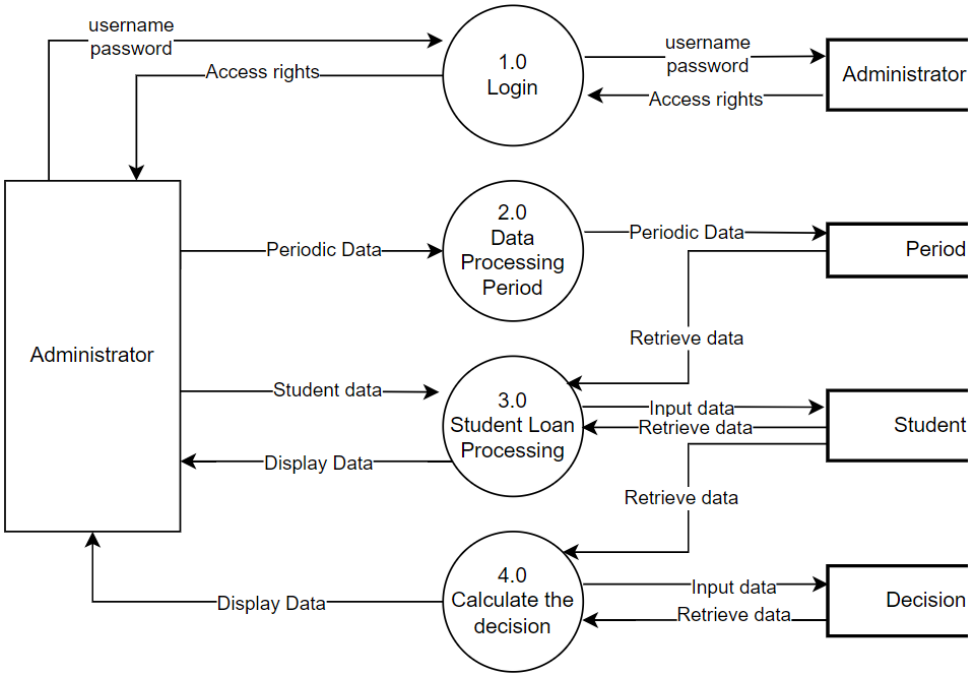

Fig. 11. DFD Level 1.

DFD is illustrated in Fig. 11, where the Admin enters the username and password into the system via the Login feature. If the username and password are valid, the system grants access rights to the admin so the admin can process data in the system. The Admin enters period data into the system in the Period Data Processing process. The system will save period data into the period table. Process of Processing Student Data: The Admin enters student data into the system. The system will take period data from the period table, which is used as a period marker for the data entered, and then the system will save the data into the student_data table. The system will take data from the student_data table and display it to the Admin via the system. The system will take data from the student_data table and then perform calculations in the decision-calculation process. After the system performs calculations, it will save the calculation results in the decision table. The system takes data from the decision table and displays it to the Admin through the system.

3.4. System development

The program creation stage is to translate Fuzzy rules into code that can be run by a computer and implement membership functions, inference rules, and defuzzification methods by the Fuzzy system design that has been created. In this stage, the system is created using the PHP programming language with the CodeIgniter4 Framework.

3.5. System testing

At the system testing stage, it is carried out to find out whether the system has been created well or not. Black box and MAPE testing were carried out in this research. Black box testing can be used to find whether there are still features that are wrong, invalid, and/or information that needs to be added to the software, including finding errors in the data structure or use of external databases in the application. Meanwhile, MAPE testing is used in the system to find error values based on a comparison of manual calculation results and the designed system (Sonalitha et al., 2019). The MAPE value can be obtained using Eq. (21), where A_t is the actual value, and F_t is the predicted value.

$$MAPE = \sum \left| \frac{(At - Ft)}{At} \right| \times 100\% \quad (21)$$

3.6. Conclusion

At this stage, conclusions will be drawn (Fitriani, 2018) based on the results of tests carried out on the system and whether the system has been made well and correctly.

4. Results and Discussion

The results of implementing CodeIgniter4 and Fuzzy Mamdani in this research are presented in Fig. 12 which shows the home view of the system with the role as administrator and admin account name. This home page will appear if the admin logs in. On the home page, the admin can see various information, such as a lot of student data, a lot of recommended student data, a lot of student data that is not recommended, and a list of recommended students. Fig. 13 is the Student Data page, where the admin carries out the process of processing student data. Admin can input, edit and delete data. The Student Data page in the admin role can see data on students whose status has not received a scholarship which is displayed by the system in tabular form. Fig. 14 is the Decision page which can display decision data resulting from system calculations based on previously entered data. On the Decisions page, the admin can see the results of the SPK recommendations for scholarship recipients.

Table 2
Student dataset.

StudentID	GPA	Parent's income (IDR 000)	Parent's dependent	Semester	Achievement	Certificate	Granted history
BSS	3.62	1,150	6	8	National	3	Not yet
PMDK	2.89	2,800	2	8	International	2	Accepted
IMGW	2.11	3,650	2	12	Province	4	Accepted
RPSU	2.65	3,150	1	4	National	1	Not yet
MFA	3.94	550	5	7	International	5	Not yet
ALKS	2.78	2,950	3	9	Province	3	Accepted
RPS	3.11	1,800	6	3	Province	1	Not yet
DAP	3.87	3,300	2	10	National	5	Accepted
AAP	3.55	900	5	5	International	4	Not yet
IPSF	2.57	3,550	2	4	Province	2	Accepted
IMS	3.20	2,000	5	10	National	1	Not yet
AMH	3.50	2,000	5	9	Province	3	Not yet
DPK	3.89	2,650	5	6	International	5	Not yet
APN	3.21	1,500	5	6	National	4	Menerima
WAS	3.67	1,050	5	6	Province	2	Not yet
RAH	3.32	1,990	5	6	International	1	Not yet
DRSP	3.65	2,400	4	4	Province	5	Not yet
SNDR	3.32	1,650	3	5	National	3	Not yet
DM	3.87	1,950	4	4	International	4	Not yet
AM	3.68	1,150	5	7	Province	2	Not yet

In this research, Fuzzy Mamdani's performance was tested using 20 data. Examples of data used are shown in Table 2. Table 3 shows the results of the SPK recommendations. Based on the test results, Fuzzy Mamdani got a MAPE value of 8%, meaning that Fuzzy Mamdani's performance was very good because the MAPE value was less than 10% (Mubin et al., 2012). Meanwhile, based on the results of black box testing with various test scenarios, it shows that each function tested produces a valid status, meaning that the system has been successfully created well and is valid.

Test results based on time for the same amount of data of 70 applicants. When using a manual system, a head of study program to enter scholarship applicant data, verify file completeness, and select 70 applicants is estimated to take a total of around 160 minutes. Meanwhile, with the system proposed in this research, the time required from the start of entering the data until the recommendation results come

out takes 100.33 minutes. Apart from that, if time is needed to search for data in the past, the proposed system provides results faster than the manual system because the proposed web-based system has a search feature. So the system proposed based on testing is proven to be able to solve the problems being faced by the Informatics Study Program at Universitas Madura.

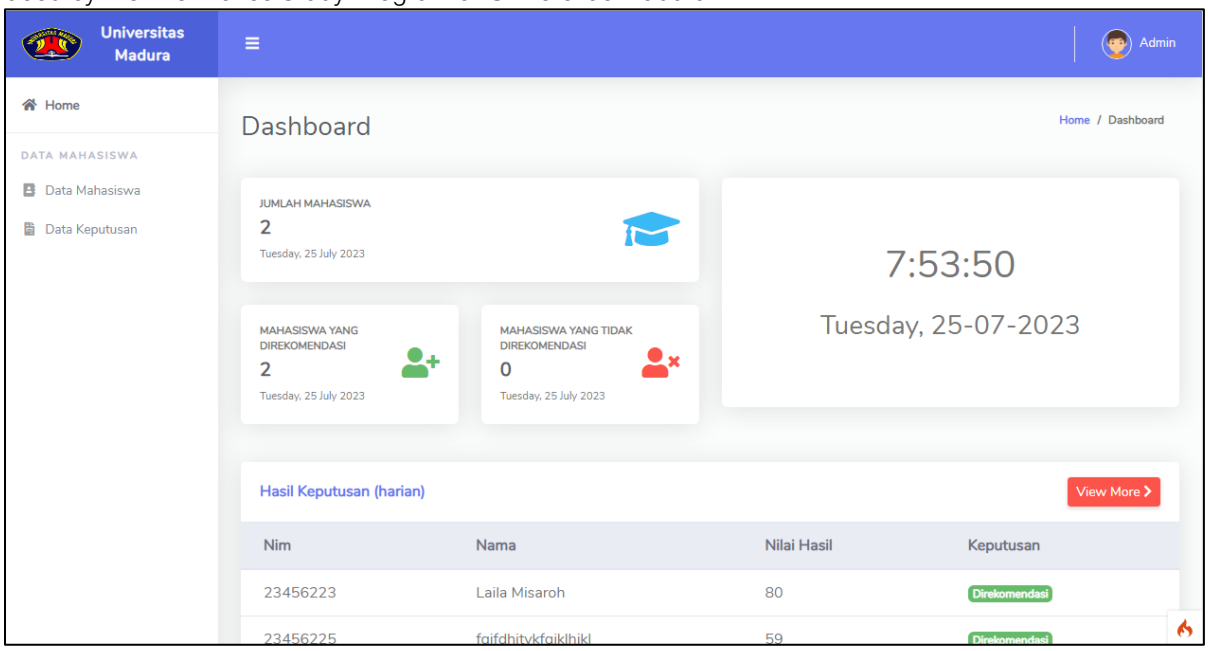

Fig. 12. Home web interface.

Table 3
Sample student dataset.

StudentID	Decision value	Result
RPS	258.14	Recommended
MFA	121.069	Recommended
AM	76.5625	Recommended
DRSP	76.5625	Recommended
WAS	76.5625	Recommended
IMS	76.5625	Recommended
RPSU	76.5625	Recommended
RAH	73.4451	Recommended
AAP	59.2322	Recommended
DPK	59.2322	Recommended
SNDR	58.1342	Recommended
AMH	58.1342	Recommended
DM	58.1342	Recommended
BSS	58.1342	Recommended
IPSF	50	Not recommended
IMGW	36.7347	Not recommended
APN	24.3767	Not recommended
DAP	23.308	Not recommended
PMDK	22.4981	Not recommended
ALKS	21.9231	Not recommended

Table 4
Black box testing result.

No.	Function	Testing scenario	Result	Status
1	Login	Input form login, press login button	Login successful	valid
2	Add data	Add Student data, press save button	Student data added successful	valid
3	Edit data	Edit Student data, and press save button	Student data updated	valid
4	Delete data	Selected Student data, and press Delete button	Student data deleted	valid
5	Logout	Pres Logout button	Back to login form	valid

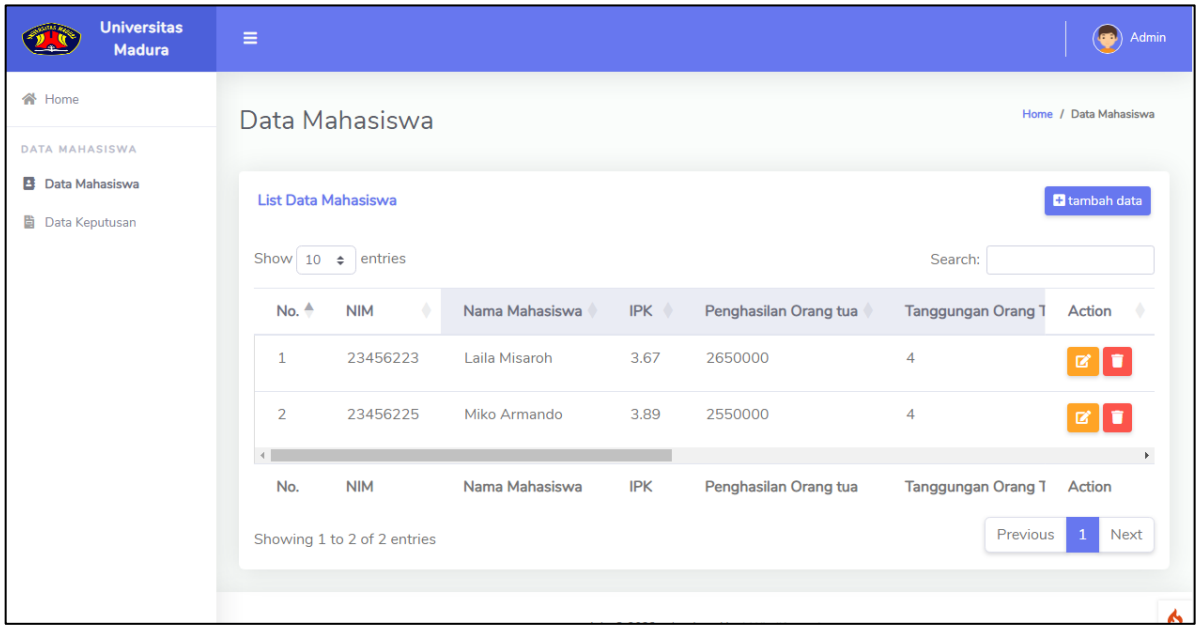

Fig. 13. Student data web page interface.

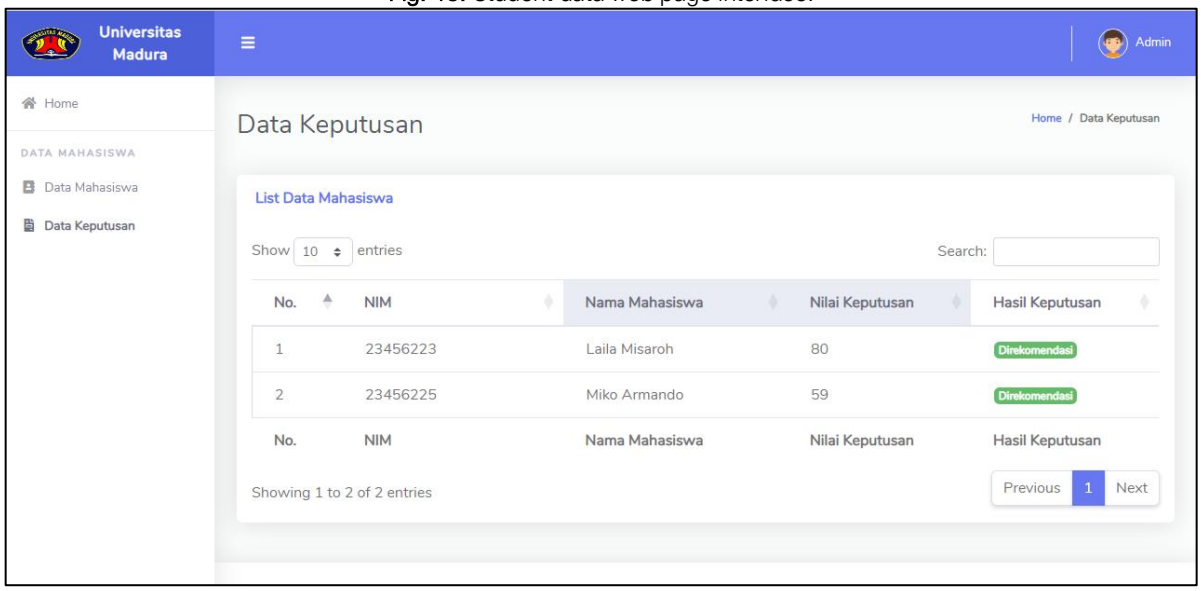

Fig. 14. Decision interface page display.

5. Conclusions

Based on the test results in this research, it can be concluded that the proposed system, namely DSS for (UKT) Scholarship Awardee on Fuzzi Mamdani with six criteria in the Informatics Study Program at Universitas Madura, has succeeded. This is proven based on the performance of the proposed DSS, which produces a MAPE value of less than 10%, and the time required by the proposed system is faster than the current system. The proposed system also follows the required functions based on the results of black box testing. This research still has future work that can be research continued, two of which are: 1) Backup feature to avoid data that is prone to being lost if one day there is a system failure, hacker attack, or other undesirable things; and 2) Security features in the form of captcha for person or robot verification and Two Factor Authentication.

6. CRediT Authorship Contribution Statement

M. Kholifaturrahman: Conceptualization, Data Curation, Formal Analysis, Investigation, Methodology, Project administration, Software, Visualization, Writing – original draft, and Writing – review & editing. **Sholeh**

Rachmatullah: Investigation, Project administration, Resources, Supervision, and Writing – review & editing. **Badar Said**: Writing – review & editing.

7. Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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9. Data Availability

Data will be made available on request.

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11. References

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