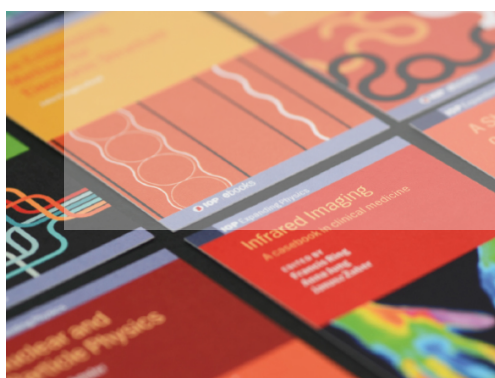
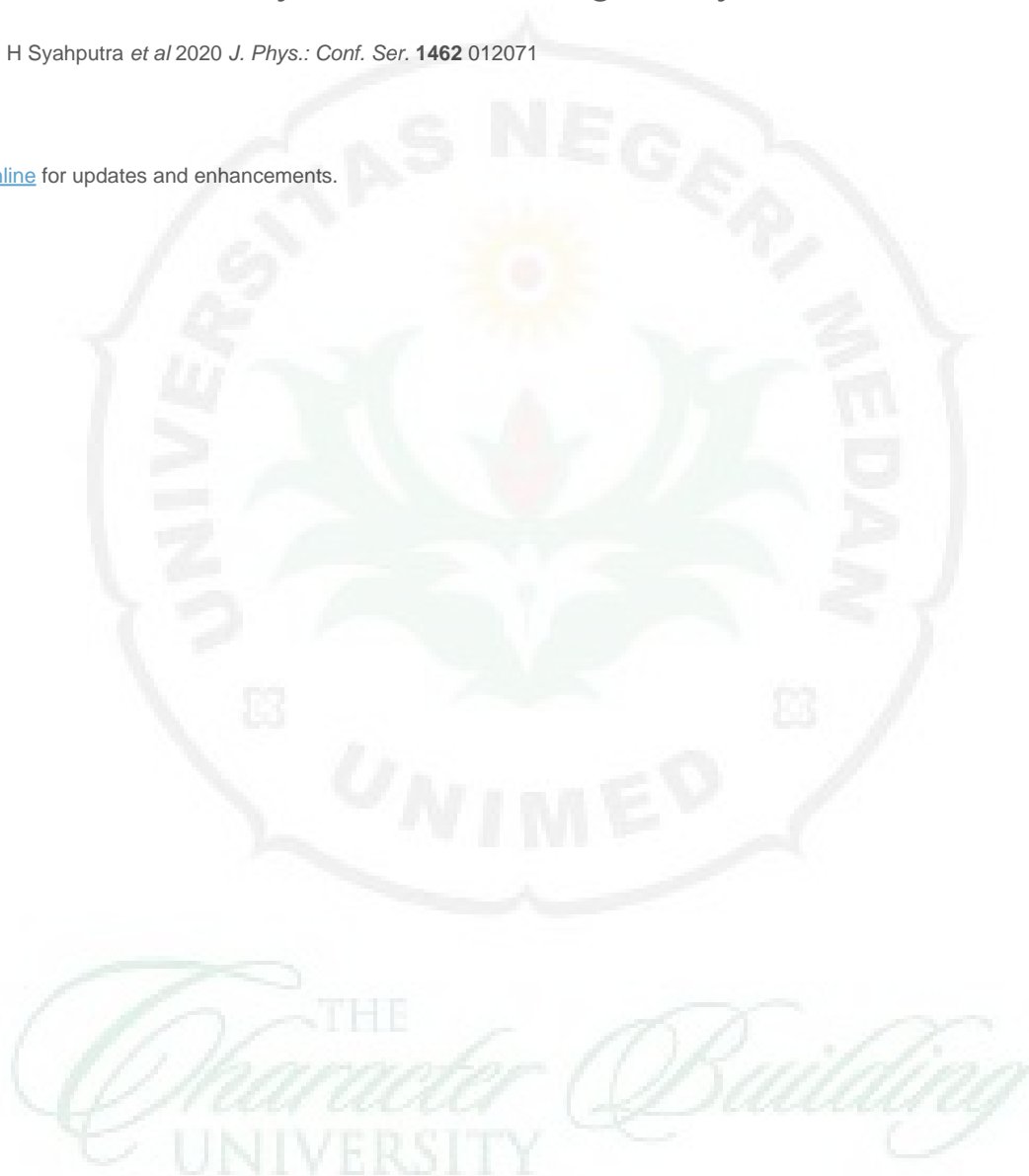


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Decision Support System For Determining The Single Tuition Group (UKT) In State University Of Medan Using Fuzzy C-Means

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Abstract. The Single Tuition System (UKT) is a portion of the Single Tuition Fee that is paid to each student based on his economic ability. UKT which applied at State Universities in Indonesian is a policy aimed at helping and reducing the cost of student education. Decree of Menristekdikti Number 91/M/ KPT/2018 concerning Single Tuition Fee (BKT) and Single Tuition (UKT) at State Universities in the Ministry of Research, Technology, and Higher Education in 2018 divides UKT into seven groups. The purpose of this study is to develop a decision support system to determine the UKT group using the Fuzzy C-Means Clustering method. The decision support system is developed based on the web using the Fuzzy C-Means Clustering method. The data used as a sample is the data of undergraduate students of the Faculty of Mathematics and Natural Sciences, The State University of Medan in 2018/2019. The parameters used for grouping UKT are: the amount of parents' income, the number of siblings based on the Family Card, the condition of the Father (Life or Death), the condition of the Mother (Life or Death), the Building Land Tax (PBB), the Motor Vehicle Tax (PKB) total last one year, and the last one month electricity costs. The grouping results showed that 76% were in groups 1 to 4, and 24% were in groups 5 to 7. However, the results of this clustering are not final due to inaccuracies in filling data for several parameters, so that data validation is required by checking from other sources of information.

Keyword: Single Tuition, Decision Support System, Fuzzy C-Means

1. Introduction

Since 2013 the government has decided to change the tuition payment system for all state universities into the Single Tuition Payment System (UKT). The UKT financing system merges the tuition that needs to be paid by students with all other costs charged to students being a single fee that will be paid at each semester so that it is expected that all parents or other parties who finance feel more mitigated by this UKT system.

Each State University has different UKT rates. This is influenced by the regional economic level and the need for study program costs [1]. UKT is determined based on the Single Tuition Fee (BKT) which is reduced by assistance from the government or referred to as Higher Education Operational Assistance (BOPTN) [1]. UKT has the basic principle of cross-subsidized financing, where people



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who are economically capable (rich) provide subsidies to people who are less able (poor). The determination of a single tuition fee also makes it easy to predict student tuition expenses each semester. The size of the costs incurred also follow the size of the needs such as the cost of practicum in each study program. For underprivileged students, UKT provides an opportunity of payment of Rp. 0, of course, with proven requirements and data from the authorities. So the function of the UKT here is as a cross subsidy between able and economically disadvantaged students.

Decree of the Menristekdikti No. 91/M/KPT/2018 concerning Single Tuition Fees and Single Tuition Fees at State Universities in the Environment Ministry of Research, Technology and Higher Education for the Year of 2018 Force which divides UKT into 7 groups. The criteria for grouping UKT to VII are based on the economic ability of students, parents of students or other parties who finance it. This UKT is paid every semester and there are no more fees charged to students. UKT group I quota is set at least 5 percent of the number of students accepted by each tertiary institution. Likewise group II, the quota for the number of students in this group was set at least 5%.

Several studies related to the determination of UKT have been carried out before, including 1) Decision Support Systems Determination of Single Tuition Fees To New Students At Nusa Cendana University Using Technique For Order Preference Method By Similarity To Ideal Solution (TOPSIS) [2]. The developed system selects each alternative using five criteria, namely parental income, water and electricity bills, assets, number of dependents and employment. The results of testing the weight change sensitivity, the greatest is in the water and electricity bills with 91.66% and the least is in jobs with 35%. Whereas standard accuracy testing obtained 26.66% results. 2) Development of a Decision Support System for the Determination of a Single Kulliah Money Category Using the Multifactor Evaluation Process Method (Case Study: Mulawarman University) [3]. There are seven criteria for determining the group used in this application: parents' occupation, parents' income, land and building tax (PBB), electricity bills, telephone bills, water bills, and motor vehicle tax (PKB). By implementing the MFEP method and the seven criteria, an application of decision support systems for the determination of the UKT group at the Mulawarman University was produced. 3) Development of Decision Support System for Determination of Student UKT by Using Moora Method Case Study of Malang State Polytechnic [4]. In this study implementing the Multi Objective Optimization Method on the Base of Ratio Analysis (MOORA) using these methods can provide the best alternative in determining a single tuition based on the economic capabilities of students.

Medan State University (Unimed) has determined the tuition fees or Single Tuition Fees (UKT) for Academic Year 2018/2019 as tuition costs borne by every student, both Bachelor and Diploma programs. However, there is no decision support system with certain criteria to determine the UKT class. Thus the formula and decision support system are needed to determine the UKT group for students so as to minimize the mismatch between the student economy and the UKT that is applied to it.

2. Basic of Theory

2.1 Decision Support System (DSS)

Decision Support System (DSS) is a system that is able to provide problem-solving and communication skills for problems with semi-structured and unstructured conditions. This system is used to assist decision making in semi-structured and unstructured situations, where no one knows for sure how decisions should be made [5]. DSS aims to provide information, guide, provide predictions and direct information users to be able to make better decisions. DSS is the implementation of decision-making theories that have been introduced by sciences such as operation research and management science, the only difference is that if first to find a solution to the problem at hand it must be calculated manually iteration (usually to find the minimum, maximum, or optimum), now the PC computer has offered its ability to solve the same problem in a relatively short time. Sprague and Watson define Decision Support System as a system that has five main characteristics, namely [6]: 1. Computer-based systems. 2. Used to help decision makers. 3. To solve complex problems that are impossible to do with manual calculations. 4. Through interactive simulation methods. 5. Where data and analysis models are the main components.

2.2 Single Tuition (UKT)

The government has issued a regulation regarding the amount of tuition fees at State Universities (PTN), the provisions contained in Minister of Education and Culture Regulation (Permendikbud) No. 55 of 2013 dated May 23, 2013. This regulation is implemented from the 2013/2014 school year and beyond.

Important things in the regulation:

1. Single tuition fees (BKT) are used as a basis for determining fees charged to community students and the Government.
2. Single Tuition (UKT) is a portion of the single tuition costs borne by each student based on his economic ability.
3. State Universities may not collect tuition fees and other fees other than a single tuition fee from new undergraduate students and diploma programs from the 2013-2014 academic year.
4. Single tuition is based on the economic capacity of the community which is divided into 7 (seven) groups from the lowest to the highest, namely Groups I, II, III, IV, V, VI and VII.

In essence, single tuition is a portion of the single tuition fees borne by each student based on their economic ability which is divided into 7 groups. The Single Tuition Fee (UKT) which applies at State Universities in Indonesia is a policy aimed at helping more and reducing student education costs. There are no additional fees that will be charged for 8 semesters.

The determination of a single tuition fee also makes it easy to predict student tuition expenses each semester. The size of the costs incurred also follow the size of the needs such as the cost of practicum in each study program.

BKT calculations use certain formulas, namely:

$$\text{BKT} = C \times K1 \times K2 \times K3$$

C = Base tuition fees (calculated from data in PTN)

K1 = Study program index

K2 = PTN quality index

K3 = Expensive Index.

UKT is determined based on the cost of a Single Tuition less PTN Operational Assistance (BOPTN). Determination of BOPTN, BKT and UKT using the principle of tuition fees borne by students is increasingly getting smaller by paying attention to the poor (affirmations), cross subsidies (the rich subsidize the poor), and proper cost control.

2.3 Algoritma Fuzzy C-Means

Fuzzy clustering is a technique for determining optimal clusters in a vector space based on the Euclidian normal form for distances between vectors. Fuzzy clustering is very useful for fuzzy modeling, especially in identifying fuzzy rules. There are several data clustering algorithms, one of which is fuzzy C-Means (FCM) [7].

Clustering with Fuzzy C-Means (FCM) is based on fuzzy logic theory. This theory was first introduced by Lotfi Zadeh (1965) with the name fuzzy set (fuzzy set). In fuzzy theory, membership of a data is not explicitly given a value of 1 (being a member) and 0 (not being a member), but with a degree of membership whose value ranges from 0 to 1. The membership value of a data in a set becomes 0 when absolutely not become a member, and become 1 when becoming a full member in a set. Generally the value of membership is between 0 and 1. The higher the value of membership, the higher the degree of membership, and the smaller the value of membership, the lower the degree of membership. In relation to k-means, actually FCM is a fuzzy version of K-Means with several modifications that distinguish it from K-Means [8].

The basic concept of Fuzzy C-Means (FCM) is to first determine the cluster center which will mark the average location for each cluster. In the initial condition, the cluster center is still inaccurate. Each data point has a degree of membership for each cluster. By improving the cluster center and the degree of membership of each data point repeatedly, it will be seen that the cluster center will move to the

right location. This loop is based on the degree of membership that represents the distance from the data point given to the center of the cluster weighted by the degree of membership of that data point.

1. The output of the FCM is not a fuzzy inference system, but is a degree of cluster center and some degree of membership for each data point. Fuzzy C-Means algorithm is arranged in the following steps [7]:
2. Data input
3. Input data to be clustered X, in the form of matrix size $n \times m$ (n = amount of data, m = attribute of each data). X_{ij} = i sample data ($i = 1, 2, \dots, n$), j th attribute ($j = 1, 2, \dots, m$).
4. Determine:
5. Number of clusters = c ;
6. Rank = w (w does not have a provision, usually a value of $w > 1$ and generally given a value of 2) [8];
7. Maximum iteration = Maxiter;
8. The smallest expected error = ξ ;
9. Initial objective function = $P_0 = 0$;
10. Initial iteration = $t = 1$;
11. Generating random numbers μ_{ik} , $i = 1, 2, \dots, n$; $k = 1, 2, \dots, c$; as elements of the initial partition matrix U. μ_{ik} is the degree of membership that refers to how likely a data can be a member into a cluster. The position and value of the matrix are constructed randomly. Where the membership value is located at intervals of 0 to 1. In the initial position the U partition matrix is still inaccurate as is the center of the cluster. So that the tendency for data to enter a cluster is also inaccurate [9].

$$\sum_{k=1}^c \mu_{ik} = 1 \quad (1)$$

12. Calculates the center of the cluster - k : V_{kj} with $k = 1, 2, \dots, c$; and $j = 1, 2, \dots, m$.

$$V_{kj} = \frac{\sum_{i=1}^n (\mu_{ik})^w X_{ij}}{\sum_{i=1}^n (\mu_{ik})^w} \quad (2)$$

13. Calculating an objective function on the t -iteration, P_t :

The objective function is used as a loop condition to get the right cluster center. So that the data tendency is obtained to enter which cluster in the final step (Ridwan Rismanto, 2017).

$$P_t = \sum_{i=1}^n \sum_{k=1}^c \left(\left[\sum_{j=1}^m (X_{ij} - V_{kj})^2 \right] (\mu_{ik})^w \right) \quad (3)$$

14. Calculate changes to partition matrices:

$$\mu_{ik} = \frac{\left[\sum_{j=1}^m (X_{ij} - V_{kj})^2 \right]^{-\frac{1}{w-1}}}{\sum_{k=1}^c \left[\sum_{j=1}^m (X_{ij} - V_{kj})^2 \right]^{-\frac{1}{w-1}}} \quad (4)$$

where $i = 1, 2, \dots, n$; and $k = 1, 2, \dots, c$

15. Check stop condition:

- If : $(|P_t - P_{t-1}| < \xi)$ or $(t > \text{MaxIter})$ then stop;
- If Not : $t = t + 1$, repeat step 4 (calculate V_{kj})

3. Research methods

3.1 Prototype Model

This section will discuss the methodology that will be used in this research, namely the Development of a UKT Student Group Decision Support System Using the Fuzzy C-Means Clustering Method. The method used in this study is the Prototype method. The process contained in this Prototype method will be explained in Figure 1 as follows.

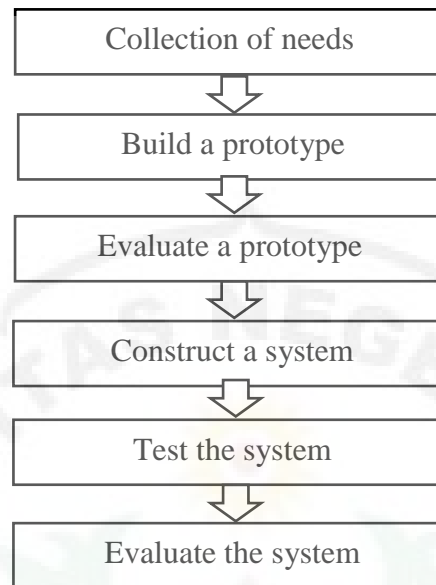


Figure 1. Prototype Model

Decision support system for determining the category of Single Tuition Fee (UKT) using the Fuzzy C-Means method is an application that helps the University in determining the UKT magnitude category for new students according to the criteria owned by the student. There are seven criteria used in determining the UKT magnitude category: parents' occupation, parents' income, land and building tax (PBB), electricity bills, telephone bills, water bills, motor vehicle taxes.

4. Result and Discussion

This research is a type of case study research regarding the nominal determination of Single Tuition at Medan State University. The data used is secondary data obtained from the Office of the State University of Medan, in the form of data from Medan State University Faculty of Mathematics and Natural Sciences class of 2018. The data obtained is data of various data attributes.

4.1 Data Cleaning

Data cleaning process needs to be done so that the data is clean from data duplication, inconsistent data, or print errors. The following are the columns and rows of data that are cleaned along with the reason the rows and columns are undergoing a cleaning process.

1. Registration column, Pathway, Faculty, Study Program, Car, Motorcycle, Father's Job, Father's Salary, Other Salary Father, Mother's Work, Mother's Salary, Other Salary Mothers, and Electricity. The column was omitted because it was not required for the Single Tuition Grouping attribute.
2. There are 51 incomplete data, from a total of 657 total data reduced to 606 data that will be used in the mining process. The incomplete data is due to students who did not re-register.

4.2 Data Transformation

At the Data Transformation step, the data that has been selected is changed or merged into a format suitable for processing in data mining.

1. Data in the total father's income column and total maternal income are added up and made in one column to be the income of both parents.
2. Add up the data in the brother and sister column and made in one column to be the number of siblings column.
3. Transforming from string data into numerical data, such as for the attributes of Father's and Mother's condition. After that the work that has the largest frequency is given the initials with

the number 1, and the work that has the second largest frequency is given the initials with the number 2.

4.3 Data Mining

Based on the Fuzzy C-Means algorithm, the data clustering process is carried out using the Fuzzy C-Means algorithm with the following steps:

1. Input the data to be clustered, in the form of matrix $n \times m$ (n = amount of data, m = attribute of each data data that is the amount of parents' income, number of siblings, father's condition, mother's condition, PBB, PKB, and electricity costs) . X_{ij} = i sample data ($i = 1, 2, \dots, 606$), j -th attribute ($j = 1, 2, \dots, 7$).

$$X = \begin{pmatrix} 0 & 2 & 2 & 0 & 225000 & 0 & 57500 \\ 1 & 1 & 1 & 0 & 1500000 & 700000 & 400000 \\ 4 & 1 & 1 & 75000 & 0 & 29000 & 120000 \\ 4 & 1 & 1 & 250000 & 0 & 0 & 70000 \\ 1 & 1 & 2 & 250000 & 0 & 141289 & 34879 \\ M & M & M & M & M & M & M \\ 2 & 1 & 1 & 12760756 & 217000 & 201669 & 191097 \\ 2 & 1 & 1 & 16490000 & 2464875 & 187828 & 600000 \end{pmatrix}$$

2. Set boundaries:

- a. Number of clusters = $c = 7$;
- b. Rank = $w = 2$;
- c. Maximum iteration = Maxiter = 1000;
- d. The smallest expected error = $\xi = 10^{-3}$;
- e. Initial objective function = $Po = 0$;
- f. Initial iteration = $t = 1$;

3. Generating random numbers μ_{ik} , $i = 1, 2, \dots, 606$; $k = 1, 2, \dots, 7$; as elements of the initial partition matrix U . This matrix shows the degree of membership of the i -th data in the k to cluster.

$$U = \begin{pmatrix} 0,144 & 0,143 & 0,148 & 0,147 & 0,34 & 0,144 & 0,140 \\ 0,144 & 0,142 & 0,148 & 0,146 & 0,135 & 0,144 & 0,141 \\ 0,144 & 0,143 & 0,148 & 0,148 & 0,133 & 0,144 & 0,140 \\ 0,144 & 0,143 & 0,148 & 0,148 & 0,133 & 0,144 & 0,140 \\ 0,144 & 0,142 & 0,148 & 0,148 & 0,133 & 0,144 & 0,140 \\ M & M & M & M & M & M & M \\ 0,142 & 0,143 & 0,141 & 0,141 & 0,147 & 0,142 & 0,144 \\ 0,143 & 0,143 & 0,141 & 0,141 & 0,146 & 0,142 & 0,144 \end{pmatrix}$$

4. Calculating the cluster center to k : V_{kj} with $k = 1, 2, \dots, 7$; and $j = 1, 2, \dots, 7$ using equation (2):

$$V_{kj} = \frac{\sum_{i=1}^{606} (\mu_{ik})^w X_{ij}}{\sum_{i=1}^{606} (\mu_{ik})^w}$$

Then the cluster center value is obtained:

$$V = \begin{pmatrix} 2,664 & 1,015 & 1,058 & 3830568,765 & 288155,304 & 82512,906 & 161729,040 \\ 2,606 & 1,019 & 1,047 & 3895936,004 & 289816,352 & 68925,700 & 164043,108 \\ 2,565 & 1,015 & 1,065 & 3863994,848 & 312858,154 & 88545,907 & 176978,212 \\ 2,582 & 1,018 & 1,073 & 3966895,448 & 233254,795 & 95201,188 & 163636,566 \\ 2,601 & 1,016 & 1,056 & 3897696,548 & 362916,262 & 83166,553 & 185971,624 \\ 2,665 & 1,028 & 1,071 & 3985288,541 & 245104,747 & 105515,845 & 154983,046 \\ 2,586 & 1,014 & 1,059 & 3886518,696 & 268704,577 & 80607,076 & 158574,982 \end{pmatrix}$$

5. Calculating the objective function on the 1st iteration, P1 can be calculated using equations (3)

$$P_1 = \sum_{i=1}^{606} \sum_{k=1}^7 \left(\left(\sum_{j=1}^7 (X_{ij} - V_{kj})^2 \right) (\mu_{ik})^2 \right)$$

$$P1 = [(0 - 2, 664)^2(0, 144)^2 + (1 - 2, 664)^2(0, 144)^2 + \dots + (2 - 2, 664)^2(0, 143)^2] + [(2 - 1, 015)^2(0, 144)^2 + (1 - 1, 015)^2(0, 144)^2 + \dots + (1 - 1, 015)^2(0, 43)^2] + \dots + [(57500 - 161729, 040)^2(0, 144)^2 + (400000 - 161729, 040)^2(0, 144)^2 + \dots + (600000 - 161729, 040)^2(0, 143)^2] + \dots + [(0 - 2, 586)^2(0, 140)^2 + (1 - 2, 586)^2(0, 141)^2 + \dots + (2 - 2, 586)^2(0, 144)^2] + [(2 - 1, 014)^2(0, 140)^2 + (1 - 1, 014)^2(0, 141)^2 + \dots + (1 - 1, 014)^2(0, 144)^2] + \dots + [(57500 - 158574, 982)^2(0, 140)^2 + (400000 - 158574, 982)^2(0, 141)^2 + \dots + (600000 - 158574, 982)^2(0, 144)^2] = 9, 3950609221079e + 14$$

So the value of P1 is obtained = 9, 3950609221079e + 14

6. Calculate changes in partition matrices based on equation (4):

$$\mu_{ik} = \frac{\left[\sum_{j=1}^7 (X_{ij} - V_{kj})^2 \right]^{-1}}{\sum_{k=1}^7 \left[\sum_{j=1}^7 (X_{ij} - V_{kj})^2 \right]^{-1}}$$

$$\mu_{11} = \frac{[(0-2,664)^2+(2-1,015)^2+\dots+(57500-161729,040)^2]}{[(0-2,664)^2+(2-1,015)^2+\dots+(57500-161729,040)^2+\dots+(57500-158574,982)^2]} = 0,147$$

$$\mu_{12} = \frac{[(0-2,606)^2+(2-1,019)^2+\dots+(57500-68925,700)^2]}{[(0-2,664)^2+(2-1,015)^2+\dots+(57500-161729,040)^2+\dots+(57500-158574,982)^2]} = 0,147$$

∩

So obtained a value of new membership degree:

$$U = \begin{pmatrix} 0,147 & 0,140 & 0,161 & 0,159 & 0,115 & 0,146 & 0,132 \\ 0,147 & 0,141 & 0,158 & 0,156 & 0,118 & 0,146 & 0,134 \\ 0,147 & 0,140 & 0,161 & 0,159 & 0,115 & 0,146 & 0,131 \\ 0,147 & 0,140 & 0,162 & 0,160 & 0,114 & 0,146 & 0,131 \\ 0,147 & 0,140 & 0,163 & 0,161 & 0,112 & 0,1447 & 0,130 \\ M & M & M & M & M & M & M \\ 0,141 & 0,143 & 0,135 & 0,136 & 0,157 & 0,141 & 0,147 \\ 0,141 & 0,143 & 0,138 & 0,138 & 0,153 & 0,141 & 0,146 \end{pmatrix}$$

7. Next check the stop condition. Because $| P1 - P0 | = 9, 3950609221079e + 14 - 0 = 9, 3950609221079e + 14$. Means $| P1 - P0 | > \xi$ and Iteration = 1 < Max iteration (= 1000) then proceed to the 2nd iteration (t = 2). Back to Fuzzy C-Means algorithm step 4 and so on.

In this case, the stop condition is reached after 255 iterations, with objective function values $|P_{255} - P_{254}| = |1,963337313654E + 14 - 1.963337313654E + 14| = 0 (< \xi)$.

Cluster center:

$$V = \begin{pmatrix} 2,798 & 1,013 & 1,106 & 1448419,183 & 100995,811 & 41626,712 & 89036,662 \\ 2,786 & 1,001 & 1,021 & 5394486,984 & 255908,241 & 71500,705 & 197978,994 \\ 2,403 & 1,008 & 1,069 & 2702263,757 & 194472,334 & 58863,829 & 143153,041 \\ 2,727 & 1,000 & 1,046 & 9499189,566 & 538142,061 & 138932,801 & 252647,519 \\ 2,506 & 1,000 & 1,011 & 7361200,841 & 372096,496 & 99680,000 & 190621,001 \\ 2,047 & 1,000 & 1,001 & 15563039,916 & 1318367,443 & 240698,283 & 456161,791 \\ 2,632 & 1,027 & 1,013 & 4060462,085 & 242818,707 & 72495,348 & 170101,106 \end{pmatrix}$$

Degree of membership:

$$U = \begin{pmatrix} 0,641 & 0,082 & 0,185 & 0,025 & 0,046 & 0,006 & 0,015 \\ 0,493 & 0,040 & 0,238 & 0,122 & 0,073 & 0,009 & 0,025 \\ 0,656 & 0,078 & 0,180 & 0,023 & 0,044 & 0,005 & 0,014 \\ 0,692 & 0,020 & 0,165 & 0,069 & 0,038 & 0,004 & 0,012 \\ 0,691 & 0,069 & 0,020 & 0,166 & 0,038 & 0,004 & 0,012 \\ M & M & M & M & M & M & M \\ 0,27 & 0,6 & 0,035 & 0,046 & 0,325 & 0,383 & 0,120 \\ 0,009 & 0,022 & 0,012 & 0,011 & 0,015 & 0,894 & 0,37 \end{pmatrix}$$

From the U matrix can be obtained information about the tendency of a data to enter into which cluster.

Table 1. Degree of membership of each data in each cluster with Fuzzy C Means

Data (i)	Data membership degree							Cluster
	1	2	3	4	5	6	7	
Student 1	0,641	0,082	0,185	0,025	0,046	0,006	0,015	1
Student 1	0,493	0,040	0,238	0,122	0,073	0,009	0,025	1
Student 1	0,656	0,078	0,180	0,023	0,044	0,005	0,014	1
Student 1	0,692	0,020	0,165	0,069	0,038	0,004	0,012	1
Student 1	0,691	0,069	0,020	0,166	0,038	0,004	0,012	1
\mathbb{N}	\mathbb{N}	\mathbb{N}	\mathbb{N}	\mathbb{N}	\mathbb{N}	\mathbb{N}	\mathbb{N}	\mathbb{N}
Student 1	0,027	0,064	0,035	0,046	0,325	0,383	0,120	6
Student 1	0,009	0,022	0,012	0,011	0,015	0,894	0,037	6

Based on the table above, the results of clustering are obtained using the Fuzzy C-Means method, namely: the first cluster consists of 193 students, the second cluster consists of 88 students, the third cluster consists of 141 students, the fourth cluster consists of 39 students, the 5th cluster consists of 47 students, the 6th cluster consists of 8 students, the 7th cluster consists of 90 students.

4.4 Determination of Single Tuition Category with Index Xie Beni

Index Xie Beni (XB) aims to determine the UKT class of students from the largest to the smallest or from the smallest to the largest by looking at the value of the xie beni index from each cluster (Muchsin 2015). The xie beni index value can be determined using the following equation:

$$XB = \frac{\sum_{k=1}^c \sum_{i=1}^n \mu_{ik}^w * ||V_i - X_j||^2}{n * \min_{i,j} ||V_i - X_j||^2}$$

To calculate the size of cohesion, what needs to be done first is to elevate the degree of data membership of each cluster with the weight parameter. Then we also determine the square of the distance to the centroid, and the lifting of the weight of the degree of membership is multiplied by the square of the distance to the centroid, and summed to produce a cohesion measure.

$$\text{Cohesion} = \sum_{k=1}^c \sum_{i=1}^n \mu_{ik}^w * ||V_i - X_j||^2$$

By using the formula xie beni, a separation value of one to seven is obtained as shown in Table 2.

Table 2. Index values of XB (Xie-Beni)

Cluster	index XB (Xie-Beni)
Cluster 1	5,29748E+25
Cluster 2	8,31185E+26
Cluster 3	8,67286E+25
Cluster 4	1,53708E+26
Cluster 5	2,70285E+27
Cluster 6	2,69595E+29
Cluster 7	1,68114E+27

Based on the table above, after sorting the XB index value from the smallest to the largest, the UKT class of students can be determined from the smallest to the largest as in Table 3.

Table 3. Determination of the UKT category

Cluster	Index XB (Xie-Beni)	Category UKT
Cluster 1	5,29748E+25	UKT Category -1
Cluster 3	8,67286E+25	UKT Category -2
Cluster 4	1,53708E+26	UKT Category -3
Cluster 2	8,31185E+26	UKT Category -4
Cluster 7	1,68114E+27	UKT Category -5
Cluster 5	2,70285E+27	UKT Category -6
Cluster 6	2,69595E+29	UKT Category -7

From the calculation results at Tabel 4.5, we will get a result where cluster 1 will be classified into UKT 1, cluster 2 will be classified into UKT 4, cluster 3 will be classified into UKT 2, cluster 4 will be classified into UKT 3, cluster 5 will be classified into in UKT 6, cluster 6 will be classified into UKT 7, and cluster 7 will be classified in UKT 5.

4.5 Clustering Results

Following are the results of clustering the Single Tuition category with the Fuzzy C-Means method.

Knowledge Presentation

a. Cluster 1

Based on the calculation results of the Fuzzy C-Means algorithm in cluster 1 (UKT category 1) there are 193 students, with a final centroid score ie for the number of siblings = 2,798; Mother's condition = 1,028; Father's condition = 1,106; income = 1448419,183; PKB = 100995,812; PBB = 41626,712; electricity load = 89036,662.

b. Cluster 2

Based on the calculation results of the Fuzzy C-Means algorithm on cluster 2 (UKT category 4) there are 88 students, with the final centroid score ie for the number of siblings = 2,786; Mother's condition = 1,001; Father's condition = 1,021; income = 5394486,984; PKB = 255908,241; PBB = 71500,705; electricity load = 197978,994.

c. Cluster 3

Based on the calculation results of the Fuzzy C-Means algorithm on cluster 3 (UKT category 2) there are 141 students, with a final centroid grade namely for the number of brothers = 2,403; Mother's condition = 1,009; Father's situation = 1,070; income = 2702263,757; PKB = 194472,334; PBB = 58863,829; electricity load = 143153,041.

d. Cluster 4

Based on the calculation results of the Fuzzy C-Means algorithm on cluster 4 (UKT 3rd category) there are 39 students, with final centroid grades namely for the number of brothers = 2,727; mother's condition = 1,0002; the circumstances Father = 1,046; income = 9499189,566; PKB = 538142,061; UN = 138932,801; electricity load = 252647,519.

e. Cluster 5

Based on the calculation results of the Fuzzy C-Means algorithm on cluster 5 (UKT 6th category) there are 47 students, with final centroid grades namely for the number of siblings = 2,506; Mother's condition = 1,0003; the circumstances Father = 1,011; income = 7361200,841; PKB = 372096,496; UN = 99680,0001; electrical load = 190621,001)

f. Cluster 6

Based on the calculation results of the Fuzzy C-Means algorithm on cluster 6 (7th UKT category) there are 8 students, with final centroid grades namely for the number of brothers = 2,047; mother's condition = 1,0002; the circumstances Father = 1,001; income = 15563039,916; PKB = 1318367,443; The United Nations = 240698,283; electricity load = 456161,791.

g. Cluster 7

Based on the calculation results of the Fuzzy C-Means algorithm on cluster 7 (UKT category 5) there were 90 students, with final centroid grades namely for the number of siblings = 2,632; Mother's condition = 1,027; Father's situation 1,013; income = 4060462,085; PKB = 242818,707; PBB = 72495,348; electricity load = 170101,106.

4.6 Software Implementation

Following is the implementation of the Single Tuition Determination software at Medan State University, especially the Faculty of Mathematics and Natural Sciences, using the PHP programming language and MySQL database.

1. Main Page

When the application is first run it will display the main page or form as shown in Figure 2.

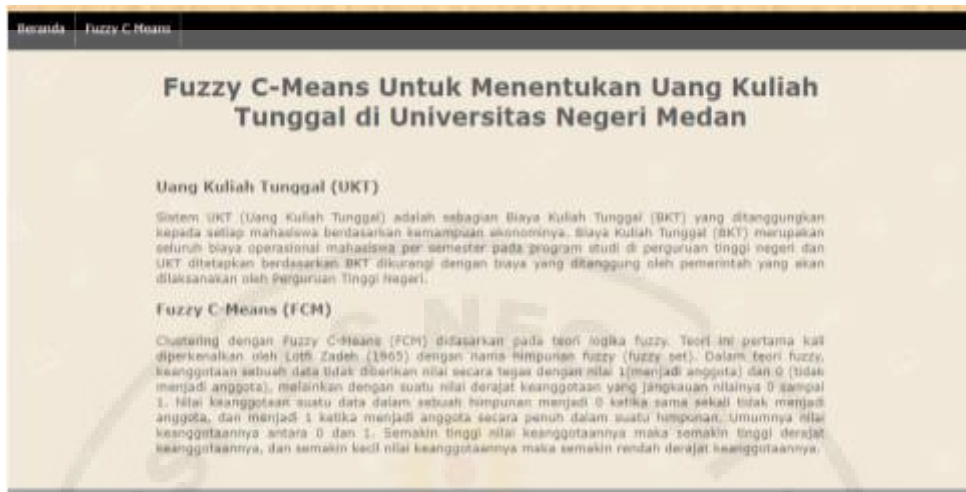


Figure 2. Main page of Decision Support System for Determination of Student UKT

On this main page there are two main menus namely the Home page that displays the Main Page and Fuzzy C-Means which will lead to the Fuzzy C-Means calculation page.

2. Fuzzy C-Means page

Nama	Ortaria						
	Jumlah Saudara	keadaan Ibu	keadaan Ayah	Penghasilan	PKB	PBB	Beban Listrik
Mahasiswa 1	0	2	2	0	225000	0	57500
Mahasiswa 2	1	1	1	0	1500000	700000	400000
Mahasiswa 3	4	1	1	75000	0	29000	130000
Mahasiswa 4	4	1	1	250000	0	0	70000
Mahasiswa 5	1	1	2	250000	0	141289	34879
Mahasiswa 6	2	1	1	500000	0	0	0
Mahasiswa 7	4	1	1	700000	0	30000	40000
Mahasiswa 8	3	1	1	850000	0	0	50000
Mahasiswa 9	4	1	1	3000000	0	0	70000
Mahasiswa 10	4	1	1	900000	0	10000	50000
Mahasiswa 11	5	1	1	1250000	0	0	40000
Mahasiswa 12	5	2	1	1239200	227000	4964479	130000
Mahasiswa 13	15	1	1	2000000	0	30500	100000
Mahasiswa 14	4	1	1	1300000	0	40000	50000
Mahasiswa 15	7	1	1	800000	0	30000	30000
Mahasiswa 16	3	1	1	1000000	0	0	0
Mahasiswa 17	3	1	2	1000000	200000	0	150000
Mahasiswa 18	7	1	1	1000000	160000	0	31000

Figure 3. Data to be clustered

This page is the next page after pressing the Fuzzy C-Means button on the main page. This page contains the implementation of the Fuzzy C Means algorithm (FCM) to group Single Tuition Fees based on the amount of parents' income, the number of biological siblings, father's condition, mother's condition, PBB, PKB, and electricity costs. The contents of this page is the display of Student data to be clustered, imported through the MySQL database.

Then there are input parameters that will be input for the clustering process with the Fuzzy C-Means algorithm. These parameters are:

- The number of clusters is sought with a default value of 7, which is many UKT categories at UNIMED
- Maximum iteration with a default value of 1000, i.e. the iteration limit is stopped if the results of clustering have not been obtained. The greater the maximum iteration limit, the better the results of clustering.
- Weight value (rank) with default value 2

- d. The smallest error value with a default value of 0.001, the smaller the error value, the better the results of clustering. But the error value that is too small can cause the length of the clustering process.

In addition users can also enter these parameters manually. The default value is intended so that if the user forgets to enter the FCM parameter values in the application then the default values can be used as parameters for the clustering process.

Then the user can do the clustering process by pressing the Process button, and then the results will appear in the results column. The implementation of the input parameter set and the clustering results are shown in the Figure 4.

Jumlah Cluster Dicari	<input type="text" value="7"/>
Maksimum Iterasi	<input type="text" value="1000"/>
Nilai Pembobot (Pangkat)	<input type="text" value="2"/>
Nilai Error Terkecil	<input type="text" value="0.001"/>
<input type="button" value="Proses"/>	

Figure 4. Set input parameters

Hasil Didapatkan, Selsih Fungsi Objective Sudah Tidak Lebih Besar dari Selsih Fungsi Objective yang diharapkan

Keanggotaan Cluster Akhir

Nama	Kelompok UKT
Mahasiswa 1	Cluster 1
Mahasiswa 2	Cluster 1
Mahasiswa 3	Cluster 1
Mahasiswa 4	Cluster 1
Mahasiswa 5	Cluster 1
Mahasiswa 6	Cluster 1
Mahasiswa 7	Cluster 1
Mahasiswa 8	Cluster 1
Mahasiswa 9	Cluster 1
Mahasiswa 10	Cluster 1
Mahasiswa 11	Cluster 1
Mahasiswa 12	Cluster 1
Mahasiswa 13	Cluster 1
Mahasiswa 14	Cluster 1
Mahasiswa 15	Cluster 1
Mahasiswa 16	Cluster 1
Mahasiswa 17	Cluster 1
Mahasiswa 18	Cluster 1
Mahasiswa 19	Cluster 1
Mahasiswa 20	Cluster 1
Mahasiswa 21	Cluster 1
Mahasiswa 22	Cluster 1
Mahasiswa 23	Cluster 1

Figure 5. Results of clustering

4.7 Test Result

The following is the Single Tuition Category from the research results as well as the Single Tuition category applicable at Medan State University, Faculty of Mathematics and Natural Sciences. Where UKT P is a Single Tuition result of research and UKT S is actually Single Tuition Fee at Medan State University.

Comparison of the number of students from the research results with the UNIMED UKT data in each Single Tuition category as in the Table 4.

Table 4. Comparison of research cluster results with actual data

Category of UKT	Result of Research	Factual Data	Difference
UKT Category 1	193	51	142
UKT Category 2	141	31	110
UKT Category 3	39	39	0

UKT Category 4	88	133	45
UKT Category 5	90	216	126
UKT Category 6	47	110	63
UKT Category 7	8	26	18

Based on the results of the calculation of the Fuzzy C-Means algorithm in the 1st UKT category there were 193 students, 142 more students with a previous UKT UNIMED number of 51 students. For the 2nd category UKT, there were 141 students more than 110 students with 31 previous UKT UNIMED students. For the 3rd category UKT, 39 students had the same results as the previous UKT UNIMED. For the 4th category UKT, there were 88 students in the study, fewer 45 students with 133 previous UKT UNIMED students. For the 5th category UKT, in the research results there were 90 fewer students 126 students with a previous UKT UNIMED number of 216 students. For the 6th UKT category there were 47 students, 63 fewer than the previous UNTED UKT of 110 students. For the 7th UKT category, there were 8 students in the study, fewer 18 students with 26 previous UKT UNIMED students.

5. Conclusions

Based on the results of the discussion in the previous chapter, conclusions can be drawn which are as follows:

1. Determination of the Single Tuition Category using the Fuzzy C-Means Method in Medan State University especially the Faculty of Mathematics and Natural Sciences class of 2018, obtained grouping data, namely for the 1st category UKT there were 193 students, the second category UKT there were 141 students, UKT category 3 there are 39 students, UKT category 4 there are 88 students, UKT category 5 there are 90 students, UKT category 6 there are 47 students, and UKT category 7 there are 8 students.
2. Group 1 is the cluster that has the most difference between the research data and the actual data, where the results of the study were 141 students more than 142 students with the previous UKT UNIMED cluster as many as 31 students.

6. References

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