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Combination of The MADM Yager Model and k-NN to Group Single Tuition Payments

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Abstract

Tuition payments at State Universities (PTN) in Indonesian use a Single Tuition Fee (UKT) payment system. It has been implemented to make it easier for students to pay their tuition. The UKT system is divided into several groups starting from the UKT group I to VIII. Universitas Sembilanbelas November (USN) Kolaka is a state university and the university should determine the amount of tuition fees for each student according to the UKT system. In determining the UKT group for each student, several variables were used to make it easier to group student into their UKT groups. However, the large number of students, a number of variables and the limited time to determine the amount of UKT for each student become an issue, so a method was needed to help USN Kolaka in grouping UKT for each student. One thing that can be done was to use the MADM Yager model and k-NN in order to make it easier to group UKT students. The results of the study showed that the use of the MADM Yager model and k-NN could determine the UKT group of the students, and the results obtained for the UKT group I were 63 people (21.95%), the UKT group II were 72 people (25.09%), the UKT group III were 120 people (41.81%), UKT group IV were 7 people (2.44%), and UKT group V were 25 people (8.71%).

Keywords: K-NN; MADM Yager Model; PTN; UKT; USN Kolaka.

Introduction

Education system of Indonesia is divided into several stages starting from the most basic, namely kindergarten and the highest is the tertiary level. Higher education is divided into two, private universities and there are state universities (PTN). PTN management is regulated by the government through the ministries of education and culture, Research and Technology, while private universities are managed by non-governmental organizations or usually managed by a foundation. For higher education to run well, funding is needed from various sources. One source of higher education funding is tuition fees charged to students. Determination of tuition fees at the private universities level does not get direct intervention from the government or in other words, universities can determine the amount of tuition fees charged to each student. However, the determination of the amount of tuition fees charged to each PTN student is regulated by the government so that PTN is not able to arbitrarily determine the amount of student tuition fees.

Single Tuition Fee (UKT) is an educational fee applied at PTN and regulated by the government. Before the UKT system was implemented by the government, the education covered by students were tuition fees, practicum fees, graduation fees, KKN fees, exam fees, and others [1]. The purpose of the UKT system is for all educational costs unified into one and payments are made every semester so that students are not burdened with various types of tuition bills [2]. UKT is regulated in the Decree of the Minister of Research, Technology and Higher Education of the Republic of Indonesia number 194/M/KPT/2019 where UKT is divided into eight groups, namely UKT Groups I-VIII [3]. Determination of student UKT is based on the economic condition of each student.

Universitas Sembilanbelas November Kolaka (USN Kolaka) is one of the state universities in Southeast Sulawesi Province. As one of the new PTNs, USN Kolaka is required to follow the UKT system set by the Government. In response to the government regulations, the Rector of USN Kolaka issued a Chancellor's Regulation which regulates the mechanism for determining UKT group of students. In this regulation, the variables for consideration in determining the amount of UKT for students are regulated. The specified criteria aimed to determine the amount of student UKT in accordance with the student's economic situation.

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In practice, USN Kolaka implemented the UKT system in accordance with regulation of the rector, but encountered problems with the large number of new students each year and the short time to determine the student's UKT. This was a problem that always came in new student admission. The huge amount of student data that had to be verified in a short time, the large number of UKT groups and other regulations overwhelmed USN Kolaka. A fair analysis was needed so that the determination of student UKT can be determined as it should be.

To determine the UKT group of students in short and precise time, a system that can provide recommendations based on predetermined variables is required. One method that can be used in providing recommendations is the Decision Support System (DSS). There are several DSS models, one of which is Multiple Attribute Decision Making (MADM). The way MADL works was that it first assigned a value to each criterion, then calculated it and then did a ranking to select each alternative [4].

One method that can be used to solve the problem was the MADM Yager model and k-NN. There were several studies that applied DSS using the MADM Yager model in solving problems, such as: research on the selection of PPA scholarship recipients by applying the MADM Yager model [5], DSS for new student admissions using the fuzzy MADM Yager Model [6], then fuzzy the yager MADM model was used to determine apartment investment locations [7]. The results obtained from this study were that the MADM yager model could assist users to make decisions based on the criteria and alternatives that had been determined.

The k-Nearest Neighbor (k-NN) method has several advantages, including fast data training, simple and easy to learn, robust training data against noise, and efficient for large training data. The k-NN method has also been widely used in data mining applications because of its simple implementation [8]. Several studies related to k-NN include analysis of k-NN performance in identifying glass types, in this study it was concluded that k-NN can classify objects based on learning data that were close to the object [9]. Comparative research of the k-NN method with other methods in classification showed that the accuracy value of k-NN was better than the Local Binary Pattern Histogram method [10], and SVM [11]. Meanwhile, several studies related to determining the UKT amount have been carried out using several different methods, namely using the backpropagation method [12], and WP-Topsis [13].

The difference between the current research and the previous ones lies in the criteria and sub-criteria used, as well as the method. In this study, the method used was a combination of the MADM Yager Model and k-NN where the process of determining UKT amounts used the MADM Yager Model, while k-NN was used to classify into UKT groups.

Method

A. A Single Tuition Payment

A Single Tuition Payment (UKT) is the tuition fee charged to each student at State Universities in Indonesia. UKT is a central government policy where the purpose of it is to make it help students to pay tuition fees by determining tuition fees based on the economic conditions of each student [2]. Based on the regulation of the rector of USN Kolaka No. 01/UN56/KP/2020 regarding the determination of UKT, several variables were applied to determine the amount of UKT for each student, namely the employment status of student's parents/guardians, fixed income and additional income of parents/guardians of students, the number of family members who are dependents to parents/guardians of students, education of the parents/guardians, orphans, divorced parents, and owned assistance cards from the government. The UKT group that is enforced at USN Kolaka is only from UKT Groups I-V.

B. Multiple Attribute Decision Making (MADM) Yager Model

MADM is a type of DSS where MADM first determines a weight value for each criterion then performs a calculation and ranks process to select each alternative according to the value that has been given [4]. MADM is widely used in the assessment of the given alternatives [14].

MADM Yager model is the basic form of Fuzzy MADM where alternative sets and attributes are represented in fuzzy sets $\tilde{C}j = 1, \ldots, m$. W_j is the denotation of the weight which is the most important level in the jth attribute. membership degree $mc(X_i)$ is an expression of the alternative achievement value ai to the attribute C_j. The final decision will be taken from the interaction by all the following fuzzy attributes Equation 1

$$\widetilde{D} = \tilde{C}_1^{w_2} \cap \tilde{C}_2^{w_2} \cap \ldots \tilde{C}_m^{w_m} \quad (1)$$

The steps for completing the Yager model are as follow Equation 2:

1. Establishing a pairwise comparison matrix between attributes (M)

$$M = \begin{bmatrix} \frac{\alpha_1}{\alpha_1} & \frac{\alpha_1}{\alpha_2} \cdots & \frac{\alpha_1}{\alpha_n} \\ \frac{\alpha_2}{\alpha_1} & \frac{\alpha_2}{\alpha_2} & \frac{\alpha_2}{\alpha_n} \\ \frac{\alpha_n}{\alpha_1} & \frac{\alpha_n}{\alpha_2} & \frac{\alpha_n}{\alpha_n} \end{bmatrix} \quad (2)$$

2. Establishing the value of w_j that should be consistent in each attribute
3. Calculating the value of $\left(\tilde{C}j(x_i)\right)^{wi}$
4. Determining the interaction from all $\left(\tilde{C}j(x_i)\right)^{wi}$ using Equation 3

$$\widetilde{D} = \left\{\left(x_i, \,^{min}_{j} \left(\mu_{cj}(x_i)\right)^{wi}\right) i = 1, \ldots, n;; j = 1, \ldots., m\right\} \quad (3)$$

5. Choosing xi for the largest degree of membership with $\widetilde{D}$, then it is determined as the optimal alternative

C. *K-Nearest Neighbor*

K-Nearest Neighbor (k-NN) is a simple yet effective classification method [15][16]. It is capable of classifying new objects based on attributes and training data samples [17]. In classifying groups, k-NN compares learning data with objects by calculating the distance of all learning data then taking a value, for example k, which is closest to the object value and then calculating the average value. If a value of $k = 2$ is found, then the object is considered a member of the closest group [11].

The following is wow k-NN works:

1. Determining the parameter k = the number of nearest neighbors
2. Calculating the distance of all training data to the evaluation power of (x, y) using Equation 4

$$d(x, y) = \sqrt{\sum_{k=1}^{n} (x_k - y_k)^2} \quad (4)$$

3. Sorting the distance that has been formed then determining the shortest distance to the k order
4. Pairing the same class (c)
5. Finding the largest number of classes from the nearest neighbors, then determining that class as the evaluated data class

Results and Discussion

A. Weighting of each sub-criteria

The criteria and weighting used in determining the UKT at USN Kolaka was based on the Rector's Decree number 01/UN56/KP/2020. The process of determining the criteria, sub-criteria and the weight of each sub-criteria was carried out by the academic staff of USN Kolaka. Based on the consideration, four criteria were determined, namely family conditions, ownership of a Smart Indonesia Card (KIP), income of parents/guardians, and family dependents. For the criteria for family conditions, there were four sub-criteria with a weight value of 1 for both parents who were still alive, a value of 2 for divorced parents, a value of 3 for a student with a single parent, and a value of 4 for orphans (no parents). The condition of an orphaned family gets a high score considering the financial condition of an orphaned student was considered lower than a student with the condition that both parents were still alive. The criteria for KIP ownership consist of sub criteria, namely having a KIP with a value of 2 and not having a KIP with a value of 1. KIP was a facility provided by the state for students who were economically disadvantaged. The value of the sub-criteria for having KIP was higher than the sub-criteria for not having KIP because ownership of KIP is an indicator of an economically disadvantaged student. The income criteria for parents/guardians were not divided into sub-criteria directly, but a normalization process must be carried out so that the rating scale was equal. Family dependents were divided into 5 sub-criteria, namely dependents greater than or equal to 5 with a value of 5, 4 dependents with a value of 4, 3 dependents with a value of 3, 2 dependents with a value of 2, and 1 dependent 1 with a value of 1. The value for sub criterion for greater than or equal to 5 dependents was higher because the number of dependents was related to the amount of expenses supported by the parents of the students.

For more details on the criteria, sub-criteria, and weights used in determining the UKT at USN Kolaka, it can be seen in **Table 1** below.

Table 1. Table of weighting criteria and sub criteria

Criteria	Sub Criteria	Value
Family Condition (C1)	Orphans	4
	One parent died	3
	Divorced Parents	2
	Both Parents are alive	1
Ownership KIP (C2)	Having KIP	2
	Not having KIP	1
Income of parents/guardins (C3)	NORMALISATION	
Family dependents (C4)	>= 5 persons	5
	4 persons	4
	3 persons	3
	2 persons	2
	1 person	1

B. Weighting of each sub-criteria

The student data obtained from Academic Staff Unit of USN Kolaka can be seen in **Table 2**.

Table 2. Data of the student conditions

No	Code	C1	C2	C3	C4
		Conditions	***Cards***	***Income***	***Dipendent***
1	4220004376	One parent died	Having KIP	100000	3 people
2	4220004764	Both parents are alive	Having KIP	2000000	2 people
3	4220009633	Both parents are alive	Having KIP	100000	6 people
4	4220013204	Both parents are alive	Not having KIP	100000	0 people
5	4220028581	Both parents are alive	Having KIP	1200000	2 people
6	4220029765	Both parents are alive	Having KIP	700000	2 people
7	4220041610	Both parents are alive	Having KIP	1000000	2 people
8	4220043155	Both parents are alive	Having KIP	100000	3 people
9	4220046212	Both parents are alive	Not having KIP	100000	0 people
10	4220049213	Both parents are alive	Not having KIP	100000	0 people
…	…	…	…	…	…
280	4220636103	Both parents are alive	Having KIP	5044500	4 people
281	4220638624	Both parents are alive	Not having KIP	600000	3 people
282	4220640153	Both parents are alive	Having KIP	500000	3 people
283	4220640682	Both parents are alive	Having KIP	800000	3 people
284	4220640913	Both parents are alive	Having KIP	500000	6 people
285	4220641203	Both parents are alive	Having KIP	200000	3 people
286	4220646386	Both parents are alive	Not having KIP	100000	0 people
287	4220649875	Both parents are alive	Not having KIP P	100000	0 people

The data obtained for each student was then given a weighting value based on the criteria and sub-criteria in **Table 1**. The results of each condition weighting of students can be seen in **Table 3**.

Table 3. Weighting of students subciteria

No	Code	C1	C2	C3	C4
		Condition	*Cards*	*Income*	*Dependent*
1	4220004376	3	2	100000	3
2	4220004764	1	2	2000000	2
3	4220009633	1	2	100000	6
4	4220013204	1	1	100000	0
5	4220028581	1	2	1200000	2
6	4220029765	1	2	700000	2
7	4220041610	1	2	1000000	2
8	4220043155	1	2	100000	3
9	4220046212	1	1	100000	0
10	4220049213	1	1	100000	0
…	…	…	…	…	…
280	4220636103	1	2	5044500	4
281	4220638624	1	1	600000	3
282	4220640153	1	2	500000	3
283	4220640682	1	2	800000	3
284	4220640913	1	2	500000	6
285	4220641203	1	2	200000	3
286	4220646386	1	1	100000	0
287	4220649875	1	1	100000	0

C. MADM Yager Model Processing

After the data was collected, the data was then processed using the MADM Yager model. Following are the results of data processing using Yager.

1. Pairwise comparison matrix between attributes

Table 4. Pairwise comparison matrix

	C1	C2	C3	C4
C1	1	3	5	7
C2	0.333	1	3	5
C3	0.200	0.333	1	3
C4	0.143	0.200	0.333	1
Sum	1.676	4.533	9.333	16.000

2. A consistent of W_j value for every attribute

Table 5. W_j values

	W_1	W_2	W_3	W_4	W_j
C1	0.597	0.662	0.536	0.438	0.558
C2	0.199	0.221	0.321	0.313	0.263
C3	0.119	0.074	0.107	0.188	0.122
C4	0.085	0.044	0.036	0.063	0.057

3. Calculating the value of C_j

Afterwards, normalization of student data was carried out which aimed to equate the scale of data attributes into a specific distance. The results of normalization can be seen in Table 6.

Table 6. Normalization Table

No	Code	C1	C2	C3	C4
1	4220004376	0.750	1.000	1.000	0.333
2	4220004764	0.250	1.000	0.050	0.222
3	4220009633	0.250	1.000	1.000	0.667
4	4220013204	0.250	0.500	1.000	0.000
5	4220028581	0.250	1.000	0.083	0.222
6	4220029765	0.250	1.000	0.143	0.222
7	4220041610	0.250	1.000	0.100	0.222
8	4220043155	0.250	1.000	1.000	0.333
9	4220046212	0.250	0.500	1.000	0.000
10	4220049213	0.250	0.500	1.000	0.000
…	…	…	…	…	…
280	4220636103	0.250	1.000	0.020	0.444
281	4220638624	0.250	0.500	0.167	0.333
282	4220640153	0.250	1.000	0.200	0.333
283	4220640682	0.250	1.000	0.125	0.333
284	4220640913	0.250	1.000	0.200	0.667
285	4220641203	0.250	1.000	0.500	0.333
286	4220646386	0.250	0.500	1.000	0.000
287	4220649875	0.250	0.500	1.000	0.000

An example of calculating normalization for student code 4220004376 is obtained from 3 (Table 3 conditions) divided by 4 the maximum number of condition criteria, so $c_{11} = \frac{3}{4} = 0.750$

After normalization, next was to calculate the C_j value. The results of calculating the Cjw value are seen in Table 7.

Table 7. Result of C_j^w Calculating Value

No	Code	C1	C2	C3	C4
1	4220004376	0.852	1.000	1.000	0.939
2	4220004764	0.461	1.000	0.694	0.918
3	4220009633	0.461	1.000	1.000	0.977
4	4220013204	0.461	0.833	1.000	0.000
5	4220028581	0.461	1.000	0.739	0.918
6	4220029765	0.461	1.000	0.789	0.918
7	4220041610	0.461	1.000	0.755	0.918
8	4220043155	0.461	1.000	1.000	0.939
9	4220046212	0.461	0.833	1.000	0.000
10	4220049213	0.461	0.833	1.000	0.000
…	…	…	…	…	…
280	4220636103	0.461	1.000	0.620	0.955
281	4220638624	0.461	0.833	0.804	0.939
282	4220640153	0.461	1.000	0.822	0.939

No	Code	C1	C2	C3	C4
283	4220640682	0.461	1.000	0.776	0.939
284	4220640913	0.461	1.000	0.822	0.977
285	4220641203	0.461	1.000	0.919	0.939
286	4220646386	0.461	0.833	1.000	0.000
287	4220649875	0.461	0.833	1.000	0.000

4. Grouping UKT using k-NN
   After the yager process was completed, then the k-NN method was used to group them into UKT groups. The results of UKT grouping using k-NN can be seen in the **Table 8**.

Table 8. The result of UKT grouping

No	Code	Value	C1	C2	C3	C4	C5	Group
1	4220004376	0.852	0.841	0.401	0.390	0.336	0.125	5
2	4220004764	0.461	0.450	0.011	0.000	0.054	0.516	3
3	4220009633	0.461	0.450	0.011	0.000	0.054	0.516	3
4	4220013204	0.000	0.011	0.450	0.461	0.516	0.977	1
5	4220028581	0.461	0.450	0.011	0.000	0.054	0.516	3
6	4220029765	0.461	0.450	0.011	0.000	0.054	0.516	3
7	4220041610	0.461	0.450	0.011	0.000	0.054	0.516	3
8	4220043155	0.461	0.450	0.011	0.000	0.054	0.516	3
9	4220046212	0.000	0.011	0.450	0.461	0.516	0.977	1
10	4220049213	0.000	0.011	0.450	0.461	0.516	0.977	1
…	…	…	…	…	…	…	…	…
280	4220636103	0.461	0.450	0.011	0.000	0.054	0.516	3
281	4220638624	0.461	0.450	0.011	0.000	0.054	0.516	3
282	4220640153	0.461	0.450	0.011	0.000	0.054	0.516	3
283	4220640682	0.461	0.450	0.011	0.000	0.054	0.516	3
284	4220640913	0.461	0.450	0.011	0.000	0.054	0.516	3
285	4220641203	0.461	0.450	0.011	0.000	0.054	0.516	3
286	4220646386	0.000	0.011	0.450	0.461	0.516	0.977	1
287	4220649875	0.000	0.011	0.450	0.461	0.516	0.977	1

The recapitulation results obtained from the UKT determination process with the MADM Yager model and k-NN obtained the following results **Table 9**.

Table 9. Recapitulation of the number of UKT group

No	UKT group	Number
1	I	63
2	II	72
3	III	120
4	IV	7
5	V	25

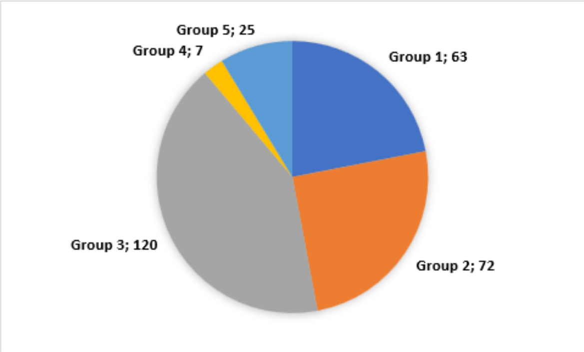

Figure 1. Recapitulation of calculation result

The number of students who classified in the UKT group I was 63 people, group II was 72 people, group III was 120 people, group UKT IV was 7 people, and group UKT V was 25 people.

Conclusion

The results of the current research on the implementation of the combination of the MADM Yager model and KNN to determine the UKT group for new students was successfully conducted. The calculation results obtained 63 people (21.95%) in Group I, 72 people (25.09%) in Group II, 120 people (41.81%) in Group III, 7 people (2.44%) in Group IV, and 25 people (8.71%) in Group V. For future research, it is suggested to use other methods as comparisons and use more training data and more alternatives.

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