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GROUP DECISION SUPPORT SYSTEM BASED ON AHP-TOPSIS FOR CULINARY RECOMMENDATION SYSTEM

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Abstract

Formerly, Group Decision Support System (GDSS) for culinary recommendations has been developed with the TOPSIS method. TOPSIS has low algorithm complexity, so it is suitable to be applied in mobile devices. However, GDSS with TOPSIS has its disadvantages, TOPSIS have not been able to facilitate the preferences of each user inside a group so the recommendation result always consists only on dominant user. TOPSIS method produces unchanging rankings, because this method recommends a food menu based on the one dominant user so that the ranking is always consistent. Meanwhile, this study contributes to integrate AHP for weighting criteria and TOPSIS for ranking culinary recommendations based on the group aggregation value where each user has a priority value for each alternative. Based on rank consistency testing results that conducted in 6 different user groups, unlike the previous research, AHP-TOPSIS shows inconsistency ranking, which means that changes in user preferences affect the recommendation results that are generated by application. The AHP-TOPSIS method proved can be accommodated the computation of various preferences of each user in GDSS culinary recommendation.

Keywords: *AHP-TOPSIS, Recommendation, Culinary, Group DSS, Decision Support System*

Abstrak

Sistem Pendukung Keputusan Kelompok (Group Decision Support System/ GDSS) untuk rekomendasi kuliner telah dikembangkan dengan metode TOPSIS. TOPSIS memiliki kompleksitas algoritma yang rendah, sehingga sangat cocok untuk diterapkan pada perangkat seluler. Namun, GDSS dengan TOPSIS memiliki kelemahan, TOPSIS belum dapat memfasilitasi preferensi masing-masing pengguna dalam suatu kelompok sehingga hasil rekomendasi selalu tergantung dari pengguna dengan nilai vektor akhir yang dominan. Metode TOPSIS menghasilkan peringkat yang tidak berubah, karena metode ini merekomendasikan menu makanan berdasarkan pada 1 pengguna dominan sehingga peringkat selalu konsisten. Sementara itu, penelitian ini berkontribusi mengintegrasikan AHP untuk pembobotan kriteria dan TOPSIS untuk memberikan peringkat rekomendasi kuliner berdasarkan nilai agregasi grup dimana masing-masing pengguna memiliki nilai prioritas untuk masing-masing alternatif. Berdasarkan hasil pengujian konsistensi peringkat yang dilakukan pada 6 kelompok pengguna yang berbeda, AHP-TOPSIS menunjukkan adanya perubahan peringkat, yang berarti bahwa perubahan dalam preferensi pengguna mempengaruhi hasil rekomendasi yang dihasilkan oleh aplikasi. Metode AHP-TOPSIS terbukti dapat mengakomodasi preferensi pengguna dalam kasus GDSS rekomendasi kuliner.

Kata Kunci: *AHP-TOPSIS, Rekomendasi, Kuliner, Sistem Pendukung Keputusan Kelompok, Sistem Pendukung Keputusan*

1. Introduction

In Indonesian tourism context, micro, small and medium sized enterprises (MSMEs) are many developing businesses and employ more workers. Advances in information technologies make MSMEs can achieve their full potential contribution to improving economic condition in a country. Levy in [1], stated that implementation of information systems have a positive impact on improving administrative processes and transaction inside of a MSME.

Malang is one of most favorite tourist destination in Indonesia. An application especially mobile recommendation system which can assist a user to locate various MSMEs will have greater impact to local tourism business especially culinary sales. In addition, the usage of appropriate technology will help MSMEs to expand their product marketing approach in order to reach more customers. The mobile culinary recommendation application not only have value to culinary MSMEs but also It existence can make tourists easily to find their culinary destination during a trip.

This study focuses on the implementation of information technology in culinary recommendation system to support the marketing activities of culinary MSME products in Malang. Previous works have proposed many mobile culinary recommendation systems to help the marketing and promotion of MSME products. Initially has been done by Tolle et al [2]. Many algorithms are included to improve the result of application recommendation such as Analytic Hierarchy Process which is conducted by Pinandito [3], AHP-TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) which is conducted by Nurrachman [4] and fuzzy AHP which is also implemented in this field by Pinandito [5].

However, most of the mobile culinary recommendations that have been conducted only discuss on single personal decision support systems (DSS). From the pilot study in real implementation scenarios, it turns out that there is a scenario usage that has not been covered by a personal DSS. A condition when the user doing culinary tours in groups. Group preference data are certainly different from personal preference, so it is necessary to develop applications that accommodate a group of users for culinary recommendations.

In 2017, Group Decision Support System for culinary recommendations with the TOPSIS method has been developed by Dewi [6]. TOPSIS has low algorithm complexity, so it is suitable to be applied in mobile devices. However, GDSS with TOPSIS has its disadvantages, TOPSIS have not been able to facilitate the preferences or desires of each user. Meanwhile, this study aims to integrate AHP for weighting criteria from each user and TOPSIS for ranking culinary recommendations in order to provide better recommendation results.

2. Research Method

The Group Decision Support Systems (GDSS) has been proposed in this research using AHP-TOPSIS method. AHP-TOPSIS method used in a group-based culinary recommendation system to find the best recommendation of user's choice. The steps for designing the AHP-TOPSIS method to solving the problem by choosing the best solution are as follows:

Analytical Hierarchy Process (AHP)

Analytic Hierarchy Process (AHP) is one of the extensively methods in sustaining multi-criteria decision making. AHP is a functional hierarchy model with perception of human as its main input and able to solve the multi-criteria problem. The unstructured and complex problems are broken down into the groups and they will be arranged into a hierarchy form.

Steps of determining the weight of criteria by using the AHP method as follows [7,8,9,10]:

1. Define the problems and determine the necessary solution, then arrange a hierarchy of the problems.
2. Determine the priority of the element by creating a coupled of matrix comparison filled up with numbers to be regarded as the relative importance between elements. The value is entered by the user or culinary expert.
3. Matrix normalization
   a. Sum up the values of each column in the coupled of matrix comparison shown in Equation 1

      $$n = \sum_{i=0}^{z} x_{ij} \quad (1)$$

      where,
      n = the sum of each column
      z = number of alternatives
      i = 1, 2, 3, …, z
      x = value of each cell
   b. Divide each column value by the total column concerned to obtain the normalization matrix shown in Equation 2.

      $$m = \frac{x_{ij}}{n} \quad (2)$$

      where,
      m = result of normalization
      x = value of each cell
      n = the result of the number of each column
4. Calculate priority weights. Sum up the

values of the row and divide the results by the elements number to get the featureless value / priority weight shown in Equation 3.

$$bp = \frac{\sum_{j=0}^{n} x_{ij}}{n} \quad (3)$$

5. Calculation in decision making, it is principal to be informed how well there is consistency, because decisions are not expected based on considerations with low consistency. The things that are done in this stage are:
   a. Multiply by each of the first cell values with the first priority weights, the values in the second cell column with the second priority, and so on.
   b. Add the result to each row of the matrix.
   c. The result of the line sum is divided by the respective priority element in question.
   d. Add up the results of the lambda for each criterion divided by the many elements that are available, the results are referred to in Equation 4.

$$\lambda maks = \frac{\sum \lambda}{n} \quad (4)$$

   where,
   λ = Maximum eigen
   n = many criteria
6. Calculate the Consistency Index (CI) shown in Equation 5.

$$CI = \frac{\lambda maks - n}{n-1} \quad (5)$$

   where,
   n = elements
7. Calculate the Consistency Ratio (CR) shown in Equation 6.

$$CR = \frac{CI}{RI} \quad (6)$$

   where,
   RI = random index value
   CR = consistency ratio

TABLE 1
LIST OF RANDOM INDEX

Matrix (N)	RI	Matrix (N)	RI
1,2	0	9	1,45
3	0,58	10	1,49
4	0,90	11	1,51
5	1,12	12	1,48
6	1,24	12	1,56
7	1,32	14	1,57
8	1,41	15	1,59

8. Check hierarchy consistency. If the CR value > 0.1 then the judgment data assessment is inconsistent and must be corrected. If the consistent ratio of CR 1 0.1 then the data calculation is consistent and correct. RI is the random index value shown in Table 1.

TOPSIS

The TOPSIS method is used to rank by the following steps [11,12]:

1. Building normalized decision matrix. The first element results from normalizing decision matrix R with the Euclidean method length of a vector shown in Equation 7.

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x^2_{ij}}} \quad (7)$$

   where,
   r_{ij} = result of normalization of decision matrix R
   i = 1, 2, 3, ..., m
   j = 1, 2, 3, ..., m
2. Building a weighted normalized decision matrix shown in Equation 8 with weights W = (w1, w2, ..., wn) obtained from the calculation of Analytical Hierarchy Process (AHP) weighting.

$$V = \begin{bmatrix} w_1 r_{11} & \cdots & w_n r_{1n} \\ \vdots & \ddots & \vdots \\ w_1 r_{m1} & \cdots & w_n r_{mn} \end{bmatrix} \quad (8)$$

   where,
   i = 1, 2, 3, ..., m
   j = 1, 2, 3, ..., n

Determine the ideal solutions of positive and negative value. The positive ideal solution is denoted by the A + symbol and the negative ideal solution is denoted by the symbol A- which is shown in Equation 9 and Equation 10.

$$A^{+} = \{(\max v_{ij} | j \in J) \ (\min v_{ij} | j \in J`), i = 1,2,3,...,m\} = \{v_1^{+}, v_2^{+}, ..., v_m^{+}\} \quad (9)$$

$$A^{-} = \{(\min vij \mid j \in J)(\max vij \mid j \in J')i = 1,2,3,\ldots,m\} = \{v1^{-}, v2^{-}, \ldots, vm\} \quad (10)$$

3. Calculates severance measure which is a calculation of distance from an alternative to positive ideal solution and negative ideal solution shown in Equation 11 and Equation 12, where i = 1, 2, 3, …, n.

$$S_i^{+} = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^{+}\right)^2} \quad (11)$$

$$S_i^{-} = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^{-}\right)^2} \quad (12)$$

4. Calculate alternative proximity to ideal solutions. The relative proximity of alternative A + with ideal solution A- shown in Equation 13, where 0 < Ci+ < 1 and i = 1, 2, 3, ..., m;

$$C_i^+ = \frac{S_i^-}{S_i^- + S_i^+} \quad (13)$$

5. Alternative ranking. Alternatives can be ranked according to the order of Ci + from the largest to the smallest. Therefore, the best alternative is nearest to the ideal positive solution and inmost away from the negative ideal solution. The alternative with the enormous Ci + is the best solution.

AHP-TOPSIS Method for Group Decision Support System

After the weight is calculated using AHP, then the results of the weight of each criterion are processed into TOPSIS calculation. This process results in an alternative ranking for 1 user. Adapted from [13], the results of each user are then put together in the following way:

1. Collect CR (consistency ratio) values from each user. Each user (k) has a CR value, this CR value is then used to calculate αk as in Equation 14:

$$\alpha_{k=} \frac{CR}{\sum_{k=1}^{K} 1/CR} \quad (14)$$

2. Calculates group aggregation values. Each alternative is ranked based on the group aggregation value where each user (k) has a priority value for each alternative symbolized as obtained from the TOPSIS calculation as Equation 15:

$$Z_i^G = \prod_k^K [Zi(k)^{\alpha k}] \quad (15)$$

3. Results and Analysis

The implementation of our design will be an Android application which is server-based. The data that have been used are restaurant name, address, location, menu, price, and facility. Data of this research was taken from [2].

The user has been asked by the system to specify menu they want to eat by marking it as chosen one by clicking the check box, and then food and drink menu are assigned by the user by using criteria of price, distance and rating. User can fill the ratings star, and push the price & distance bar. Figure 1 shows the result of the culinary recommendation system in a group of users. This application gave one culinary recommendation for every user. Figure 1 shows there were 3 recommendation for 3 users that was calculated using AHP-TOPSIS for personal DSS. This results processed to Group DSS by using AHP-TOPSIS and resulted the recommendation of a place to eat in a group of user.

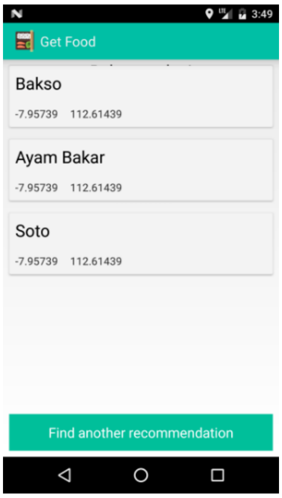

Figure. 1. Recommendation result

In the testing phase, the rank consistency testing methodology is used. Rank consistency testing is done to determine the consistency of ranks generated by GDSS with the difference in the number of users. In the this phase, there were 6 different test scenarios using 7 decision makers in each of the five tested food combinations. The six kinds of test scenarios are from 2 decision makers to 7 decision makers. These decision makers have different weight for each criterion criterion as shown in Table 2 to Table 8. The number of preferences is subjective for each user.

TABLE 1
USER PREFERENCE OF USER 1

Criteria	P	D	R
P	1.00	2	3
D	0.50	1	2
R	0.33	0.5	1

TABLE 2
USER PREFERENCE OF USER 2

Criteria	P	D	R
P	1.00	3	7
D	0.33	1	6
R	0.14	0.166666667	1

TABLE 3
USER PREFERENCE OF USER 3

Criteria	P	D	R
P	1.00	3	4
D	0.33	1	2
R	0.25	0.5	1

TABLE 4
USER PREFERENCE OF USER 4

Criteria	P	D	R
P	1.00	2	3
D	0.50	1	4
R	0.33	0.25	1

TABLE 5
USER PREFERENCE OF USER 5

Criteria	P	D	R
P	1.00	4	6
D	0.25	1	2
R	0.17	0.5	1

TABLE 6
USER PREFERENCE OF USER 6

Criteria	P	D	R
P	1.00	4	3
D	0.25	1	1
R	0.33	2	1

TABLE 7
USER PREFERENCE OF USER 7

Criteria	P	D	R
P	1.00	3	5
D	0.33	1	2
R	0.20	0.5	1

The five food menu combinations that are chosen randomly, are used as a combination of food menus tested to a combination of decision makers. The example of menu combination are shown in Table 9.

TABLE 9
EXAMPLE OF MENU COMBINATION

	Price	Distance	Rating
Ria Djenaka Fried rice	14900	1.2	4
Sea Food Fried rice Ala Wakul	15000	1.6	3.8
Fried rice 69	19000	1	4.2
Vegetarian Fried rice	22000	2.9	4.2
Nasgor Mawut	11500	1.8	3.8

TABLE 10
CR AND 1/CR VALUE

User	CR	1/CR
1	0.01	125.9683
2	0.09	11.44865
3	0.02	63.25919
4	0.09	10.67634
5	0.01	125.8169
6	0.02	63.25919
7	0.003186783	313.7961

Using 6 different scenarios and involving 7 decision makers that is tested to a combination of food menus, the results of the GDSS calculation with AHP TOPSIS generate Consistency Ratio (CR) for each user and the value of α_k. The results of the GDSS calculation with AHP TOPSIS generate Consistency Ratio (CR) for each user can be seen in Table 10.

Next step is calculation of α_k value as can be seen in Table 11.

TABLE 81
AK VALUE FOR USER 1,2,3,4,5,6,7

User	αk
1	0.176371
2	0.016029
3	0.08857
4	0.014948
5	0.176159
6	0.08857
7	0.439352

Value of αk and calculation of Ci+ in TOPSIS for each alternative then used for calculation of group aggregation value. Each alternative is ranked based on the group aggregation value where each user (k) has a priority value for each alternative.

The conducted rank consistency testing aimed to determine whether the recommendation by GDSS AHP-TOPSIS is consistent with changes of different decision maker's preferences. Table 12 is a table representing rank comparison that was tested for 6 testing scenarios (scenario 1 for user 1 & 2; scenario 2 for user 1-3; scenario 3 for user 1-4; scenario 4 for user 1-5; scenario 5 for user 1 6; and scenario 6 for all users). As shown in Table 12, there is a ranking inconsistency for different user preferences with rank consistency average 53,33 % for 6 testing scenarios. This indicated the improvement of the method of the previous study, GDSS with TOPSIS.

TABLE 12
RANK OF RECOMMENDATION FOR EACH MENU WITH DIFFERENT USER GROUPS

Test Scenario:	**1**	**2**	**3**	**4**	**5**	**6**
Ria Djenaka Fried rice	1	2	2	2	4	4
Sea Food Fried rice Ala Wakul	3	3	3	3	3	2
Fried rice 69	4	4	4	4	2	3
Vegetarian Fried rice	5	5	5	5	5	5
Nasgor Mawut	2	1	1	1	1	1
Rank Consistency	60%	60%	60%	60%	40%	40%

In the GDSS TOPSIS method group recommendations are built based on dominant user preferences so that the ranking is always consistent (100%). For example, the dominant user is user 2, so the recommendation is built based on ranking from user 2 without regard to other users because the vector value of other users is less than user 2.

The TOPSIS algorithm on [6] gave the culinary recommendation with the top ranking of the decision maker (DM), so DM with the highest vector value was chosen to have the first rank and the recommendation for this DM become the recommendation for groups. It was conducted by comparing each decision maker the alternative ranking value of as in Table 13.

TABLE 93
MATRIX OF GDSS TOPSIS

DM Group	Alternatives			
	A1	A2	A3	A4
DM1	1	2	4	3
DM2	2	3	1	4
DM3	1	3	2	4

4. Conclusion

The conducted rank consistency testing aimed to determine whether the recommendation by GDSS AHP-TOPSIS is consistent with changes of different decision maker's preferences. Rank consistency was used to show if the recommendation is consistent if different user preferences are combined. In the previous work, GDSS TOPSIS for group recommendations are built based on dominant user preferences so that the ranking consistency is always consistent (100%). This work shows that the development of GDSS using AHP-TOPSIS have rank inconsistency for 6 groups of users with a combination of menus. Based on rank consistency testing conducted in 6 different user groups, AHP-TOPSIS shows 53,33% of rank consistency , which means that changes in user preferences can affect the recommendations generated.

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