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Research article

TOPSIS for mobile based group and personal decision support system

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ARTICLE INFO

ABSTRACT

Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is an algorithm that can be used for alternative design in a decision support system (DSS). TOPSIS provides recommendation so that users can get information that support their decision, for example a tourist wants to visit a tourist destination in Malang, then TOPSIS provides recommendations of tourist destinations in the form of ranking recommendation, with the highest rank is the most recommended recommendation. TOPSIS-based Mobile Decision Support System (DSS) has relatively low algorithm complexity. However, there are some cases that require development from personal DSS to group DSS, for example tourists rarely come alone, in which case most of them invite friends or family. For users who are more than 1 person, the TOPSIS algorithm can be combined with the BORDA algorithm. This study explains about the implementation & testing of TOPSIS and TOPSIS-BORDA as algorithms for personal and group DSS in mobile-based tourism recommendation system in Malang. Correlation testing was conducted to test the effectiveness of TOPSIS in mobile-based recommendation system. In previous study, correlation testing for personal DSS showed that there was a relationship between the recommendation and user choice, with correlation value of 0.770769231. In this study, correlation testing for group DSS showed there is a positive correlation of 0.88 between the recommendations of the group produced by TOPSIS-BORDA and personal recommendations for each user produced by TOPSIS.

1. Introduction

A technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is an algorithm that can be used for alternative design in a decision support system (DSS). Personal DSS provides recommendations to a user so that the user gets information that can support his decision. For example a tourist wants to visit a tourist destination in Malang, then personal DSS provides recommendations in the form of ranking, with the highest rank is the most recommended tourist destination.

TOPSIS-based Mobile Decision Support System (DSS) has relatively low algorithm complexity. When compared to the 3 AHP (Analytical Hierarchy Process)-based recommendation algorithms namely AHP, AHP-TOPSIS and fuzzy AHP shows that TOPSIS combined with AHP provides lower complexity than AHP itself and fuzzy AHP [1]. The complexity of TOPSIS [2] in the normalization of attributes and weighting is $O(n^2)$, whereas the complexity of the ideal solution and V distance are respectively $O(n)$.

Various studies on personal DSS [3, 4, 5, 6] are implemented in mobile applications, as the use of smartphones is widespread. The development of a mobile-based culinary recommendation system in Malang [3] uses AHP while [4] uses fuzzy AHP. Research [5] uses SAW algorithms for mobile-based recipe recommendations. The development of TOPSIS-based mobile recommendation system was carried out in the recommendations of tourist destinations in Malang [6].

Some cases require development from personal DSS to GDSS, tourists rarely come alone, in which case most of them invite friends or family. For more than one user, the TOPSIS algorithm can be combined with the BORDA algorithm as an algorithm in the group DSS. Research on the Group DSS was also conducted previously on a mobile application [7] and culinary recommendations using TOPSIS [8] and AHP-TOPSIS [9].

This study describes the implementation & testing of TOPSIS and TOPSIS-BORDA as algorithms for personal and group DSS in mobile-based tourism recommendation system in Malang. TOPSIS is an algorithm in multiple attribute decision making that ranks recommendations based on the best solutions, where the best solution is close to the positive ideal vector and away from the negative ideal vector [10]. BORDA is an algorithm in the group DSS that uses the concept of voting so that the preferences of multiple users can be combined into one decision [11].

In the previous study, TOPSIS based mobile DSS [12] for personal DSS showed that there was a relationship between the recommendation and user choice, with a correlation value of 0.770769231. But, there the TOPSIS-BORDA correlation testing hasn't been conducted yet. Mobile based group DSS with TOPSIS-BORDA [8] only discussed the usability testing of the tourism recommendation application, but there is no further study on its algorithm in detail. Therefore, this research contributes to testing the effectiveness of the algorithm. This study will compare the results of correlation testing in TOPSIS [12] and TOPSIS-BORDA. In this study, correlation testing will be conducted on the recommendations of the group produced by TOPSIS-BORDA and personal recommendations for each user produced by TOPSIS.

The structure of the discussion in this study is preliminary in section 1 which contains the background of the research and the development of related research (state of the art), followed by section 2 that explains research methodology, section 3 of the research results and discussion and the last section is the conclusions of this study.

2. Research Methodology

A decision support system (DSS) provides recommendations to user so that he can get information that can support his decision. Making decisions remains a human responsibility, DSS only helps provide recommendations to support human decision-making. DSS has three main components: data management, model management and communication management [13] as in Fig. 1.
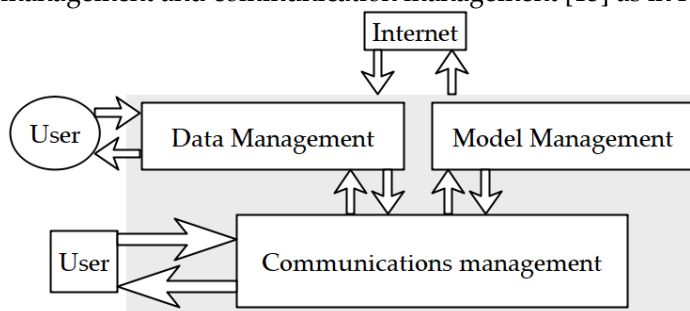

Fig. 1. Decision Support System [14]

DSS consists of two types, based on the number of decision makers, personal DSS [14, 15] and group DSS [16, 17]. Personal DSS provides recommendations for one person, while group DSS for more than one person. Personal DSS in this study was implemented using TOPSIS and Group DSS in this system implemented using TOPSIS-BORDA. The case study used in this study is a recommendation system of tourist destinations in Malang.

The implementation of TOPSIS [18, 19, 20, 21, 22] as a basic algorithm in this study has the following steps and the manual calculation will be described in the next section:
a. Determine the criteria and alternatives.
b. A user can input the weight of every criteria.

c. Building a normalized decision matrix (r_{ij}) as in Eq. 1 where x_{ij} is the value of decision matrix.

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x^2_{ij}}} \tag{1}$$

$$V = \begin{bmatrix} w_1 r_{11} & & w_n r_{1n} \\ & & \\ w_1 r_{m1} & & w_n r_{mn} \end{bmatrix} \tag{2}$$

d. Building a weighted normalized decision matrix (V) that can be calculated as in Eq. 2 where w is the value of weight.

e. Determine the positive (A^+) and negative (A^-) ideal solutions.

f. Calculates separation measure. Positive separation measure (S_i^+) as in Eq. 3 can be calculated from a weighted normalized decision matrix (V_{ij}) and V_j^+ is a positive ideal vector (A^+). It has the same calculation for negative separation measure (S_i^i) as in Eq. 4.

$$S_i^+ = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^+)^2} \tag{3}$$

$$S_i^- = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^-)^2} \tag{4}$$

g. Calculate alternative proximity to ideal solutions (C_i^+) as in Eq.5. Alternatives can be ranked according to the order of C_i^+ from the largest to the smallest.

$$C_i^+ = \frac{S_i^-}{S_i^- + S_i^+} \tag{5}$$

User acceptance testing of an application is conducted by usability testing, while testing of algorithms in this study is conducted with correlation testing. This study will compare the results of correlation testing in TOPSIS [12] and TOPSIS-BORDA. In this study, correlation testing will be conducted on the recommendations of the group produced by TOPSIS-BORDA and personal recommendations for each user produced by TOPSIS.

3. Results and Discussion

Model management can be a model or algorithm that can generate recommendations that supports decision making. The model management used in this research is TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) for personal DSS and TOPSIS-BORDA algorithm for group DSS.

3.1. Manual calculation step of TOPSIS

Model management in this research is TOPSIS for personal DSS and TOPSIS-BORDA algorithm for group DSS. The computation steps of TOPSIS algorithm are:

a) Determine the criteria and alternatives. Criteria used in recommendation for places to buy souvenirs in Malang are distance, price and time of standing in years. They are variables that can affect decision makers to make a choice where to buy souvenirs. Alternatives are some places to buy souvenirs in Malang. Table 1 shows alternatives and criteria used in this research.

Table 1. Alternative and criteria

Name	Criteria 1: Distance	Criteria 2: Price	Criteria 3: Time of standing in year
Alternative 1	6.7	20000	5
Alternative 2	6.6	55000	7
…			
Alternative 15	0.9	15000	29

Table 2. Weight from every decision maker

User	Criteria 1	Criteria 2	Criteria 3
1	1	1	1
2	0.4	0.4	0.2

b) A user can input the weight of every criteria as in Table 2. In personal DSS there is only 1 user (user 1), but in group DSS there can be more than one user, for example there are 2 users as decision makers (user 1 & 2).

c) Building a normalized decision matrix (r_{ij}) as in Table 1.

d) Building a weighted normalized decision matrix (V) that can be calculated as in Eq. 2 where w is the value of weight as in Table 2. The results of weighted normalized decision matrix (V) can be seen in Table 3.

e) Determine the positive (A^+) and negative (A^-) ideal solutions from step c and d. A^+ is the minimum value of column Criteria 1 and A^+ is the maximum value of column Criteria 1, because Criteria 1 (distance) is a cost value so the positive ideal vector can't be calculated with the maximum value. Criteria 2 is also cost value so it can be calculated with the same calculation as Criteria 1. But, Criteria 3 is a profit value so A^+ is the maximum value of column Criteria 3 and A^- is the minimum value of column Criteria 3. The positive and negative ideal solutions of every decision maker can be shown in Table 4.

f) Calculates separation measure as in Table 5. Positive separation measure (S_i^+) as in Eq. 3 can be calculated from a weighted normalized decision matrix (V_{ij}) in Table 3 and V_j^+ is a positive ideal vector (A^+) in Table 4. It has the same calculation for negative separation measure (S_i^-) as in Eq. 4.

Table 3. Weighted normalized decision matrix (V)

Name	Criteria 1	Criteria 2	Criteria 3
Alternative 1	0.070812	0.007527	0.018699
Alternative 2	0.069755	0.020699	0.026179
…			
Alternative 15	0.009512	0.005645	0.108454

Table 4. Positive and negatice ideal solutions of every decision maker

User		Criteria 1	Criteria 2	Criteria 3
1	A+	0.023780001	0.01034966	0.037397884
	A-	0.898355595	0.84679069	0.542269254
2	A+	0.009512441	0.004139866	0.007479576
	A-	0.359342238	0.338716275	0.108453851

Table 5. Separation measure

Name	S_i^+	S_i^-	Sum of S_i^+ and S_i^-
Alternative 1	0.163412921	1.18627581	1.349688727
Alternative 2	0.182037022	1.15128369	1.333320711
…			
Alternative 15	0.504885402	1.20757373	1.712459128

3.2. TOPSIS-BORDA for group DSS

The TOPSIS-BORDA algorithm is selected as an algorithm for group DSS. In Borda, the first alternative in the ranking is given a value greater than the other alternative with the rank position below it as in a pairwise comparison. Table 6 shows the value of Ci+, the rank generated by TOPSIS (step g) and Borda value. The highest rank generated by TOPSIS, the greater the Borda value. For example, there are 15 alternatives, the first rank has 15 for Borda value.

Table 6. C_i^+ 1st decision maker

Name	C_i^+	Rank	Borda Value	C_i^+ × Borda Value
Alternative 1	0.878925476	5	11	9.668180233
Alternative 2	0.863470941	6	10	8.634709409
Alternative 3	0.897669572	3	13	11.66970444
Alternative 4	0.834769632	7	9	7.512926674
Alternative 5	0.831245729	8	8	6.649965832
Alternative 6	0.765597872	11	5	3.827989352
Alternative 7	0.392192275	15	1	0.392192275
Alternative 8	0.766961013	10	6	4.601766078
Alternative 9	0.912930935	1	15	13.69396403
Alternative 10	0.889418187	4	12	10.67301824
Alternative 11	0.666525542	13	3	1.999576619
Alternative 12	0.483363502	14	2	0.966727005
Alternative 13	0.776300562	9	7	5.434103932
Alternative 14	0.897873181	2	14	12.57022453
Alternative 15	0.705169371	12	4	2.820677484

Table 7. Group recommendation

Name	C_i^+ ×Borda Value from 1st decision maker	C_i^+ ×Borda Value from 2nd decision maker	TOPSIS-BORDA	Group Rank
Alternative 1	9.67	9.66	19.32	5
Alternative 2	8.63	8.70	17.33	6
Alternative n	...	....	....	....
Alternative 15	2.82	4.96	7.78	11

Group recommendation can be obtained from the sum of multiplying C_i^+ and Borda value for every decision maker as shown in Table 7. It can be concluded that alternative 14 is highly recommended.

3.3. Testing for TOPSIS and TOPSIS-BORDA

After discussion of the algorithm is conducted, then correlation testing is conducted to test the effectiveness of the proposed algorithm in a mobile-based recommendation application. In the previous study, TOPSIS based mobile DSS [12] for personal DSS showed that there was a relationship between the recommendation and user choice, with correlation value of 0.770769231. But, there the TOPSIS-BORDA correlation testing hasn't conducted yet. Mobile based group DSS with TOPSIS-BORDA [8] only discussed the usability testing of the tourism recommendation application, but there is no further study on its algorithm in detail. Therefore, this research contributes in testing the effectiveness of algorithm. This study will compare the results of correlation testing in TOPSIS [12] and TOPSIS-BORDA. In this study, correlation testing will be conducted on the recommendations of the group produced by TOPSIS-BORDA and personal recommendations for each user produced by TOPSIS as in Table 8. Average of correlation testing for each user recommendation and the group recommendation is 0,8830357143. So, it can be concluded that they have positive correlation.

Table 8. Results of correlation testing

Testing Scenario	The Value of Correlation Testing
User 1 vs group	0.9714285714
User 2 vs group	0.9964285714
User 3 vs group	0.6857142857
User 4 vs group	0.8785714286

4. Conclusion

In the previous study, TOPSIS based mobile DSS [12] for personal DSS showed that there was a relationship between the recommendation and user choice, with correlation value of 0.770769231. But, there the TOPSIS-BORDA correlation testing hasn't conducted yet. Therefore, this research will test the effectiveness of the algorithm. Correlation testing will be conducted on the recommendations of the group produced by TOPSIS-BORDA and personal recommendations for each user produced by TOPSIS. Correlation testing for group DSS showed there is a positive correlation of 0.88 between the recommendations of the group produced by TOPSIS-BORDA and personal recommendations for each user produced by TOPSIS. Future works can be conducted by adding the AR/VR technology for the virtual tourism recommendation because it will be useful for tourism in the pandemic era.

Declaration of Competing Interest
We declare that we have no conflict of interests.

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