Developing web apps based on multi-criteria decision making and user preferences

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Abstract. There are different perspectives on the ideal place for dining, including the taste, parking lot, service, price, and other support facilities. Therefore, accommodating tourist preferences is essential to produce appropriate recommendations since tourists are very subjective and diverse when defining their favorite culinary places. Culinary support systems may help the community to obtain a culinary location recommendation as they please. This study aims to develop a web-based system that provides an appropriate recommendation for gastronomic tourists using the VIKOR method as a ranking advisor. The results showed that the algorithm ensures optimal decision-making based on user and expert assessments.

1. Introduction

Culinary has become an important sector of tourism [1]–[3]. Nowadays, finding information about culinary places is relatively easy because there are already many information systems or applications that provide information about restaurants and other culinary places. However, visitors often face the thing when using the application to get the right restaurant based on their preferences. Visitors will generally choose the restaurant based on food type, price, location, style, and restaurant service. From a geographical point of view, it is also difficult to find existing restaurants based on the address. This problem becomes a hindrance for tourists who have never visited or have lacked knowledge about the areas. The recommendation system can be combined with the mapping of culinary tourism sites; the collected knowledge is not only textual but also interactive or spatial charts. With the increasing development of wireless communication technology, the traditional GIS desktop has a strong tendency to develop cloud computing.

Web GIS is more commonly used for all types of activities. GIS Cloud itself has the benefit of meeting the needs of applications to get geoinformation for anything, wherever, whenever. If a recommendation system is implemented using a location context approach, this restaurant may be recommended by the system due to its proximity. Everyone has a different list of favorite food or taste. Ideally, when choosing food, someone will understand taste or flavor [4]. Several previous studies were carried out using different techniques on the recommendation method, such as conscious context [5], collaborative screening [6]–[8], personal preferences [9]–[13], or a combination. Each of the above techniques has its strength and weakness.

Decision support systems are tools for decision-makers in systems that display information, manipulation, and data modeling without changing decision-makers’ judgment [14]. Decision support
systems can also assess the most suitable culinary tourism locations based on tourists’ criteria. Vise Kriterijumska Optimizacija I Kompromisno Resenje (VIKOR) method focuses on ranking and collecting alternatives used to rank several qualitative and quantitative[15]. Evaluation and selection process based on company requirements against existing alternatives. In this paper, we implement VIKOR on website applications to produce the support decision for selecting culinary locations with several criteria chosen by users, namely distance, facilities, price, rating, parking space, and taste.

2. Methodology
In this stage, the criteria obtained from literature studies would be selected and verified by 50 respondents. This verification is used to identify factors influencing user needs. After confirmation, the derived criteria will be used as the selection criteria for the system’s culinary destinations. Also, the results of gathering data on culinary destinations are used as an alternative in the system. Ten culinary experts will assess all these alternatives.

The system implements a decision support system to compare several restaurants using the VIKOR method. The VIKOR method is used to allow users to determine the comparison weight for restaurant choices. The program will also have an appraisal and review feature for restaurants, where users can provide values and views for the system’s restaurants. The ranking or review value for each restaurant is later used as a reference measure. Therefore, each restaurant’s value of comparable variables is dynamic and up-to-date, based on users’ values and opinions. The geographical location of the restaurant registered in the system is also visualized using the Google Map API. The VIKOR method uses a multi-criteria ranking index based on a certain closeness measure to the ideal solution [16]. The VIKOR method is one method that can be categorized in Multi-Criteria Decision Analysis [17]. This method is handy when decision-makers cannot make choices during the system’s initial design [17].

According to [17], there are seven stages in determining the compromise ranking using the VIKOR process. Positioning steps as follows :

Step 1. Make an alternative decision matrix and criteria (F) with the equation below:

\[
F = \begin{bmatrix}
A_1 \\
A_2 \\
\vdots \\
A_m
\end{bmatrix}
\begin{bmatrix}
C_{x1} & C_{x2} & \ldots & C_{xn} \\
x_{11} & x_{12} & \ldots & x_{1n} \\
x_{21} & x_{22} & \ldots & x_{2n} \\
\vdots & \vdots & \ddots & \vdots \\
x_{m1} & x_{m2} & \ldots & x_{mn}
\end{bmatrix}
\]

Where F is the decision matrix, Ai is the i\textsuperscript{th} alternative, Cj is the j\textsuperscript{th} criterion, and Xij is an alternative response to the criteria.

Step 2. Determine the weights for each criterion. Determine the criteria weights obtained from the user according to the needs or desired criteria. The general formula for the criteria weights is a valid equation:

\[
\sum_{j=1}^{n} w_j = 1
\]

w\textsubscript{j}: the weighting of the criteria j
j: 1,2,3, ..., n is the order number of the attribute or criterion

Step 3. Normalize Ri\textsubscript{j} with the following formula:

\[
N_{ij} = \frac{f_i}{f_i^+ - f_i^-}
\]

f\textsubscript{ij}: Alternative response function i to criterion j
f\textsuperscript{+j}: the best / positive value in one criterion j
f\textsuperscript{−j}: worst / negative value in one criterion j
i: 1,2,3, ..., m is an alternative sequence number
j: 1,2,3, ..., n is the order number of the attribute or criterion
N: Normalized Matrix
Determination of the best / positive \((f_j^+\) and worst / negative \((f_j^-)\) data values or by the term Cost and Benefit in one research variable is determined by the type of data of the higher-the-better or lower-the-better research variable. The values \((f_j^+)\) and \((f_j^-)\) are stated as follows:

\[(4) \quad f_j^+ = \max (f_{1j}, f_{2j}, ..., f_{mj})\]

\[(5) \quad f_j^- = \min (f_{1j}, f_{2j}, ..., f_{mj})\]

**Step 4.** Determine the weighted value of normalized data for each alternative and criterion with the following formula:

\[(6) \quad F_{ij} = w_j \cdot N_{ij}\]

\(F_{ij}\): normalized data values that have been weighted for alternative \(i\) to the criteria \(j\)

\(w_j\): the weight value in the criterion \(j\)

\(N_{ij}\): normalized data values for alternative \(i\) to criterion \(j\)

**Step 5.** Calculate the utility measures \(S_i\) and \(R_i\) as the highest solution and the lowest solution for each alternative, with \(i = 1, 2, ..., n\). The equation as follows:

\[(7) \quad S_i = \sum_{j=1}^{m} \left( w_j \cdot \frac{f_j^+ - f_{ij}}{f_j^+ - f_j^-} \right)\]

\[(8) \quad R_i = \text{Max}_j \left( w_j \cdot \frac{f_j^+ - f_{ij}}{f_j^+ - f_j^-} \right)\]

**Step 6.** Calculate VIKOR index \(Q_i\), with \(i = 1, 2, ..., n\). The equation as follows:

\[(9) \quad Q_i = \left( \frac{S_i \cdot S^+}{S^- \cdot S^+} \right) + \left( 1 - \nu \right) \frac{R_i \cdot R^+}{R^- \cdot R^+}\]

with

\[(10) \quad S^+ = \min_j (S_j), S^- = \max_j (S_j)\]

\[(11) \quad R^+ = \min_j (R_j), R^- = \max_j (R_j)\]

\(V\) is the maximum group utility strategy weighting, while \((1-\nu)\) is the individual regret weight, both of which range from 0 to 1. Generally the value of \(\nu = 0.5\).

**Step 7.** Perform alternative ranking. There are three types of ranking: \(S\), \(R\), and \(Q\) sorted from the smallest value. Propose alternative compromise solution \(A^{(i)}\) that has the best rating by measuring \(Q\) (minimum) if the following two conditions are fulfilled:

**C1. Acceptable advantage**

\[(12) \quad DQ = 1 / (J-1)\]

\[(13) \quad Q(A^{(2)}) - Q(A^{(1)}) \geq DQ\]

where alternative \(A^{(2)}\) is the second rank of \(Q\).

**C2 Acceptable stability in decision making**

Alternative \(A^{(i)}\) must also be ranked the best in ranking \(S\) and \(R\). This compromise solution is stable in the decision-making process, which can be: voting by majority rule (when \(\nu > 0.5\)) or “by consensus “(\(V \approx 0.5\)), or with veto (\(\nu < 0.5\)).

If one of the conditions not fulfilled, then some compromise solutions can be proposed as follows:

- a. Choose alternatives \(A^{(i)}\) and \(A^{(2)}\), if only C2 conditions not fulfilled, or
- b. Choose alternatives \(A^{(i)}, A^{(2)}, ..., A^{(M)}\), if C1 conditions are not fulfilled.

\(A^{(M)}\) is an alternative determined from the relation:

\[(14) \quad Q(A^{(M)}) - Q(A^{(1)}) < DQ\]

where maximum \(M\) is an alternative whose position is in conditions that are close together.

3. Result and Discussion

We create a scenario with a user who enters a keyword for calculation purposes. For instance, the “bakso” keyword would make the system return the restaurant’s data, with the “bakso” in the menu. The user shall manually enter each criterion’s weight, considering that only the user knows the food or restaurant requirements. The criteria and their weight entered by the user are shown in Table 1. After
entering the keyword and the parameters’ weight, the system displays the alternative and its value for each criterion from the database, as shown in table 2. The VIKOR normalizes the alternative using the formula (3). Then subtract the normalized table with the weight of the parameters, as shown in Table 3. Utility measures S, R, and VIKOR index Q Calculate with the formula (7), (8), and (9). The result is shown in table 4. After testing the conditions of C1 and C2 using formulas (12), (13), and (14), it can be concluded that “Bakso PakJan” is the best alternative based on the criteria and weights chosen by the user.

Figure 1 and figure 2 shows a web view of the Culinary Search Decision Support System. In addition to displaying the search results, this website may also display each alternative’s details, including distance and direction.

### Table 1. Weight of Criteria

| Variable | Criteria | Weight(%) |
|----------|----------|-----------|
| C1       | Distance | 30        |
| C2       | Facilities | 20       |
| C3       | Price    | 10        |
| C4       | Rating   | 15        |
| C5       | Parking Space | 10      |
| C6       | Taste    | 15        |

### Table 2. Alternative

| Alternative          | C1 | C2 | C3 | C4 | C5 |
|----------------------|----|----|----|----|----|
| Bakso PakJan         | 9  | 9  | 9  | 10 | 9  |
| Bakso Klenger        | 10 | 7  | 8  | 10 | 10 |
| Bakso Pak War        | 8  | 7  | 9  | 8  | 8  |
| Bakso Solo Rindu Malam | 8 | 8  | 9  | 8  | 8  |
| Bakso Cak Man        | 7  | 7  | 7  | 7  | 7  |

### Table 3. Normalization

| Alternative                      | C1    | C2    | C3    | C4    | C5    | C6    |
|----------------------------------|-------|-------|-------|-------|-------|-------|
| Bakso PakJan                     | 0.100 | 0.000 | 0.000 | 0.033 | 0.000 |
| Bakso Klenger                    | 0.000 | 0.200 | 0.050 | 0.000 | 0.075 |
| Bakso Pak War                    | 0.200 | 0.200 | 0.000 | 0.050 | 0.000 |
| Bakso Solo Rindu Malam           | 0.200 | 0.100 | 0.050 | 0.067 | 0.075 |
| Bakso Cak Man                    | 0.300 | 0.200 | 0.100 | 0.150 | 0.100 |

### Table 4. S, R, and Q result

| Alternative          | S    | R    | Q    | Ranking |
|----------------------|------|------|------|---------|
| Bakso PakJan         | 0.133| 0.100| 0.000| 1       |
| Bakso Klenger        | 0.325| 0.200| 0.361| 2       |
| Bakso Pak War        | 0.517| 0.200| 0.471| 3       |
| Bakso Solo Rindu Malam | 0.542 | 0.200 | 0.486 | 4       |
| Bakso Cak Man        | 1.000| 0.300| 1.000| 5       |

**Figure 1. Weight input**

**Figure 2. Search result**

Black-box testing is used to test the system’s reliability in making recommendations for selecting culinary tourism destinations. Device assessment shall be carried out to assess user satisfaction with decision support systems using MOS (Mean Opinion Score). The users who offer ratings are 20 end-users and five experts. There are five user-assessed categories: usability, functional completeness, accuracy, efficiency, and overall subjective user evaluation (overall). The evaluation results show that the user gives 3 for the accessibility category, 3 for the practical completeness category, and 3.5 for the precision category, 3.5 for the efficiency category, and 3.6 for the overall category. The MOS results
for each category are then recalculated with MOS to obtain the overall device score. Calculations for the full ranking of the program are as follows:

\[
\text{Score of the system} = \frac{3 + 3 + 3.5 + 3.5 + 3.6}{5} = 3.32
\]

From the results of calculating the system score, it was found that five users of the system gave a value of 3.32 from the four scales.

The VIKOR method can help determine the location based on the criteria set and weighted by the user. Users’ parameters include distance, facilities, price, rating, parking space, and taste. The integration of the network and the Geographic Information Systems help provide an excellent interface and easy access because it can be used anywhere and anywhere with various devices and connected to the internet. To compare the accuracy and computational time, we compared the fuzzy TOPSIS method with three criteria: distance, facility, and price. In the VIKOR and TOPSIS methods, the best alternative is chosen based on the alternative that is the furthest from the negative solution and the nearest to the positive solution. This approach is considered the most effective way to produce as much profit as possible and eliminate as much risk as possible. The basic concept of these two methods is to classify existing samples by looking at the utility (S) results, regret (R), and the solution’s distance as the best alternative for each sample. In [3], A mobile-based application has been created to get the best culinary locations based on user preferences. With the same keywords, both systems aim to produce the same first rank/recommendation. In comparison, the proposed VIKOR method computation time is slightly faster than the fuzzy TOPSIS. Table 5 summarizes the results of the analysis of the two processes.

| Method         | Recommendation | Computation time (second) |
|----------------|----------------|---------------------------|
| VIKOR          | Bakso PakJan   | 0.1078                    |
| Fuzzy TOPSIS   | Bakso PakJan   | 0.1092                    |

4. Conclusion

This system assists users in deciding the attractions to be visited by offering culinary location recommendations. The system’s recommendations are derived from analyzing the user’s requirements to make suggestions that meet their criteria. These requirements included distance, facilities, price, rating, parking space, and taste. The apps have a profound effect on culinary goals by recommending food that is in line with the users’ needs and tendencies. In this analysis, the application works with marginal highlights for end-users so that, for further development, it is recommended that this application additionally has a client-based network where all clients can post surveys, feedback, and reviews so that the exposure rating of each alternative can be resolved. This critique can be associated with culinary objectives so that this procedure can be a critical and neutral stage for individuals who need a recommendation for culinary purposes.

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