Comparison of Gap Weighting Methods in a Combination of Profile Matching and Topsis in Decision Support System for Healthy Food Menu

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Abstract. Maintaining health is an important matter for human’s life. There are so many people who do not really concern about their health, moreover they also have a bad dietary habit. A healthy dietary habit itself requires healthy and nutritious foods to be consumed regularly in the form of food menus. This research is conducted to make a decision support system to give users a recommendation of the proper menus to fulfil their daily consumption needs by combining methods of Profile Matching and TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution). The focus of this research is on the comparison of two methods used in gap weighting on Profile Matching. In the first method, gap weighting is done by converting the gap using weighting table. This method is commonly used by researchers. Meanwhile, in the second one, which is more rarely used, gap weighting is done by using a gap weighting formula. The result shows that the later method is able to solve the problem founded on the first one when the density of the data is dense and very dense.

1. Introduction

Maintaining health is an important matter for human’s life. There are so many people who do not really concern about their health, moreover they also have a bad dietary habits. A healthy dietary habits itself require healthy and nutritious foods to be consumed regularly in the form of food menus. In order to help people choose healthy and nutritious foods, we need a decision support system which can help solve that problem. Henceforth, this decision support system (DSS) will be called “DSS Menu”.

There are so many researches about DSS Menu which have been done by many other researchers like what was done by [1] who researched about developing DSS Menu to determine the best dietary menu to help people suffering from anaemia. Meanwhile, [2] conduct a research in order to develop DSS Menu to determine the best dietary menu to help people suffering from diabetics. Both researches used Analytical Hierarchy Process (AHP) and validated by the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS). In this research, we use combination of Profile Matching and TOPSIS to give users healthy menu recommendation with 5 different criteria: nutrition (carbohydrate, protein, and fat), price, and variation. Research about the combination of Profile Matching and TOPSIS has previously been done by [3] who developed a DSS which was able to determine the best type of goat to be bred under certain environmental conditions. The result of this study showed that
three methods above couldn’t be used alone but must be collaborated. AHP was used for weight calculation, Profile Matching was used for environmental evaluation, and TOPSIS was used for alternatives ranking.

In this research, Profile Matching is used to determine the gap weights of the nutrient criteria. Those weights then are processed using TOPSIS along with non-nutrient criteria (Price and Variation) in order to get the rank of healthy menus to be recommended to the users. Based on that case, the research focuses on methods used in gap weighting in Profile Matching. There are two methods used in Profile Matching weighting. The first one is commonly used while the other one is rarely used. The first method begins with defining the range for each variable of the criterion and the gap to weight conversion table. The ideal solution (provided by users) and the alternatives (menus’ criteria) is converted using the range defined before. The gaps between the ideal solution and the alternatives then are calculated and converted using the gap to weight conversion table. Meanwhile, the second method uses a formula to calculate the gap’s weight by mapping the gap into a new range initialized before. This research aims to compare the performance of both methods by testing them using 3 types of datasets with 3 different data densities.

2. Theoretical Background

2.1. Profile Matching
Profile matching is a method that is often used in decision making by assuming that there is an ideal level of predictor variable that must be met by the subjects rather than the minimum level that must be met or skipped [5].

2.2. TOPSIS
TOPSIS is one of some methods in decision making used to solve the problem of Multi Attribute Decision Making (MADM). TOPSIS is based on the concept that the best alternative doesn’t just have the shortest distance from the ideal solution, but also has the longest distance from the ideal solution [4].

TOPSIS requires performance rating $r_{ij}$ for every alternative ($A_i$) on every normalized criteria ($C_j$) which can be written as (1).

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}$$  \hspace{1cm} (1)

Where $i=1,2,\ldots,m$ and $j=1,2,\ldots,n$.

$$D^*_{i} = \sqrt{\sum_{j=1}^{n} (y_{ij}^* - y_{ij})^2}$$  \hspace{1cm} (2)

Where $i=1,2,\ldots,m$
The distance ($D^+_i$) between each alternative ($A_i$) with positive ideal solutions is defined by (2). Meanwhile, the distance ($D^-_i$) between each alternative ($A_i$) with negative ideal solutions is defined by (3).

$$D^+_i = \sqrt{\sum_{j=1}^{n} (y_{ij}^+ - y^-_i)^2}$$

$$V_i = \frac{D^-_i}{D^-_i + D^+_i}$$

The preference score for each alternative ($V_i$) is calculated using (4). Alternative ($A_i$) which has the greatest preference score ($V_i$) will be chosen as the best alternative. So the output of TOPSIS isn’t only the rank of every alternative but also its preference score.

3. Research Methodology

There are some criteria used in this research to determine the healthy menu as people’s needs such as: Nutrition (Carbohydrate, Fat, and Protein), Food Price, and Variety of Food.

3.1. Main Process

There are several processes in the determination of healthy food menu implemented in this decision support system, those are: nutritional criteria weighting using Profile Matching and then generating alternatives ranking based on all criteria’s weights using TOPSIS. This main process is described in Figure 1.

3.2. Gap Weighting on Profile Matching

In this research, Profile Matching is performed to get the weights from the gaps between user’s criteria and alternatives’ criteria. The smaller the gap, the higher the weight. These gaps then will be used as feeds for TOPSIS [6].

Gap weighting on this research is obtained using two different methods explained below.
3.2.1 The First Method. The first method is the most common method used in obtaining the gap, as done on [7], [8], and [9], where the criteria’s values are converted to the weights using ranges defined before by users. Gap then are calculated using (5).

\[
\text{Gap} = \text{Attribute’s Value} - \text{Target’s Value}
\]  \hspace{1cm} (5)

After obtaining the gap, the gap then is converted to the weight using the gap to weight conversion table that has been defined before. The example of this table can be seen in Table 1.

**Table 1.** Gap to Weight Conversion Table

| Num | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  |
|-----|----|----|----|----|----|----|----|----|----|
| Gap | 0  | 1  | -1 | 2  | -2 | 3  | -3 | 4  | -4 |
| Weight | 5  | 4.5| 4  | 3.5| 3  | 2.5| 2  | 1.5| 1  |

The flow of the first method starting from the initial criterion’s values to the gap weighting process is illustrated in Figure 2 below.

![Figure 2. First Method’s Flow](image)

3.2.2 The Second Method. The flow of this method starting from the initial criterion’s values to the gap weighting process is illustrated as in Figure 3. The result of the gap weighting step shown by Figure 3 is the gap weights that will be used as feeds for TOPSIS.

![Figure 3. Second Method’s Flow](image)

The result of the gap weighting step shown by Figure 2 is the gap weights that will be used as feeds for TOPSIS.
If we see the Figure 3, there is a difference between the first method and the second method. The first method uses Data Range Conversion Table in order to get the value needed for gap calculation. This value then are calculated using (5) in order to get the gap. The gap then are converted using “gap to weight conversion table” like the example showed by Table 1 to get the weight.

Meanwhile, the second method uses a formula which is used by Primasari, etc. in [3] in order to get the weight. There is no data range conversion table and gap to weight conversion table which are needed in the first method. The second method’s formula is shown in (6).

\[
y = \begin{cases} 
\frac{x - x_a}{x_1 - x_a} (y_2 - y_1) + y_1, & \text{if } x_a \leq x \leq x_1 \\
\frac{x - x_2}{x_b - x_2} (y_2 - y_1) + y_2, & \text{if } x_1 \leq x \leq x_2 \\
\frac{x - x_b}{x_2 - x_b} (y_1 - y_2) + y_2, & \text{if } x_2 \leq x \leq x_b 
\end{cases}
\]

(6)

Where:

- \(y\) is gap score to be found,
- \(y_1\) is minimum score gaps,
- \(y_2\) is maximum score gap,
- \(x\) is alternative value,
- \(x_a\) is minimum value,
- \(x_b\) is maximum value,
- \(x_1\) is minimum ideal value,
- \(x_2\) is maximum ideal value.

3.3 Testing Scheme

Weighting methods comparison, in a big system scheme, is performed in the section shown by the red area in Figure 4.
Figure 5 shows several processes inside the red area shown by Figure 4. As described previously, there are two methods that can be used in gap weighting which in the next process will be used as feeds for TOPSIS. These two methods will be compared to find out the difference in the results given by both of this methods in the combination of Profile Matching and TOPSIS.

Both methods are tested with 2 datasets which have different data densities. The first dataset contains data whose density is normal, it means that the distance between the data is so wide. The second dataset contains data whose density is dense with the distance between the data is only 1. While the third dataset contains data whose density is very dense with distance between the data is only 0.1.

In order to compare the performance of these two methods, we will compare the rank of menus and the preference score resulted by TOPSIS (see Figure 4). The result will show the ability of these two methods in handling data with different density.

4. Result and Discussion

Comparison were done by testing each method and its effect on Profile Matching and TOPSIS.

4.1 Dataset

There are 3 main datasets which act as alternative’s nutritional criteria on Profile Matching (see Figure 4). These 3 datasets, which have different data density, will be used both on the first method testing and the second method testing.

Table 2. The First Dataset

| Menu   | Criteria’s Values |   |
|--------|-------------------|---|
|        | Carbohydrate      | Protein | Fat |
| Menu 1 | 66.7              | 24.2    | 4.6 |
| Menu 2 | 59                | 19.3    | 12.3|
| Menu 3 | 44.6              | 24.4    | 5.2 |
| Menu 4 | 91.77             | 22.85   | 3.61|
| Menu 5 | 69.7              | 24.7    | 1  |

Table 3. The Second Dataset

| Package | Menu | Criteria’s Value |   |
|---------|------|------------------|---|
|         | Menu | Carbohydrate     | Protein | Fat |
|         | Menu 1 | 79.2         | 4.3     | 3.3 |
|         | Menu 2 | 78.2         | 4.3     | 3.3 |
|         | Menu 3 | 77.2         | 4.3     | 3.3 |
|         | Menu 4 | 76.2         | 4.3     | 3.3 |
|         | Menu 5 | 75.2         | 4.3     | 3.3 |
|         | Menu 6 | 74.2         | 4.3     | 3.3 |

The first dataset, shown by table 2, contains menus whose data density is normal. While the second dataset which is shown by table 3 contains data whose density is dense. As we can see in Table 3, the difference between menu 1 and menu 2, menu 2 and menu 3, and so on, in the second dataset on the carbohydrate column is only 1.
Meanwhile, the third dataset contains data whose density is very dense. The third dataset is shown by Table 4.

| Package Menu | Criteria’s Value |  |
|--------------|------------------|---|
|              | Carbohydrate     | Protein | Fat  |
| Menu 1       | 79.2             | 4.3      | 3.3  |
| Menu 2       | 79.1             | 4.3      | 3.3  |
| Menu 3       | 79               | 4.3      | 3.3  |
| Menu 4       | 78.9             | 4.3      | 3.3  |
| Menu 5       | 78.8             | 4.3      | 3.3  |
| Menu 6       | 78.7             | 4.3      | 3.3  |

Table 4. The Third Dataset

As we can see in Table 4, the difference between menu 1 and menu 2, menu 2 and menu 3, and so on, in the second dataset on the carbohydrate column is only 0.1.

Meanwhile, if we see Figure 4, beside 3 datasets explained before, we also need user’s nutritional criteria as Profile Matching’s targets. This user’s nutritional criteria is shown by Table 5.

### 4.2 TOPSIS’ Preference Data
As we can see in Figure 4, TOPSIS needs user’s preference and variation’s - price’s value in order to perform the ranking process. Table 6 shows variation’s and price’s preference and Table 7 shows the user’s preference.

| Variation | Price |
|-----------|-------|
| Non-Profile-Matching Criteria | 4 | 10000 |

Table 5. User’s Preference

| User’s Preference | Carbohydrate | Protein | Fat |
|-------------------|--------------|---------|-----|
| User              | 79.2         | 4.3     | 3.3 |

Table 6. Variation’s and Price’s Value

The first method needs data range conversion table like what we can see on Figure 2. There are 3 conversion tables needed, those are range conversion for carbohydrate, protein, and fat.

Range conversion tables for carbohydrate, protein, and fat are shown by Table 8, 9, and 10. As we can see on the Table 8, the data range of carbohydrate for every criteria score is 10 with the minimum
value is 30 and the maximum value is 200. For protein and fat, the data range for every criteria score is 3 with the minimum value is 5 and the maximum value is 50.

Table 8. Carbohydrate’s Range Conversion Tables

| Range  | Criteria Score |
|--------|----------------|
| <30    | 1              |
| >=30<40| 2              |
| >=40<50| 3              |
| …      | …              |
| >=200  | 19             |

Table 9. Protein’s Range Conversion Tables

| Range  | Criteria Score |
|--------|----------------|
| <5     | 1              |
| >=5<8  | 2              |
| >=8<11 | 3              |
| …      | …              |
| >=50   | 17             |

Table 10. Fat’s Range Conversion Tables

| Range  | Criteria Score |
|--------|----------------|
| <5     | 1              |
| >=5<8  | 2              |
| >=8<11 | 3              |
| …      | …              |

4.3 Testing

4.3.1 First Method Testing

Table 11. First Method Testing Using the First Dataset Result

| Rank | Menu | Preference Score |
|------|------|------------------|
| 1    | Menu 4 | 0.91086600478919 |
| 2    | Menu 1 | 0.84161366880374 |
| 3    | Menu 3 | 0.80015463857309 |
| 4    | Menu 5 | 0.69974687186652 |
| 5    | Menu 2 | 0.33750445363993 |
| 6    | Menu 6 | 0.33286369114225 |

Table 12. First Method Testing Using the Second Dataset Result

| Rank | Menu | Preference Score |
|------|------|------------------|
| 1    | Menu 4 | 0              |
| 2    | Menu 1 | 0              |
| 3    | Menu 3 | 0              |
4.3.1.1 First Method Testing Using The First Dataset. On the first test to the first method, we use the first dataset to test the performance of the first method in handling the problem in the first dataset. Table 11 shows the result of this test. This result includes rank of menus and preference score as the result of TOPSIS (see Figure 4).

As we can see in Table 11, the first method can handle the problem in the first dataset well. It is proved by the ability of the first method to give the output.

4.3.1.2 First Method Testing Using The Second Dataset. The first method then is tested using the second dataset. The result of this test is shown by Table 12. Table 12 shows that the first method fails to solve the data density problem in the second dataset. This is because all values in each criterion are classified in the same class. Then it makes the gap’s value same too and as the result TOPSIS isn’t able to rank them.

4.3.2 Second Method Testing

Table 13. Second Method Testing Using the First Dataset Result

| Rank | Menu   | Preference Score |
|------|--------|-----------------|
| 1    | Menu 4 | 0.5981773002551 |
| 2    | Menu 1 | 0.58347390018647 |
| 3    | Menu 3 | 0.56740170567358 |
| 4    | Menu 5 | 0.47501883182487 |
| 5    | Menu 2 | 0.44226065479088 |
| 6    | Menu 6 | 0.40211874834788 |

Table 14. Second Method Testing Using the Second Dataset Result

| Rank | Menu   | Preference Score |
|------|--------|-----------------|
| 1    | Menu 1 | 1               |
| 2    | Menu 2 | 0.8             |
| 3    | Menu 3 | 0.6             |
| 4    | Menu 4 | 0.4             |
| 5    | Menu 5 | 0.2             |
| 6    | Menu 6 | 0               |

Table 15. Second Method Testing Using the Third Dataset Result

| Rank | Menu   | Preference Score |
|------|--------|-----------------|
| 1    | Menu 1 | 1               |
| 2    | Menu 2 | 0.7999999999998 |
| 3    | Menu 3 | 0.5999999999999 |
| 4    | Menu 4 | 0.4000000000001 |
| 5    | Menu 5 | 0.1999999999999 |
| 6    | Menu 6 | 0               |
4.3.2.1 Second Method Testing Using The First Dataset. We then test the second method using the first dataset. The result of this test is shown by Table 13. Then if we compare the result, showed by Table 12 above, with the result of the first method showed by Table 11, there is a difference in the ranking results between the first method and the second method. This is due to the different methods of data conversion and the method of gap weighting. The difference between these two methods causes these two methods to produce different gap weights.

4.3.2.2 Second Method Testing Using The Second Dataset. The second method then is tested using the second dataset to know its performance in handling the problem in the second dataset. The result of this test is shown in Table 14.

From Table 14, we can see that the second method is capable of solving the data density problem in the second dataset. We can see that the result is also correct because menu 1 is the closest menu compared to the user preference, which is followed by Menu 2, Menu 3 and so on.

4.3.2.3 Second Method Testing Using The Third Dataset. To see the performance of the second method in handling the data whose density is very dense, we test the second method using the third dataset. The result of this test is shown by Table 15.

Table 15 shows that the second method is capable of solving the data whose density is very dense with the difference between the data is only 0.1.

5. Conclusion

Some conclusions which is obtained in this research are as follows:

1. At data whose density is normal, both gap weighting methods are capable of performing the ranking process, although there is a difference between the results of the two methods due to the different methods of gap weighting.

2. At data whose density is dense and very dense, the first method is incapable of performing the ranking process because all values in each criterion are classified into the same range. Meanwhile, the second method is success to solve the problem and able to perform the ranking process.

6. References

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