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Development of a Smartphone Recommendation System Based on the TOPSIS Method for Multi-Criteria Selection

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ABSTRACT

The rapid development of smartphone technology presents a variety of options for consumers, making purchasing decisions increasingly complex. This research aims to design a decision support system based on the TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method. The system is designed to help consumers choose smartphones based on criteria such as camera, battery, price, RAM, and performance. The research process involves collecting data through interviews, observations, and literature studies; determination of criteria; normalization of the matrix; weighting; and calculation of preference values. The results showed that the TOPSIS method was effective in providing accurate and relevant recommendations, with Xiaomi Mi Note 10 as the best choice in this study. The system proved to be efficient and satisfying to the users, although improvements to the interface and additional features were suggested for further development. This study proves that the TOPSIS method can be applied efficiently in the context of smartphone selection, providing real benefits for consumers in choosing the product that best suits their needs and preferences.

Keywords: recommendation system; TOPSIS method; Multi-criteria selection

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INTRODUCTION

The rapid development of technology in the smartphone world in recent years has opened up many options for consumers (Febriani & Dewi, 2019; Timbowo, 2016). Hundreds of smartphone models with various features and specifications are now present on the market (Syahputra, 2023). This of course makes consumers more confused in deciding the right choice. Therefore, a support system is needed that can guide consumers in determining which smartphone best suits their wants and needs (Bhalqis, 2020).

The decision to choose the right smartphone is becoming increasingly complex as consumers must consider various aspects, such as performance, camera quality, battery capacity, price, and durability of the device (Citra et al., 2024; Jakaria et al., 2024; Rahman, 2013), Limited information or inability to evaluate specifications make consumers make less than optimal decisions. Therefore, a decision support system is needed that can help consumers assess and choose smartphones based on relevant criteria (Fahlevi & Putri, 2022).

One effective method for dealing with multi-criteria decision-making problems is*Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)*. This method identifies the best alternative based on the closest distance from the positive ideal solution

and the furthest distance from the negative ideal solution. TOPSIS has proven to be efficient and simple in its application, so it is often used in purchase recommendations, including in the selection of smartphones (Boys, 2022). Using TOPSIS to recommend gaming smartphones, this method is to help buyers choose a smartphone based on eight main criteria (Hertyana & Rahmawati, 2020).

The application of the TOPSIS method in the decision support system aims to provide recommendations that are more accurate, relevant, and in accordance with consumer needs (Panjaitan et al., 2021; Rozi et al., 2019; Setiawan et al., 2024). By using data-driven algorithms, the system is able to process information from various alternatives to produce the most appropriate smartphone ranking. As a result, consumers can make more informed decisions, save time, and maximize the benefits of their chosen devices (Simanjuntak et al., 2024).

METHOD

This study aims to create a decision support system (SPK) in choosing a smartphone using *the TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution)* ***method.*** The following are the stages in the research method:

1. **Data Collection**

   This stage is the first step to ensure that the research has an accurate and relevant data base. Methods used include:

   a. Interview: Researchers speak directly with potential buyers to understand the key criteria they consider important when buying a smartphone. For example, a potential buyer might prefer a camera or battery life (Hertyana & Rahmawati, 2020).
   b. Observation: Researchers directly observe the behavior of potential buyers, such as how they compare products or what information they frequently search for (Fitriansyah et al., 2022).
   c. Literature Studies: Researchers read references from scientific journals, books, or other related documents, such as information about the TOPSIS method and the technical criteria of smartphones.

2. **Determination of Criteria and Alternatives**

   Criteria are the factors used to evaluate alternatives, while alternatives are smartphone choices to be assessed (Ardiansyah et al., 2024).

   a. Criteria: From the data collected, the researcher established 8 main criteria:
      1) Front Camera: Front camera resolution.
      2) Rear Camera: The resolution of the rear camera.
      3) Price: The cost of purchasing a smartphone.
      4) RAM: Memory capacity to support performance.
      5) ROM: Internal storage capacity.
      6) Processor: CPU type and speed.
      7) Battery Capacity: Battery life in mAh.
      8) Warranty: After-sales guarantee (official or distributor warranty).

b. Alternative: An alternative is a list of smartphones to be evaluated. This smartphone was selected based on popularity or initial recommendations, for example Vivo V19, Xiaomi Mi Note 10, and others (Boys, 2022).

3. Analysis Process with the TOPSIS Method

The TOPSIS method is used to determine the best alternative by comparing the distance of each alternative to the ideal solution (best) and the anti-ideal solution (worst) (Digita et al., 2023). Here are the steps:

Creating a Decision Matrix: All alternatives are recorded in a table based on criteria. For example:

Front Camera: 32 MP (score 4), 16 MP (score 3).

Price: <2 million (score 5), >8 million (score 1).

a. Decision Matrix Normalization: Normalization is done so that each criterion has a uniform scale. Normalization formula:

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

Explanation:

- x_{ij}: Is the original data value for the *element to -i* on the variable or attribute to *-j*.
- $\sum_{i=1}^{m} x_{ij}^2$: Shows the sum of the squares of all the values of *the xij* element in a single column (variable to *-j* from a dataset that has *m* rows.
- $\sqrt{\sum_{i=1}^{m} x_{ij}^2}$: The square root of the sum of the squares of the elements. This is used to calculate the length (or magnitude) of the vector of that column.
- r_{ij}: It is the normalized value of *xij*. This value is obtained by dividing *xij* by the magnitude (or length) of the vector of that column.
- For example, if the resolution of the front camera of a smartphone is 32 MP, its normalization is calculated based on the maximum value in the criterion.

b. Calculating the Weighted Normalized Decision Matrix: The normalized results are multiplied by the weights of each criterion. For example, if the rear camera has a weight of 4, then the normalized value is multiplied by 4.

c. Determining Positive and Negative Ideal Solutions:
Positive Ideal Solution: Best value for each criterion, e.g. maximum camera resolution.
Negative Ideal Solution: Worst value for each criterion.

d. Calculating Solution Distance
Positive solution distance:

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

Component Description:

- D_i^+: The distance of the alternative to -*i* to the positive ideal solution (PIS) measures how far alternative *i* is from the best condition.
- v_{ij}: Weight normalization value for alternative to -*i* in criterion - *j* Usually this value is the result of normalization of the original data that has been multiplied by the criterion weight.
- v_j^+: The positive ideal solution for criterion to –*j* This is the best value of each criterion (for example, the maximum value for the benefit criterion or the minimum value for the cost criterion).
- $\sum_{j=1}^{n}$: Summing is done for all criteria (*j* = 1, 2, ..., *n*).
- $(v_{ij} - v_j^+)^2$: The difference between the square of the alternative normalization value to -*i* and the positive ideal solution for each criterion.
- $\sqrt{\cdots}$: The square root of the total difference of squares is used to calculate the Euclidean distance.

Negative solution distance:

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

Explanation:

- D_i^-: Expressing the distance of the alternative *i* to the negative ideal solution the smaller the value v_{ij}: the closer the alternative to the negative solution.
- v_{ij}: Value the criterion to -*j* for the alternative to -*i*.
- v_j^-: The negative ideal value for criterion *to j* in the TOPSIS method, v_j^-: is usually the worst value for criterion *j*.
- n: The number of criteria in decision-making.
- $\sum_{j=1}^{n}$: Summing for all *criteria j* (from *j* = 1 to *n*).

- $(v_{ij} - v_j^-)^2$: Measure the square of the difference between the value of the alternative criterion $i\,(v_{ij})$ and the negative ideal solution (v_j^-).

e. Calculating the Preference Value: The preference value is calculated by the formula:

$$P_i = \frac{D_i^-}{D_i^+ + D_i^-}$$

The alternative with the highest Pi value is the best.

Explanation:

- P_i: The relative preference value of the alternative to -*i* value Pi is in the range [0, 1] The larger the Pi, the better the alternative (closer to the positive ideal solution).
- D_i^-: The alternative distance to -*i* from the **negative ideal** solution (worst value for each criterion).
- D_i^+: The alternative distance to -*i* from the **positive ideal** solution (the best value for each criterion).
- $D_i^+ + D_i^-$: The total sum of the distances from the ideal solution is positive and negative. It is a normalization to ensure Pi is of relative value.

f. Ranking: Once the preference value is calculated, all alternatives are ranked from highest to lowest value.

RESULTS AND DISCUSSION

This study uses interviews, observations, and literature studies to understand the preferences of potential buyers in choosing smartphones. Through interviews, researchers explore the needs of diverse users, ranging from priorities on gaming performance, camera quality, to affordable prices. Data is collected from a variety of user backgrounds to ensure diversity in preferences. Observations were made by observing the behavior patterns of potential buyers on e-stores and e-commerce platforms, including their habits of reading reviews and comparing features before making a purchase decision. Meanwhile, literature studies are the foundation for understanding the TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) method used in the recommendation system, as well as in updating information related to the latest smartphone technical specifications. Case studies from similar studies are also used to strengthen the analysis and devise relevant frameworks. The combination of these three approaches is expected to provide a comprehensive picture of the factors influencing

smartphone purchasing decisions and help in designing an effective and accurate recommendation system.

Assessment Criteria

1. Main Criteria: Front Camera (resolution in MP), Rear Camera (resolution in MP), Price (in the IDR range), RAM (capacity in GB), ROM (capacity in GB), Processor (chipset type), Battery Capacity (mAh), Warranty (term and type: official or distributor).

Table 1. Main Device Criteria

Alternative	Front Camera (MP)	Rear Camera (MP)	Price (Million Rp)	RAM (GB)	ROM (GB)	Processor	Battery (mAh)	Warranty (Years)
Vivo V19	32	48	5	8	128	Snapdragon 712	4500	1
Xiaomi Mi Note 10	32	108	7	6	128	Snapdragon 730G	5260	2
Samsung A71	32	64	6	6	128	Exynos 9611	4500	1

2. Assessment Weight: Weights are given based on the results of the interview survey, for example: Rear Camera (30%), Battery Capacity (25%), Price (20%), and the rest is distributed to other criteria.

Smartphone Alternatives

1. Smartphone List: Use a list of popular smartphones on the market in the year of study (e.g. Vivo V19, Xiaomi Mi Note 10, Oppo Reno 5, Samsung Galaxy A72). Data is taken based on user reviews and specifications from the manufacturer's official website or trusted e-commerce.
2. Alternative Characteristics: Each smartphone is recorded complete with specifications according to the criteria, for example the Vivo V19 has a 32 MP Front Camera, 8 GB RAM, 128 GB ROM, 4500 mAh Battery Capacity, Price IDR 4,000,000.

TOPSIS Method Steps

1. Decision Matrix: The raw data of the specification of each alternative is recorded in a table based on criteria. For example: Vivo V19 (32 MP front camera, 48 MP rear camera, price IDR 4,000,000).
2. Matrix Normalization: The data on each criterion is adjusted to have a scale of 0-1. For example, the 32 MP Front Camera value is normalized against the maximum value of 44 MP, resulting in 32/44 = 0.727.
3. Matrix Weight: The normalization value on each criterion is multiplied by the set weight (example: Rear Camera is 30% weighted, normalized value is 0.8, so the weighted score = 0.8 × 0.3 = 0.24).

Table 2. Weight Matrix Device

Alternative	Front Camera	Rear Camera	Price	RAM	ROM	Processor	Battery	Warranty
Vivo V19	0.12	0.10	0.08	0.14	0.14	0.12	0.10	0.04
Xiaomi Mi Note 10	0.12	0.12	0.10	0.11	0.14	0.12	0.12	0.08
Samsung A71	0.12	0.14	0.09	0.11	0.14	0.10	0.10	0.04

4. Positive/Negative Ideal Solution: The maximum (positive ideal) and minimum (negative ideal) values of each criterion are specified. For example, the ideal solution for the Front Camera is 44 MP, while the negative solution is 8 MP.
5. Solution Distance: Calculates the distance from each alternative to the positive and negative ideal solution using the Euclidean distance formula.
6. Assess Preferences: The preference value is calculated by comparing the distance from the positive and negative solutions, resulting in a score in the range of 0-1. The alternative with the highest score is the best recommendation.

Test and Evaluation Results

1. System Functions: The system is tested using alternative data to ensure all features run smoothly, including input processing, TOPSIS calculations, and recommendation results.
2. Processing Speed: The system processes data in seconds even though the number of alternatives and criteria is quite large, demonstrating the efficiency of the algorithm.
3. Algorithm Accuracy**:** The results of the recommendations are compared to manual calculations using the TOPSIS method. The system shows identical results to manuals, ensuring the algorithm is applied correctly.
4. User Satisfaction**:** Surveys are conducted on users to measure satisfaction with recommendations. The majority of respondents were satisfied, although some proposed improvements to the user interface and additional criteria filter features.

Alternative Ranking

Here is an alternate order based on the highest to lowest preference values:

Table 3. Alternative order based on highest to lowest preference values

Alternative	**Positive Distance (D+)**	**Negative Distance (D-)**	**Preference Value (P)**
Xiaomi Mi Note 10	0.0520	0.1183	0.6946
Samsung A71	0.0953	0.0509	0.0375
Vivo V19	0.1245	0.0375	0.2314

The 3. ini table shows the order of preferences based on the highest to lowest scores. Xiaomi Mi Note 10 is in first place with the highest score. The best alternative based on

preference value is **the Xiaomi Mi Note 10** with the highest preference value (0.6946). As calculated in the following table:

CONCLUSION

Based on the results and discussion, it can be concluded that this study develops a decision support system (SPK) to help users choose a smartphone that suits their needs using the TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) method. This method was chosen because of its ability to evaluate various alternatives based on certain criteria, such as camera quality, battery capacity, price, RAM, and overall performance. The system development process involves a series of steps ranging from data collection, determination and normalization of criteria, weighting, to calculation of preference values for each smartphone alternative.

The results showed that the system was able to provide accurate and relevant recommendations, with the Xiaomi Mi Note 10 voted the best smartphone in the study. SPK based on TOPSIS has proven to be effective, fast, and makes it easier for users to make purchase decisions. Nonetheless, the study also identified several areas that needed improvement, such as a more intuitive user interface (UI) and the addition of more specific criteria filter features.

Overall, this study proves that the TOPSIS method can be applied efficiently in the context of smartphone selection, providing real benefits for consumers in choosing the product that best suits their needs and preferences. With further development, the system has the potential to be widely adopted in the e-commerce and e-retail industries, supporting a better and more informed shopping experience for users.

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