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# A Spectrum of Intelligent System Concerned with the Ranking of Hotels

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**Abstract:** *Selecting an appropriate hotel for tourists has become an increasingly complex decision-making task due to multiple influencing factors. In practice, many tourists rely on online travel service platforms such as Agoda, Skyscanner, and MakeMyTrip to select hotels based on photographs and customers reviews.*

*To address this challenge, the present study proposes an intelligent hotel ranking framework using the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). The decision variables are cost, location, amenities, service quality, ratings, cleanliness, hotel quality, hotel feedback, hotel ambience, hotel advertising and customer reviews. The proposed method provides a ranking of hotels for a given tourist destination. Further, to examine the robustness and sensitivity of the proposed intelligent system, Positive Ideal Solution (PIS) and Negative Ideal Solution (NIS) are computed using different distance measures, including Euclidean, Hamming and Cosine distances to determine hotel rankings.*

**Keywords:** Tourist hotel, TOPSIS, Euclidean distance, Hamming distance, Cosine distance

## 1. Introduction

Tourism in India is one of the largest and fastest-growing industries, contributing around 5.8% to the country's GDP and supporting millions of jobs across various sectors. The country's diverse landscape, ranging from the Himalayan mountains to tropical beaches, along with its rich history, art, architecture, and festivals, makes it a global tourist destination. India attracts both domestic and international tourists, offering experiences in cultural tourism, adventure tourism, medical tourism, and eco-tourism. Historically, organized tourism in India began during the British period, with the establishment of infrastructure such as Dak Bungalows and the Archaeological Survey of India to preserve and promote heritage sites.

Over the last 75 years, the way hotels are evaluated and ranked has undergone significant changes as the tourism and hospitality industry has grown and diversified. In the 1950s and 1960s, hotel evaluation was primarily based on basic infrastructure and physical facilities, including the number of rooms, cleanliness, restaurant availability, and essential guest services. Early formal classification systems, developed by organizations such as the American Automobile Association and Forbes Travel Guide, introduced structured star and diamond rating systems, where hotels were primarily judged based on tangible amenities and operational standards. As tourism expanded during the 1970s to 1990s, the focus gradually shifted toward service quality and customer experience, emphasizing aspects such as staff responsiveness, reliability, comfort, and overall guest satisfaction. This shift reflected the growing realization that a hotel stay is not only about facilities but also about the quality of hospitality provided to guests.

With the rapid advancement of internet technology and digital tourism platforms in the 2000s, the process of selecting a hotel underwent a dramatic change. Today, travellers have access to a large amount of information through online travel agencies and meta-search platforms. Websites such as Agoda, Skyscanner, MakeMyTrip and etc enable tourists to easily compare hotels based on cost, location, amenities, service quality, ratings, cleanliness, hotel quality, hotel feedback, hotel ambience, hotel advertising and customer reviews.Most of the time tourists of cheated specially in average class hotel that's why we thought to fuse respective input variables. These platforms also serve as important channels for hotel promotion and advertising, where hotels attract potential guests through special offers, promotional discounts, and enhanced online visibility. As a result, modern tourists typically evaluate hotels from multiple perspectives simultaneously, including price affordability, brand reputation, service quality, safety, accessibility, and online customer reviews.

Several researchers have contributed to the development of intelligent ranking systems in 2020, Srivastava Pankaj and Srivastava Saurabh [1] evaluated the options designed by the system using fuzzy TOPSIS, and the robustness of the ranking system was also examined. Haifei et al. [2] combined sentiment analysis with a neural network to enhance ranking accuracy based on customer reviews. Manish et al. [3] applied fuzzy logic to integrate qualitative and quantitative factors for hotel ranking. Kabir et al., Sidorov et al., Zhang et al., Chakraborty et al., Zhang, L. et al., Almeida et al., Wang et al., Bhattacharya, Opricovic et al., Hwang et al., [4–13] utilized TOPSIS, to optimize hotel rankings by considering traveller preferences. These studies highlight the effectiveness of computational intelligence in hotel ranking systems.

The contribution of this study is the development of a multi-distance TOPSIS-based decision-support framework for hotel evaluation using real-world crisp data from hotel websites. Unlike conventional approaches that rely on a single distance, the proposed method integrates multiple distance measures to enhance ranking accuracy, reliability, and discrimination among alternatives, making it more practical for real hospitality decision environments and giving hotel managers insights to improve service, competitiveness, and customer satisfaction.

## 2. Material and Methodology

In order to process, we follow the computational procedure with TOPSIS;

**2.1 Decision Matrix**:- A decision matrix is a systematic tool used to assess and compare multiple options by considering various factors.

Let *m* and *n* represent the number of options and factors, respectively, and let $p_{ij}$ denote the performance of option *i* under factor *j*. i.e. $[p_{ij}]_{m\times n}$ , *i* = 1,2,...,*m* and *j* = 1,2,…,*n*.

**2.2 Normalized Decision Matrix**:- A normalized decision matrix is an essential tool in the decision-making process, particularly in multi-factor decision-making (MFDM), where multiple options are assessed based on various factors. The normalized value $\boldsymbol{n_{ij}}$ for each element of the matrix is evaluated as:

$$\boldsymbol{n_{ij}} = \frac{\boldsymbol{p_{ij}}}{\sqrt{\sum_{i=1}^{m} \boldsymbol{p_{ij}}^2}}, \quad i=1,2,...,m \text{ and } j=1,2,...,n$$

**2.3 Weighted Normalized Matrix**:

It refers to the relative importance or priority assigned to a particular factor when evaluating different options. They are evaluated as;

$$v_{ij} = n_{ij} \times w_j \qquad i = 1,2,\dots,m \text{ and } j=1,2,\dots,n$$

**2.4 Positive Ideal Solution**:

For benefit factors (where higher values are better), the ideal value is the maximum of all weighted normalized values; $v_j^+ = \max(v_{ij})$, for $j = 1,2,....,n$

For cost factors (where lower values are better), the ideal value is the minimum of all the weighted normalized values; $v_j^+ = \min(v_{ij})$, for $j = 1,2,...,n$

**2.5 Negative Ideal Solution:**

For benefit factors, the negative ideal value is the minimum of all the weighted normalized values;

$$v_j^- = \min(v_{ij}), \qquad \text{for } j = 1,2,...,n$$

For cost factors, the negative ideal value is the maximum of all the weighted normalized values;

$$v_j^- = \max(v_{ij}), \qquad \text{for } j = 1,2,....,n$$

**Geometric Distance**

a. **Euclidean Distance:** The proximity of each option to both the optimal and least favorable solutions using Euclidean distance,

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

$$D_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2}, \quad i=1,2,...,m$$

b. **Hamming Distance:** The proximity of each option to both the optimal and least favorable solutions using Hamming distance,

$$D_i^+ = \sum_{j=1}^{n} |v_{ij} - v_j^+|, \quad i=1,2,...,m$$

$$D_i^- = \sum_{j=1}^{n} |v_{ij} - v_j^-|, \quad i=1,2,...,m$$

c. **Cosine Distance:** The proximity of each option to both the optimal and least favorable solutions using Cosine distance,

$$D_i^+ = 1 - \frac{\sum_{j=1}^{n} v_{ij} \cdot v_j^+}{\sqrt{\sum_{j=1}^{n} v_{ij}^2} \sqrt{\sum_{j=1}^{n} {v_j^+}^2}}, \quad i=1,2,...,m$$

$$D_i^- = 1 - \frac{\sum_{j=1}^{n} v_{ij} \cdot v_j^-}{\sqrt{\sum_{j=1}^{n} v_{ij}^2} \sqrt{\sum_{j=1}^{n} {v_j^-}^2}}, \quad i=1,2,...,m$$

where, $$D_1^+ = 1 - \frac{v_{11} \cdot {v_1}^+ + v_{12} \cdot {v_2}^+ + \dots + v_{1n} \cdot {v_n}^+}{\sqrt{{v_{11}}^2 + {v_{12}}^2 + \dots + {v_{1n}}^2} \sqrt{{v_1^+}^2 + {v_2^+}^2 + \dots + {v_n^+}^2}}$$

Similarly, for other options.

## 3. Algorithm of the TOPSIS Method

Input: Number of options (tourist hotels) ($m$)

1) $H_i$ , i = 1,2,...,$m$
2) i ← 1

Input: Number of factors ($n$)

1) $F_j$ , j = 1,2,....,$n$
2) j ← 1

Input: Weights of factors ($n$)

1) $w_j$ , j = 1,2,....,$n$
2) j ← 1

Output: Order of preference of tourist hotels

Step 1: Construct decision matrix-

$$C = [p_{ij}]_{m\times n}, \quad \text{where } i=1,2,....,m \ \& \ j=1,2,...,n$$

Step 2: Normalization decision matrix-

The normalized value $n_{ij}$ for each element of the matrix is evaluated as:

$$n_{ij} = \frac{p_{ij}}{\sqrt{\sum_{i=1}^{m} p_{ij}^2}}, \quad i=1,2,...,m \ \& \ j=1,2,...,n$$

Step 3: Weighted normalized decision matrix

The weighted normalized decision matrix is given by

$$v_{ij} = n_{ij} \times w_j \quad , i = 1,2,...,m \text{ and } j=1,2,...,n$$

Step 4: Selection of positive and negative ideal solution

Positive ideal solution

For benefits factors

$$v_j^+ = \max(v_{ij}), \quad \text{for } j = 1,2,....,n$$

For cost factors $v_j^+ = \min(v_{ij})$, for $j = 1,2,....,n$

And negative ideal solution

For benefits factors $v_j^- = \min(v_{ij})$, for $j = 1,2,....,n$

For cost factors $v_j^- = \max(v_{ij})$, for $j = 1,2,....,n$

Step 5: Distances of PIS and NIS

by Euclidean method,

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

$$D_i^- = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^-)^2} \quad , \ i=1,2,...,m$$

by Hamming method,

$$D_i^+ = \sum_{j=1}^{n}\left|v_{ij} - v_j^+\right|, \quad i=1,2,...,m$$

$$D_i^- = \sum_{j=1}^{n}\left|v_{ij} - v_j^-\right|, \quad i=1,2,...,m$$

by Cosine method,

$$D_i^+ = 1 - \frac{\sum_{j=1}^{n} v_{ij} \cdot v_j^+}{\sqrt{\sum_{j=1}^{n} v_{ij}^2}\sqrt{\sum_{j=1}^{n} {v_j^+}^2}}, \quad i=1,2,...,m$$

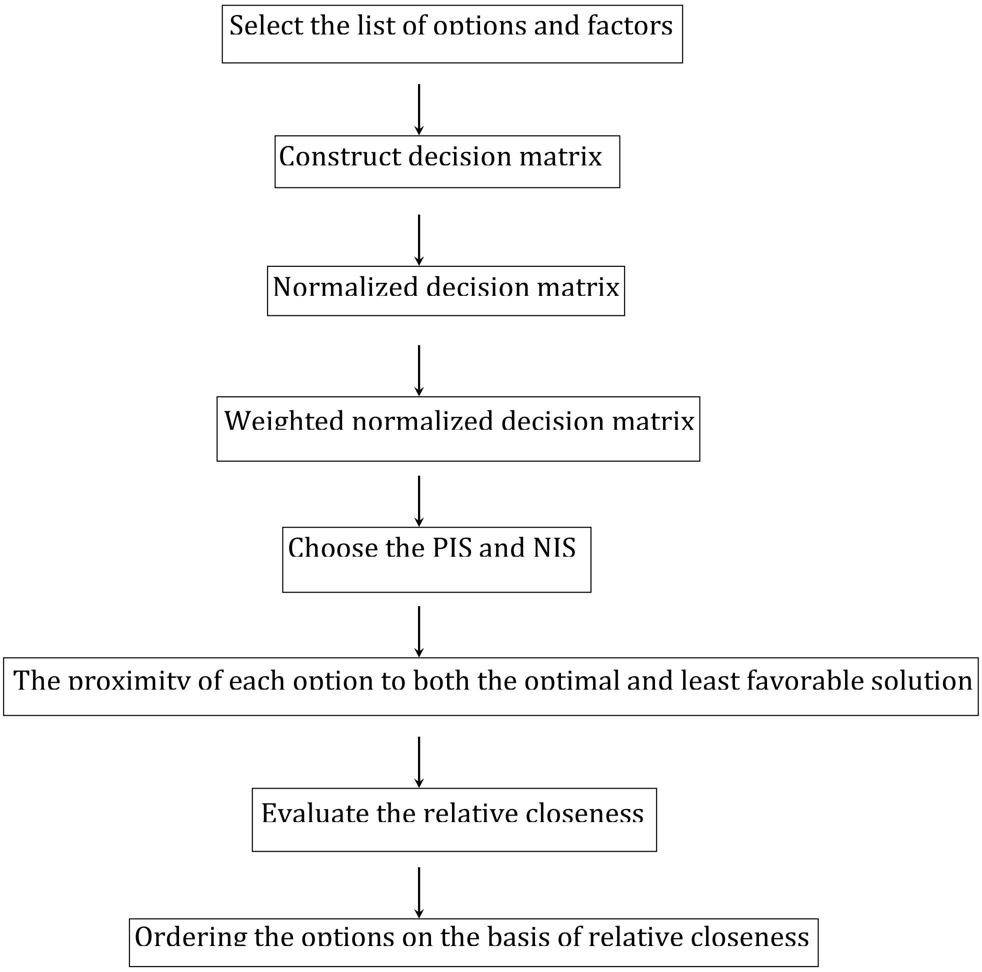
$$D_i^- = 1 - \frac{\sum_{j=1}^{n} v_{ij} \cdot v_j^-}{\sqrt{\sum_{j=1}^{n} {v_{ij}}^2}\sqrt{\sum_{j=1}^{n} {v_j^-}^2}}, \quad i=1,2,...,m$$

Step 6: Evaluate the relative closeness

$$C_i^* = \frac{D_i^-}{D_i^- + D_i^+} \quad , \quad i = 1,2,....,m$$

Step 7: Ordering the options accordance to the relative closeness

## 4. A Flowchart of the Process of TOPSIS Method




## 5. Methodology

*A.* ***Selection of tourist hotels****:* As our focus area is Gorakhpur, India, we select some of the most renowned hotels in the city.

*B.* ***Identification of factors:*** The identification and selection factors are determined based on a literature review, as well as an analysis of tourist and customers preferences.

*C.* ***TOPSIS:*** TOPSIS operates on the principle of simultaneously measuring the distance to both the positive ideal solution and the negative ideal solution.

The fundamental procedure of TOPSIS is outline below:

Step 1: Construct decision matrix-

$$C = [p_{ij}]_{m \times n}, \text{ where } i=1,2,....,m \ \& \ j=1,2,...,n$$

Step 2: Normalization decision matrix-

$$n_{ij}=\frac{p_{ij}}{\sqrt{\sum_{i=1}^{m} p_{ij}^{2}}}, \quad i=1,2,...,m \ \& \ j=1,2,...,n$$

Step 3: Weighted normalized decision matrix

$$v_{ij} = n_{ij}\times w_j, \quad i = 1,2,...,m \text{ and } j=1,2,...,n$$

Step 4: Selection of positive and negative ideal solution

Positive ideal solution

For benefits factors $v_j^+ = max(v_{ij}), \quad for\ j = 1,2,....,n$

For cost factors $v_j^+ = min(v_{ij}), \quad for\ j = 1,2,....,n$

And negative ideal solution

For benefits factors $v_j^- = min(v_{ij}), \quad for\ j = 1,2,....,n$

For cost factors $v_j^- = max(v_{ij}), \quad for\ j = 1,2,....,n$

Step 5: Distances of PIS and NIS by Euclidean method,

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

$$D_i^- = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^-)^2} \qquad i=1,2,...,m$$

by Hamming method,

$$D_i^+ = \sum_{j=1}^{n}\left|v_{ij} - v_j^+\right|, \quad i=1,2,...,m \text{ and } D_i^- = \sum_{j=1}^{n}\left|v_{ij} - v_j^-\right|, \quad i=1,2,...,m$$

by Cosine method,

$$D_i^+=1-\frac{\sum_{j=1}^{n} v_{ij}\cdot v_j^+}{\sqrt{\sum_{j=1}^{n} v_{ij}^2}\sqrt{\sum_{j=1}^{n} {v_j^+}^2}}, \quad i=1,2,...,m$$

$$D_i^-=1-\frac{\sum_{j=1}^{n} v_{ij}\cdot v_j^-}{\sqrt{\sum_{j=1}^{n} v_{ij}^2}\sqrt{\sum_{j=1}^{n} {v_j^-}^2}}, \quad i=1,2,...,m$$

Step 6: Evaluate the relative closeness

$$C_i^* = \frac{D_i^-}{D_i^- + D_i^+}, \qquad i=1,2,....,m$$

Step 7: Ordering the options in descending order based on their relative closeness

## 6. Performance Assessment of Proposed Ranking System

In order to identify the options, we have selected the most popular hotels of Gorakhpur (Uttar Pradesh), India and the selection of options are based on the factor identify on the basis of the expert of hospitality specialists, industry concerned literature of tourism based on Gorakhpur and views/ratings of tourists.

### 6.1 Options:

$H_1$-Park Regency, $H_2$-Radisson Blu, $H_3$-Courtyard, $H_4$-Radiant Resort, $H_5$-The Royal Residency, $H_6$-Clark Inn, $H_7$-Nirvana Sarovar.

### 6.2 Factors:

$F_1$-Price, $F_2$-Location, $F_3$-Ratings, $F_4$-Amenities, $F_5$-Service-Quality, $F_6$-Cleanliness, $F_7$-Quality of Hotels, $F_8$-Feedback of Hotel, $F_9$-Ambience of Hotel, $F_{10}$-Advertisement of Hotel

Here, All factors are benefits factors except price (i.e. cost factor)

In this step, we have taken data from online site of hotels, which have been used to construct decision matrix as given below

**Table 1.** Decision Matrix

| | $F_1$ | $F_2$ | $F_3$ | $F_4$ | $F_5$ | $F_6$ | $F_7$ | $F_8$ | $F_9$ | $F_{10}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| $H_1$ | 4 | 5 | 7 | 8 | 6 | 9 | 7 | 6 | 5 | 6 |
| $H_2$ | 8 | 7 | 9 | 9 | 7 | 7 | 8 | 9 | 7 | 9 |
| $H_3$ | 9 | 6 | 8 | 7 | 5 | 6 | 5 | 7 | 8 | 8 |
| $H_4$ | 6 | 7 | 6 | 6 | 7 | 5 | 6 | 5 | 6 | 7 |
| $H_5$ | 8 | 4 | 7 | 5 | 8 | 8 | 7 | 8 | 9 | 8 |
| $H_6$ | 4 | 5 | 4 | 8 | 4 | 7 | 6 | 7 | 4 | 6 |
| $H_7$ | 7 | 8 | 6 | 6 | 9 | 6 | 8 | 8 | 6 | 9 |

In the next steps, we have evaluated normalized decision matrix for factor $F_1$ and option $H_1$ by using step 2 as given below:

$$n_{ij}= \frac{p_{ij}}{\sqrt{\sum_{i=1}^{m} p_{ij}{}^2}}$$

$$n_{11}= \frac{4}{\sqrt{4^2+8^2+9^2+6^2+8^2+4^2+7^2}} = 0.2215$$

Similarly, we have evaluated all the other values.

As per evaluation, normalized decision matrix developed that is normalized below

**Table 2.** Normalized Decision Matrix.

| | $F_1$ | $F_2$ | $F_3$ | $F_4$ | $F_5$ | $F_6$ | $F_7$ | $F_8$ | $F_9$ | $F_{10}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| $H_1$ | 0.2215 | 0.3077 | 0.3848 | 0.4246 | 0.3354 | 0.4881 | 0.3895 | 0.3128 | 0.2854 | 0.2960 |
| $H_2$ | 0.4431 | 0.4308 | 0.4947 | 0.4777 | 0.3913 | 0.3796 | 0.4451 | 0.4692 | 0.3995 | 0.4439 |
| $H_3$ | 0.4985 | 0.3693 | 0.4397 | 0.3715 | 0.2795 | 0.3254 | 0.2782 | 0.3649 | 0.4566 | 0.3946 |
| $H_4$ | 0.3323 | 0.4308 | 0.3298 | 0.3184 | 0.3913 | 0.2712 | 0.3338 | 0.2606 | 0.3424 | 0.3453 |
| $H_5$ | 0.4431 | 0.2462 | 0.3848 | 0.2654 | 0.4472 | 0.4339 | 0.3895 | 0.4170 | 0.5137 | 0.3946 |
| $H_6$ | 0.2215 | 0.3077 | 0.2199 | 0.4246 | 0.2236 | 0.3796 | 0.3338 | 0.3649 | 0.2283 | 0.2960 |
| $H_7$ | 0.3877 | 0.4924 | 0.3298 | 0.3184 | 0.5031 | 0.3254 | 0.4451 | 0.4170 | 0.3424 | 0.4439 |

In order to develop weighted normalized decision matrix, we proceed as follow we have taken equally weight for each factor,

i.e. $w_j$ = (0.1), $j$ =1,2,...,10

weighted value for factor $F_1$ and option $H_1$, using step 3 as given below

$v_{11} = n_{11}\times w_1$ = (0.2215)×(0.1) = 0.02215

weighted value for factor $F_1$ and option $H_2$ as given below

$v_{21} = n_{21}\times w_1$ = (0.4431)×(0.1) = 0.04431

similarly, we have evaluated all the other values, which are presented in Table 3

**Table 3.** Weighted Normalized Decision Matrix.

| | $F_1$ | $F_2$ | $F_3$ | $F_4$ | $F_5$ | $F_6$ | $F_7$ | $F_8$ | $F_9$ | $F_{10}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| $H_1$ | 0.02215 | 0.03077 | 0.03848 | 0.04246 | 0.03354 | 0.04881 | 0.03895 | 0.03128 | 0.02854 | 0.02960 |
| $H_2$ | 0.04431 | 0.04308 | 0.04947 | 0.04777 | 0.03913 | 0.03796 | 0.04451 | 0.04692 | 0.03995 | 0.04439 |
| $H_3$ | 0.04985 | 0.03693 | 0.04397 | 0.03715 | 0.02795 | 0.03254 | 0.02782 | 0.03649 | 0.04566 | 0.03946 |
| $H_4$ | 0.03323 | 0.04308 | 0.03298 | 0.03184 | 0.03913 | 0.02712 | 0.03338 | 0.02606 | 0.03424 | 0.03453 |
| $H_5$ | 0.04431 | 0.02462 | 0.03848 | 0.02654 | 0.04472 | 0.04339 | 0.03895 | 0.04170 | 0.05137 | 0.03946 |
| $H_6$ | 0.02215 | 0.03077 | 0.02199 | 0.04246 | 0.02236 | 0.03796 | 0.03338 | 0.03649 | 0.02283 | 0.02960 |
| $H_7$ | 0.03877 | 0.04924 | 0.03298 | 0.03184 | 0.05031 | 0.03254 | 0.04451 | 0.04170 | 0.03424 | 0.04439 |

In this step, the Positive Ideal Solution (PIS) and Negative Ideal Solution (NIS) have been determined in accordance with Step 4, as detailed in Table 4.

**Table 4.** Positive and Negative Ideal Solution

| | PIS | NIS |
|---|---|---|
| $F_1$ | 0.02215 | 0.04985 |
| $F_2$ | 0.04924 | 0.02462 |
| $F_3$ | 0.04947 | 0.02199 |
| $F_4$ | 0.04777 | 0.02654 |
| $F_5$ | 0.05031 | 0.02236 |
| $F_6$ | 0.04881 | 0.02712 |
| $F_7$ | 0.04451 | 0.02782 |
| $F_8$ | 0.04692 | 0.02606 |
| $F_9$ | 0.05137 | 0.02283 |
| $F_{10}$ | 0.04439 | 0.02960 |

To evaluate distances $D_i^+$ and $D_i^-$ from the Positive Ideal Solution (PIS) and Negative Ideal Solution (NIS), respectively, the Euclidean distance method is applied as outlined in Step 5 below. for option $H_1$

$$D_1^+=\sqrt{A}$$

$$A = (0.02215 - 0.02215)^2 + (0.03077 - 0.04924)^2 + (0.03848 - 0.04947)^2 + (0.04246 - 0.04777)^2 + (0.03354 - 0.05031)^2 + (0.04881 - 0.04881)^2 + (0.03895 - 0.04451)^2 + (0.03128 - 0.04692)^2 + (0.02854 - 0.05137)^2 + (0.02960 - 0.04439)^2$$

$$D_1^+ = 0.0423$$

$$D_1^-=\sqrt{B}$$

$$B = (0.02215 - 0.04985)^2 + (0.03077 - 0.02462)^2 + (0.03848 - 0.02199)^2 + (0.04246 - 0.02654)^2 + (0.03354 - 0.02236)^2 + (0.04881 - 0.02712)^2 + (0.03895 - 0.02782)^2 + (0.03128 - 0.02606)^2 + (0.02854 - 0.02283)^2 + (0.02960 - 0.02960)^2$$

$$D_1^-=0.0459$$

Similarly, we have computed all $D_i^+$ and $D_i^-$, as presented in Table 5 below.

Furthermore, the relative closeness has been determined, based on which all options have been ranked accordingly.

**Table 5.** Relative Closeness Based on Euclidean Distance

| | ${D_i}^+$ | ${D_i}^-$ | ${D_i}^+ + {D_i}^-$ | $C_i^* = \dfrac{D_i^-}{D_i^- + D_i^+}$ | Ranking |
|---|---|---|---|---|---|
| $\boldsymbol{H_1}$ | 0.0423 | 0.0459 | 0.0882 | 0.5204 | 4 |
| $\boldsymbol{H_2}$ | 0.0300 | 0.0566 | 0.0866 | 0.6535 | 1 |
| $\boldsymbol{H_3}$ | 0.0477 | 0.0392 | 0.0869 | 0.4510 | 5 |
| $\boldsymbol{H_4}$ | 0.0472 | 0.0351 | 0.0823 | 0.4264 | 6 |
| $\boldsymbol{H_5}$ | 0.0426 | 0.0485 | 0.0911 | 0.5323 | 3 |
| $\boldsymbol{H_6}$ | 0.0574 | 0.0363 | 0.0937 | 0.3874 | 7 |
| $\boldsymbol{H_7}$ | 0.0372 | 0.0506 | 0.0878 | 0.5763 | 2 |

Therefore, using the Euclidean method, the results are presented in Table 5. Among the options, $H_2$(Radisson Blu) is recommended as the top preference due to its highest score, followed by $H_7$(Nirvana Sarovar) in second place and $H_5$(The Royal Residency) in third. $H_1$(Park Regency) ranks fourth, $H_3$(Courtyard) is fifth, $H_4$(Radiant Resort) holds the sixth position, and $H_6$(Clark Inn) is ranked seventh.

By using step 5, we have evaluated distances ${D_i}^+$and ${D_i}^-$ from PIS and NIS by Hamming method as given below for option $H_1$

$${D_1}^+ = |0.02215 - 0.02215| + |0.03077 - 0.04924| + |0.03848 - 0.04947| + |0.04246 - 0.04777| + 0.03354 - 0.05031| + |0.04881 - 0.04881| + |0.03895 - 0.04451| + |0.03128 - 0.04692| + |0.02854 - 0.05137| + |0.02960 - 0.04439|$$

$$= 0.1104$$

$${D_1}^- = |0.02215 - 0.04985| + |0.03077 - 0.02462| + |0.03848 - 0.02199| + |0.04246 - 0.02654| + |0.03354 - 0.02236| + |0.04881 - 0.02712| + |0.03895 - 0.02782| + |0.03128 - 0.02606| + |0.02854 - 0.02283| + |0.02960 - 0.02960|$$

$$= 0.1212$$

Similarly, we have computed all ${D_i}^+$ and ${D_i}^-$, as presented in Table 6 below.

Furthermore, the relative closeness has been determined, based on which all options have been ranked accordingly.

**Table 6.** Relative Closeness Based on Hamming Distance

| | ${D_i}^+$ | ${D_i}^-$ | ${D_i}^+ + {D_i}^-$ | $C_i^* = \dfrac{D_i^-}{D_i^- + D_i^+}$ | Ranking |
|---|---|---|---|---|---|
| $\boldsymbol{H_1}$ | 0.1104 | 0.1212 | 0.2316 | 0.5233 | 4 |
| $\boldsymbol{H_2}$ | 0.0618 | 0.1698 | 0.2316 | 0.7331 | 1 |
| $\boldsymbol{H_3}$ | 0.1325 | 0.0990 | 0.2315 | 0.4276 | 5 |
| $\boldsymbol{H_4}$ | 0.1415 | 0.0900 | 0.2315 | 0.3887 | 6 |
| $\boldsymbol{H_5}$ | 0.1057 | 0.1258 | 0.2315 | 0.5434 | 3 |
| $\boldsymbol{H_6}$ | 0.1550 | 0.0766 | 0.2316 | 0.3307 | 7 |
| $\boldsymbol{H_7}$ | 0.0877 | 0.1439 | 0.2316 | 0.6213 | 2 |

Therefore, using the Hamming method, the results are presented in Table 6. Among the options, $H_2$(Radisson Blu) is recommended as the top preference due to its highest score, followed by

$H_7$(Nirvana Sarovar) in second place and $H_5$(The Royal Residency) in third. $H_1$(Park Regency) ranks fourth, $H_3$(Courtyard) is fifth, $H_4$(Radiant Resort) holds the sixth position, and $H_6$(Clark Inn) is ranked seventh.

By using step 5, we have evaluated distances $D_1{}^+$ and $D_1{}^-$ from PIS and NIS by Cosine method as given below for alternative $H_1$

$$D_1^+=1-\frac{\sum_{j=1}^n v_{1j}\cdot v_j^+}{\sqrt{\sum_{j=1}^n v_{1j}{}^2}\sqrt{\sum_{j=1}^n v_j^{+2}}}$$

$$\sum_{j=1}^n v_{ij}\cdot v_j^+ = 0.02215\times 0.02215 + 0.03077\times 0.04924 + 0.03848\times 0.04947 + 0.04246 \times 0.04777 + 0.03354\times 0.0503 + 0.04881\times 0.04881 + 0.03895\times 0.04451 + 0.03128\times 0.04692 + 0.02854\times 0.05137 + 0.02960\times 0.04439$$

$$\sum_{j=1}^n v_{ij}{}^2 = 0.02215^2 + 0.03077^2 + 0.03848^2 + 0.04246^2 + 0.03354^2 + 0.04881^2 + 0.03895^2 + 0.03128^2 + 0.02854^2 + 0.02960^2$$

$$\sum_{j=1}^n v_j^{+2} = 0.02215^2 + 0.04924^2 + 0.04947^2 + 0.04777^2 + 0.05031^2 + 0.04881^2 + 0.04451^2 + 0.04692^2 + 0.05137^2 + 0.04439^2$$

$D_1{}^+ = 0.0179$

Similarly, we have computed all $D_i{}^+$ and $D_i{}^-$, as presented in Table 7 below.

Furthermore, the relative closeness has been determined, based on which all options have been ranked accordingly.

**Table 7.** Relative Closeness Based on Cosine Distance

| | $D_i{}^+$ | $D_i{}^-$ | $D_i{}^+ + D_i{}^-$ | $C_i^* = \frac{D_i^-}{D_i^- + D_i^+}$ | Ranking |
|---|---|---|---|---|---|
| $\boldsymbol{H_1}$ | 0.0179 | 0.0840 | 0.1019 | 0.8243 | 1 |
| $\boldsymbol{H_2}$ | 0.0209 | 0.0378 | 0.0587 | 0.6439 | 4 |
| $\boldsymbol{H_3}$ | 0.0468 | 0.0286 | 0.0754 | 0.3793 | 6 |
| $\boldsymbol{H_4}$ | 0.0228 | 0.0503 | 0.0731 | 0.6880 | 3 |
| $\boldsymbol{H_5}$ | 0.0389 | 0.0472 | 0.0861 | 0.5481 | 7 |
| $\boldsymbol{H_6}$ | 0.0325 | 0.0717 | 0.1017 | 0.7050 | 2 |
| $\boldsymbol{H_7}$ | 0.0286 | 0.0510 | 0.0796 | 0.6407 | 5 |

Therefore, using the Cosine method, the results are presented in Table 7.

Among the options, $H_1$(Park Regency) is recommended as the top preference due to its highest score, followed by $H_6$(Clark Inn) in second place and $H_4$(Radiant Resort) in third. $H_2$(Radisson Blu) ranks fourth, $H_7$(Nirvana Sarovar) is fifth, $H_3$(Courtyard) holds the sixth position, and $H_5$(The Royal Residency) is ranked seventh.

## 7. Results and Discussions

**Table 8.** As for the adapted procedure, the ranking of the respective hotels were calculated on the

basis of Euclidean, Hamming, and Cosine method followed by relative closeness.

| Alternatives | Ranking of Hotels (Based on Euclidean) | Ranking of Hotels (Based on Hamming) | Ranking of Hotels (Based on Cosine) |
|---|---|---|---|
| $H_1$ | 4 | 4 | 1 |
| $H_2$ | 1 | 1 | 4 |
| $H_3$ | 5 | 5 | 6 |
| $H_4$ | 6 | 6 | 3 |
| $H_5$ | 3 | 3 | 7 |
| $H_6$ | 7 | 7 | 2 |
| $H_7$ | 2 | 2 | 5 |

As per the output of the ranking, it is observed the Intelligent system evaluated ranking of selected hotels in Gorakhpur, as per Euclidean distance method, Hamming distance method, and Cosine distance method followed by TOPSIS method that gives fluctuations of ranking in accordance with Cosine where as remaining two provides the same.

Ranking variations observed when using the Cosine distance measure. Such variations occur because the Cosine metric evaluates the directional similarity and overall performance pattern of alternatives relative to the ideal solution, rather than focusing solely on absolute numerical gaps. In contrast, Euclidean distance measures straight-line separation based on magnitude differences, while Hamming distance captures stepwise deviations across criteria. The Cosine measure, by considering the alignment of performance profiles in a curvilinear manner, provides deeper insight into how closely an alternative matches the ideal preference structure. Therefore, the Cosine measure provides more stable and meaningful decision outcomes.

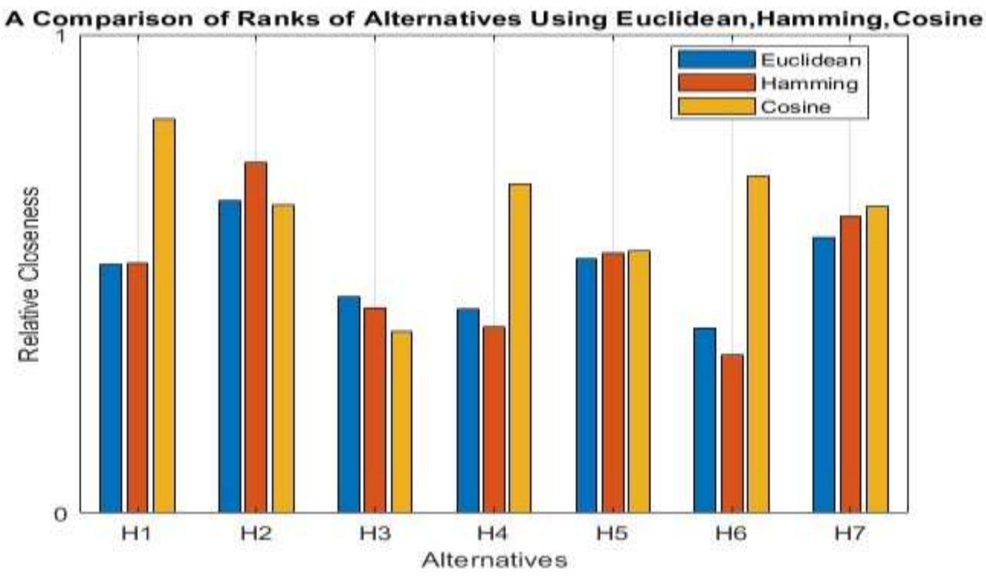



**Fig.1.** A Comparison of Ranks of Alternatives Using Euclidean, Hamming and Cosine Method

## 8. Conclusion

The Intelligent system evaluated ranking of selected hotels in Gorakhpur, Uttar Pradesh, India as per Euclidean distance method, Hamming distance method, and Cosine distance method followed by TOPSIS method that gives fluctuations of ranking due to Cosine distance approach where as remaining two provides the same. The Cosine distance performs best, as it captures overall similarity

more effectively and curvilinear relationships, leading to more stable and meaningful rankings whereas Euclidean measures straight-line gaps and Hamming reflects stepwise differences.
The final ranking, as presented in Table 8, has been generated by the proposed intelligence system using these preferences. This system is designed to function as a referral platform for tourist agencies , helping them make informed decisions when choosing accommodations as per comfort and budgets.
For future research, the framework can be extended by incorporating dynamic factors such as incorporate advanced weighting techniques to examine the sensitivity of the ranking results and changing tourist preferences and seasonal service variations to improve adaptability.

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