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Research Article

Tour Recommendation System Based On User Interest and Surrounding Facilities in North Sumatera Using Simple Multi-Attribute Rating Technique With Dijkstra's Algorithm

Luluk Muthoharoh[1,*] , Ahmad Luky Ramdani[2] , Ira Safitri[3], Muhammad Dhoni A[4]

[1,2,3,4] Data Science Study Program, Sumatera Institute of Technology

**Corresponding author: luluk.muthoharoh@sd.itera.ac.id*

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Abstract: In this study, we collected data on tourist attractions, tourist attractions utilities, on the island of Sumatra, especially in Toba and Samosir districts in North Sumatra Province. In this process, information was collected on 100 tourist destinations with the highest popularity based on Google Maps Review. To determine the interest of tourists, the SMART method is used to obtain the value of tourist interest in each tourist spot based on the weight determined on each criterion. Meanwhile, entropy is used to determine the value of facilities available at tourist attractions. The value represents the interest of tourists and the facilities available around the tourist attractions. The results of this research show that in the aspect of running time Dijkstra's algorithm is fast algorithms.

Keywords: Dijkstra's Algorithm, SMART, Surrounding Facilities, User Interest

Introduction

The tourism sector in most regions in Indonesia is a key component that can trigger economic growth in a country [1]. Such expenditure can be considered as a stimulus for consumption, which is obtained from visiting foreign tourists[2]. Based on data in 2022, Indonesia's tourism sector is one of the main components of the country's economy with a contribution of 4.1% to Gross Domestic Product (GDP) [3]. Based on the publication of the Central Statistics Agency (BPS) of North Sumatra, North Sumatra Province, which is located in the north of Sumatra Island, is ranked seventh in Indonesia in terms of the number of tourist visits. In the period from January to June 2023, the BPS of North Sumatra Province recorded 14,333,140 tourist visits [4], [5]. Since ancient times, Lake Toba has been a tourist destination visited by many tourists. The natural beauty, cultural charm and legends that have unique characteristics make tourists interested in visiting this place until finally in 2011. The increase in tourism can advance economic activities, including employment, community income, regional income, and state foreign exchange earningsThe Government of the Republic of Indonesia made Lake Toba one of the National Tourism Strategic Areas (KSPN) and in 2020 the Government of the Republic of Indonesia made Lake Toba one of the five super priority KSPNs [6]–[8].

Although there are many tourism options and attractions available, planning an optimal travel route can be a complicated task[9]. However, in this case, there is no existing system to recommend tourist attractions in Lampung Province, making it difficult for people and tourists to find the right tourist attractions for a vacation in North Sumatra, especially tourism around Lake Toba [9]. In determining the tourist attractions to be visited for a vacation, it will be easier if through an existing recommendation system that has been rated by the community and tourists who have visited the place. And it can also be seen what tourism is currently popular and is the most popular tourist attraction in the community. If the tourist attraction recommendation process is done manually and the amount of data is small, of course the manual

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process is not a problem. However, if the amount of data is large and the process is still done manually, of course it will take a lot of time and energy [10]–[13].

Recommendation systems are systems based on information filtering to recommend content to users (e.g. movies, books, news, web pages, etc.) One of the most popular approaches, called collaborative filtering methods, uses knowledge gathered from monitoring the behavior and personal choices of system users. This approach is currently the most popular and most effective technology used in web recommendation system applications [14]–[17]. In the tourist recommendation system conducted by Ida et al., using the Naïve Bayes Algorithm to recommend general tourist destinations based on personal motivations of tourists, which are based on attributes of age, gender, natural interests, artificial interests, cultural interests of tourists, using 200 training data consisting of 14 classes of tourist attractions. In addition, this tourist recommendation system is equipped with recommendations for routing tourist attractions using the Cheapest Insertion Heuristic Algorithm, to organize a list of tourist route [18]. Then the research conducted by Mardhani, Djiehaddan Edwardo (2023) on the Development of Tourism Recommendation Information Systems in the City of Surabaya Using Genetic Algorithms produced a model output that was displayed through a web-based application, which allows users to see tourism route recommendations based on their location. The results of this study are expected to contribute to the growth and development of tourism, as well as the growth, development, and application of technology in the City of Surabaya [19].

Recently, in order to improve In this study, we collected data on tourist attractions information, tourist attractions utilities on the island of Sumatra, especially Toba and Samosir districts in North Sumatra Province. In this process, information was collected on 100 tourist destinations with the highest popularity based on Google Maps Review. Then, to create a tourist attraction recommendation system, we will use the System Based On User Interest and Surrounding Facilities in North Sumatra Using SMART With Dijkstra's algorithm.

Materials and Methods

Smart Methods

The recommendation system in its implementation requires an interest preference value from the user. To get this value, there are 2 ways that can be done. The first is by utilizing the interaction between the user and the recommendation system. The second is to study previous trips that have been made. In the first way, the value of user interest is obtained by focusing on the criteria and weights given by the user. So the multi criteria decision making (MCDM) method approach, such as multi attribute utility theory (MAUT)[8], and simple multi attribute rating technique (SMART). Compared to MAUT, SMART uses simple calculations and allows adding or reducing the number of alternative tourist attractions irregularly[20]. However, these changes will not affect the calculation results.

SMART is formulated using the following equation:

$$u(a_i) = \sum_{j=1}^{m} w_j v_j(a_i)\,; \qquad i = 1, 2, 3, \ldots m \tag{1}$$

Description :

u	:	evaluation value of the tourist attraction
w	:	coefficient used as a priority measure (wight) from user
v	:	actual value of the attribute at iteration like popularity or tourist rating
m	:	tourist attraction candidate

Entropy

Entropy is a function used to normalize the attribute values of a candidate object. In[21], entropy is used for the representation of place attributes in the selection of places that are not dominated by other places (skyline). The entropy function is formulated with the following equation:

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$$f = \frac{D[a_i] - \min(a)}{max(a) - \min(a)} \quad (2)$$

$$E(D) = \sum_{i=1}^{d} \ln(f + 1) \quad (3)$$

Description:

$\min(a)$	:	the minimum value of attribute a in all candidates
$\max(a)$	:	the maximum value of attribute a in all candidates
$d\ and\ D[a_i]$	:	actual value of the attribute at iteration like popularity or tourist rating
E	:	entropy value is used to represent related to facilities around tourist attraction

Data Collection

The data collection process was carried out from data on tourist attractions, tourist attractions utilities, on the island of Sumatra, especially in Toba and Samosir districts in North Sumatra Province. In this process, information was collected on 100 tourist destinations with the highest popularity based on Google Maps Review. The data focuses on information on tourist destinations and facilities in the vicinity. The tourist attractions that are the object of research are in the Toba and Samosir districts in North Sumatra. The data was obtained using the Google Maps API.

User Inerest and Surrounding Facilities

SMART is a method to get the preference value of tourist interest which is then used in the recommendation system. By using equation (1) and the weight value that comes from tourists on 3 criteria, namely rating, popularity, and ticket fees for tourist attractions. While entropy is used to get a representation value related to facilities around the place. At this stage, the SMART and entropy values are generated which are then summed up as the value of tourist attractions. This multi-criteria decision-making technique is based on the theory that each alternative consists of a number of criteria that have values and each criterion has a weight that describes how important it is compared to other criteria. This weighting is used to assess each alternative in order to obtain the best alternative [22].

Weight Taking

The process of taking weights is selected by the user, this process is carried out so that the proportions are appropriate and save them for use in the next process.

The weights taken are as follows:

user_rating_weight	=	20
user_ticket_cost_weight	=	40
user_distance_weight	=	20
user_popularity_weight	=	20

Generate Route

At this stage, the process of finding the best route that not only considers distance, but also maximizes the value obtained from each tourist spot visited based on time constraints. Exact and heuristic algorithms are used in this research is Dijkstra [23].

Implementation

The last stage is the development of a prototype of a travel recommendation application. The application is built in a web-based system. The programming language used is python 3.6 using Flask 3.0 as a web framework, Google Maps APIas a visualization and python libraries such as numpy and pandas. Numpy and pandas are python libraries for data preprocessing. Preprocessing data for implementing exact

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and heuristic algorithms. Google Maps API is used for visualization of tourist travel routes. The application development environment is macOS Monterey as the operating system and MySQL 5.5 (Oracle 2010) as the database.

Results and Discussions

Dataset

Using parameter data from each criterion and user weights, the SMART score is calculated using equation (1). Table 1 is an example of a Parameter data on Rating criterion. This table groups the tourist attractions based on user ratings, with categories ranging from Very Good (≥4.5) to Insufficient (<3.5). This shows that the quality of service or tourism experience greatly influences user perception. It means thas Destinations with high ratings tend to be more popular because satisfying experiences encourage more reviews from visitors.

Table 1. Parameter data on Rating criterion

Rating	
Very good	Attractions with a rating of 4.5 or higher
Good	Attractions with a rating between 4.0 and 4.49
Fair	Attractions with a rating between 3.5 and 3.99
Insufficient	Attractions with a rating of less than 3.5

Table 2 groups tourist attractions based on ticket prices, from the Expensive (>50,000) to Cheap (<5,000) categories, which reflect the variation in costs that tourists must pay to access certain tourist attractions. So, the tourist destinations with cheaper ticket prices have the potential to be more attractive to tourists with limited budgets, but may have simpler facilities than destinations with higher ticket prices.

Table 2. Parameter data on Ticket Cost Criterion

Expensive	Tourist attractions with prices above 50,000
Medium	Tourist attractions with ticket prices of 10,000-15,000
Affordable	Tourist attractions with ticket prices of 5,000-10,000
Cheap	Tourist attractions with prices below 5,000

Meanwhile, Table 3 measures the level of destination popularity based on the number of user reviews, where destinations with more than 500 reviews are categorized as Very Popular and those with less than 50 reviews are considered Less Popular. Tourist attractions with a low number of reviews (Less Popular) can increase their appeal by improving service quality, optimizing promotions, or providing incentives for tourists to provide reviews.

Table 3. Parameter Data on Popularity Criterion

Very Popular	Attractions with more than 500 user reviews.
Popular	Attractions with 100 to 500 user reviews.
Moderately Popular	Attractions with 50 to 100 user reviews.
Less Popular	Attractions with less than 50 user reviews.

Table 4 presents a description of tourist attraction data that includes various important information about tourist destinations. The information presented in the table includes the tourist location address, geographic coordinates, place name, and unique identification (Place_id) on Google Maps. In addition, this table also displays user ratings (scale 1-5) and the number of users who have given reviews (User_ratings_total), which

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in this example shows that the tourist attraction "Menara Pandang Tele" has a high rating (5.4) from 3,438 reviews. This table also lists the type of tourist attraction according to Google Maps (for example as a tourist attraction or point of interest) and information about the entrance ticket price (in the example, IDR 7,000 for one adult).

Tabel 4. Tourist Description Data

Name of Column	Description	Example of value
Address	Tourist attractions address	Tele Partungkot Naginjang Village, Turpuk Limbong, Kec. Harian, Samosir Regency, North Sumatra 22396, Indonesia
Geometry	Geographic coordinates	2.5520625,98.6398125
Name	Place name	Menara Pandang Tele
Place_id	Place id on Google Maps	ChIJCxjj8GDQMTARGKoI8EW6YbU
Rating	User rating (1-5)	5.4
User_ratings_total	Number of users who rated	3438
Type	Place types on GoogleMaps	tourist_attraction,point_of_interest
Ticket Price	Entrance ticket price for 1 adult (IDR)	Rp. 7.000

The data is focused on tourist destinations in Toba and Samosir Regencies in North Sumatra. The data consists of 100 tourist attractions, with 10 columns/attributes related to tourist information. These columns include various important information about each tourist attraction, such as destination name, location (latitude and longitude), Rating, Popularity, Ticket Cost. SMART score for a tourist attraction with a weight of 0.3 (rating), 0.2 (popularity) and 0.5 (ticket price). The SMART Score calculation in Table 5 is done by multiplying each criterion value by the appropriate weight, then adding up the results to get the final score. This SMART score provides a clearer picture of the tourist attraction based on user preferences, where the tourist attraction with the highest score is considered the best choice based on the specified criteria.

Table 5. SMART scores of tourist attractions

Destination Name	Rating	Popularity	Ticket Cost	SMART
Toga raja	4.8	86	Rp.10.000,00	0.3270
Pantai Bebas Parapat Danau Toba	4	7408	Rp.0	0.4288
Ancol Pangururan Beach	4	146	Rp.0	0.1805

In addition, this research also collects data related to information on facilities located around tourist attractions such as ATMs, restaurants, and inns/hotels. The entropy equation (10) is used to normalize the value of facilities at candidate tourist attractions. An example of tourist attraction facility data is shown in Table 6 is The entropy method that helps to assess the diversity and availability of these facilities, ensuring

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that the score reflects not only the attractiveness of the location but also the convenience and accessibility of essential services for visitors. This normalization process adjusts the weight of each facility type to provide a more balanced and fair comparison between different tourist destinations. Count Surrounding Facilities (1000 meter radius) consisting of ATM, ATM (ALR), Restaurant, Restaurant (ALR), Hotel/Lodging, Hotel/Lodging (ALR). This information is used to evaluate and rank each tourist attraction based on predetermined criteria, with the aim of helping tourists choose the best destination in the area.

Table 6. Entropy value of tourist facilities

Place Name	Number of Facilities			Entropy
	ATM	Restaurant	Lodging	
Toga raja	0	1	0	0.0488
Pantai Bebas Parapat Danau Toba	8	20	14	1.6094
Pantai Ancol Pangururan	11	20	4	1.3744

Based on the SMART and entropy values, the summation process is carried out to get the value of tourist attractions. The location in space and time of the high entropy parts of the tourist trajectory would allow making better decisions related to the management of tourism in a given territory[24]. This value is then used in the generate route stage, where it aids in determining the optimal travel paths for tourists. By integrating both the attractiveness (SMART score) and the diversity of facilities (entropy), the generated route ensures a more efficient and satisfying experience for tourists, optimizing both time and cost while enhancing overall visitor satisfaction.

The Result

In generating travel routes for recommendations, the exact algorithms is employed to find the best solutions. The exact algorithms used include Dijkstra. The evaluation process considers two main aspects: performance testing and running time testing. Performance testing is based on the accumulated value of tourist attractions and the distance traveled, while running time testing focuses on the execution time of each experiment. A total of 100 tourist destinations from the Toba and Samosir districts were involved in this study. The performance is assessed based on the optimal outcomes of key travel route aspects, including the total value of tourist attractions (TN), the shortest travel distance (TJ), and the running time (RT).

Toba is a district situated between 2°03'-2°40' N and 98°56'-99°40' E, covering an area of 2,021.8 km². The primary attraction of Toba is the stunning beauty of Lake Toba and its surrounding landscape. With a vast area of 1,145 square km, the lake offers breathtaking views that captivate visitors and invite them to explore further. Observing Lake Toba is akin to gazing upon an ocean, as it is the largest lake in Indonesia and Southeast Asia. In addition to the lake, the lush Bukit Barisan mountain range provides another fascinating area to explore. There are numerous tourist destinations in Toba, ranging from its natural beauty and rich Batak history and culture to spiritual tourism experiences[25].

If we assign a weight of 20 to the rating criteria, 40 to the popularity criteria, and 40 to the ticket price criteria, we will obtain numerous recommended places as tourist attractions based on the value of tourist attractions. As shown in Table 7, the top five recommended tourist destinations which started from Pantai Danau Toba Marom, based on user interest and surrounding facilities are Pemandian Air Panas Rianiate, Bukit Holbung Samosir, Pantai Batuhoda, Batu marhosa, dan Bukit Holbung Sipege. These locations stand out due to their high SMART and entropy values. The higher the SMART and entropy scores, the greater the value of the tourist attractions, which are then used in the recommendation results. The results showed that user interest and Surrounding Facilities facility are the most important factor affecting the Tour recommendation experience and personalization the least. Smart tourism technology experience is shown to be significantly associated with travel experience satisfaction, and travel experience satisfaction has a positive effect on both tourists' happiness and revisit intention[26].

Tabele 7 provides an overview of how the SMART and Entropy methods can be used to compile objective, data-based tourism destination recommendations. Destinations with high scores tend to have more tourist attractions and supporting facilities. These recommendations can help travelers choose the best tourist destinations based on certain criteria, such as accessibility, facilities, and beauty of the place. Tourism

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managers can use this data to improve the competitiveness of destinations by adding facilities or improving services. Destinations with low scores may need to improve facilities or promotions to make them more attractive to tourists.

Table 7. The Top Five Recommended Tourist Destinations Which Started From Pantai Danau Toba Marom

No.	Destination Name	Total Score
1	Pemandian Air Panas Rianiate	1.007071
2	Bukit Holbung Samosir	0.087256
3	Pantai Batuhoda	0.048271
4	Batu marhosa	0.003132
5	Bukit Holbung Sipege	0.000377

Total Score is a combined score calculated based on two main components: SMART score and Entropy score. Each of these components provides a certain assessment of the attractiveness and relevance of a tourist destination. SMART score is calculated using dynamic weights determined by the user, with the values of each criterion normalized to be comparable. The higher the SMART score, the greater the attractiveness of the destination based on that criterion. Entropy is used to provide additional value based on how many supporting facilities are available at the destination. The tourist destinations that appear in the list have the highest Total Score among other destinations. Recommended travel destinations are usually based on popularity, high ratings, positive reviews, and external factors such as current travel trends. Destinations with higher Entropy scores may have more facilities that support tourist comfort, such as accommodation, transportation, and restaurants.

This selection also takes into account time constraints calculated based on the distance and travel time from the starting location to the destination, so that only destinations that can be reached within the available time will be considered. Thus, these destinations are the most recommended to visit, both because of their attractiveness and accessibility. Pemandian Air Panas Rianiate has the highest TotalScore (1.007071), indicating an optimal combination of SMART score (attractiveness) and entropy score (availability of facilities). This destination is also within the permitted travel time limit. This order represents recommendations based on the highest scores, thus helping in determining the most worthy locations to visit.

Conclusion

Based on the results of testing and analysis, it can be concluded that Dijkstra's algorithm is fast in the aspect of running time. The higher the SMART and entropy scores, the greater the value of the tourist attractions, which are then used in the recommendation results. The results showed that user interest and Surrounding Facilities facility are the most important factor affecting the Tour recommendation experience and personalization the least. This order represents recommendations based on the highest scores, thus helping in determining the most worthy locations to visit.

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