Tourism recommender system using hybrid multi-criteria approach

M S P Maru’ao¹ and Suharjito²*

¹Computer Science Department, BINUS Graduate Program - Master of Computer Science, Bina Nusantara University, Jakarta, Indonesia 11480
²Computer Science Department, BINUS Online Learning, Bina Nusantara University, Jakarta, Indonesia 11480

Email: suharjito@binus.edu

Abstract. Traveling has become a part of life at the time of the current urbanization. The growth rate of the internet and the availability of information allows travellers to access tourist information easier and faster. However, the individual's ability to find the information that they want is not proportional to the complexity of the information. This research would like to develop a reliable tourism recommender system that is able to provide destination recommendations according to user preferences with a combination of several methods i.e., Content-based, Collaborative Filtering, Multi-Criteria ratings, Demographic and Ontology-based. This research aims to implement a recommendations system for tourism through mobile devices by using the Android operating system. The results of this research indicate that the Hybrid Multi-Criteria method is able to provide recommendations to the user in accordance with the user's personal preferences and history of previous user rating with the average precision is 0.7. Evaluation metric of each methods indicate the lowest RMSE 0.84 in Multi-Criteria.

Keywords: tourism, recommender system, hybrid multi-criteria

1. Introduction

The development of Indonesian tourism from year to year continues to show an increasing. Tourism is one sector that is being developed by the Indonesia government which has a very important role in generating foreign exchange for the country of Indonesia besides the gas and oil sector. Information Technology (IT) is the backbone of information that facilitates tourism. The IT development has implications that are deep in the management of the tourism industry and allows an efficient cooperation in the industry as a means of globalization. The Concept of Smart Tourism emerged from the development of Smart City, with technology that is embedded in the urban areas will synergize the social component and support the tour experience. By applying smart travel concept to the needs of tourists during and before a trip, the level of competition in the tourist destinations will certainly increase [1].

The concept of Smart is not apart from the term Artificial Intelligence, which is an artificial intelligence in the computer technology or machinery that has intelligence as a human being. Recommendations of the attractions are very needed by tourists when traveling. With the artificial intelligence approach to this problem can be overcome. Information about the existing tourist destinations in the province of Jakarta has been developed through the media, both print and digital media that can be accessed through the website and mobile. However, the information available today
is very complex and not yet served efficiently in accordance with personal preferences so that consuming a lot of time in selecting the attractions when making travel arrangements. To find the tourist information in accordance with the wishes of the tourists then needed a recommendation system as a tool to offer and recommend places of interest in accordance with their wishes. There are several methods used to support the workings of the system resulted in a recommendation in information including such Content-based recommendation, Collaborative recommendation, Demographic recommendation, Hybrid recommender systems and Knowledge-based recommendation [2].

Thus, this research is conducted to design a Smart Tourism recommendation system in the development of tourism in DKI Jakarta. Therefore, recommendations for tourist attractions can be applied in accordance with the preferences and personal characteristics of each visitor as well as supporting elements of the tourism sector are well integrated through the Jakarta Smart Tourism application.

2. Literature review
Smart tourism can be interpreted as an innovative tourist destination with the development of tourist areas using sustainable technology. The quality of tourist attractions can improve the quality around it [3]. Smart tourism system is a combination of several elements including Information Exchange Centre (IEC), tourist, government, scenic zones, business. Generally, tourists dig some information about tourist attractions, conducting searches, purchasing tickets, booking and so on, then IEC will respond in accordance with the request for information and results that have been processed. IEC is also obliged to monitor directly, all sources of tourist destinations obtained. Every tourist visit data per day is reported to IEC for analysis and archiving management. Statistical data is given to the government specifically in tourism administration as a basic consideration for determining the next policies. Tourism business, for example, enterprise tourisms such as Hotels, Restaurants, Entertainments, can ask IEC to promote events or their attractions to tourists [4].

A recommender system is a software tool and technique that aims to give advice about what items are most attractive to certain users [5]. The recommendations given are expected to help users in the decision-making process, such as what items to buy, what books to read or what music to hear and so on [6]. The Recommender system can be defined as an expert system that is able to recommend a product or service to certain users. Research in the recommendation system has been widely carried out, with various algorithms including the method of combining content-based with collaborative filtering [7]. The benchmark of a good recommender system is in the accuracy of the user profile. The basic approach is getting demographic characteristics and context-aware information and personal preferences [8]. Demographic characteristics are also not enough to produce good recommendations, but this is used in the initial data collection by comparing social characteristics.

The important component in recommender system is the user profile, which all the user preferences are stored. Every recommender system builds and maintain the user profile that contains user preferences. User models forming user profiles have been widely developed, the simplest model is by listing keywords of interest or by categories. However, this model is commonly used to get an accurate result of recommendations [2]. According to [9], the features of an item are associated with user ratings, thus ratings will be used as training data for classification. Collaborative Filtering recommender system evaluates the utility function of the user j towards item i, compared to other users who have previously responded to the item. In general, Collaborative Filtering is categorized into memory-based or neighborhood and based on the model-based or latent factors [10].

3. Methodology
Generally, this research starts by looking at the background of the existing problems, namely tourism information in Jakarta today are very complex. This system has not been designed with the Smart Tourism recommendation system. The result of the formula of these problems was an inspiration in making the topic of this study. By examining the existing literature, then determined a suitable
recommendation applied in DKI Jakarta. Proceed with the development of Android-based mobile applications in accordance with the concept of a recommendation system that has been determined.

Overall, this research is divided into 4 stages, i.e. the stage of system analysis, system design, implementation and testing of the system.

a) System Analysis
At this stage will do the analysis of the interaction between users with systems using UML (Use Case diagrams, Activity Diagrams), Flowchart to know the flow of the program in accordance with the respective recommendation system and method calculation of the system recommendations.

b) Design of the System
At this stage the system would be designed architecture, software needs to be used, designing the device interface in the form of mobile database design and continued with the relationships between the tables.

c) Implementation
At this stage, the Smart Tourism recommender system will be integrated into the mobile application with the operating system Android.

d) Testing
Testing against the application that has been designed, whether in accordance with the performance of the application in accordance with the algorithm that is being built. This recommendation in the evaluation system with the approach of RMSE (Root Mean Square Error) to know the accuracy of the recommendation system by comparing the value prediction and value user input. Then the quality of the recommendations will be measured with Top-N Recommendation with Precision and Recall method to determine whether a given recommendation is relevant or not.

4. Results and discussions
4.1. Use case diagram
In this study, use case diagram was used to summarize information about interactions between users and systems in this case actors with use cases.

![Use Case Diagram](image-url)
Based on Figure 1, there are two actors who can use the system. User and Administrator. On the picture obtained described relations between some Use Case include:

- Register: register new user.
- Login: verification, i.e. the User who signed up prior to using the application.
- Main page, i.e. the main page display application recommendation system that consists of a navigation menu, and the destination profile.
- Recommendation Page, i.e. the page that shows the rating prediction tourist destinations in accordance with your preferences.
- See Destinations, i.e., see the details of the tourist destinations.
- Give Rating, i.e. give a rating to a tourist destination.
- Profile Page, i.e. doing a personal user profile setting associated with it.
- Logout: do log out or exit the system.

4.2. Application architecture
The recommendation system starts from user interaction with the mobile platform as a client. The input data from the user will be saved to the server, in this case using the PHP web server with JSON connections, the database server is built using MySQL. The recommendation system architecture can be seen in the Figure 2.

![Figure 2. Application Architecture.](image)

The integration of some methods is urgently needed in building a reliable recommendation system, on this research, Smart recommendation system is designed with a combination of several methods i.e., Hybrid recommendation (Content-based Collaborative & Filtering), Multi-Criteria rating. The interaction between components can be seen in Figure 3.
4.3. User interface of the application

Figure 4 shows the application’s main page. The first Figure shows the main page that displays all the destinations with rating bar. The second Figure shows the user profiles tab, this tab displays the travel motivation of user namely Beach, Culture, Event, Nature, Relaxation, Shopping and Sports.

4.4. Recommendation process

Content/features that can be owned in tourist destinations, namely: Wi-Fi, Parking, Restaurant, 24-hour Front Desk, Toilet, Guide, air conditioning, Smoking Area, ATM/Banking, Security. The rating criteria in the study include Security, Sanitation, Airy, and Scenic. The following is a scenario Smart Tourism Recommender System. The Content-based calculation in the first criteria rating is shown in Table 1.
Table 1. Item Features First Criteria Rating

| i1  | f1 | f2 | f3 | f4 | f5 | f6 | f7 | f8 | f9 | f10 | R  |
|-----|----|----|----|----|----|----|----|----|----|-----|----|
| i2  | 1  | 1  | 0  | 0  | 1  | 0  | 0  | 0  | 0  | 1   | 4  |
| i3  | 0  | 1  | 1  | 0  | 1  | 0  | 0  | 1  | 0  | 0   | 3  |
| i4  | 1  | 1  | 1  | 1  | 1  | 0  | 0  | 1  | 1  | 1   | 4  |

The Table 1 is a table of feature items owned by a user $u_1$ (for the first rating criteria). Then, calculate the user's weight for each feature using Weighted Sum [10]:

$$w(u, j) = \frac{1}{|I_u|} \sum_{i \in I_u} x(i, j)r(u, i)$$

$w(u, j)$: weight of user $u$ to features $f_j$
$I_u$: a set of items rated by user $u$
$x(i, j)$: presence of numbers 1 and 0 in an item
$r(u, i)$: user $u$ rating to item $i$

Table 2. The Weight of Item Features

|   | f1 | f2 | f3 | f4 | f5 | f6 | f7 | f8 | f9 | f10 |
|---|----|----|----|----|----|----|----|----|----|-----|
| i1 | 3  | 3.75 | 2.75 | 2 | 3.75 | 1 | 1 | 2.75 | 2 | 3   |

Table 3. The Scenario of Weight Calculation

| i1  | f1 | f2 | f3 | f4 | f5 | f6 | f7 | f8 | f9 | f10 | R  |
|-----|----|----|----|----|----|----|----|----|----|-----|----|
| i2  | 0  | 1  | 1  | 0  | 1  | 0  | 0  | 1  | 0  | 0   | 3  |
| i3  | 1  | 1  | 1  | 1  | 1  | 0  | 0  | 1  | 1  | 1   | 4  |
| i4  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1   | 4  |
| i5  | 1  | 0  | 1  | 0  | 1  | 1  | 1  | 0  | 0  | 0   | ?  |

After rating prediction is calculated with Content-based, then calculate the prediction using the Collaborative-filtering method.

Table 4. User Matrix First Rating Criteria Item

| ID  | i1 | i2 | i3 | i4 | i5 |
|-----|----|----|----|----|----|
| i10 | 4  | 3  | 4  | 4  | ?  |
| i2  | 4  | 4  | 4  | 4  | 4  |
| i3  | 3  | 5  | 3  | 3  | 5  |
| i4  | -  | 4  | 3  | 1  | 4  |
| i5  | -  | 5  | 4  | -  | 5  |

To find the level of similarity between one user and another user based on preference for rating history. It is necessary to determine the similarity function using the Cosine-based formula [11]:

$$sim(u, v) = \frac{\sum_{i \in I_u \cap I_v} x(i, u) \cdot x(i, v)}{\sqrt{\sum_{i \in I_u} x(i, u)^2} \cdot \sqrt{\sum_{i \in I_v} x(i, v)^2}}$$

$$\text{Cosine-based formula [11]}$$
calculation, \[ R_{\text{hybrid}} = \frac{(w_1 R_1 + w_2 R_2 + \cdots + w_n R_n)}{(w_1 + w_2 + \cdots + w_n)} \]

4.5. The evaluation results

In the implementation process, the methods mentioned earlier are applied to this recommendation system. After the recommendation system is able to produce item recommendations, then several testing processes are carried out to analyse the performance of the recommendation system. The first evaluation is done is evaluating the accuracy of the calculation of recommendations and the second is evaluation to see the precision of application recommendations with the wishes or preferences of actual users. Precision is carried out to measure the level of accuracy between the information requested by the user and the results given by the system.

Table 5. The Precision & Recall for User Recommendation

| User | # Recommended | Relevant | Irrelevant | Good | Precision | Recall |
|------|---------------|----------|------------|------|-----------|--------|
| 5    | 10            | 7        | 3          | 5    | 0.7       | 1.4    |
| 6    | 10            | 9        | 1          | 6    | 0.9       | 1.5    |
| 7    | 10            | 6        | 4          | 4    | 0.6       | 1.5    |
| 8    | 10            | 6        | 4          | 3    | 0.6       | 2      |
| 9    | 10            | 7        | 3          | 4    | 0.7       | 1.75   |

Table 5 is the test results obtained after the user login into the application. The number of relevant destinations is the destinations recommended by the system that are in accordance with user preferences or profiles while the irrelevant number of destinations is a recommendation given but not in accordance with the user’s preference or profile the average precision based on five users testing application is 0.7.

Table 6. The Comparison Result of RMSE

| Methods         | RMSE            |          |          |
|-----------------|-----------------|----------|----------|
|                 | Average | Minimum | Maximum  |
| Content-based   | 0.95    | 0.06    | 2.25     |
| Collaborative-filtering | 1.15    | 0.25    | 2.25     |
| Hybrid          | 0.87    | 0.14    | 1.96     |
| Multi-criteria  | 0.84    | 0.2     | 1.7      |

In summary, based on the result of RMSE calculation in Table 6, smaller error rate was obtained in the Multi-Criteria Rating method with an average error of 0.84. It can be concluded that Multi-Criteria ratings method is most effective algorithm to give recommendation. Figure 5 shows the comparison error rate for each method.
Figure 5. The RMSE Average Comparison.

5. Conclusion

Based on the analysis of research results obtained, it can be concluded that the recommender system with Multi-Criteria rating is better than other methods. The Multi-Criteria ratings recommender system can provide reliable destination recommendations according to user preferences. Multi-Criteria ratings has smallest error rate than all the other methods.

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