A Recommendation System for Heritage-Tourism based on Mobile Application and Ontology Technique

Kunyanuth Kularbphettong, Bundit Ngamkam

Abstract
This research proposes to apply ontology and hybrid recommendation techniques to develop an effective heritage-tourism recommender system that help tourists search and make decisions and plan on their trip. Also, with the explosive growth of mobile applications, the development of recommender system is increasing gradually. A critical challenge with mobile trend is to develop travel recommender systems that support and fulfill users’ satisfaction. The recommendation process is separated to two parts: analyzing the current position and examine the suitability places for users by using Ontology, Location based service and collaborative filtering recommendation techniques. The system used a relationship schema to associate traveler’s choice with designated trip with the means of a distance function. Experimental results reveal that the system is able to recommend tourists’ preferences trip. Development and challenges on implementing the prototype of mobile recommender system are promising preliminary realm of research on mobile application development.

Keywords: ontology, hybrid recommendation, mobile application, heritage-tourism

1. Introduction
With the rapid advancement of technology, the ubiquity of smart phones and tablets has affected significant changes the way of traveling especially tools for planning and managing trips. According to Global online travel research from PhoCusWright [1], traveler booking hotels on mobile phones will jump to reach $39.5 million by 2015. Additionally traveler can connect Internet anytime so as to explore their travel activities whether where to shop, where to eat, where to stay, and etc. Hence, with very tremendous information, recommendation systems play an important role to assist and provide customized products to appropriated users. In the last few years, recommendation systems have been widely used on e-Commerce web sites to suggest short list of items from very large catalogs to customers [2]-[3]. There is much of traveling researches applied recommendation techniques to plan and manage traveler activities. Also, ontology is applied to many fields like semantic web, e-Commerce, and information retrieval. Ontology is used to explain the meaning of interested thing and to categorize the documents in the interested data area.

Bangkok has many tourist attractions and a variety of genres and palace and temples. To strengthen the heritage tourism of Thailand, the purpose of this research aims to design and implement a recommendation system for Heritage-Tourism based on mobile application and ontology technique by focusing on time geography and similarity measurements. Moreover, transportation information is used to automatically advice to users with his/her position so as to determine which way a person would travel to recommended location.

The remainder of this paper is organized as follows. Section 2 presents related works and research methodologies used in this work. Section 3 we describe the system architecture based on the purposed model and section 4 shows the results of this experiment. Finally, the conclusion and future research are presented in section 5.

2. Related Works
In this section we briefly present some of the research literature related to collaborative filtering, ontology and location based services.
Collaborative Filtering is a well known approach used in recommender systems to suggest products and services for customers on e-Commerce systems. This approach advises user based on the preferences of similar users and it generally analyzes relationships between users and products or services to identify the user product/service associations [4]. Ratings were given by customers to catalog items/products and users who have similar tastes will have similar tastes in the future [5]. The number of items associated with users is evaluated the accuracy of a collaborative filtering approach. There are two types of collaborative filtering: user-based and item-based. User-based collaborative filtering predicts user’s preference items from rating preference of similar users in the past and item-based collaborative filtering depends on the similarity items and this approach is based on the user rating history to indicate the ratings pattern [6].

There are many tourism systems using collaborative filtering. Pierpaolo et al [7] presented the recommender system for cultural heritage support both tourists and teachers based on user-centered and collaborative approaches to promote knowledge and using a set of metadata that allows the resources to be contextualized in the culture of a territory. Maarten et al [8] proposed a recommending touristic location based on a user’s visiting history in a geographically remote region and the results showed that recommendations based on the co-occurrence model are both more accurate and more surprising than a ranking based on the prior travel probability. Also, the mobile recommender system was combined genetic algorithm and fuzzy logic and this system matched a user profile based on a user’s personal preferences [9].

Additionally, an event-based system and a location-based service applied to a mobile environment were introduced as the personalized tourist information provider [10]. The proposed recommendation system based on collaborative filtering in the case of Macedonia was implemented being capable to generate a personalized list of favorable and tailor-made [11]. From our observation, most recommender systems are able to suggest preference items and also to give educational knowledge tourists to users. In contrast, our proposed recommendation system is adopted various techniques like the user-centered and collaborative technique, location based service and ontology for optimal and flexible solutions to promote the local cultural heritage.

3. The Methodologies

In this section, we illustrate the specified methodologies used in this project including Ontology, Collaborative filtering and location based services.

3.1. Ontology

Ontology has become a popular approach in many appliances to provide a semantic framework for knowledge management. According to Greg Linden and et.al, ontology describes a content representing specific knowledge primitives (classes, relations, functions and constants). Ontology stands for the hierarchical knowledge structure about things by subcategorizing them by their essential qualities. Also, ontology can be described in different ways as vocabulary, thesaurus or taxonomy. Ontology refers to problem domain, where entity of the domain, its properties and its relations are explained. The enormous advantage of ontology is not in processing. However in sharing meaning, appearance and finding of gaps and for a tacit knowledge improving transferring. Ontology holds information in a specified declarative language. Anyway, it also includes unstructured information expressed in technical code or natural language.

3.2. Collaborative filtering

Collaborative filtering (CF) is one of the most effective and successful techniques of recommender systems. This technique uses the relevant feedback from other similar users to predict or recommend to other users. Amazon.com [13] is the most famous recommendation system. This recommendation system incorporates a matrix of the item similarity. The process of collaborative filtering algorithms can be divided in to three steps by following this:
a) Data Description

Table 1. User rating data matrix.

<table>
<thead>
<tr>
<th>User</th>
<th>Item₁</th>
<th>...</th>
<th>Itemₖ</th>
<th>...</th>
<th>Itemₙ</th>
</tr>
</thead>
<tbody>
<tr>
<td>User₁</td>
<td>R₁,₁</td>
<td>...</td>
<td>R₁,k</td>
<td>...</td>
<td>R₁,n</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td></td>
<td>...</td>
</tr>
<tr>
<td>Userᵢ</td>
<td>Rᵢ,₁</td>
<td>...</td>
<td>i,k</td>
<td>...</td>
<td>Rᵢ,n</td>
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<td>Rᵢ,k</td>
<td>...</td>
<td>Rᵢ,n</td>
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</tbody>
</table>

The fundamental components of collaborative filtering involve a rating matrix over m user \{u₁, u₂, ... ,uᵢ, ... ,uᵢₙ\} and n items \{i₁, i₂, ... ,iₖ, ... ,iₙ\}, whose (u,i) presents how user u rated item i [14]. User rating data matrix is shown as Table 1.

b) Similarity Computation

In order to find the similarity of the users, the Pearson’s correlation coefficient is used to compute similarity between user \(a\) and user \(u\)

\[
C_{a,u} = \frac{\text{covar}(r_a, r_u)}{\sigma_a \sigma_u}
\]  

where \(C_{a,u}\) is the Pearson’s correlation coefficient between user \(a\) and user \(u\)

\[
\text{covar}(r_a, r_u) = \frac{\sum_{i=1}^{n} (r_{a,i} - \bar{r}_a)(r_{u,i} - \bar{r}_u)}{m}
\]

Let \(r_{a,i}\) and \(r_{u,i}\) are the received score of product i from user \(a\) and user \(u\)

\(\bar{r}_a\) and \(\bar{r}_u\) are the average of score product from user \(a\) and user \(u\)

and \(m\) is the number of the co-rated items

According to Herlocker et al [15], they suggested to weight user similarity and computed a prediction by performing a weighted average of deviations from the neighbor’s mean.

\[
p_{a,i} = \bar{r}_a + \frac{\sum_{u=1}^{n} (r_{a,i} - \bar{r}_a)w_{a,u}}{\sum_{u=1}^{n} w_{a,u}}
\]

where \(p_{a,i}\) is the prediction for item i of user \(a\)

\(n\) is the number of neighbors

\(w_{a,u}\) is the similarity weight between user \(a\) and user \(u\)

c) Recommendation data set

To produce the recommendation data set, we select the prediction of items that have the highest rating to compose recommendation set.
3.3. Location Based Services (LBS)

Location Based Services (LBS) are significant information services accessible with smart mobile phones through the mobile network and utilizing the ability to make use of the location of the mobile device [16]-[17] and also LBS is the important functionality in smart phone application to retrieve information about user’s current location and near location of user. Global Positioning System (GPS) can be able smart phone to get the user’s location [18]. This project was based on Android operating system and Android supports LBS Application Programming Interfaces (APIs) for mobile software development to determine the location of user's mobile device [19]. With LBS service, users can access information about traffic, restaurants, retail stores, travel arrangements, routes, vehicle tracking and etc.

4. The Proposed Framework and Experimental Results

This section presents the proposed framework of a recommendation system for Heritage-Tourism based on Mobile application and Ontology technique for design and implements this mobile application. This section is organized as follows: Section 4.1 explains the Proposed Framework of this system. Section 4.2 presents the experimental results.

4.1. The Proposed Framework

In this section, the framework of the system, as shown in Figure 1, presents the process of query and recommendation interested places for users. Furthermore, this application displays the routes and how to get to the attraction place. The database of this project was implemented by the SQLite relational embedded database to store and retrieve data.

![Figure 1. System Framework](image)

The ontology of this project is implemented in Protégé [20], a free open-source ontology editor and framework for building intelligent systems.
As presented in figure 2, this ontology of this research was assessed by experts and users to evaluate accuracy of this ontology in concepts and relationships among concepts and fig 3 was shown the Bangkok-Cultural Ontology of this project.
4.2. Experimental Results

In this section, experimental results were separated to 2 parts: developing the Heritage-Tourism recommender system based on Mobile application and Ontology technique and evaluating the performance and satisfaction of the application as shown in figure 4 to 5.

![Figure 4. Example of the Heritage-Tourism recommender system](image)

![Figure 5. Example of recommendation results to users](image)

To test and evaluate the qualities of the system, Black box Testing and Questionnaires by 5 experts and 112 evaluators were used to test this application. Users were asked to rate the recommendation results and the rating scale was from 1 to 5. And black box testing was assessed in the error of the project as following: functional requirement test, Function test, Usability test, Performance test and Security test.

The ability of this mobile application was evaluated by Functional Requirement test in needs of the users and Functional test was used to evaluate the accuracy of the system. Usability test was tested the suitability of the system. Performance test was used the processing speed of the system. Finally, Security test was evaluated the security of the system and Table 2 and Fig 6 were shown the results of Black box testing.

<table>
<thead>
<tr>
<th>Table 2. The results of Black box testing</th>
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<tr>
<td>Experts</td>
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<tr>
<td>---------</td>
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<td>x</td>
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<tr>
<td>1. Function Requirement Test</td>
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<tr>
<td>2. Functional Test</td>
</tr>
<tr>
<td>3. Usability Test</td>
</tr>
<tr>
<td>4. Performance Test</td>
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<tr>
<td>5. Security Test</td>
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</tbody>
</table>
The results showed that the Heritage-Tourism recommender system based on Mobile application was satisfied the requirements of users. Means for 3 experts and 112 evaluators were 3.94 and 4.07, and standard deviation for experts and evaluators were 0.79 and 0.80 respectively.

![Figure 6. The results of Black box testing](image)

5. Conclusion

In this paper we presented our preliminary system of Heritage-Tourism recommender system based on Mobile application. This system provides more suitable recommendation results to users. Initial results of this project indicate that using hybrid approaches like ontology, location based service and recommendation techniques, was successfully generated the recommendation results matching with the group of tourists in Heritage-Tourism Thailand. As for the future work, we need to explore more reasonable other technologies to apply in this project to enhance the quality and quantity of services to users.

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7. References