L-PRS: A Location-based Personalized Recommender System*

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Abstract

As the wireless communication technology advances rapidly, a personalization technology can be incorporated with the mobile Internet environment, which is based on location-based services to support more accurate personalized services. A location-based personalized recommender system is one of the essential technologies of the location-based application services, and is also a crucial technology for the ubiquitous environment.

In this paper we propose a framework of a location-based personalized recommender system for the mobile Internet environment. The proposed system consists of three modules; the interface module, the neighbor selection module, and the prediction and recommendation module. The proposed system incorporates the concept of the recommendation system in the Electronic Commerce along with that of the mobile devices for possible expansion of services on the mobile devices. Finally a service scenario for entertainment recommendation based on the proposed recommender system is described.

Keywords:

Recommender system; Personalization; Location-based Service

1. Introduction

There are a myriad of the goods traded in commercial transactions in online and off-line. These goods include physical products as well as digital contents. It is not easy for the users to search the best suitable goods among almost countless items. In order to provide valuable information on the items to the users who have various preferences, we need an effective personalized recommender system.

A personalized recommender system predicts the best suitable goods for the users according to their individual preferences and recommends the predicted results to them. Thus the users can save time and efforts in searching the goods they want. It is very important for a recommender system to have a capability to predict accurately by analyzing the preferences of the users. A recommender system utilizes in general an information filtering technique called collaborative filtering (CF), which is based on the ratings of other users who have similar preferences and is widely used for such recommender systems as Amazon.com and CDNow.com [1,2,3,4,5].

As the wireless communication technology advances rapidly, a personalization technology can be incorporated with the mobile Internet environment, which is based on location-based services to support more accurate personalized services. So it can serve location dependent and context sensitive information to the mobile users [11]. A location-based personalized recommender system is one of the essential technologies of the location-based application services, and is also a crucial technology for the ubiquitous environment.

In this paper we propose a location-based personalized recommender system in the mobile Internet environment. The proposed system consists of three modules; the interface module, the neighbor selection module, and the prediction and recommendation module. The proposed system incorporates the concept of the recommendation system in the Electronic Commerce along with that of the mobile devices for possible expansion of services on the

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mobile devices. A service scenario for entertainment recommendations based on the proposed recommender system is also presented.

The rest of this paper is organized as follows. Section 2 describes location-based services. Section 3 illustrates a recommender system based on CF. In Section 4 the proposed location-based personalized recommender system is provided. The conclusions are given in Section 5.

2. LBS: Location-based Services

In a wireless mobile communication network, the accurate location of a user or an item can be obtained using a mobile device such as a cell phone or a PDA. Based on the locations found, there are various types of services to provide valuable location-dependent and context sensitive information to the mobile users [11]. LBS have various applications such as museum or travel information guides, advertisement, emergency services, local maps, local weather, traffic information, and shopping guides. The application areas are diversified as the technology of mobile communication advances and the mobile devices are more and more popular [6,7,8].

In Figure 1 a framework of LBS is shown. LBS are in great need of three types of technologies; they are the location determination technology, a location-processing platform, and location application services. The location determination technology tracks and finds locations. A location-processing platform is called a *LBS middleware* and stores and maintains location information. And location application services are location-based application programs to provide application services to the users.

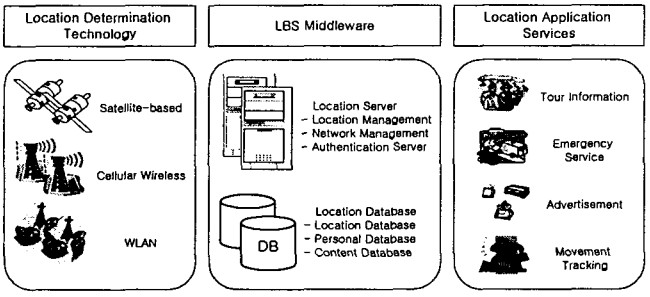

Figure 1 - Location-based Services

3. RS: A Recommender System

In online commercial transactions, if a recommender system is capable of providing the information on the best suitable goods for the users, then they could have great satisfaction on the transactions. An automated collaborative filtering method plays a crucial role in reducing the user's burden of searching. It filters necessary information and provides it to the users. CF is widely used in recommender systems until now among various information filtering methods.

CF makes a set of user's preference for an item, compares it to other users' preferences. CF filters the proper information through it. That is, CF calculates the degrees of similarity between the preference of the current user and each of those of other users using the correlation of preferences for the same item. CF then filters suitable items based on their preferences and the similarities, and recommends the items to the current user. CF works quite well for a recommender system, because it is based on the ratings of other users with similar preferences in order to predict user's preference. It may also recommend the items that a user has never expected. In CF, preferences are represented by numeric values rated by the users.

3.1 A Recommender System Architecture

A recommender system architecture using CF is shown in Figure 2. A recommender system consists of three modules; they are *the interface module*, *the neighbor selection module*, and *the prediction and recommendation module*.

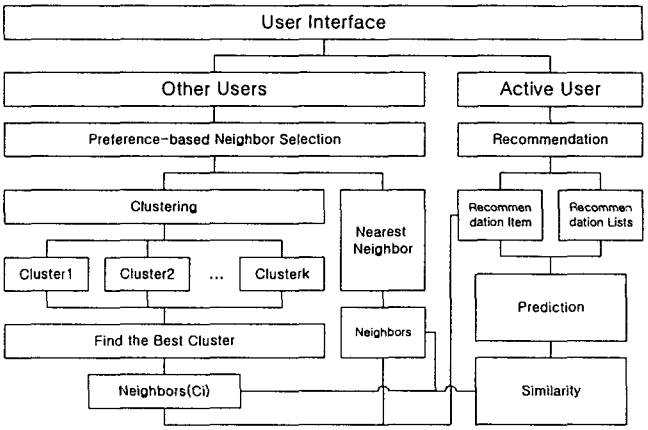

Figure 2 - A Recommender System Architecture

In the interface module, the users can rate their preferences for the items or can get the results of recommendation from the system. The users rate their preferences in numeric values and receive recommendation lists calculated by the prediction and recommendation module. The neighbor selection module selects a proper number of neighbors with a similar preference for better recommendation to each user. Finding similar neighbors is very important for providing more accurate predictions. The prediction and recommendation module predicts how much a user prefers to a new item. The prediction is calculated using the opinions of the users who have already rated the same item. Hence calculating degrees of similarity of preferences between a pair of users is essential for more accurate predictions.

3.2 Neighbor Selection Methods

In a CF-based recommender system, for a given user, the prediction of the preference of the user on a new item is made based on the ratings of other users (called the neighbors) for the item. So it is quite important to find similar neighbors for better recommendations [10].

3.2.1 *The Nearest Neighbor Method*

The nearest neighbor method selects the nearest k neighbors who have similar preferences to a given user by computing the similarity based on their preferences. This method has better prediction accuracy than a method using the whole neighbors, because it uses k neighbors who have higher correlation with the given user [3,4].

3.2.2 *The Clustering Method*

The clustering method creates k clusters each of which consists of the users who have similar preferences among themselves [7,9,10]. If clustering process is terminated, all users in each cluster are registered as the candidates of the neighbors. Then the cluster with the highest similarity between a user and the representative value of each cluster is chosen. Finally, all users in the chosen cluster are selected as the final neighbors for calculating predictions [7,10].

4 L-PRS: A Location-based Personalized Recommender System

4.1 L-PRS Architecture

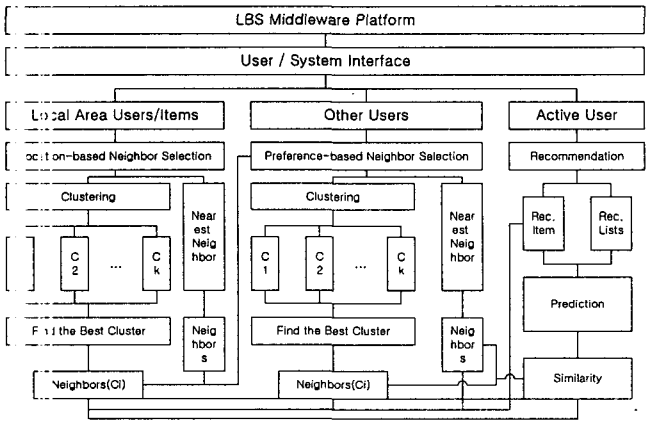

Figure 3 - L-PRS: A Location-based Personalized Recommender System

Figure 3 depicts the proposed L-PRS architecture. L-PRS consists of three modules — the interface module, the neighbor selection module, and the prediction and recommendation module. L-PRS receives location related information from the LBS middleware platform through the interface module.

The interface module is divided into the user interface and the system interface. The users query for their needs to the system and get some results through the user interface. They also rate their preferences to the recommended items through the user interface. The system interface bridges between the recommender system and the LBS middleware to obtain user's location and other location based information from the LBS middleware platform.

There are two neighbor selection methods in the neighbor selection module. One is the preference-based neighbor selection and the other is the location-based neighbor selection. The preference-based neighbor selection method selects neighbors with similar preferences for high quality recommendations to the users as in a recommender system. The location-based neighbor selection selects the nearby neighbors with respect to the location of a given user, where the location information of the users is provided by the LBS middleware platform. It selects proper neighbors based not only on the users but also on the items.

The prediction and recommendation module predicts and recommends the best suitable items for the users using the location-based and preference-based information. When there is no inquiry from any user, this module may provide helpful notification services to the users such as the current events or advertisements based on the location information.

The LBS middleware platform is a target system for the interface to give and take location related information with L-PRS. It includes two functional servers such as the location information server for obtaining and maintaining the location information, the large scaled location data server for tracking, saving, maintaining, and searching of mobile objects. They are in charge of location maintenance mainly.

4.2 Neighbor Selection Method

As aforementioned, there are two neighbor selection methods in L-PRS — the preference-based and the location-based neighbor selection methods. The location-based neighbor selection method can be divided into the user-based method and the item-based method. The preference-based method is the same as the neighbor selection method used in a recommender system, so we describe the location-based neighbor selection method only.

The user-based method selects properly neighbors located within the local area of the location of the given user. Similarly, the item-based method selects items to recommend to the user through event notifications or advertisements with or without user's inquiries. An item is selected based on its location and attributes. The item-based method selects the items that are located in the vicinity of the location of the user or selects the neighboring items that the user prefers to. For example, the system may recommend the nearest theater to the user, or recommend the store list the neighboring items.

4.2.1 The Nearest Neighbor Method

The nearest neighbor selection method is based on location information and selects k users/items in the nearest location from the user's location. This method may give important surrounding information with respect to the current user's location, so it may give great satisfaction to the user. Note that k is the number of users/items.

4.2.2 The Clustering Method

The clustering method considers all users/items around the current location of the user, and constructs k clusters based on their location and either on the profiles of users or on the attributes of items. If the best suitable cluster to the user is

determined, then all users/items in the chosen cluster are selected as the final neighbors.

4.3 A L-PRS based Entertainment Recommendation Service Scenario

A simple example scenario of a L-PRS based entertainment recommendation service is as follows. Mr. Smith is now in the downtown area of a city. He wants to go to the movies but does not decide yet which movie he wishes to see. He comes up with the idea that he can get some help from the L-PRS. The following steps shows how the L-PRS proceeds for his inquiry.

- Step1: Mr. Smith connects to the L-PRS with his cell phone.
- Step2: He sends a query of a recommendation about the movies to the L-PRS.
- Step3: The L-PRS requests his current location to the LBS middleware and receives his location and the proper information regarding his location.
- Step4: The L-PRS tries to get a list of movies along with theaters using his profile and the information received from the LBS middleware.
- Step5: The L-PRS sends the list to his cell phone.
- Step6: He examines the result and transmits his feedback to the L-PRS.
  The result is a recommendation list that contains the best suitable movies for him along with the locations of the movie theaters.
- Step7: The L-PRS updates its related database according to the feedback from him.
- Step8: He books a ticket to see a movie chosen from the recommendation list.
- Step9: After watching the movie, he transmits his rating for the movie to the L-PRS.
- Step10: The L-PRS updates his profile accordingly.

In Step 7 Mr. Smith may be quite happy with the recommendation list from the L-PRS. But he may think that the list does not include what he expected. If so, we should go back to Step 4 with his feedback for better recommendation.

5. Conclusion

In this paper we have proposed a location-based personalized recommender system in the mobile Internet environment. The proposed system consists of three modules — the interface module, the neighbor selection module, and the prediction and recommendation module. The proposed system utilizes neighbor selection methods based on both location and preferences for making high quality recommendations. We have described a service scenario for entertainment recommendations on the proposed L-PRS. The proposed system incorporates the concept of the recommendation system in the Electronic Commerce along with that of the mobile devices for possible expansion of services on the mobile devices.

A location-based personalized recommender system will play a very important role for the location-based application services, and will be an important technology for the ubiquitous systems in the near future. But the following two issues among others should be resolved for the recommender systems. One is developing more robust algorithm for higher prediction accuracy. The other is the personal privacy problem. Users can be daunted psychologically by an exposure of their locations, so they may refuse to use the system. Therefore, it is necessary to research for protecting an invasion of their privacy.

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