A Mobile Location-Aware Recommendation System

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Abstract: Improvements in mobile technology provide greater personal information accessibility, data incorporation, and public resources accessibility, "anytime, anywhere". Smartphones are not only devices that make phone calls, but have also become a gateway to the Internet. Mobile devices offer the capabilities of usage flexibility, mobility, fast wireless communication, and location-awareness. Location is determined by GPS satellite tracking, position relative to GSM base stations, and the device's media access control. Similarly, usage of social networks is increasing steadily. Widespread usage of social networks introduces new requirements of Internet application. Users of such networks share their ideas and interests, as well as the activities they plan to attend. In addition, they follow other users' information and shape their planned activities accordingly. In this study, an intelligent context-aware system is described. In this field, context-awareness is a mobile paradigm in which applications can discover and take advantage of contextual information, such as user location, nearby people and devices, and user activity. This system provides an activity list that users plan to attend. Our recommender system creates results based on data mining techniques, by using personal identification data and user activities. The recommender system brings novel methodology to the activity-decision process by utilizing the right location and real-time information.

1 INTRODUCTION

Most people consider mobile technologies to be an integral part of their lives. Recently released mobile phones provide users not only with numerous features (e.g., camera and video capture devices, GPS localization, and Wi-Fi connectivity), but also the capacity to program these mobile devices with additional applications. Among the most popular applications are location-based services (LBSs), in which knowledge of the end user's location is utilized to deliver relevant, timely, and engaging content (Rao and Minakakis, 2003).

The idea of context awareness is nearly as old as the mobile devices themselves. Context awareness is a mobile paradigm that uses context to provide relevant information and/or services to the user, where its relevancy depends on the user's current task (such as user location, nearby people and other devices, and user activity). Context awareness in the form of allowing designers to learn about what users are doing with the app, where and when, is also important to further improve that very same context awareness of the applications (Fahy and Clarke, 2004). A mobile application can provide more specific information that is suitable for the current situation if it knows about its location and time, which is particularly important since mobile devices have certain limitations that affect the usability for their users.

Social media too are becoming an important part of everyday life. One goal of social navigation is to utilize information about other people's behavior for our own navigational needs (Dieberger, 2003). Social media encourage people to use resources from these social networks and apply them to their real lives, to avoid isolationism, and to understand social trends by observing the users' contents on their social networks. When Dourish and Chalmers introduced the concept of social navigation in (Dourish and Chalmers, 1994), they defined it as "navigation towards a cluster of people or navigation because other people have looked at something". In social navigation, people watch the activity of other people to make choices about what is popular, to see which paths to follow, and to find links to related information (Hook et al., 2003). Social navigation can potentially transform different spaces by encouraging people to explore those spaces that might otherwise be ignored or overlooked (Gay, 2009).

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Data mining is the application of specific algorithms for extracting patterns from data. Its main goal is to extract information from a data set and transform it into an understandable structure for further use. Data mining is also used in location management wherein the mobility patterns are determined to predict the next location of the mobile user in (Yavaş et al., 2005). In essence, activity selection can be used in the development of a collective spirit. Social media provides a rich source of such information, for marketing professionals and others interested in extracting opinions.

In this study, a mobile platform, LOAS (LOcationAwareSystem) is presented, for monitoring and collecting information about people's activities. We suggest not only a context-aware mobile location-based service, but also one that employs data mining techniques to relate them to their hobbies and activities. In addition to places and venues, collective activity is represented in real time on a public map as a social-navigation recommendation and guidance system. As far as we know, there is currently no user study that exclusively investigates people's location-based search motivations and the opportunities for context aware data mining. In order to improve and optimize location-based services, it is necessary to understand people's location-based information needs and the context in which they occur. With this in mind, we have implemented search recommendations based on users' hotspots and social networks, with respect to information privacy and security.

The rest of this paper is organized as follows. Section 2 discusses some related work. In Section 3, we describe the architectural, functional, and implementation aspects of LOAS. The results of our experimental evaluation are provided in Section 4. In Section 5, we present our conclusions and plans for future work.

2 RELATED WORK

Research topics related to our system include location awareness, context-aware recommender systems and campaigns in social network, mobile information access and collaboration of these in data mining.

Location used to be considered as important context information (Baldauf et al., 2007). Location awareness is a general term used for something that can show that it is aware of your current location services built on the location awareness capabilities of mobile devices and networks (Lee et al., 2006). Location detection techniques, including from indoor and outdoor is provided in (Hightower and Borriello, 2001). The major issue is that location detection is hard to use in popular applications and done in an ad-hoc way since it has no general method for every device. (Fischmeister, 2003) uses the concept of location awareness in which the services can be accessed by the user with their user agent. The infrastructure of the system provides supports for proactive location-aware services.

Recommender systems (RS) are tools and techniques used in various web-based applications to provide users suggestions for items to be chosen (Ricci et al., 2011). Recommender system consists of three key components - users, items and user-item matching algorithms. The utility of an item is usually represented by a rating, measuring how much a specific user is (or is predicted to be) interested in a specific item. Depending on the application, the ratings can either be specified by the users, or computed by the application. RS techniques are classified into six different classes of recommendation approaches; context-based collaborative filtering, demographic, community-based and hybrid (Burke, 2007). Suggested system uses hybrid recommendation approach because, recommender is not only giving context-based information, but also makes recommendations based on personal interest. The issue of finding hidden links between users and items based on the similarity of the user preferences/interests and the item content features is the essence of the already presented hybrid recommender systems. Contextual information is important to facilitate suggestions for users. The context-aware RS will take into account companion, time, atmospheres and weather that help user to make better choice. In our system, we integrated time, location and users' social network preferences into contextual information.

Context awareness has been the focus of many research areas, especially in social network structures. Most of the available applications focus on human factors and physical environment. While human factors can be categorized into information on the user, the users' social environment, the user's task; physical environments are structured into location, infrastructure and physical conditions (Bellavista et al., 2012). Context information is shared by subscribing a platform designed using the WASP Subscribing Language in (Costa et al., 2004). Chen and Kotz introduced middleware, Solar, in which a platform for context aware mobile applications consisting of one star and several planet nodes in (Chen and Kotz, 2002). Client applications subscribe to context changes at the central star rather than collect, aggregate or process context themselves.

Our approach also related with mobile information access that there are some remarkable studies of user behavior of mobile devices. In Church et al. (Church et al., 2008), the result of a detailed analysis of mobile search behavior of over 2.6 million European mobile subscribers presented that among those 11% executed at least one request. This study was the first to analyze the click through behavior of mobile searches. Result of this research had interesting conclusions; mobile search is used by only 8-10% of mobile internet users, mobile search engines have widely adopted a traditional Web-based approach to search, mobile searches queries are short and users tend to focus on the first few search results. Yi et al. investigated the search characteristics from mobile devices (Yi et al., 2008). The authors listed interesting points and trends from this study; (i) there is the evidence of high variability of mobile query patterns, (ii) statistics show significant variations in the regional query patterns, and (iii) the usage patterns are dynamic because users are still figuring out how to take advantage of new mobile devices and services. Another research was the result of a Web-based diary study about location based behavior search through a mobile search engine illustrated in (Amin et al., 2006). Authors were able capture users' explicit behavior and implicit intention as well as spatial, temporal, and social context of search. The results of this study show that location-based searches are usually relied on just-in-time information needs that are closely related to social activity. Among the main findings of this study, most location-based searches on mobile devices are performed when users are along with other people, such as relatives, friends, and colleagues. The importance of taking into account user information needs and context in search and recommendation processes has inspired our approach.

3 A FRAMEWORK FOR A CONTEXT-AWARE SOCIAL NETWORK

In this section, we will describe an intelligent mobile location-based application which derives activity data according to the users' current locations and their previously-attended activities, as well as associated information from user-generated posts online. With this approach, it helps users navigate standard environments, as well as temporary events, such as fairs, concerts, movies, and theaters in particular. In general, the research platform application is a social mobile service allowing users to post their current location, and for suggestion marks to be shown on a map, which can then be utilized for social navigation. A typical use case scenario is that a user wants to inform other users about a positive or negative place, by inputting the tag. Another scenario is that a user is curious and wants to see where other users are located or what are the best and the worst places to spend on a specific day. Our application also has a built-in calendar section, with which the user can arrange his/her activities, as a smart calendar.

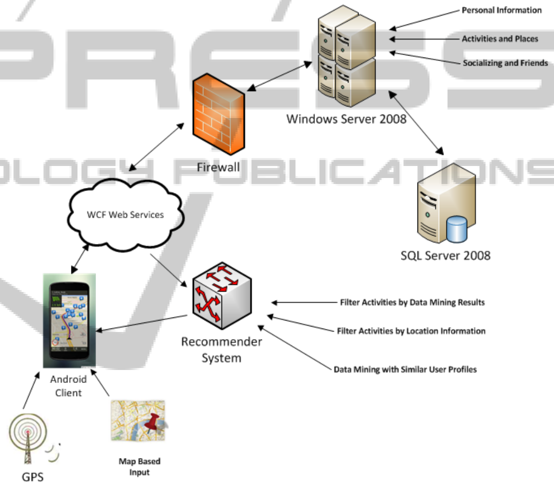


Figure 1: LOAS architecture.

LOAS is designed to support the following goals: i) Suggest to users depending on their previous choices. ii) Suggest to users depending on social groups in which they are members. iii) Track all status changes and share them with their social groups. iv) Allow users to view the map. v) Allow users to share activities and places, and to tag them. vi) Allow users to organize daily dates and tasks on a context-aware calendar. vii) Design an application that should be understandable and manageable by the typical user.

3.1 Recommender System

Recommender systems (RS) are tools and techniques used in various applications to provide users with suggestions for items to be chosen. Our RS application has three main tasks. Firstly, it is responsible for learning a user's friendships and subsequently revealing hidden friendships about previous activities and places in a given social group. Secondly, it learns the user's location, and it filters activities listed for a specific area. Thirdly, it filters activities according to the data mining results at any given time. We will now discuss these three tasks and our solutions, in turn.

Data mining with similar user profiles: The module includes the functionality of learning the user, collecting data between all the users, and then generating Association Rules based on the users' data. The purpose of association rule mining is to find frequent patterns, associations, correlations, or casual structures of sets of items or objects in any transaction database. The well-known Apriori Algorithm was chosen for the association rule mining; the implementation was written in C#. The user reaches the suggestion list by calling a web service and suggestion list function in WCF. This service operates the data mining on the database of LOAS.

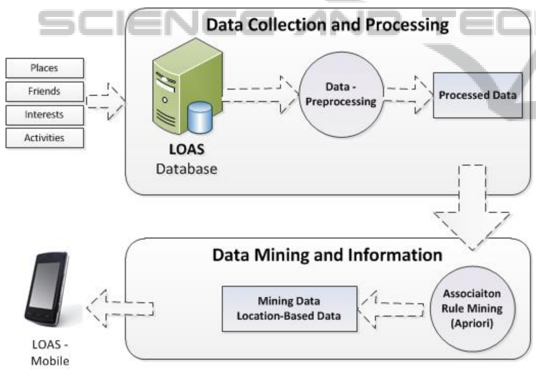


Figure 2: Two-phased data mining of LOAS.

The processing of our algorithm has two phases of data mining, which is illustrated in Figure 2. In the first phase, the user-related data (interest, profiles, etc.) are collected in the LOAS database. The preprocessing was done on the server side, such that it satisfies the user profile's interest in the mobile user and the cleaning of the data with any missing values. This organizes the data for the next phase, and it makes clear the related information before the mining process. The second phase involves processing the data using the association algorithm and creating the association rules on the information gathered. After the process, the results are returned to the user as the basis of interest to mine the relevant information.

Filter activities by Data Mining Results: The LOAS system collects user preferences and exploits this information to provide personalized recommendations about points of interest in the surroundings of the user's current position.

Consider the set of user activities that will be used in the data mining: Activity = $\{a_1, a_2, \ldots, a_n\}$. After collecting the user activities, these features are used to select the relevant attributes of User_i where it is the raw data from the LOAS database. Let SelectedTuples be the set of the selected tuples from User_i.

User data are collected in the first phase of the data mining by selecting the tuple(s) that satisfy the Activity that will be included in SelectedTuples. Then, these data will be processed by deleting the missing values of the tuple(s). There are some preprocessing techniques that fill up the missing values, but this may consume a prohibitive amount of time for processing. As a second phase in the Data Mining, the association rule algorithm is implemented on the data sets of the preprocessed data. The association rules creates a rule set based on the associated data sets. After the results are acquired, the output of the data mining is sent to the mobile side.

Filter activities by Location Information: Mobile recommender systems make recommendations based on a users' interests and present location. Identifying the position of the user is the first step to providing location-aware services. Estimating location can be done in several different ways. The user can be located by the GPS (Global Positioning System) module of the user's device, which provides accuracy of 1.5 – 20 meters. However, GPS data is not always available indoors, and it may not work in all urban areas. The second way is cell-based solutions using a GSM (Global System for Mobile Communications) base station in the network. The position can be calculated based on the mobile network cells. Other methods for locating the user are device-based solutions that use the device's media access control systems, such as WLAN (Wireless Local Area Network, Bluetooth, or 3G). There is a service working in the background of LOAS detecting to the user's current location every 5 minutes. Users are suggested activities according to their profiles within a 25-km diameter area. All activities are filtered using the Haversine Algorithm (Sinnott, 1984). Furthermore, users are provided with a map presenting a list of relevant activities and places, including how to get to any selected activity by car or by public transportation using the shortest distance.

3.2 Server Side

Since mobile devices have less computational power than desktops as well as relatively smaller screens, in order to improve the response time of the system, most of the heavy tasks have been put onto the server side. The server has tables storing the users' personal information, social networks the users are members of, and lists of activities and places. These data might also be used for other web-based services.

3.3 Mobile Application

The LOAS mobile agent middleware provides an advanced infrastructure that integrates the application with core services and tools, to permit communication to mobile elements. The mobile agent core services layer consists of components for position acquisition and filtering, background services, a content provider, and the LOAS database. The LOAS application layer has a social network extension, a suggestion system, and a location-aware component.

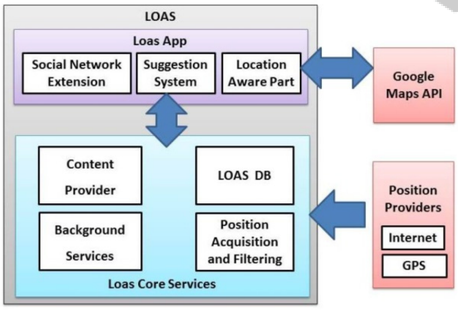


Figure 3: LOAS mobile agent middleware.

The general structure of our proposed model is shown in Figure 3.

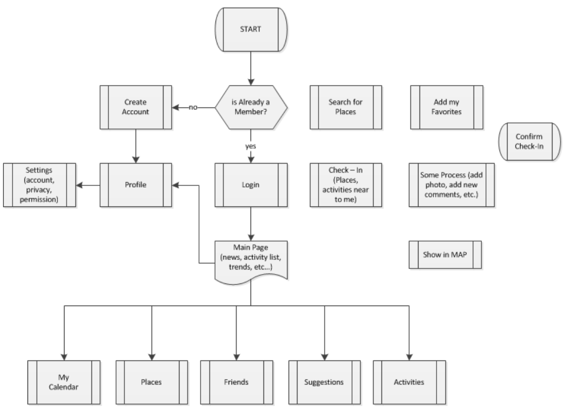
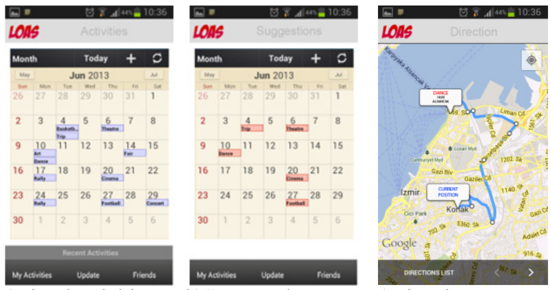


Figure 4: Structure of the LOAS model.

Activities: An activity has a name, an explanation, a start date, a finish date, and its location information. There are Hobbies in the database of the system, which are added beforehand and maintained statically. Thus we can give a hobby type to each activity when any user adds a new activity. An activity detail page has information about an activity, a check-in button, a rating bar, the user that created this activity, and top visitors of this activity. Also, the user can see and add comments, shown in the map, and invite friends to this activity using the tabs on the bottom of the page.

MyCalendar: MyCalendar is a typical calendar application, similar to many other calendar apps that allow a user to organize daily dates and tasks. We have included more functions to make it context-aware. Typical calendar apps already provide the concept of user-defined categories. For each date entry, a user can define some planned activities. The activities of the user are added to the calendar according to their start date. When any activity starts, the user is warned, via an alert. Any activity that is added to the calendar is signed on the interface. The color style changes according to the selected activities. There are different 'suggested' and 'selected' color styles. Suggested activities that are more relevant to the user's activity list are displayed more obtrusively (e.g., in bold), whereas other activities are presented unobtrusively or even hidden. Figure 5 shows an example MyCalendar page containing some activities that are displayed in purple (suggested by the RS system), while some activities are in orange (those that have been accepted). The recommendation system suggested a Dance activity rather than the Art activity on June 10th because it takes more than 30 minutes to get to where the Art activity is being held.



a)Listed activities b)Suggested activities c)Direction to selected activity

Figure 5: Calendar page some activities are purple (suggested by RS), some activities are orange (accepted).

Friends: With a Facebook extension, the friends' activities and comments are collected and integrated into our system. While a preferable activity list is being prepared, the filtering is done according to the user profile and the choices of similar profiles. Two main processes are used for find matching profiles. At first, the initial user interests can be collected during the first registration by using the user's personal identification data. Then, the transaction data that is provided by users is added to the database. The recommender system generates the user's possible activity list by using data mining according to the user's personal information, location information, and activities.

Places: A place has a name, an explanation, some location information describing where this place is located, and a Place Type which gives information about the type of this place. These Place Types are kept in the server database statically. Users can add a new place to this information. Users can list places by a place type, within 1, 3, 5, 7, 10, and 15 kilometers distance.

4 MOBILE LOCATION-AWARE MODEL

4.1 Data Mining

We proposed a framework for a location-based application that uses data mining functionality to provide users with suggestions depending on their current locations and their previous activities. The proposed model consists of two phases: the generation of the activity data from the user profile, and the activity suggestion based on the generated rules. The LOAS database has a user attended activities table storing that data for each user, as shown in Table 1.

Table 1: User activities obtained from the LOAS database.

User ID	User Activities
1	{cinema, dance, trip}
2	{tennis, fair,concert, theatre, art}
3	{concert, trip}
4	{fair, concert, art}
..	..

We have applied the Apriori Algorithm in which the main objective is to extract useful information from large amounts of data. In our work, we collect the activities of a user in the form of $A = \{((id_1, a_1), (id_1, a_2)... (id_1, a_n)), ((id_2, a_1), (id_2, a_2),.., (id_2, a_n)), ...,(id_k, a_k))\}$ where id_1 denotes the ID number of the user who engages in activities from a_1 to a_n.

The execution of the Apriori mining algorithm with $supp_{min} = 4$ instances and using the activity table, is illustrated in Tables 2 through Table 4. The candidate patterns (C_1), with a set of length-1 and the large patterns (L_1), are depicted in Table 2.

Table 2: Length-1 candidate patterns (C_1) and length-1 large patterns (L_1).

C_1		L_1	
CANDIDATE	SUPPLY	PATTERN	SUPPLY
{tennis}	12	{tennis}	12
{theatre}	11	{theatre}	11
{dance}	10	{dance}	10
{trip}	13	{trip}	13
….			

Next, using the candidate generation algorithm generates C2. In this algorithm initially the candidates set is empty for each length-k large pattern L determine all the cells which are neighbors of Ik in G for each of these neighbor cells, v generate a candidate by attaching v end of L. L1 is used to generate C2 . Then, the supports of these candidates are counted, and the patterns which have a support value larger than suppmin are assigned to the set L2. The sets C2 and L2 are presented in Table 3.

```
CandidateGeneration()
// Generation of length-(k + 1) candidates
Candidates = ∅
foreach L = <I1, I2, ….., Ik>, L  ∈  Lk
N+ = { v | there is an edge in G such as
             Ik →v }
foreach v  ∈   N+(Lk)
{
  C' = < I1, I2, ….., Ik, v>
  Candidates ← Candidates   C'
}
return Candidates;
```

Table 3: Length-2 candidate patterns (C_2) and length-2 large patterns (L_2).

C_2		L_2	
CANDIDATE	SUPP.	PATTERN	SUPP.
{tennis, theatre}	6	{tennis, cinema}	9
{tennis, dance}	2	{tennis, football}	5
{tennis, trip}	3	{tennis, concert}	6
{tennis, fair}	1	{tennis, theatre}	6
{tennis, concert}	6	{cinema, football}	6
{tennis, art}	1	{cinema, concert}	7
….			

Having L2, C3 is generated using the CandidateGeneration( ) function, and then the large patterns in C3 are assigned to the set L3. These sets are shown in Table 4.

All possible rules and their confidence values for the activities are demonstrated in Table 5, as well as

Table 4: Length-3 candidate patterns (C_3) and length-3 large patterns (L_3).

C_3	
CANDIDATE	SUPPLY
{tennis, cinema, football}	4
{tennis, cinema, concert}	3
{tennis, cinema, theatre}	4
{tennis, cinema, dance}	2
{tennis, cinema, art}	0
….	
L_3	
PATTERN	SUPPLY
{tennis, cinema, football}	4
{tennis, cinema, theatre}	4
{cinema, theatre, trip}	4

the set of length-4 candidate patterns, C_4. If the threshold confidence value, $conf_{min}$ is assumed to be 60, then the rules having a confidence bigger than or equal to $conf_{min}$ will be the same as the rules in Table 5, since all these rules have a confidence bigger than $conf_{min}$.

Table 5: All Possible Rules.

RULE	CONFIDENCE
{theatre, trip} ➔ {cinema}	0.95
{dance} ➔ {cinema}	0.89
{theatre} ➔ {cinema}	0.82
{tennis, football} ➔ {cinema}	0.80
{tennis} ➔ {cinema}	0.75
{trip} ➔ {cinema}	0.67
{art} ➔ {concert}	0.67
{cinema, football} ➔ {tennis}	0.67
{tennis, theatre} ➔ {cinema}	0.67

4.2 Results of Data Mining

Our experiments are based on data obtained from 37 graduate and undergraduate students' activities for 2 months. The results were evaluated utilizing association rule mining techniques. Table 1 presents the activity sequences entered by the users. Once these values were analyzed, candidate (C1) item sets with 10 different activity frequencies were determined, as depicted in Table 2. Among these groups, the movie with 23 instances has the maximum value; the rally with 3 instances has the minimum activities. When the value of suppmin is chosen as 4, the activity rally with 3 instances is removed from the length-1 large patterns (L1) set. The rest of the cluster has created the large-1 item set with 9 items.

There are 33 pairs in Candidate-2 item sets, in which 14 of them have passed the threshold value, $supp_{min}$=4. In order to have a cluster of 3 pairs, 17 of them were analyzed and 3 of them had passed the minimum threshold level, and thereby formed Large-3 pattern. A cluster with the candidate-4 item set could not be found by using the Apriori Algorithm. Table 4 depicts the last established item set.

The rules obtained from these item sets are shown in Table 5. The minimum confidence value is taken as 60% when calculating the association rules. By using this confidence value, a total of 14 rules were obtained. According to the trends of these users, it was observed that everyone who attends the theatre and goes on a trip also goes to 100% of the movies, and everyone who attends the theatre 82% also goes to movies.

5 CONCLUSIONS AND FUTURE WORK

Mobile social networks have been a challenging research direction in recent times. Although the number of users involved in social networks has increasing tremendously in recent years, these participants are lacking in coordination and collaboration. It is hard to quickly and easily discern where other friends in one's social network are located, what other activities are available for a given location and time, who else is participating in those activities, and what are the shortest paths to go there.

In this paper, we presented a mobile application for monitoring and collecting information about people's activities in the social media space, to facilitate user-centric collaboration and coordination. Three promising contextual attributes - time, location, and interest – have been taken into consideration. We have designed a specialized application for these social networks for use with mobile devices, augmented with recommendation systems and a data mining algorithm. Our proposed model suggests to users various activities and places depending on their social groups, their previous choices, and their current location, by using data mining techniques. The algorithm proposed is based on mining the user profile, forming activity rules from these patterns, and finally suggesting a mobile user's activities by using the mobility rules. Suggested activities can be viewed on the map, and directions can also be provided. Additionally, our research shows that using the data mining function enhances the context and location awareness of mobile users. Another benefit of LOAS is that it will enable users to choose more appropriate activities and to share them with their friends, to socialize more efficiently. The results of an evaluation performed on real users show that the proposed approach provides significant benefits in terms of effectiveness compared with nonpersonalized recommendation algorithms.

In this study, experimental tests have been conducted to demonstrate the accuracy and feasibility of the study. The next stages of the study, people can be grouped according to the activities by using k-means algorithm. Then, by using appriori algorithm, more detailed guidance to these groups is planned. The study was conducted to demonstrate the use of contex-aware system by using collected data in the mobile environment. Nowadays, it is believed that the people can be consciously directed with the participation of increasingly widespread and social networks. In this preliminary study, positive results have been taken in this direction. In the next stages, evaluation of the results is planned on more subjects by using clustering and association rule mining. On the other hand, we plan to combine the users' demographic data and activity trends, to be investigated in detail in future studies. In addition, we intend to prepare a model for the creation of specific groups of users and the development of helpful guidance for new members in these groups. Thus, we will be able to analyze and make suggestions based on not only users but also groups. Furthermore, augmented reality implementations have become more widespread in various mobile environments. In order to present activity-related information more effectively, we intend to include additional application into LOAS to track the users' impacts.

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