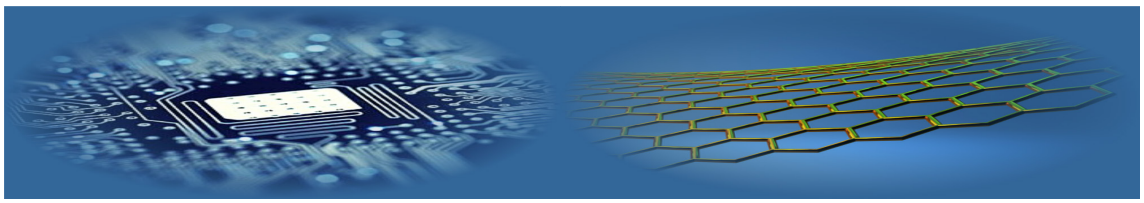

Architecture design of a context-aware recommender system in the tourism domain

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Abstract

Great diversity of tourist attractions and large amount of data available on the Internet and its ever-increasing trend have posed many problems for tourists in finding the desired information at the right time, so that finding the data tailored to their needs has turned into a complex and time-consuming process. To address these challenges, we propose a context-aware travel-package recommender system to help the tourists in the selection of tourist attractions to suit their interests, and to save the needed time for decision-making. The constraint satisfaction problem solving is used to consider the constraints of the tourists in proposing travel packages. Finally, the proposed system tries to recommend a personalized travel package to the tourist by taking advantage of contextual information such as time and place of travel, tourism interest and budget and duration of travel. The proposed system is implemented in the form of an android-based software for mobile devices. For evaluating the system, the "usage prediction" for short, medium and long travels are investigated. We have used 12 tourists for evaluation of the proposed system, and the results of the implementation of the system shows the high values of precision and recall criteria.

Key words

Ubiquitous computing, Recommender systems, Context-awareness, Travel-package

1 Introduction

In the digital and electronic world, a large amount of data has been stored on data servers and databases. In the tourism domain, this large amount of data available on the Internet has posed problems for tourists in finding the desired information at the right time, so that finding the data tailored to their needs has turned into a complex and time-consuming process. Given the diversity of tourist attractions

and points of interest, searching and selecting the most attractive sites tailored to users' interests is a hard and time-consuming task [1]. As a result, the existence of a system with the ability to recognize interests and priorities of the users is strongly felt. Recommender systems are of the tools that can guide users to find information and services of interest [2].

A recommender system typically deals with a large and increasing volume of information and offers users personalized recommendations [3]. The use of travel recommender system is a basic requirement for tourists to better manage the trip and save time. In this paper, the research problem is designing a Context-Aware Travel-Package Recommender System (CATPRS) for tourism, which recommends a personalized travel package tailored to the interests and needs of them. According to the requirements of tourists, in accordance with contextual information such as interests, requirements, duration of travel, and travel budget, this system should provide personalized travel package. As a result, in this paper, a context-aware recommender system is proposed, which offers a travel package. The travel package is consistent to the contextual information of user such as interest, travel duration, and travel budget. The system is developed on Android platform and evaluated by using a well-known data set.

In the remainder, this paper is organized as follows. In summary, in Section 2, we have discussed literature and basic concepts such as ubiquitous computing, recommender system and its types, context-aware systems, electronic tourism and so on, in Section 3, we have reviewed the past studies, and in Section 4, we have explained the architecture of the proposed system and its components. In Section 6, implementation of the proposed system and the evaluation are discussed. Conclusions and recommendations are presented in Section 6.

2 Background

In this section, the fundamental concepts concerning ubiquitous computing, recommender systems, context-awareness and e-tourism are introduced.

2.1 UBIQUITOUS COMPUTING

Ubiquitous computing is an area in which the objects have processing power and are connected to the global network. This model is known as the third wave of computing, where services are provided every-where and in anytime to users. In this generation of computing, each person automatically gets personalized services from the computers embedded in the environment. In ubiquitous computing, context is a fundamental concept, which is introduced to characterize the situation of the environment [4]. The applications are context-aware, which means that they use contextual information to provide adaptive services to users.

2.2 RECOMMENDER SYSTEM

Recommender systems are effective systems in guiding the users among a huge amount of possibilities to achieve useful options of their interest. A personalized recommender system produces suggestions and recommendations suitable to specific people who are looking for customized information. Recommender systems are generally classified into four types from the perspective of the method of suggestion and recommendations to users:

- Collaborative filtering recommender system: They search for users who have the same beliefs with the active user, and then recommend items of their interest to them. Collaborative filtering identifies common interests of users and is not a descriptive solution i.e. it does not try to figure out why a user likes a particular item [5]. In these systems users who have had similar behaviours in the past or present can act as recommender of unknown items to each other.
- Content-based filtering recommender system: The ideology of Content-Based Filtering is that the system recognizes what item the user likes according to content of the entities. In these systems, each user acts independently and the information extracted by the system includes the information derived from the content of documents and items. Independence of each user means that each user has his own preferences that form his own model of priorities. In content-based recommender systems, the focus is on finding similarities between items, whereas in Collaborative Filtering Recommender Systems, the focus is on finding similarities among users [5].
- Knowledge-based filtering recommender

system: Knowledge-Based systems offer recommendations based on perception of the needs of customer and characteristics of the goods.

- Context-aware recommender system: A system is context-aware if it uses contextual information associated with the user to provide enhanced services to them [6]. Context-aware recommender systems are the systems that are able to offer the most suitable solutions to users based on their needs and interests [7]. In fact, context-aware and recommender systems have a similar central goal, which is providing services and information related to users. It should be noted that these two systems are not competing but are complementary to each other.

2.3 ELECTRONIC TOURISM

Electronic Tourism refers to the application of information technology in the tourism sector such as booking travel packages, flights, hotels, and offering tourist information [8]. Attraction refers to all resources, features and capabilities of a given location that can attract individuals and groups for various purposes, including recreation and entertainment, adventure and sports purposes, and sometimes scientific research purposes.

Contextual Information may affect interests of tourists in terms of visiting one or multiple locations in a specified sequence [9]. In the tourism domain, typical contextual information includes:

- Current time and location of the tourist
- Needs and interests of the tourist
- Tourist's restrictions
- Destination-related attractions

Choosing attractive tourist places is different in different seasons. For example, a flower garden has many visitors in spring and fewer visitors in the winter. Moreover, weather information plays an important role in selecting and visiting places of interest for tourism. For example, we often prefer to visit a park on a sunny day, whereas on a rainy day, we may prefer to visit a museum.

2.4 TRAVEL PACKAGE

A travel package is a customized service package for an individual or a group of tourists based on their interests and needs. A travel package usually includes information such as budget of travel, duration of travel, type and style of traveling, list of visiting places and so on. In general, travel planning as a critical service in tourism domain is a process that involves searching, selecting, and determining a sequence of visiting places and tourist attractions.

3 Related work

Location-based social networks such as Gowalla, Foursquare and Facebook have developed fast in recent years. In these networks, users can communicate, make friends, and share the information of the places they have visited [10]. Visiting a location or checking-in a location is one of the main services in these networks. Each trip includes information such as time and location of visit and the type of that sight. This information is displayed on the page of their friends. Thus, real life experiences can be shared in the virtual world and be discussed and also a new kind of interaction between the virtual world and the physical takes place.

In a study in 2014, a travel-package recommender system has been suggested by using data measured by the mobile crowd to help users create travel plans [11]. Mobile Crowd Sourced data empowers ordinary citizens who use sensed data of their mobile equipment (such as smart phones, wearable computers and smart vehicles, etc.) for high-level inference and data mining and provides human-centred services. Mobile Crowd Sourcing uses Location Based Social Networks to provide the required information and interests of the persons. They have proposed a travel package recommender system on smartphones whose architecture consists of three main components: location and user modelling, recommendation engine, and mobile interface. Location model and user profile are made using data measured by crowd. In location-based social networks, users visit various sites, upload photos from those locations, and show that these are their favourite places. Thus, user's interests, places of interest and their correlation between the places visited are derived from visiting records. The system recommends three kinds of places, including dining, attractions, and entertainment, and measures user's interests in these three types of places at each time slot. Another system has been proposed for analysis

of travel packages and personalized package recommendations [12]. At first, features of travel packages are analyzed and a model for extracting issues related to tourists and intrinsic features of sights including places and travel season are presented. Then, a dataset of a tourism company in China has been used where the users of the system are the tourists and recommended items are travel packages. A travel package includes landscapes located in one or more areas.

In another study [13], enrichment of tourist sites using Crowd Sourcing has been investigated. The system consists of four components: mobile client requestor, tourist spot recommender system, crowdsourcing platform and crowd resources. In this system, client requestor is a mobile user searches for tourist sites located near its current location that are in accordance with user's interests. Then recommender of tourist sites produces a list of nearby recommended sites and crowdsourcing platform collects some information about each of these places. This information is obtained by sending a questionnaire to mobile phones along with other crowd sources located in the desired site and by receiving answers from them. Then crowdsourcing platform aggregates the received information and gives it to the user. This location-aware recommender system helps tourists in decision-making process to visit desirable tourist sites in proximity.

In addition, a context-aware travel recommender system based on data mining of social media is proposed [9]. It uses data mining on the images collected by people from different tourist sites to propose tourist sites near the current location of the user that are consistent with their interests.

In most previous research, specific tourist needs and travel restrictions are not included in the process of recommending attraction to them, and customized travel package is not produced. In fact, a single version of travel packages is recommended to all tourists and interests and travel restrictions of them are neglected. In this paper, we try to use contextual information of the tourist area including interests, needs and travel restrictions (i.e. duration and budget of travel) to offer customized travel packages where tourists have choices to select from among.

4 The proposed travel package recommender system

The architecture of the proposed system is composed of three main layers: data access layer, decision making layer and user interface layer, each of which has different functions and applications. The decision making layer, also called recommendation engine, has three components: search and discovery of PoIs, planning travel routes and production of travel package. The proposed architecture is shown in Figure 1.

User interface layer is the topmost layer and lets the user interact with the system Through the interface, which is based on Android platform, the tourist enters the interests and requirements of the travel. After the tourist enters travel needs through the user interface, this information will be moved to the decision-making layer; therefore, the recommendation process begins. Choosing tourist attractions and determining visiting sequence are of great

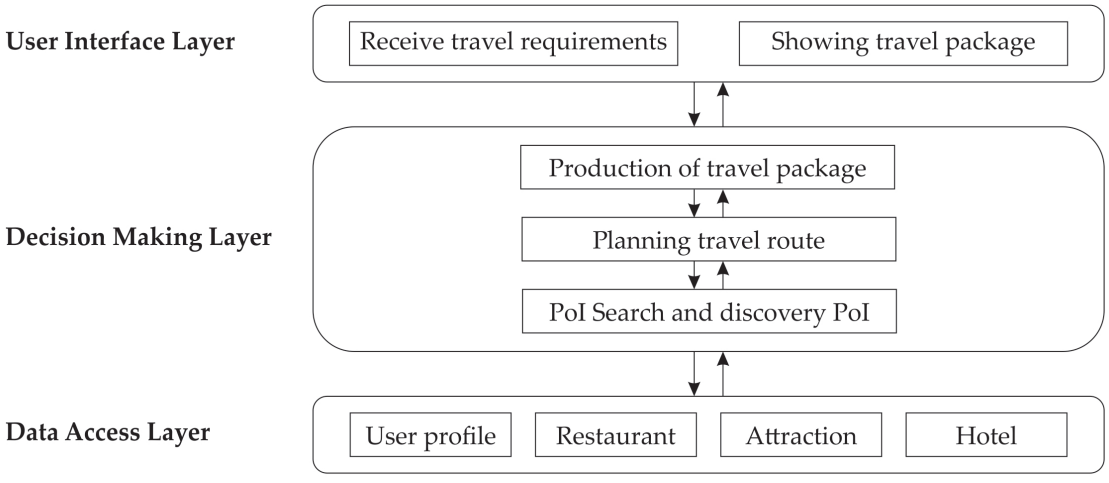

FIGURE 1 Overview of the proposed system architecture

importance in planning a trip. We use graph G = (V, E), which consists of set V of vertices and set E of edges for modeling. The route graph is composed of a number of nodes, which are the points of interest, and a number of edges, which are, the path between the two selected sites. An example of the path between two sites is given in Figure 2.

Each node in this graph has two features including Stay Time and PoI-Cost. Moreover,

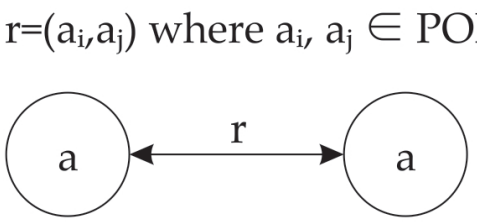

FIGURE 2 Sample path between two locations

the variety of places that a tourist chooses to visit along the route includes tourist attractions, dining rooms (café, restaurants, etc.) and accommodation (hotel, hospitality, etc.).

Travel time of a short trip between two tourist attractions ai and aj is obtained from Formula 1, where AT (ai) is the arrival time to the tourist attraction ai , and ST (ai) is the stay time (residence) in ai , and TT (ai, aj) is the travel (moving) time between ai and aj. Assume that r is a path between two attractions ai and aj, then:

$$\text{Trip-Time}(r)=AT(a_i)+ST(a_i)+TT(a_i,a_j)\text{-Start Time}, \quad (1)$$

where Start Time is the start time of the tourist travel. Travel cost in a short trip between two tourist attractions ai and a_j is obtained from Formula 2, where AC (a_i) is the attraction cost of a_i , and Cost (a_i, a_j) is the cost of travel between a_i and a_j.

$$\text{Trip-Cost}(r) = AC(a_i) + \text{Cost}(a_i, a_j). \quad (2)$$

At each stage of planning travel route, assume the two PoIs of ai and aj, as vertices of the graph and r as the path between them as edge. If path r does not violate restrictions of tourists, including travel time and travel budget that are determined at the beginning of the travel, the path is added as an authorized path to travel routes. It should be noted that at the beginning of the travel, the value of authorized travel paths is empty. Pseudo-code of the proposed algorithm of travel path planning is given in Figure 3.

Data access layer contains all data of the system. In general, the data in this layer depends on the type of algorithm used in the recommender system and the area of application. Data access layer includes the data stored temporarily and permanently. To this end, information related to three types of locations including hotels, restaurants, and tourist attractions are stored in the data access layer. Besides, it includes profile information of the tourist, including general and personal information of the tourist as well as his needs and interests.

5 Experiments

Android platform [14] has been able to get the major part of the market. Therefore, it has been used for implementation from among the existing platforms. Programming has been done using the Integrated Development Environment of Eclipse [15].

After installing the software, the user must enter travel requirements according to Figure 4. Using Google Maps service [16], the tourists can search their origin and destination of travel and then click on the map to choose the location of their choice. After the tourist made the initial settings of the travel, as shown in Figure 5, she should choose the type of trip interest that includes religious travel, entertainment, and historical. Afterward, the user goes to travel planning phase. Finally, recommendation engine of the recommender system produces travel package tailored to the interests and constraints of the tourist.

Precision and recall are the basic criteria used for evaluation of recommender systems. In this study, we have used a data set extracted from location-based social network of Gowalla [17] to evaluate precision and recall. Gowalla was a location-based social network launched in 2007 and finished in 2012. In this social network, users share the places they have visited with each other. The data has been collected in the period from February 2009 to October 2010.

In offline evaluation of the usage prediction

Algorithm: Trip Path Planning

1. INPUT: Start Point origin, Start Time st, End Time et, Total Budget CBudget
2. OUTPUT: Travel Package
3. Initialization Valid Trip← origin, Travel Package◎ origin, travel.t ←st, travel.c←0
4. WHILE Valid Trip! = NULL {
5. x = Header of Valid Trip
6. Remove x from Valid Trip
7. FOR y in candidate(x) {
8. travel.t = travel.t + Movement (x, y) + Stay(y)
9. travel.c = travel.c + Movement Cost (x, y) + Cost(y)
10. IF travel.t < et AND travel.c < CBudget {
11. Valid Trip←y
12. Travel Package ← y
13. }// END IF
14. }// END FOR
15. }// END WHILE

FIGURE 3 Travel path planning algorithm

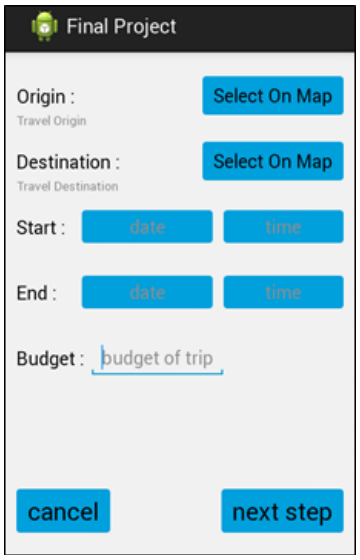

FIGURE 4 Travel requirements

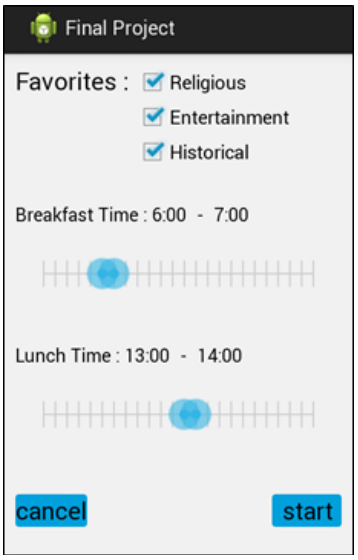

FIGURE 5 Select the type of travel interest

metric, usually there is a dataset including items that every user has used [18]. Then we choose a test user and hide some of his choices and ask the recommender system to predict a set of items that the user will choose. Four possible outcomes and states for the items are shown in table 1.

Now we can calculate the following quantities:

$$\text{Precision}=(\#TP)/(\#TP+\#FP);$$
$$\text{Recall}=(\#TP)/(\#TP+\#FN). \quad (3)$$

We have used 12 tourist samples for testing and evaluating the proposed system. First, we have extracted Digital Footprint of these sample tourists, randomly from Gowalla. The results of implementing the approach proposed are given in Table 2.

Given that in this study, three types of travels including short, medium and long have been defined, in accordance with each type of trip, we calculate the average precision and recall, as shown in Table 3. The results show a satisfactory performance of the proposed system.

TABLE 1 Results of recommending one item to a user

	Not-recommended	**Recommended**
False-Negative (FN)	True-Positive (TP)	Used
True-Negative (TN)	False-Positive (FP)	Not-used

TABLE 2 The results of computing precision and recall

Proposed approach	Number of PoI	TP	FP	FN	Precision	Recall
Test tourist 1	12	10	1	1	90.91	90.91
Test tourist 2	16	15	1	0	93.75	100
Test tourist 3	18	17	1	0	94.44	100
Test tourist 4	23	21	1	1	95.45	95.45
Test tourist 5	32	30	0	2	100	93.75
Test tourist 6	35	34	0	1	100	97.14
Test tourist 7	41	38	1	2	97.44	95
Test tourist 8	46	42	3	1	93.33	97.67
Test tourist 9	60	56	2	2	96.55	96.55
Test tourist 10	62	60	0	2	100	96.77
Test tourist 11	90	87	2	1	97.75	98.86
Test tourist 12	125	120	3	2	97.56	98.36

TABLE 3 Mean average precision and recall criteria

	MAP	MAR
Short Travel	93.64	96.59
Medium Travel	97.69	95.89
Long Travel	97.97	97.64

6 Conclusion

In this paper, a context-aware recommender systems of travel package has been proposed. The proposed system offers a personalized travel package according to contextual information of the tourist such as interest, travel duration, and travel budget. It is implemented on Android platform. The user enters his requirements, interests, and travel restrictions; therefore, the system produces and offers the travel package. For evaluation, we have considered 12 random tourists as experimental group and a variety of travels including short, medium and long trips. The results obtained show the performance of the proposed system in terms of precision and recall.

For the next direction of this work, it is suggested that before beginning the process of recommending the travel package to tourists, other important parameters be considered in this process. These parameters include weather condition of the tourist attractions, working hours of tourism centers, hotels and restaurants, as well as traffic conditions of roads leading to tourist's destinations.

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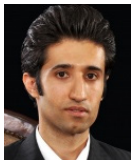

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