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An Architecture for a Mobile Recommender System in Tourism

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Abstract—**During the last decade, scholars have paid a lot of attention to the Mobile Recommender Systems in tourism industry. With reducing information overload and narrowing the results according to tourists' characteristics and conditions, these systems lead to the development of tourism industry. These recommendations are in the form of multimedia contents, context-aware services, comments and points of peer users, travel schedule and etc. Recent advances in mobile and computing technologies has created more opportunities for detailed and personal recommendations, through historical and contextual parameters. This paper studies Recommender System's models and techniques in order to propose a new architecture for a Recommender System in tourism. The proposed architecture uses hybrid filtering technique, contextual information of the user, and Model-View-Controller architecture. Also our proposed architecture covers many gaps in previous studies. After that, the design and implementation of a mobile phone application associated with this architecture was examined. Based on The 3-layered Model-View-Controller architecture and Client-Server architecture, its development has taken place. In addition to location and map services using Google Maps API, place suggestion services are offered to users, that here, a private host and domain is used.**

Keywords- Recommender Systems, Mobile tourism, Hybrid filtering, Model View Controller architecture, Personalization.

I. INTRODUCTION

Before the trip or during the trip many tourists face with data confusion about where and which places they should visit, because there are a lot of places to visit, they face data confusion which makes searching and selection difficult for them, and sometimes they may not have enough time and knowledge in searching for appropriate places. More over there is another problem and it is being static of these information, and sometimes the given information to the user does not suit with the user's condition and his/her contextual condition and it doesn't consider his/her limitations and purposes. Recommender systems are very valuable tools which help the users to overcome with the information overload and they can decide easiest, more accurate and more efficiently. In the recent years these systems are paid much attention by researchers in the field of academic

and applied researches. Many recommender systems in the field of tourism, use the information of users 'profile and with a comparison with some special features of tourism items(such as destination), try to obtain the point of the user's interest about that tourism items which the user have not visited them yet [1,2]. In these systems, the user based on some special parameters, brings up his/her needs, priorities, interests and limitations and the recommender system by using some general or special methods and techniques, connects the users' information with these classifications in the system, and gives some proposals such as destination, point of interest, activities during the trip, and trip planning, based on the time, money, and other limitation of the user [1,2]. The main purpose of these systems is to make it easier to search information and giving services and appropriate recommended packages to the user. Some of studies same as [18] describe an adaptive recommender system which adopts a semantic approach to assist the user both in the travel planning phase and, on-site, during the trip. Finally, the software system provides a module that infers the user's interests and preferences using data mining techniques aimed at improving the quality of the suggestions made by the system.

With entering mobile technologies to this field and presenting information and tourism services on mobile devices, including cell phones, personal digital assistants, tablets and etc, and many provided functionalities on them including audiovisual contents, interactive maps, location based services, compass, and wireless internet connections, it have created some new research opportunities in this field which is brought up in a means of mobile tourism [1,3,12]. The unique features of these devices have created some opportunities and new challenges for the evolution of personal services, which were not existed in E – tourism before. For instance, knowing the exact location of the user has created a field for location-based services. Moreover, the mobility of the user allows that the user's moving history is identified and stored. Based on each user's moving history, the system predicts his next possible target and gives knowledge to improve future predictions about him. Recent advances in the areas of mobile technologies have greatly extended traditional location-based services. These advanced context-aware services are provided by using sensors integrated and embedded inside the devices which can provide immediate information according to user's context [2].

Some of the recommender systems use the interests and points of other tourists for presenting a proposal to a special tourist. Tourists' interests can be saved in stationary systems and it can be shared among other tourists with its special method. In fact a prelude to these systems is that as the time is passing, the role of the tourists in the process of content creation is highlighted and with the technology of web2, for instance social networks, weblogs and Wikipedia they can publish their own information and share their own experiences about those places which they have visited dynamically [3,7].

Moreover, some researches [18,19] propose the general architecture of an integrated adaptive system that exploits Semantic Web technologies to perform such tasks effectively. The combined use of all three such components, a *pre-travel virtual assistant*, *on-site recommender system* and a *semantic data mining module* makes it possible to offer personalized services to users, assisting them in all the operations they have to perform and trying to satisfy their requests [18]. In [19] has proposed an Adaptive Tourist Recommendation System(ATRS) which can be adapted to the new situation by employing different adaptive approaches. Moreover, to be adaptive there is a need to have a holistic perspective with regards to traveler dimensions and travel elements.

But the problem which was seen in many works is lack of attention and lack of not feasibility in using different information resources to represent better and more comprehensive proposals to user, so that can cover the entire effective factors which were considered by the user. Moreover a standard development architecture as the step by step guidelines from the design to development stage is often not used in these systems. In this research, we have represented an architecture for a recommender system in the field of mobile tourism which uses hybrid filtering technique, which is created from a combination of content based filtering and collaborative filtering, and according to the facilities of the mobile devices, after assigning to the contextual information of the user, gives proposals to the user. This architecture is formed with an adoption from the three-tier architecture of Model-View-Controller architecture, is composed of layers of management, representation and process.

In this research, in section 2 we would have a review on literature and other researches in the field of tourism recommender systems which had occurred designing a model or an architecture. Then in the following section 1-2 we would discuss about personalizing and receiving information from the user and in the following section 2-2 our discussion will be about types of recommendation techniques; Model-View-Controller architecture will be expressed in the following section 3-2; In section 3 we will discuss about this research method; and finally our recommender system architecture will be explained in section 4 and in section 5 conclusions and the differences of this system with previous studies will be expressed.

II. LITERATURE REVIEW

Recommender systems in E-tourism industry and mobile tourism with receiving information from the users either implicitly or explicitly, use different methods and techniques, and with creating profile, and of course user's model, give some proposals about tourism destination, favorite places, services during the trip, events and a schedule for the whole of the trip. In the recent years several theoretical or practical systems in this field are introduced. In continue a summery about some of these systems which have designed a method based on a model is explained. A summery about these system and some of the most important of them are shown in Table 1.

The first system is iTravel [1]. This system uses peer to peer communication and the user can get point to tourism attractions in a mobile way. Architecture of this system consists several parts: 1) Interface manager, is for showing graphical information to the user, receiving his/her orders, getting the user's points from visited places; 2) Location manager is for receiving the location of the user via sending and receiving signals; 3) Communication manager: for communication among the users in close distances via Wi-Fi or Bluetooth; 4) Rating data manager, management of the user's points from visited places and received points from other users; 5) Recommendation manager, to make decision about points of not visited places by saving points in data base and with the use of collaborative filtering method.

The next system is SAMAP [4]. This system with the use of different modules, receives the user's model dynamically, and by using the experience of other similar users, the system proposes a list of useful activities to the user, and also creates a trip schedule for him/her. The architecture of this system consists one ontology and three components: 1) User module is a middleware for other agents and is used for exchanging user's information to other modules including personal information, priorities, interests, user's limitations and also user's contextual information(for instance mood and immediate location of the user). This module creates user's model; 2) Case-based module: according to the information of the last module proposes a list of activities for this visit of the user to him/her. By case-based reasoning technique the needed information can be received from other similar users; 3) Planning module, after ranking activities in case-based reasoning in this module, the activities are selected and proposed to the user that are matched with the limitations of tourism places.

On-tour attraction recommender system architecture, by Yang et al. [5] is in such way that a server is in each tourism attraction which is responsible for sending and receiving users points to each other at that location. Recommender architecture is server–client and the user is client. In this architecture, data manager component is located in one side with the server, and is responsible for receiving user's points from that tourism location and also send points of other users to the target user. This component has a data base. The located components in client side include the location component for finding the user's location, and also there is a local storage for saving the points of the user. Recommendation manager is also in this side and after receiving the points from data manager and the points of the user and his/her location represents its own proposals.

The e–Tourism recommender system [6] is present as a recommender system based on user's interests, demographic classification and visited places. This system can represent its proposals to one or a group of users. The group model is presented by using aggregation and intersection of the profile of each user in that group. Architecture of the system includes four subsystems: 1) Control subsystem, works as a user interface, information exchange control, changing the user's requests to technical requests of the system and also presentation of the list of activities and trip schedule for the user; 2) Data base interface processes the received requests from other modules; 3) Generalist Recommender System Kernel (GRSK) has to create a list of activities to the user; 4) Planning subsystem with selection of appropriate activities starts to make a trip schedule.

The mobile recommender system which is presented by Noguera et al. [12] considers contextual factors of the user, including location and after receiving his/her priorities, displays the proposals in 3D view in a map. The architecture steps of this work includes pre-filtering and post-filtering: 1) location-aware hybrid recommender system: in this step the contextual pre-filtering is used to reduce the number of the items that can be proposed to the user based on his/her location. These items are N-tuple list of the user's interests which is produced by the recommender system; 2) Distance-based re-ranking: In this step, a post-filtering for re-ranking the produced items in the last step is done based on physical distance of the user from each item.

Table 1 shows the summary of the evaluated systems.

Table 1: Summary of evaluated models and systems

System Architecture| Author	The used filtering	Addressed issues	How to Evaluate	Findings	Identified architecture for development
iTravel -2013	Collaborative filtering,	Similarity based on Pearson correlation coefficient, using Various methods of data exchange (Unconditional, Preference-based, Hybrid)	Simulation methods for data exchange, asking from users(questionnaire)	1) Design and development of a tourism recommender system 2) People who visit the same places, they have similar tastes and needs 3) Better accuracy of data exchange methods that allow data propagating from one peer to another	No
Hwang et al.-2012	Collaborative filtering,	Various methods of data exchange (Conservative preference-based, Generous preference-based, Diversity-based, Aggregate)	Simulation methods for data exchange	1) Design and development of a tourism recommender system 2) diversity-based method is promising in an environment where attraction servers are newly operational, and the aggregate method is the best when attraction servers have been operational for quite some time and collected a large amount of rating data	Server-client architecture
Noguera et al. -2012	Collaborative filtering, Knowledge based filtering, location information	Context of the user, creating three-dimensional maps	Questionnaire after using System Preview	1) Design and development of a mobile travel recommender system 2) positive reviews of users about system ,location based recommendation	Server-client architecture
e-Tourism -2011	Content-based filtering, Demographic filtering	Individual and group recommendation	Evaluation based on questionnaire, precision and recall standards, and assess group satisfaction or intersection rate	1) Design and development of a tourism recommender system with travel planning 2) Intersection mechanism obtains better results than aggregation mechanism	No
SAMAP -2008	Content-based filtering, Collaborative filtering,	Programming based on artificial intelligence technologies	-	1) Design and development of a tourism recommender system with travel planning	No

A. Personalization and receiving information from users:

One of the most important features of recommender system is, to personalize their interaction with each user. Personalization includes designing systems in such a way they can receive the user's need and provide them intelligibly [8]. Personalization as a critical factor, has a role in performance, value and commercial success of tourism industry [3]. A personalized system is based on three main applications: choosing content, matching the model of the user and showing results. Choosing content is related to choosing destinations and tourism attractions, resorts, restaurants, routing or trip schedule. Matching the model of user is related to preserving up to dated models of the user, and finally showing results includes the used technology such as multimedia, geographic information system and etc for interaction of the system and the user [8].

In the field of mobile tourism, recommender systems try to propose a content to users which is matched with their interests and priorities that is said in his/her profile. Two common methods for creating a profile for the user, in such way they can get some data, are implicit and explicit methods [2,3,5].

In explicit method the user's information including the user's points in a special rate to various items, and the user's orders from the most to least rate of interest to items, expressing the list of interests and etc are gotten from the user explicitly. In implicit method the user's information including visited pages by the user, visit duration and visit recurrences, selected or bought content, analysis of interests in social network and etc, are received implicitly.

B. Context-aware recommender systems (CARS)

Several lines of research have successfully exploited multi-criteria ratings to improve the accuracy of recommendations. Although the users still provide unidimensional ratings, the situational context of users (e.g., age, time or weekday) introduces additional dimensionality to the ratings. The concept of context-awareness agrees with the ubiquitous nature of mobile devices. Mobility adds several contextual dimensions, either implicitly fed(e.g. change of location) or inferred (e.g. multiple visits or spending more time than average in a POI (Point Of Interest) may be regarded as a positive 'vote'). A recent survey revealed that recommendations offered by CARS may significantly improve the appreciativeness of tourists in comparison to the recommendations provided by 'plain' RSs [20]. For instance, museum visits are more highly appreciated in less crowded days, walking paths are rated worse at night time and open archeological sites are rated higher in sunny days.

The [21] proposed a context-aware system for mobile devices that incorporates the user's location, trajectory and speed (while driving) to personalize POIs recommendations. POIs are chosen among those located within a radius around the user's location; the radius is calculated based on the user's trajectory and speed.

Some papers [22] introduced the concept of 'context-aware rating' to denote the higher credibility of users that upload reviews, ratings and comments while on site (via their mobile devices) in comparison with others that perform similar actions through standard web interfaces.

C. Model-View-Controller architecture

The architecture of Model-View-Controller was introduced in smalltalk-76 in 1970 by Trygve Reenskaug, and today it is acceptable for most of computer programs with different programming languages all around the world. This architecture is a design approach of dividing software into Model, View, and Controller component to better control the software quality, according to processing, and interface design. In the architecture of Model-View-Controller, user interface module is displayed in one or several view components [15]; in fact, View component is responsible for displaying data to user [16,17]. Functionality of all agents is defined in Model component in the form of behavior and data [15]. The manipulation of data and objects is also done by this component [16,17]. Controller component manages events and changes the state of Model and View [15]. Controller component collects appropriate data objects and send them to View component. In Model-View-Controller architecture, the user interface of application is apart from the services/business logic of the application despite the data connection between them, in a way each of them can be developed separately [15]; and maintenance and reusing application source code is feasible.

Because in the process of design and development of software, it is better to use a special standard which other researchers and developers have experienced it; In this recommendation architecture for a tourism recommender system, we have tried to get help from the Model-View-Controller architecture and match the logic of the application with this architecture. Moreover, the features of this architecture make development and management of the application easier and safer and it also can personalize the application based on the user's tastes.

III. METHODOLOGY

Methodology of this research is qualitative and it is a kind of Meta-analysis is called Meta-synthesis. The purpose of this method is to achieve a development in a theory or a clear model which can explain some of the results of similar qualitative studies. In fact Meta-synthesis method tries to interpret and integrate results from a number of different while also interrelated qualitative studies [13]. Meta-synthesis method, with combination of analysis and interpretation of other studies with different approaches, can cause an innovative approach to the presentation of meta-synthesis [14]. In this paper, after a review of the main topics and concepts in recommender systems and their relative importance in terms of the frequency, their key characteristics were evaluated and compared. Based on this evaluation a new architecture is proposed for a mobile recommender system in tourism. Unlike previous studies, the proposed architecture uses Model-View-Controller as a known architectural pattern for implementing user interfaces. In the next section, we discuss on this issue in more detail.

IV. THE PROPOSED ARCHITECTURE, IMPLEMENTATION AND EVALUATION

The previous systems we have studied before have some problems including lack of attention or feasibility in usage of different information resources for providing better and more comprehensive proposals for the user, in such a way it doesn't have considered all of the effective factors, which the user has required. Moreover a standard development architecture as the step by step guidelines from the design to development stage is often not used in these systems.

A. Proposed Architecture

The recommended architecture is displayed in Fig.1This architecture which is derived from three-tier architecture of Model-View-Controller includes three tiers, and uses hybrid technique with combination of content based filtering and collaborative filtering and some contextual information of a mobile device.

1) Management tier: this tier is in charge of managing user's requirements from data input to displaying the information, and this process will be done by sending orders to display tier and process tier. This tier receives data from the user and sends the data to process tier, and then prepares display tier for showing the sent information by process tier. The taken inputs from the user include some explicit data such as information of the user's profile, limitations (time and money), interests, priorities, destinations, attractions and his/her points to the visited places.

2) Process tier: this tier with receiving orders and information from management tier receives this information from internet:

- Receiving information of tourism attractions and tourism destinations (list of places and appropriate tourism attractions for the user, visiting hours, their location and etc).
- Services (type of service, facilities and etc.).
- Climate condition, street status (traffic, rush hours, one way streets and etc.).

Also with accessing to social networks and data centers receives points and comments of other users with internet or Bluetooth. The location of the user can be found by GPS and AGPS. More information is received from context information (such as time and day of week, type of vehicle), and implicit information of the user (such as movement pattern, visit frequencies and etc.), are also received. The most logical reason for this tier is to save, receive, update and deleting data and information in data bases. The most important function of this tier is to compute the similarity of the user to other users and to match the requirement of the user with tourism attraction or service. After this process, this tier informs management tier to send the order of displaying information via display tier.

3) Display tier: this tier is used for displaying information to the user. The information displayed to the user includes tourist attractions and destinations in form of list view and multimedia format, map and routing, proposals, and sent travel plans from process tier.

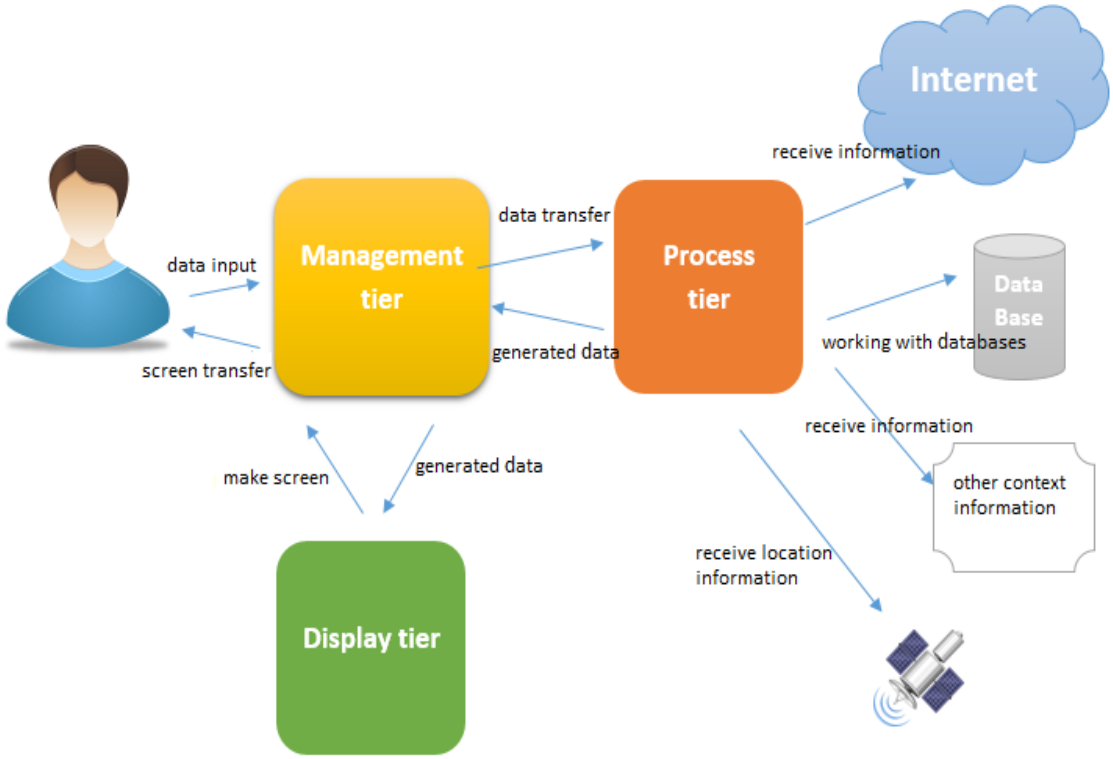

Fig.1: proposed architecture for tourism recommender system

The process of the operations in this architecture is said in the followings:

- Firstly the user gives the profile information, priorities, interests and his/her profile information and his/her points to the visited places, to the system.
- The system saves the user's information, and based on the user's similarity to peer users, receives points from other users.
- The system with a combination of received points, context information and with knowledge about tourism attractions and tourism services and their main features, with a regard of priorities, gives some proposals to the user.
- The system receives user's information and also other user's information and updates its information rotationally and continuously.

In this architecture it is tried to represent a comprehensive combination from those models has been studied before, so that some of these features include:

1) Unlike some of the studies which has only used one of the techniques of content based filtering or collaborative filtering and had some problems with entering new user or new item to the system, this architecture covers each technique with the other technique in a hybrid way and with linking these techniques gives more information to the recommended system.

2) The other characteristic of this architecture is using of Model-View-Controller architecture and having its features in this architecture; in such a way being modular of this architecture cause a better management, easier development, and personalization

of display tier which is not paid attention in lots of studies.

3) Unlike most of the recommender systems which only considers the user and item entities, and do not pay attention to some of contextual information including: Location, time, climate and etc., this architecture considers all of the basic parameters because it is represented in the context of mobile devices.

Main features of proposed architecture are described in Table 2 in comparison with the formerly reported studies.

Table 2: Key features of proposed architecture

The used filtering technique	**Addressed issues and different cases with previous studies**	**Findings**	**Identified architecture for development**
Collaborative filtering, content based filtering, the context information of the user	1) A meta-synthesis point of view from other papers and covering their weaknesses 2) Using a special architecture in development stage of making a recommender system software and having a structured design unlike previous studies 3) The design of this architecture is based on Model-View-Controller architecture which is a tested architecture 4) Paying attention to content based filtering and collaborative filtering in a hybrid way and preventing each of individual problems of these filtering include cold start 5) Using context information of the user as a very important reference from contextual condition of the user for representing proposals.	1) Designing a structured architecture for a tourism recommender system	Model-View-Controller architecture

B. Implementation

In this paper, to Implement of recommendation process with collaborative filtering part, we use Pearson correlation equation as follow:

$$r = \frac{n(\sum \mathrm{xy}) - (\sum \mathrm{x})(\sum \mathrm{y})}{\sqrt{[n\sum x^2 - (\sum \mathrm{x})^2][n\sum y^2 - (\sum \mathrm{y})^2]}}$$

In this equation, two user privileges, which are supposed to be compared with each other, x and y are raised. As a result the interval correlation value between -1 to +1, which shows the linear dependency between the two sets of ratings. What this amounts close to one, positive interdependence is more .more close to zero, less dependency between them.

generating recommendation is followed by these steps:

- First, the user's profiles that rated up to 3 (from 1 to 5 points) for user A's preferred location is chosen.
- Pearson correlation equation between these users and the user A will be calculated.
- The users that have correlation above 0.5 are elected
- Then, the information about locations, where users of the previous step are rated more than 3, are recommended.

In the last step locations that have high rate are re-exanimated, because users may be privileged to other places.

C. Evaluation

Tourism recommender system can help tourists to find their desired locations such as hotels and restaurants. in addition to better manage of time, these systems help users where visit the places that really interested them. In this context, to assess the user friendliness of the system, a group of 27 members of the elite were invited to use proposed system and their opinions have been provided in the questionnaire.

In this process, individual elite is defined as a person who familiars to programming and testing of computer programs under various platforms, and has trained and experienced with relevant knowledge.

Before starting the process of system testing, the participants were asked to rate their experience of some of the places previously visited, and these data are entered to the program's Data Base.

In this statistical analysis we used 7-point Likeret scale, anchored on “strongly disagree” (1) to “strongly agree” (7). The results of the questions related to the *usability* of the system (measured by 3 questions) showed that "It helps me to find desired

locations in my area" has high average (M=5.9). the *ease of use* of the system measured by 5 questions, results shows the question " learn how to work with the system was easy for me" is high (M=5.0). *trustability* measured by 6 questions (" I know that data from the system is reliable" is high (M=5.5). *Personality characteristics* was measured by 6 questions that " Only if I use the system free of charge" , M=6.0. The results of the questions (6 questions) related to the *context* show that most of the participants have a positive response to the "Use the system When I am in trip" (M=6.0) and "ease of installation" (M=6.0). Finally, the *Desire to use* of this system measured by "I use system when I have an access" (M=4.8)

V. CONCLUSION

Today recommender systems in tourism industry with filtering and omitting irrelevant information helps tourists to make a decision in choosing places and tourism attractions easier and more accurate, according to user interests. With advent of mobile technologies in this field, and their unique features, the systems are given some other information such as contextual information of the user. Most of the researchers have focused in this field and many researchers have been done about designing of recommender systems. However, these works had problems including lack of attention in using different information resources and some effective factors in representing better and more comprehensive proposals, also some of these systems are web-based and do not have availability to the location information and context information of the user, so they have lack of these important information. Moreover, a standard development architecture as the step by step guidelines from the design to development stage is often not used in these systems, and prevents other problems which are given because of the new architecture presented by other researchers. In this research after a study in previous studies in the field of recommender systems in tourism in a meta-synthesis way, especially in mobile tourism and provided models and the process of proposal by them and the technique which is used for filtering information and its evaluation, we have represented an architecture in mobile tourism field for a recommender system that uses hybrid filtering technique. The Hybrid filtering is created from content based filtering and collaborative filtering and according to facilities of mobile devices, after assigning contextual information, gives proposals to the user. This architecture is formed with an adoption from of the three-tier architecture of Model-View-Controller includes 3 tiers which are management, display and process tier.

According to this case which it has not developed yet and lack of powerful software for simulation, experimental evaluation is not feasible, however, contextual factors which are assigned in this research cannot be evaluated in a simulated way or it is not easily possible. Researchers and developers in making and developing recommender systems in the field of mobile tourism can use this architecture. Through, other subjects include related factors to behaviors, interests, immediate decisions of the user can be considered in future researches.

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