A Mobile Tourism Recommender System

Michael Kenteris, Damianos Gavalas and Aristides Mpitziopoulos
Department of Cultural Technology and Communication
University of the Aegean
Mytilene, Greece
m.kenteris@ct.aegean.gr, {dgavalas, crmaris}@aegean.gr

Abstract—Mobile tourist guides have been in the spotlight during the past decade resulting in many prototypes, either full-fledged standalone mobile applications or web-based applications. Particular emphasis has been given to personalisation of services, typically based on travel recommender systems used to assist tourists in choosing places to visit; these systems address an important aspect of personalization and hence reduce the information burden for the user. However, existing systems fail to exploit information, behaviors, ideas, evaluations, assessments, ratings, etc., by other tourists with similar interests, which provide ground for the cooperative production of tourist content and travel recommendations. In this paper we extend this notion of travel recommender systems utilizing collaborative filtering techniques for deriving improved recommendations. We also propose the use of Wireless Sensor Network (WSN) installations around tourist sites for providing mobile users convenient and inexpensive means for uploading tourist information and ratings about Points of Interest (POI) via their mobile devices. User ratings uploaded through WSN infrastructures are weighted higher to differentiate between users that rate POIs using the mobile tourist guide application in direct proximity of the POI and others using the Internet away from the POI.

Keywords: Travel recommender systems; mobile tourism; personalization; collaborative filtering; clustering; wireless sensor networks.

I. INTRODUCTION

The tourism industry has always been open to new technologies; even more so to the web, giving rise to the field of electronic tourism (e-tourism) [9], [31]. At the same time tourists are taking a more active role in the process of content production. They systematically publish tourist information making use of Web 2.0 technologies such as social networks, blogs and wikis, publishing dynamic content about visited destinations or relevant information of their visit to be sought by other tourists.

Extending the notion of e-tourism to meet the vision of tourist services provision to nomadic users with no spatial-temporal restrictions is expected to become reality within the next few years. In this context, the field of ‘mobile tourism’ has emerged wherein tourist information and services are accessed via mobile devices [8]. Mobile tourism represents a recent trend in the field of tourism that involves the use of tourist applications offering services and tours with multimedia content executed on electronic mobile devices, e.g. mobile phones, personal digital assistants (PDA), palmtops, i-pods, psp consoles, etc. Mobile tourist guides increase tourist engagement and offer a more complete tourism experience with the benefit of audiovisual content, interactive maps, location-based services, etc [11]. Mobile tourism and mobile guides have been fields of intensive research over the past few years with a number of published prototypes [1], [3], [5] [10], [19], [21], [22], [28], [38] and commercial products [25],[26] readily available.

Personalization has been recognized by researchers as a critical factor of efficiency, added value and commercial success in tourism [29], [33]. Personalization systems originally found success in e-commerce sites providing recommendations for products and offering information to consumers to aid decisions on product or service purchases. These systems, known as ‘Recommendation Systems’, are based on information filtering in order to recommend content to users (e.g. films, books, news, web pages etc). One of the most popular approaches, referred to as collaborative filtering, utilizes knowledge collected by monitoring the behaviour and personal choices of the system’s users, collectively known as the user’s personal profile. This approach nowadays represents the most popular and effective technology used in web recommendation systems [29].

In mobile tourism, personalization has mainly been addressed in the context of guides providing content recommendations that match user preferences, typically consolidated in ‘user profiles’. The most commonly used methods to build a user profile enable extraction of user data:

- explicitly, e.g. rating content within a given scale, ordering content from the most to the least interesting item, statement of preference among various content items, statement of favourite content items list, etc.
- implicitly, e.g. recording pages visited by the user (also taking into account the visit duration and visit recurrences), monitoring the content selection/buying behaviour of users, and analyzing the interests of their social network (e.g. the list of user contacts in a social network), etc.

Recently, we proposed MyMytilene [19], a mobile tourist guide platform for the Municipality of Mytilene, Greece. MyMytilene addresses personalization in the
context of allowing users to explicitly select tourist content to be included in a customized mobile application which is generated on the fly, adapting the application so as to meet the screen size and hardware constraints of the user’s mobile phone. The mobile application may be used in either offline or online modes.

Herein, we discuss numerous extensions upon our previous work mainly addressing various aspects of mobile tourism personalization. First, our mobile guide application allows user to collaboratively contribute in uploading and sharing with peers tourist-related information, such as ratings, comments and multimedia content relevant to specific Points of Interest (POIs).

Our system differentiates users depending on the technology infrastructure used by the tourist to rate a POI (web, mobile web or mobile in the vicinity of the POI); the system assigns, accordingly, a different weight which is then assessed by the tourist recommendation system. This system captures context-aware user evaluations and ratings and uses this data to provide recommendations to other users with similar interests.

Additionally, recognizing that tourists often labour to interact with a remote tourist portal while on travel due to lack of networking infrastructures or even avoid mobile data communications due to high roaming charges, we have implemented a cost-effective Wireless Sensor Network (WSN) [2] prototype which may be deployed around tourist sites for providing mobile users effortless and inexpensive uploading of tourist information and ratings about POIs though their mobile devices.

This paper presents a content recommendation system, a commenting system and the prototype of the WSN installation. The travel recommendation system is based on collaborative filtering techniques using a rating system which distinguishes among users rating content onsite via the mobile application and others uploading ratings through a standard web interface.

The remaining of the paper is organized as follows: The following section discusses the concept of service personalization with respect to electronic and mobile tourism. Section III describes our proposed recommender system and Section IV presents the infrastructure and update mechanism for tourist information portal, while Section V draws conclusions and grounds for future work.

II. ISSUES OF PERSONALIZATION IN ELECTRONIC AND MOBILE TOURISM

In the field of tourism, existing recommendation systems typically emulate services offered by tourist agents where prospective tourists refer to seeking advice for tourist destinations under certain time and budget constraints [7], [29]. Typically these systems compare elements of the user’s profile with certain characteristics that function as threshold elements in order to predict how the user would potentially ‘rate’ content elements (e.g. product, content, service) which a user has not yet considered [29]. These characteristics can be associated with informative content (content-based approaches) or with the social environment of the user. From a technical point of view recommendation systems use content-based approaches whereby a user states their needs, interests and their constraints based upon selected parameters. The system then correlates user choices with catalogued destinations described using the same list of parameters.

As with electronic tourism, personalized services represent a crucial factor for the further adoption, infiltration and success of mobile tourism [32]. The unique characteristics of mobile tourism bring forward new challenges and important opportunities for the evolution of innovative personalized services which have no meaning in the field of electronic tourism. For instance, the knowledge of the exact user location develops appropriate grounds for the provision of location-based services (LBS). Furthermore, user mobility could allow taking advantage of a user’s social environment lying in geographical proximity.

Existing research and commercial mobile tourism prototypes incorporate personalized services that fall into one or more of the following project categories:

- Personalization based on preferences explicitly stated by users [19],[24], e.g. recommendation for a visit to the Archeological Museum of Athens to a prospective visitor that explicitly expressed interest on museums and archeological sites;
- Personalization dependant on the users geographical location (location-based) [6],[33], e.g. use of audio notification when a user lies in the vicinity of a sight, display of nearby museums, etc.
- Context-based personalization [16],[34],[37], e.g. proposing sights to visit depending on location, means of transport, time of day, weather conditions (semantic parameters could also be considered such as the sight ‘s category, its similarity to other sights, etc).

Some systems also allow for the dynamic creation and adaptation of personalized mobile applications not only based upon selection of personal content but on the characteristics of the user’s personal device (screen size, ability to handle multimedia content, free memory resources, etc) [19], [25].

Common ground for the above discussed projects are services based on personal interests, location, context of use and device capabilities; they all exclusively take into account the individual user of the mobile application. Although this approach addresses important aspects of personalization reducing the information burden for the user, it fails to take advantage of information, behaviors, ideas, evaluations, assessments and ratings of other tourists with similar interests, giving rise to the cooperative production of tourist recommendations. There is lack of tourist applications which use collaborative filtering techniques [15] or data mining [23] at content level. Such techniques have proved -as analyzed in the previous section- particularly useful to electronic tourism environments. However, collaborative
filtering approaches have not yet been investigated with respect to service personalization in mobile tourism [13].

We argue that the mobility parameter raises challenges, yet also important opportunities for service personalization; for instance, it allows the recommender system to assess user input and uploaded content with respect to user context, e.g. the user’s device type and location at the time he/she uploaded a rating or a photo of a POI. It also enables mobile tourist applications to utilize innovative services which support direct communication and social interaction between tourists sharing similar interests and situated in nearby locations.

III. DESIGN AND IMPLEMENTATION OF THE RECOMMENDER SYSTEM

MyMytilene is a web-to-mobile [18] tourist framework which allows tourists to use the web in order to ‘build’ customized mobile standalone guides that run on any mobile device offering tourist information. In the original users chose content items (information about POIs) after browsing all the available tourist content. A user evaluation [19] revealed that users experienced difficulty in locating POIs of potential interest to them (it involves a time consuming process and considerable cognitive load). They also expressed interest in knowing the choices and opinions of other tourists with the same interests; as such they did not have access to such information. Consequently, the user evaluation participants highlighted the need to implement a recommendation system which would automate the recommendation of POIs corresponding to the specialized interests of the system’s users.

One of the main design objectives of this project was to offer tourist content via the web platform which would be readily available to users, as a case of a pre-visit stage to the Municipal council. The main issue of the web application was to make obvious that the users are able to adapt the web content into a personalized selection of content to be loaded into a customized ubiquitous mobile multimedia application.

In order for users to create a customized personal mobile guide, they are asked to create a personal web space to register personal information (age, gender, tourist habits and interests, etc). Originally, the design of the platform was broken down into two separate systems:

- the website
- the mobile application

The first system was used as a tool for building customized mobile applications.

All users’ interactions are recorded by the recommendation system. The user is not obligated to explicitly create a personal account; however she is encouraged to do so in order to enable personalized recommendations by the system. Content recommendation is provided to users that have declared an explicit profile but also to users that have just used the system long enough to record an implicit profile. If no profile is available then content popular among all users is recommended. Figure 1 shows a screen where a particular user is recommended Archeological content based on her peers.

![Figure 1. Personalised recommendations for Archaeological Sites based on information collected by peers.](image)

The recommendation engine was designed and developed to exploit user decision which is collected explicitly and implicitly via users with similar interests and used to offer personalized recommendations of tourist content. In this research we are using clustering algorithms [12],[17] to classify users sharing similar interests (see Figure 2). Similar clustering methods have been applied to a wide range of fields, e.g. clustering of users with similar mobility patterns in adhoc networks [20] and also document collections [4] or web pages [36] with similar content.

In particular, the registration page is designed so as to allow the creation of an explicit personal profile used by the recommendation system to group registered users and suggest content that matches user preferences.

![Figure 2. “Categorizing” users by clustering the profiles of the registered web users.](image)

The registration form, other than the usual username/password/country, includes fields such as gender,
marital status, age, etc. Optionally, the user may also state her preferences on favourite leisure activities (e.g., hiking, climbing, resting in parks) and POIs categories (e.g., museums, archaeological sites, monuments, zoos, etc). While the user browses and selects content for her personalized guide, the system monitors and logs this activity (implicit profile data). Using this personalized content list which is transformed into statistical data per category section (e.g., how many museum-related content items has the user selected, how many walking paths she browsed, how much time was spent on archaeological site pages, etc) and utilizing the users’ explicit data, the system periodically executes a clustering algorithm based on the k-means [17] clustering algorithm.

This algorithm in turn classifies the users into separate groups (users sharing similar interests) later used by the system to suggest content initially not chosen by the user, which however, is likely to be of interest to her. In addition, the user can see the overall rating of the content by all users.

![Image](https://example.com/image.png)

Figure 3. Personalized recommendations from the tourist portal to registered users.

The actual mobile application has been developed on the top of Java ME Platform [39] (formerly known as Java 2 Platform Micro Edition or J2ME), essentially comprising a certified collection of Java APIs for the development of software for small, resource-constrained devices such as cell phones, PDAs and set-top boxes. The content of the mobile application is personalized based on input given by the recommender system, while the application is adapted to the user’s device screen size and capabilities.

The mobile tourist application allows for dual navigation, from the text menu or directly from the map where the content is shown via markers (displayed either by category or by municipal region (shown in Figure 4).

![Image](https://example.com/image.png)

(a) Main menu of the mobile application

(b) User Profile (declared user parameters)

(c) POIs of the Municipal Council

(d) Map and marker of a content page

Figure 4. Screenshots of the MyMylene e-guide Java ME-based mobile tourist application taken from a mobile phone emulator.

The rating mechanism is either selected manually from the menu or is triggered when the application senses that the user moves within a short radius away from the POI (for a given time duration), whereby the user is prompted to rate the POI (see Figure 5a). The rating form has a five (5) star rating visual which is familiar to web users (see Figure 5b). The user is also prompted to write a comment in the form of a text message which will be posted to her profile.

![Image](https://example.com/image.png)

(a) Incoming proximity detection of a user

(b) User rating and commenting screen

Figure 5. (a) Incoming proximity detection of a user; (b) user rating and commenting screen.

IV. INFRASTRUCTURE AND UPDATE MECHANISM OF TOURIST INFORMATION PORTALS FROM TOURISTS

Tourists often need to update a visit diary and convey travelling experiences while at a tourist destination (e.g., upload photos, comments, evaluations, ratings etc.) and also to communicate with their friends and families or with peers sharing similar interests. This raises the need for tourists to interact with remote content servers directly via their mobile device in such a way as to be easy and inexpensive, without requiring the deployment of an expensive installation to support such a service.

In the design of such a system, our initial objectives included a rating system that could differentiate between a user rating a POI onsite and a user via the static internet. The problem that arose at the design stage was twofold; there was a problem of how to detect the proximity of users upon
visiting a POI and also how to connect to the web server (tourist portal) not having access to a mobile connection. As of proximity a number of technologies are readily available e.g. GPS, Assisted GPS (aGPS) and sensing technologies [19]. In order to target a broad range of mobile devices, GPS could not be used since mobile devices that have GPS units represent a small range of devices today, while GPS service may not be available indoors. On the other hand, aGPS seems to be increasingly available in all new devices that support data communications. Yet, it was not chosen for proximity detection because it requires the use of a constant mobile connection to work and also due to localization accuracy concerns (assisted GPS techniques can have an accuracy of 10 meters to several hundred meters depending on the assistance technique used).

Apart from proximity detection, cases often occur where mobile device users do not have access to a mobile connection due to the rural positioning of POIs. In a city setting, a straightforward approach to the connectivity problem is to use a mobile device’s HTTP connection as does a mobile browser to navigate through mobile content. However such solutions in mobile tourism do not always represent a viable business paradigm. This is mainly due to connectivity problems which arise at some remote sites and - most importantly- due to high roaming costs incurred to tourists. A reasonable alternative for this case is the use of a WiFi installation. However, even if WiFi installations exist, again like the GPS not all mobile phones come with WiFi capabilities.

We argue that a solid solution to this problem would be to install an infrastructure to support proximity detection and a remote content update mechanism. This infrastructure should fulfill the following two conditions: (a) support practically all available mobile devices, (b) allow relatively effortless and inexpensive deployment (to compress installation and maintenance cost), yet, offer adequate coverage to its users.

The first requirement can be satisfied by the use of Bluetooth network connection which is commonly supported by the majority of mobile devices today. The second condition can be dealt with the deployment of low-cost wireless devices at points with high concentration of tourists, placed either in open-air public places or in selected buildings interior. A reasonable choice for such a solution is the use of small to medium-scale Wireless Sensor Networks (WSNs).

Sensor nodes are computational nodes of small dimensions and of very low cost shipped with embedded sensors to record measurable parameters such as temperature, humidity, acceleration, etc. WSNs represent a modern wireless technology whereby nodes communicate with each other over a wireless connection and push collected data to a processing element (sink). A basic principle of WSNs is that they do not require a stable network infrastructure to operate. Namely, WSNs enable self-configuration and self-organization of an infrastructureless ad-hoc network topology.

The typical function of WSNs involves periodic multihop recorded sensory data forwarding from distributed nodes to the centralized sink. Herein, we reverse this standard perspective and regard sensor nodes as inexpensive distributed network access points deployed around POI areas that provide the necessary infrastructure for tourists to upload multimedia content (text, photos, etc) to remote tourist portals. Within this approach, tourists located in the vicinity of a POI are discovered and prompted to connect to a remote content server (portal). The user then performs a Bluetooth handshake with the sensor node in order to establish connection. Once in sync with the node, the application receives the POI ID and the user is prompted to rate the POI. The user may also upload photos taken from her mobile device to her personal profile web pages.

![Image](Image 308x405 to 329x429)

Figure 6 The use of sensor nodes as access points for tourists to rate and comment visited POIs.

At a later stage the sensor node forwards the data received from the user’s mobile device to the sink (either directly or via multiple intermediate nodes) and the sink in turn transmits the data to the remote server (tourist portal). Direct communication of a sensor node with the remote server via end-to-end HTTP is also possible. The sensor nodes may also transmit, along with the user rating and commenting data, environmental parameters values (e.g. temperature, humidity and light measurements) as well as their GPS locality. This allows the provision of up to date local environmental information to users interested in visiting nearby POIs. The architecture of our proposed approach is illustrated in Figure 6.

In our implementation we used 20 SunSPOT sensor nodes of Sun Microsystems [35]. SunSPOTs are equipped
with a processor (32 bit Risk clocked at 180 MHz), an IEEE 802.15.4-compatible radio transceiver, a rechargeable battery (3.7 V 720 mAh) and three sensors (accelerometer, temperature and light sensor). Each SunSPOT hosts a Squawk Java VM and may execute Java ME applications. Additional sensors and modules may be also attached to sensor boards. In our testbed, we attached BlueSMiRF Bluetooth modems and GPS modules.

V. CONCLUSIONS AND FUTURE WORK

In the context of the Municipal Council of Mytilene project, a three-part system was implemented. A web tool was implemented to allow tourists to create customized mobile guides for their visit. A thick client application model was chosen that does not require constant connection to the Internet. The users ‘tag’ content items of interest through a familiar web interface and select their device model to download the application to a PC. Emphasis was given to personalized services wherein the user’s explicit and implicit profiles are used as input to the content recommendation system; as such the use of personal web profile pages allow users to upload comments and photos for other peers to view. The use of sensor nodes as a means to detect user proximity and allow users to connect and upload rating and commenting data was seen as promising when a mobile network connection was either unavailable or expensive to use.

An important aspect of the recommendation system which requires further investigation is the case where a user that has not yet interacted with the system requires content recommendations. Even more so, in the case that only few users have interacted with the content system to implicitly provide usage data. As such, the system does not store the required critical data mass to trigger the recommender mechanism and ensure reliable and suitable recommendations. For this case, ‘user stereotypes’ could be used. Stereotypes associate the attribute of a user (age, educational level, gender etc.) with relative preferences [30] so as to find which stereotype best fits the user, which is accomplished with the use of the users attributes. The stereotypes can be created by domain specialists, but can also be generated automatically with the use of techniques of machine learning which could be applied to a total of observations [27]. As such, the use of stereotypes will be considered as a future enhancement of our intelligent recommendation system.

REFERENCES


