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ScienceDirect

Procedia Environmental Sciences 22 (2014) 257 – 269

Procedia Environmental Sciences

12th International Conference on Design and Decision Support Systems in Architecture and Urban Planning, DDSS 2014

Toward personalised and dynamic cultural routing: a three-level approach

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Abstract

This paper introduces the concept of "smart routing" as a recommender system for tourists that takes into account the dynamics of their personal user profiles. The concept relies on three levels of support: 1) programming the tour, i.e. selecting a set of relevant points of interests (POIs) to be included into the tour, 2) scheduling the tour, i.e. arranging the selected POIs into a sequence based on the cultural, recreational and situational value of each, and 3) determining the tour's travel route, i.e. generating a set of trips between the POIs that the tourist needs to perform in order to complete the tour. The "smart routing" approach intends to enhance the experience of tourists in a number of ways. The first advantage is the system's ability to reflect on the tourists' dynamic preferences, for which an understanding of the influence of a tourist's affective state and dynamic needs on the preferred activities is required. Next, it arranges the POIs together in a way that creates a storyline that the tourist will be interested to follow, which adds to the tour's cultural value. Finally, the POIs are connected by a chain of multimodal trips that the tourist will have to make, also in accordance with the tourist's preferences and dynamic needs. As a result, each tour can be personalised in a "smart" way, from the perspective of both the cultural and the overall experience of taking it. We present the building blocks of the "smart routing" concept in detail and describe the data categories involved. We also report on the current status of our activities with respect to the inclusion of a tourist's affective state and dynamic needs into the preference measurement phase, as well as discuss relevant practical concerns in this regard.

Peer-review under responsibility of the Eindhoven University of Technology, Faculty of the Built Environment, Urban Planning Group

Keywords: Affective computing, cultural tourism, route recommender systesm, tourist experience, user preferences

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Peer-review under responsibility of the Eindhoven University of Technology, Faculty of the Built Environment, Urban Planning Group
doi:10.1016/j.proenv.2014.11.025

1. Introduction

Offering suitable assistance to tourists during a trip is an important concern that has been in the limelight for many years, with early examples of Cyber-guide[1] and GUIDE[2]. Tour guides are meant to help tourists select relevant places and plan a trip around the selected ones accordingly – by means of using the information provided by and collected about the tourists, such as – to name a few – their demographics, interests and temporal constraints that have to be met. In other words, the tour guide considers what pieces of information would be relevant for the current case and, on the contrary, which ones from the available pieces should be omitted; hence, it performs information filtering[3]. In one subclass of information filtering systems – recommender systems for tourists[4] – available information streams are analysed based on a number of categories, e.g., details about the tourists themselves, the items they expressed to be interested in, and various context information that is considered to be relevant. With the help of one or more filtering techniques, a recommender system is able to determine which parts of the entire information pool are (likely to be) more relevant and more interesting to the requestor, thus providing, or "recommending", only certain specific information to certain users while leaving the rest of it out.

With the recent advancements in technology, the proliferation of the internet, and the adoption of mobile and pervasive computing[5] paradigms, recommender systems for tourists have also joined the world of mobile devices and have become available on the fly. A typical target user of such a recommender system is a tourist who is interested in exploring a (historical part of a) city and therefore would like to make a tour over this city or its part on a particular day. The tour involves visiting a number of points of interest (POI) – sites of specific interest to the tourist – that may be spatially dispersed across the city area implying that travelling may be involved in implementing the tour. A potential issue with these solutions is that they are often not detailed enough in the sense that they do not fully take into account a tourist's quickly changing individual context, which stretches beyond the tourist's demographics and whereabouts. Today's information era of big data and social media caused an explosion in the amount of information that can be collected about people and assets. On the one hand, this situation greatly increased the role users – and therefore, tourists – play in the definition of the requirements for the functionality and usability of a particular (mobile) touristic service, so that it will eventually meet the needs of a larger number of tourists. On the other hand, this amount opens up opportunities of exploiting the benefits of information diversity in order to allow touristic recommender systems to deliver yet more personalised and fine-tuned solutions[6,7], further enriching tourists' experience.

In this paper we describe a concept of a new tourist recommender system focused on cultural tours in a city. We suggest that the composition of such a personalised cultural tour can be achieved by offering tourists "smart routing" – a travel route recommendation tailored to their personal profiles that includes three levels: 1) programming the tour, i.e. selecting a number of relevant POIs to be visited, 2) scheduling the tour, i.e. arranging the selected POIs into a suitable and meaningful sequence, in order to increase the cultural value of the tour, and 3) determining the tour's travel route, i.e. identifying a set of trips between the POIs that the tourist needs to perform in order to complete the tour.

The "smart routing" approach intends to enhance tourists' experience in several ways. One concern in planning a trip and identifying its content and route under such conditions is to involve a comprehensive consideration of the multi-dimensional and often dynamic preferences of tourists; in particular, their needs and affects. Our approach relies on the analysis of the tourist's individual dynamic preferences and needs, with a subsequent understanding of the priorities and importance of each activity from a tourist's point of view at a particular moment. This aspect includes, as a separate category, learning about a tourist's emotional and motivational state, which allows the system to further fine-tune the details of each of the three levels. The system's ability to reflect on the tourists' dynamic preferences and needs rests on learning the following aspects:

- which dimensions of emotions and needs can be distinguished and are relevant for the experience;
- how activities influence preferences and states; and vice versa
- how affective states and preferences determine priorities of activities (and therefore, the content of the POI selection).

Second, POIs can be logically linked with each other in a way that creates a particular storyline that the tourist will be interested to follow, which adds to the tour's cultural value. This classification into categories, sequences and their relevance to a particular collection poses the following challenges that must be fulfilled on this level:

- classifying themes and visiting sequences;
- gathering information about POIs with respect to their value for a particular theme and position within a tour;
- understanding how tourists trade-off between the cultural experiences they seek and the (travel) costs they have to keep in mind.

It must be noted here that a POI is a broader concept than a site or an attraction, in the sense that it additionally includes the tour's supporting and auxiliary locations such as restaurants and shops, which usually are the tour's equally important components from the tourist's perspective.

Third, the travel route composition relies on the information about

- multimodal transport services, such as the routes and timetables of public transport, the road network and its current traffic situation, and the options for walking and cycling.

Eventually, the items included into the tour are connected in time and space in accordance with the context of the given tour, which completes the tour's formation. And as a result, each tour can be personalised in a "smart" way, from both cultural and overall experience of taking it.

The rest of the paper is organised as follows. In section 2 we discuss related work in the area of recommender systems in tourism and the use and role of affects and emotions in providing recommendations. Section 3 talks about the tourist's dynamic preferences and their involvement in the "smart routing" approach. Section 4 presents a number of requirements for the system and describes the specifics of the involved data model and its information sources. In section 5 we further describe the dimensions of emotions, needs, and activities that shape the experience of tourists, and discuss relevant practical aspects of their detection and measurement. Finally, section 6 concludes the article.

2. Related work

2.1. Recommender systems for tourists

One aspect to look at when offering personalised advice to tourists is to address their behavioural traits and to identify implicit, but potentially valuable details of their profiles in terms of interests and preferences. Thus, Cheng et al. (2011) analysed a large pool of public travel photos taken by tourists at a number of popular destinations and applied a face detection technique to extract from those photos certain details about the tourists (namely, their age, gender, and race), which allowed them to discover travel preferences of different categories of tourists and to build a tourist recommendation model[6]. In a follow-up study[8], they showed how social relationships could also be identified from analysing group photos, which could be applied to personalise group recommendation services. In another example, Tsai & Chung (2012) leveraged the use of the RFID technology to track the behaviour of a theme park's visitors for identifying route patterns that were matched to the input the visitors provided, so that a route recommendation system was built that suggested the newly arrived visitors the most suitable visit programme based on the experience of previous visitors with similar profiles[7]. Other examples involve, e.g., an analysis and exchange of information about the road situation in self-drive tourists' vicinity in offering them real-time personalised route recommendation[9] or the use of item domain features for generating user preference models to be involved in domain recommendation[10]. Besides, recent advances in technology allow the creators of recommender systems for tourists to employ high-standard graphical solutions and thereby further improve tourists' experience. Thus, Noguera et al. (2012) developed a system that visualised recommendations in a full 3D coverage of an area on the screen of a mobile device[11]. In another example, the mTrip[12] system supports a personalised trip recommendation through an "augmented reality"-based user interface.

Dealing with a recommender system's design and development requires a separate attention to be paid to the question of the systems approach and framework[13]. In this regard, a number of architectures have been proposed for the development and support of the recommendation process for tourists in varying contexts and with the help of different technologies. Thus, e-Tourism is a tourist recommender service that is meant to assist tourists in arranging their visits in the city of Valencia (Spain) [14]. e-Tourism's architecture comprises several sub-systems, where each is responsible for a certain step: from building a tourist's profile, to identifying a list of suitable activities and attractions, to working out a plan and agenda of visiting the suggested attraction set. The e-Tourism's Generalist Recommender System Kernel (GRSK), responsible for recommendation, is built around a taxonomy of attributes used to represent tourists' interests and available attractions in the system and employs a multi-step recommendation process with a subsequent planning component to complete the recommendation. Turist@ is an agent-based recommendation system that focuses on providing assistance to tourists upon their arrival at the destination[15]. It is designed as a multi-agent system where each agent is responsible for a certain functionality (such as a recommender agent) or domain representation (such as an exhibitions agent or a cinema agent). All agents are interconnected within the system and regularly interact as appropriate. A special attention is paid to the system's ability to adapt to changes in real-time and to take into account the most recent information about the relevant trip details. In a recent review, Gavalas et al. (2014) provide a thorough analysis of approaches to designing and building recommender systems for tourists, identify their major features and differences, and discuss a generic architecture of a mobile tourism recommender system[16].

In general, there is a number of information filtering approaches, such as demographic, collaborative, or content-based filtering, that can be involved in the recommendation process, and each of them is regularly used in existing systems[4,16]. But very often, any single technique is insufficient for making recommendations of the desired quality. Besides, some of them are said to suit less than others for touristic and leisure contexts[17]. Therefore different approaches are often combined in a certain way: from an independent application of several techniques with a subsequent comparison and merging[14], to using knowledge-based recommendation by matching a user profile to the specifics of POIs[18], to agent-based hybrid recommendation[15]. These and multiple other examples illustrate that the optimal approach to tourism recommendations is not universal and will depend on the situation in question and the context of its application, so that further research challenges and efforts are still actual[16].

2.2. Affections and emotions in the recommendation process

An important dimension that shapes the experience of users – and therefore, of tourists – deals with their affects and emotions. Emotions are fundamental to largely any kind of user experience, so that understanding the influence of emotions on user preferences and subsequent decision making is important. So far, researchers have already demonstrated how the knowledge about emotions can be included into a recommendation process in different application areas. Thus, Gonzalez et al. (2007) showed how knowing about the users' emotional attributes resulted in the selection of a more relative and also more satisfying learning activity available through a learning portal[19]. Arapakis et al. (2009) investigated the application of the knowledge about the users' emotions obtained from interpreting their facial expressions to recommending movies[20]. Alternate to sensing or detecting emotions, Braunhofer, Kaminskas, & Ricci (2013) used a vocabulary of emotional tags in exploring a cross-domain item similarity[21]. The participants of their study were asked to explicitly label each element from a collection of music items and POI items with relevant emotions out of the suggested list. These data were transformed into a similarity metric, which was then used to recommend certain music items that would "match" a certain place and that the visitors would listen to while visiting the place. Tkalčič et al. (2011) have explored the steps of including emotions into a recommender system in general[22]. They distinguished three stages of emotions participation during a user's interaction with the recommender system – *an entry stage*, *a consumption stage*, and *an exit stage*. The argued reasoning for this approach is that emotions play different roles in each of these stages, so that referring to them in these three ways eventually helps to improve the quality of recommendation in which emotions are involved. Overall, these and other recent examples of results in the field[23,24], clearly indicate that interpreting an individual's emotions is currently a popular topic in research on recommender systems in many application areas and with the help of different technologies. Speaking about tourism, the involvement of affective factors and dynamic needs into the recommendation process and into improving tourists' experience has received little attention. The suggested "smart routing" system aims to address and explicitly involve a tourist's affective state and motivational considerations in order to take into account the influence emotions and affections have on the trade-offs that tourists make about their choice options.

3. The user - dynamic preferences

A typical user of the "smart routing" recommender system is a tourist who is interested in exploring a (historical part of a) city and wants to make a cultural tour around it. Such a tour comprises a number of attractions – sites of specific interest – that may be spatially dispersed across the city area, implying that travelling may be involved in implementing the tour. The composition of the tour requires knowing about various needs and preferences that the tourist may have regarding the content or the duration of the tour, as well as about personal expectations from the experience of taking the tour. Besides, it may also be necessary to be aware of other situational context information that may influence the tour's details. Together, these variables determine how a particular cultural tour will be experienced and evaluated by a particular tourist. However, many of these variables change over time, which, in turn, may have an influence on the preferred, most suitable arrangements for the tour. Therefore the main challenge of "smart routing" is to be able to keep up with the dynamic preferences and needs of tourists and to reflect on this dynamics in the most suitable way.

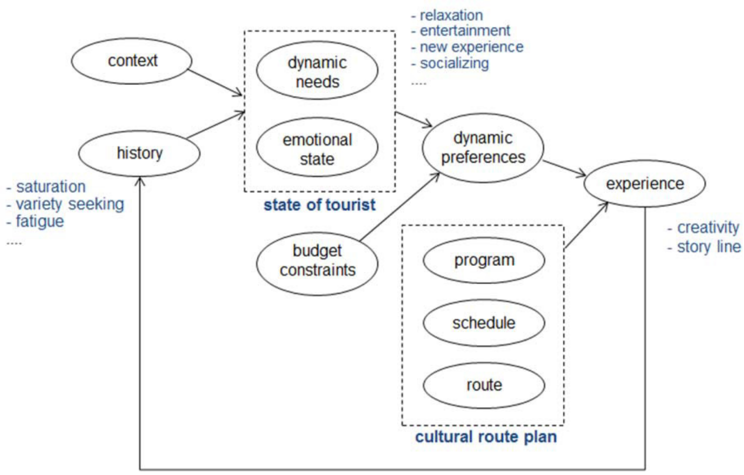

Fig. 1. Concepts and approach involved in "smart touring".

Fig. 1 depicts a schematic alignment of the concepts involved in "smart routing" and also shows the connections that exist between these concepts in the context of a cultural tour and experience. In the following we talk about and explain these concepts and their connections in detail. Tourists often differ in terms of the type of cultural experience they seek and the way they trade-off travel costs against the value of experiences. Partly, the differences relate to predispositions or conditions that are static and hold for the entire tour. However, for an important part the specific preferences for options are dynamic and depend on a momentary motivational state of the tourist. On the one hand, motivation will depend on previous activities and experiences ("history") during the tour (e.g., a need to be in the open air after having spent some time in a museum). On the other hand, the state is affected by situational variables ("context") such as the weather condition and crowdedness. In short, the emotional state (needs and affections) is influenced by history and context and determines to an important extent the preferences for available options and the subsequent choice of activities. Finally, tourists also often are exposed to budget constraints: either financial, temporal, or both, these restrictions may also affect choices (e.g., insufficient walking time).

In accordance with the tourist's dynamic state as discussed above, the "smart routing" approach suggests that the advice regarding a plan for a cultural route to be made ("cultural route plan") must fit each of the following three aspects: what to visit, in what sequence, and which transport modes and routes to use for travelling between locations. We can refer to them as three different levels of support necessary for “smart routing”: 1) the program level – a selection of sites or objects to visit, 2) the schedule level – a sequence in which the sites or objects are visited, and 3) the travel route level – a set of trips needed to reach the locations of the sites or objects. The resulting route reflects on each aspect of the tourist’s dynamic user profile and at the same time takes into account all involved situational context, thereby offering a solution that is personalised in a “smart” way and that aims at providing tourists with the best experience. In the next section we introduce the requirements the “smart routing” poses with respect to each of the three levels and describe the data model that the system relies on.

4. System requirements and data model

4.1. Smart routing

The concept of “smart routing” refers to a number of innovations the system offers compared to state-of-the-art recommender systems in tourism and elsewhere:

- enhancing the overall experience by taking into account a tourist’s affective state and dynamic needs;
- enriching the cultural experience by taking into account semantic relationships between objects and sites considered for visiting;
- enlarging the choice-set of options for travelling between sites by taking into account a multimodal transport system.

Thus, the aim of the “smart routing” recommender system is to achieve the best possible cultural and overall experience for the tourist within the resource and physical constraints that hold for the trip; and to do so by simultaneously taking into account motivational considerations coming from the tourist’s emotions and needs. This can be achieved as a three-level process, detailed in the sub-sections below.

4.2. Three levels of support

The programming level. Stimulating touristic cultural experience means offering something beyond simplistic routing over a set of POIs. An example of such a suggestion would be to suggest a tourist, who is interested in modernism and has arrived to spend a day in Barcelona, to cover the works of Antonio Gaudi, e.g., by giving them priority over other attractions. Therefore at the programming level, the system needs to ensure that the objects and sites that form a tour are selected in accordance with the individually relevant criteria and the situational context of the tourist. ***The schedulling level.*** The selection of attractions and sites to visit solves only one aspect of the tour’s composition. It is equally important to arrange the selected items in the most suitable way, so that the result will bring an added perceived value to the tourist. In other words, what the system must be able to offer additionally at the schedulling level is to arrange the objects on the tour into a sequence with semantically-enriched connections between them, thereby adding to the tour’s cultural value. ***The routing level.*** In order to complete the tour, i.e. to visit and experience the aforementioned POIs, the tourist needs to know about the available travel options. An example of a suggestion that the “smart routing” system could give to a tourist regarding moving from the attraction just visited to the next one could be *to walk* between them (e.g., instead of using public transport), which could be the result of matching both the tourist’s wish to do some physical activity and the sunny weather. Such reasoning makes the objective of supporting multimodal travel straight-forward, and recent recommender systems for daily travel (e.g., the i-Tour[25] system) have provided solutions that support and suggest different forms of transportation to users, based on their preferences and real-time information about various travel-related details such as the road, traffic, or weather conditions. In the case of “smart routing”, it is additionally important that a suitable transport connection between the sites included into the tour also reflects on the tourists’ dynamic needs and the context situation.

On all three levels above, we emphasised on the importance of the tourists’ cultural and overall experience, so that the respective selection criteria are expected to take into account an individual tourist’s dynamic preferences, state and needs during each of the three phases of activity planning (i.e. programming, scheduling, and routing). Since these details are likely to vary over time, and sometimes may do so within a short-term, the results of either level's suggestions may be influenced already during the execution of the tour, which becomes an additional challenge to consider on each of the three levels.

4.3. *Data model*

The functionality of each level of "smart routing" relies on the completeness of its information pool, i.e. the amount and level of detail of the available information. This section describes the various information concepts defined and used within one or more levels.

4.3.1. Descriptions and details of POIs

Each POI has a collection of parameters and characteristics that describe it. The information the parameters contain varies depending on the type of attraction the POI in question belongs to, the kinds of activities it offers, and so on. Possible examples of such information involve location, attraction category, a list of activities, opening hours, and its pricing policies – to name a few. Table 1 specifies a description of information categories a typical POI involves.

The *access-related* and *activity-related* data in Table 1 are usually public and easily available. There are collections of categories that can be applied to any POI in general, such as descriptors used in Google Maps[26], Google Places for Business[27] or TripAdvisor[28], which offer relatively simple but often sufficient classifications. There are also more complex vocabularies that provide a comprehensive view on the classification of objects, such as the Art and Architecture Thesaurus[29] (AAT) that has been recently released as Linked Open Data[30]. The AAT vocabulary contains over 250 thousand terms, so that it is possible to extract a sub-set of terms to be used as an own taxonomy, in accordance with the system's requirements and needs[31]. Similarly, the information about POIs can be supplemented with further details from local information repositories that have been developed for the needs of a particular collection.

The second type of information about POIs represents connections identified between POIs (the *connections* category). On the one hand, these data exist in the form of a knowledge base of links between two or more POIs, such as when they are known to be offered together as part of the same bundle (e.g., the earlier example of the works of

Table 1. Information categories for POIs.

Category	Content
Access-related	- Location: (X,Y), (Lat, Lon) - Opening hours - Entrance fees (if applicable) - Facilities
Activity-related (quick access)	- Activity-list - Activity-category: history, entertainment, sports … - Activity-type: museum, cinema, theme park …
Activity-related (extended)	- Media: images, movies, articles … - Reviews: opinions/comments from previous visitors - Ratings: ratings from previous visitors
Connections (knowledge-base)	- Complete tours - Bundles - POI set

Table 2. Information categories for transportation data.

Category	Content
Road network (car, bicycle, pedestrian)	- Road segments: start node, end node, speed profile, direction, accessibility by mode …
	- Parking: vehicle-types, current-capacity, location, schedule, fees …
	- Real-time updates: traffic congestion, car accidents …
Public transport	- Routes: mode, line, stop/station-set
	- Stop/station: arrival time, departure time, {facilities}
	- Run-time updates: delays, vehicle-status …

Antonio Gaudi). On the other hand, it is considered together with information on tours' details, with references to the POIs included into any same tour, and also combined with details about tourists' previous experiences in completing any particular tour. This type of information is mainly learning-based and is maintained and updated based on the results of offering previously generated tours and the feedback from the users.

4.3.2. Information on routing details

After the spatiotemporal conditions and restrictions of the tourist and the corresponding POIs have been identified and processed, the different POIs and their related activities have to be linked by a set of trips. Depending on the transportation means, the data can be divided into several logical parts, as presented in Table 2.

One part is the information about road networks, which is mainly used for finding driving, cycling and/or pedestrian connections. It can be accompanied by the details of a real-time situation on the road, such as traffic congestion, the average speed, or road accidents, and may include details about parking facilities, such as their locations, capacities and fees. Another part provides information about the use of public transport, which typically includes a set of available lines and their routes, with information on stops and stations, and the corresponding timetables; when available, a description of facilities (e.g., in the form of POIs) situated at each stop or station is specified. Similar to road networks, this part of routing information is supplemented with details about the real-time situation on each trip segment (e.g., deviations from the timetable). All of the above information can be taken from globally available services, such as OpenStreetMap[32], Google Maps[26], as well as weather services[33]. When available, local services providing one or more types of this information often provide better fine-tuned and up-to-date information about a certain area, so they can also be consulted in real-time for obtaining the status of the requested information.

4.3.3. Information about tourists and their preferences and needs

We have already noted in section 3 that the user profile of a tourist plays an important role in the way a particular cultural route is experienced and evaluated. One important difference between the many characteristics comprising a tourist's profile is how long a certain value of a given characteristic remains valid for. For instance, one's interest in cinema may be static for the entire duration of the trip, whereas the available budget is likely to decrease with time, and one's mood can change many times. However, they all contribute to tour planning, and therefore it is important to line them up accordingly. We arrange all information about a tourist in four categories: *long-term*, *mid-term*, *short-term*, and *ultra-short-term* information. As their names suggest, the categories are built around a time-frame criterion, so that each one relates to a different time interval and thus represents a measure of dynamicity of the parameters it contains. Table 3 summarises the alignment and shows data elements typical to each category.

The *long-term* information is a collection of general characteristics of the tourist which can be considered static for the entire duration of a single trip. The category includes knowledge about the tourist's demographic profile, a collection of items the tourist is interested in in general (*interests I*) and information on the tourist's abilities that must be taken into account when planning a tour, such as the tourist's mobility (*mobility M*) and special conditions (*health-fitness-disabilities F*). The category also lists the needs important to the tourist that are relevant for travelling and leisure scenarios. The *mid-term* category stores details that are also considered relevant for the entire trip but are

Table 3. Categories of a tourist's user profile.

Category	Content
Long-term (static)	- Demographics: age, gender, occupation … - Mobility (M): vehicle types, driver licenses, public transport cards … - State profile: interests (I), needs (N), health-fitness-disabilities (F) …
Mid-term (trip)	- Mobility (M), State profile (I, N, F) – **derived** - Accompanying persons (Y): number, relations, profiles (long-term) … - Available budget (B): time (trip length), money (rough indication) … - Program (P): wish list of things to do during trip
Short-term (day)	- Mobility (M), State profile (I, N, F), Accompanying persons (Y) – **derived** - Available budget (B): for the day - History (H) - Program (Pv): **sites visited**; Program (Pw): wish list **for the day** - Route plan (R): program, schedule, travel routes …
Ultra-short-term (moment)	- Mobility (M), Accompanying persons (Y), **updated** - Available budget (B): **remaining** for the day - State profile: I (**updated**), N (**updated**), **emotion E** - History (H), Route plan (R), **updated** - **Position: coord X-Y (Lat-Lon), current activity (position in route plan), …**

more likely to change. The category includes information about the people that the tourist may be travelling with together (*persons Y*), about the available time and money (*budget B*), and also contains a list of attractions and activities that the tourist considers visiting or doing while on trip (*program P*). Additionally, it also keeps a *derived* actual version of the previously collected information about the tourist's mobility and state profile. The *short-term* category contains information that is relevant for a particular trip segment, such as (a part of) a single day. This category includes knowing about the available time and money for the scheduled period, a possible history of the tourist's previous experience and activities and contains the details of the already completed (*program Pv*) and a preferred (*program Pw*) program at the destination. The details of executing the remaining program (*route plan R*) are also managed here. Additionally, it also keeps a *derived* actual version of the previously collected information on the tourist's details and the group. Finally, the *ultra-short-term* category refers to the information that is only relevant for a particular moment. It mainly deals with all the updates to the previously indicated details, including changes in the tourist's situation (*mobility, persons, budget*) and state of needs and preferred activities (*state profile*), updates and changes to the route that has been initially generated (*history, route plan*), the current location (*coord X,Y*) and the activity and/or attraction the tourist is on at the moment (*current activity*). Additionally, this category also keeps information about the tourist's emotional state (*emotion E*).

4.3.4. Discussion

In general, a collection of tourists' interests can be broad, containing information about very different fields. But the main aim of developing a user model is to allow the system to adapt to the specific needs of users within the particular context in which the system is operating, so that the system is able to "say the 'right' thing at the 'right' time in the 'right' way"[34]. The "smart routing" system aims at providing recommendations in the area of city-wide cultural tourism. Therefore when modelling a tourist's general interests and preferences (*interests I*), it is possible to refer to the categories of attractions and types of cultural and leisure activities that the tourist prefers, which can thus be related to the corresponding *activity-related* characteristics of POIs already discussed earlier in section 4.3.1. So that the corresponding sub-challenge of personalisation in "smart routing" refers to analysing the mapping between the two sets, with subsequent looking for a potential match of the tourist's interests to the available POIs.

5. Emotions, needs and activities: dimensions and measurement issues

5.1. Emotions

With the rise of affective computing, research on the role of affects and emotions has gained attention, and we have already discussed in the related work a number of examples and results of how knowing about one's affects can help the recommendation process. Emotions are often described and interpreted in accordance with some predefined classification. An example is Ekman's six discrete emotion categories of *anger, disgust, fear, happiness, sadness, surprise*, which can be obtained from facial expressions[35]. However, a recent study by Jack, Garrod, & Schyns (2014) suggested that this set can be reduced to four since two pairs of emotions tend to "share" their facial patterns[36]. Another classification, the OCC model of emotions[37], considers 22 different emotion types, for which a sequence of identification steps is executed (action, intensity, interaction, mapping, and expression) in order to come to a matching type. The complete set of the OCC model is the following: *joy, distress, happy-for, pity, gloating, resentment, hope, fear, satisfaction, fears-confirmed, relief, disappointment, pride, shame, admiration, reproach, gratification, remorse, gratitude, anger, love,* and *hate*. Together, the two sets provide a comprehensive list of possible emotion states. But the main practical concern in using either classification (or, where applicable, their combination or a subset) is to know which of those emotions are computable, i.e. which of them can actually be identified by the system.

There are different ways to detect the affective state or identify a particular feeling of a person (see Calvo & D'Mello (2010) for a review[38]). The possibilities depend on the technologies involved, on the quality of the sensed data and otherwise provided context information, on the suitability of the measurement method to the situation, among others. And since the result of the detection process is a set of terms that would describe this person's affective state, emotion, and/or feeling, an important part of the functionality lies in building a suitable vocabulary that would be used as the output of the affect detection process, mainly because it will determine the actual resultant affective model to be included into the tourist's profile. So far, we have re-arranged the original terms by applying them to the context of a tourist, based on their importance and similarity. The following nine groups have been elicited: *(joy, happy-for), (sadness, distress, disappointment), (satisfaction, gratification, relief), (hate, disgust), (admiration, hope), (surprise), (fear), (anger),* and *(pity)*. We plan to use this grouping as a starting reference to the emotional input, but which will be further fine-tuned and updated in accordance with the results of the affection detection functionality.

An alternative method to identify one's affection is to interpret responses to various natural (e.g., visual or audial) stimuli. This method relies on a dimensional representation of emotions along the scales of valence and arousal, so that each stimulus represents a point. A widely employed methodology to do so is to use the International Affective Picture System (IAPS)[39]. Here, subjects are shown a set of images, each with a known arousal-valence score, and are asked to evaluate for each image the degrees of arousal and valence that seeing the image has caused. Validation studies[40,41] have confirmed the applicability of the method in international settings, i.e. without language ties, which makes it a suitable technique within the context of tourism. Furthermore, a subsequent mapping of those responses to a discrete categorical (sub)set of values is possible[42]. It was also shown that this methodology could be used to induce a particular emotion, so that the corresponding induced affective conditions are used for understanding differences in preferences of choices in different affective contexts, which, in turn, helped improve recommendation[43]. The corresponding sub-challenge of this part of our work in progress is to lay ground for the involvement of the IAPS methodology within the tourists' preference measurement phase.

Despite the fact that today, automatic affect and emotion detection is able to cover a wide range of situations and states, it is necessary to keep in mind that people may be unwilling to share this kind of information with the system or the system may fail to suggest the desired choice option, so that the user may simply disagree with the result. This means that the system should be flexible about the ways in which it receives affect-based input: in addition to acquiring information about emotions and needs automatically, it is also necessary to give the users a possibility to share their feedback and provide input manually. Depending on the context of use, this step may elicit certain emotions over the others, as well as it can be used to justify the use of a constrained set of values[42]. One way of obtaining such user-generated information is with the help of a survey designed to assess users' perception and evaluation of the displayed content. Previous results have demonstrated the success of this approach in evaluating people's perception of cultural heritage and historic places[44].

At the system's development and implementation level, the description of the affective state within the framework will follow the W3C's EmotionML recommendation[45], which will make it easily serialisable to the markup format.

5.2. Needs and activities

In terms of tourist's needs, it is possible to refer to the needs-based theory of activity generation[46]. Here, an activity that has been recently experienced influences the degree of the need associated with it. As a result, this activity receives a lower priority among the available interests and preferences. The approach can also be applied to the context of cultural city tourism and its "smart routing" recommendation, where this information can be used in the subsequent mapping/matching steps, so that a corresponding task of the personalisation is to consider the "needs-activity" tie in connection with a tourist's affective state. Hence, a degree of interest in values from these categories (i.e. in participating in a relevant activity) at a certain moment is influenced by the tourist's dynamic needs; in particular, by those ones whose status can be influenced by the corresponding activity. Therefore another aspect in building the user profile of tourists concerns the question of identifying a list of needs that the tourists find valuable during the trip/tour. The results of Nijland et al. (2010)'s analysis of needs underlying a broad range of leisure activities people conduct on a more or less regular basis revealed the following six independent needs that turned out to be most important: *physical exercise, social contact, relaxation, fresh air and outdoors, new experiences*, and *entertainment*[47]. This set resulted from an analysis of a broader range of needs obtained from a number of surveys and questionnaires. The field of cultural city tourism is likely to have its own specifics, meaning a different set of "main" needs. Nevertheless, the methodology and the context that Nijland et al.'s analysis was applied to make it suitable to the case of city tourism. Therefore at the moment of writing we consider the above dimensions of needs in preparing experiments for collecting data on the preferences and dynamic needs of cultural city tourists, with an additional dimension of their affective state.

In terms of activities, "smart routing" is not bound by any particular classification of preferences and categories of attractions. This information is taken as input, so that the framework is able to work with any vocabulary of POI categories and activities they offer. One possible classification that can be considered resulted from a regular survey about people's leisure activities that is conducted in the Netherlands (Called the CVTO survey). The survey gathers information on activities that people took part in during a week's time, and the following categories are identified: *outdoor recreation, water recreation, visiting events (e.g., show, festival), fun shopping, self-sporting, culture events (e.g., concert, museum), visiting sports events (e.g., football match), visiting attractions, going out, wellness and beauty,* and *other hobbies and courses*. In the context of cultural tourism and "smart routing", these clusters of activities can be considered as a starting reference for the identification and categorisation of the activities that are available at a touristic destination, and as a way to describe and align the information on local POIs and attractions within the system, in accordance with the details of POIs as was described in section 4.3.1.

6. Conclusions

In this paper we introduced the concept of "smart routing" – a personalised recommender system for cultural tourism that takes into account the varying nature of tourists' dynamic needs and preferences. Three levels of activity specification are considered in "smart routing": 1) a program level, i.e. selecting a set of relevant points of interests (POIs) to be included into the tour, 2) a schedule level, i.e. arranging the selected POIs into a sequence based on their respective cultural, recreational and situational values, and 3) a travel route level, i.e. determining a set of multimodal trips to be made between the POIs included in the tour. We presented the specifics of and identified the challenges associated with each level, and discussed the characteristics of corresponding information sources required at one or more levels. We also described the aspects and challenges of information gathering and tourists' preference measurement phases and discussed our ongoing work and relevant considerations that have to be taken into account in this regard.

Acknowledgements

The research leading to these results has received funding from the European Community's Seventh Framework Program (FP7/2007-2013) under the Grant Agreement number 611040. The authors are solely responsible for the information reported in this paper. It does not represent the opinion of the Community. The Community is not responsible for any use that might be made of the information contained in this paper.

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