CATReS: a Context-Aware Recommender System for Indoor and Outdoor Museums Tours Planning

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ABSTRACT

Tourism is a rich and growing activity in the world. The digital support of the tourist experience is typically based on Tourist Recommender Systems (TRS). Widely spread TRSs typically recommend the visit of a set of Point of Interests (POIs). Unfortunately, some of these have also proved inappropriate because they do not consider in detail the indoor visit of a POI, such as a museum, which may contain several artworks and may have limited or regulated access. In this paper, we present our ongoing work on a Context-Aware Touristic Recommender System (CATReS). It provides an outdoor recommendation to select POIs suitable for a visit, as well as an indoor recommendation to select the artwork to visit. The overall recommendations are based on contextual information coming from both visitors' profile and the POIs' contextual information (e.g., the waiting time to access the museum, the average time to visit it). Our tour recommendation system is available and is being experimented at the Uffizi Galleries (Florence, Italy).

CCS CONCEPTS

• Software and its engineering → Contextual software domains; Software implementation planning; • Information systems → Social recommendation.

KEYWORDS

Context-aware planners; tourist recommender systems; outdoor and indoor visit.

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1 INTRODUCTION

The World Wide Web provides tourists with huge possibilities to search for interesting information and planning their activities. However, the large amount of data available makes it difficult to decide. Based on that need, Tourist Recommender Systems (TRS) are offered by many resources to support tourists in managing their long, medium and short tours. A TRS can select and filter the relevant results to the user from a large database of tourist services including transportation, accommodations, attractions, Point of Interests (POIs), and even fixed tour package.

Some approaches focus on the concept of *context*, largely associated with the delivery of service based on geographical information and weather conditions [3]. In [10] the context is defined as *any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application including the user and application themselves.* Context-aware applications are systems that can adapt their operations or behaviors to the current contexts with or without the explicit intention of the user intervention [9]. As we will see in the next sections, we have paid attention to user profile and preferences, and environmental context to respect the sustainable tourism principles.

The goal of this paper is to introduce CATReS, a Context-Aware Tourist Recommender System for the indoor and outdoor museum tour. CATReS, by taking in input both *tourists contextual information* (their user profile and preferences, current location, time availability) as well as *cultural POIs contextual information* (waiting time to access the museum, presence of artwork, museum location), generates a tourist plan at both macro-level (recommending which museums, among many, to visit in relation to the tourist time availability and preference, as well as waiting time to access it) and micro-level (recommending which specific artwork to visit in a museum).

Differently from other approaches, CATReS, when generating a touristic plan, takes into explicit account cultural POIs contextual information (together with tourists contextual information), and generates a recommendation of feasible museums to visit, as well as the indoor visit plan.

The remainder of this paper is organized as follows: in Section 2 we briefly discuss the state of the art in tourist recommendation systems. Section 3 provides our initial work towards the realization of the CATReS system. Section 4 reports on an application scenario. Finally, conclusions are provided in Section 5.

2 THE STATE OF THE ART

In the literature different touristic context-aware recommender system was proposed. Most of them use Orienteering models [7] to find paths to be suggested to tourists.

In [4], Authors discuss eCOMPASS, a context-aware mobile application that uses Time Dependent Team Orienteering Problem with Time Windows to derive personalized daily tourist itineraries in the urban area of Berlin (Germany), which comprises 113 attractions (POIs) and 100 hotels by considering also public transportation system.

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In [1], Authors proposed a POI-oriented travel route recommendation system based on IoT technology and smartphones. They adopted Bluetooth low energy beacons to sense onsite travel behaviors that imply personal tourist preference. The App constantly monitors the phone camera and acceleration sensor to record several onsite travel behaviors of tourists during a touring course. They request a querying tourist to input a simple user profile and personal constraints. Finally, they use a route ranking to retrieve and rank the candidate travel route for the querying tourist.

In [5], Scenic Athens is introduced. This is a context-aware mobile city guide that provides personalized tour planning services to tourists visiting Athene (Greece) using Mixed Team Orienteering Problem with Time Windows solved by an Iterated Local Search metaheuristic. Differently from [4], in this works authors incorporate also scenic (walking) routes. Scenic Athens offers a variety of visual means to display the recommended tours and also provides directions to move from a POI to the next scheduled attraction.

CityTripPlanner [11] is a web/mobile city tour planner that covers 76 destinations across all continents. The user is allowed to edit derived tours, remove unwanted POIs and/or adjust visiting time scheduled for particular POIs. The start/end locations may be selected.

To match the characteristics of tourism and leisure resources or attractions with the user needs, TRS uses different recommendation techniques. In [8] authors classified these techniques in two categories: classical, related to collaborative filtering and content– based filtering approach, and nonclassical focusing on personalized, context-aware and ontology-based approach. They underline how classical approaches do not satisfy TRS needs. For example, collaborative filtering (CF) methods alone do not satisfy the tourist needs because it is nearly impossible to find two people experiencing the same trip, travel duration, the same transportation mode and so on. On the other hand, using content-based (CB) methods the system will suggest to tourists the same kind of monuments, while he maybe will be more interested in items he did not discover during the last trip.

3 THE CATRES APPROACH

CATReS is a Context-Aware Tourist Recommender System for indoor and outdoor museums' tour planning. It consists of three main components: i) the context model, ii) the outdoor recommender system, and the iii) indoor recommender system.

The *context model* supports the definition and specification of contextual information. The context model takes into explicit account both visitor's/tourist's contextual information, as well as cultural POIs contextual information.

The *outdoor recommender system*, by taking in input the context model, recommends the cultural POIs that match the visitors' profile and time constraints.

The *indoor recommender system* suggests the artworks to visit (in the selected museums) to (again) match the visitors' preferences and time constraints.

Figure 1 graphically summarizes the expected output:

given a set of museums with contextual information, and a visitor with her user preferences (the context model), CATReS returns a list of museums to visit (the outdoor recommendation), as well as the artwork to visit (the indoor recommendation), so to satisfy the imposed constraints (time for the visit, entry time to museums, etc.).

The focus of this paper is on the first two components, that are currently under deployment.

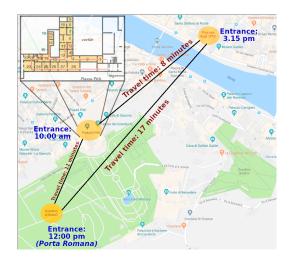


Figure 1: Resulting path

3.1 Context

In our domain, we take into account two types of contextual information: *tourists' profiles* and *cultural POIs* contextual data. The tourist context refers to all the data associated to the user profile. The cultural POIs context concerns all those parameters that cannot be directly deducted by the user and are more directly associated to the POIs environment.

We considered as dimensions: tourist location, visitor (as a single or group, focusing on age, ethnicity, and number of children), time (referred to the time availability and time-slots available for the entrance to the selected POI), POIs (other point of interests to suggests) and weather (in terms of temperature and rain). Figure 2 shows the Context Dimensions Tree structure [2] used to represent the possible contextual information in our scenario.

More precisely we focused on:

- Tourist profile: it is related to its age, gender, education degree, and nationality. The most used approach to collect those data involves the direct intervention of the tourist who fills out the forms during registration.
- Tourist preferences: those are related to the type of artwork he/she likes, art style, and the historical period he/she prefers. The most used approaches, in this case, refer to the presentation of images related to similar items to which the tourist must give a vote. From the analysis of the rating retrieved, and using the approaches mentioned in the previous section such as collaborative filtering and content-based filtering, the TRS calculates the objects that match their preferences.
- Temporal: we have three kinds of temporal context: the first is related to the total time tourists want to spend in the museum, the second regards the amount of time that historical

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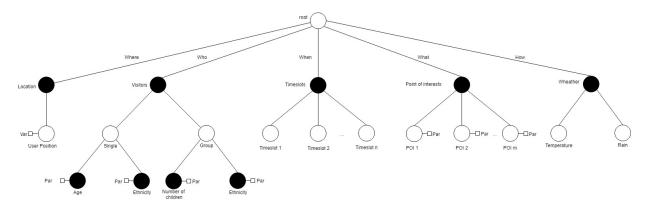


Figure 2: Context Dimension Tree

users (with similar profiles) spent watching the artworks, and the last concerns the waiting time estimated to enter into each museum.

 Weather conditions: we consider this information to suggest indoor/outdoor sites according to weather conditions (e.g., avoiding recommending to visit a garden in case of adverse weather conditions).

3.2 Outdoor tour recommendation

The outdoor tour recommendation can be formulated as a Tourist Trip Design Problem (TTDP) [6]. The optimization model most frequently used in this area is the Orienteering Problem (OP). Given an oriented graph with weights on nodes (profits) and arcs (costs), the OP seeks for a tour that maximizes the total collected profit while maintaining the travel cost under a given value. OP may be used to model the simplest version of the TTDP. Instead we used the Team Orienteering Problem with Time Windows (TOPTW) that calls for finding different paths that maximize the collective score given a predefined time budget with known crossing times between the POIs and precise time-slots of a visit on each POI. Thus, we modeled our problem by a graph in which nodes represent the POIs and there is an edge for each pair of nodes. Any node (POI) has associated: a score, the opening and closing time of the POI (expressed also in terms of time-slots) and the mean visit duration. Weights on the edges represent the travel time. The TOPTW formulation showed in [12] was then modified to consider the average visit time of the POI by changing the two constraints (26) and (28) in formulation 5.1 as follows:

$$s_{ip} + t_i + t_{ij} - s_{jp} \le M(1 - x_{ijp})$$

$$\forall i, i = 1, \dots, N; \quad \forall p = 1, \dots, P$$

$$\sum_{i=1}^{N-1} (t_i y_{ip} + \sum_{j=2}^{N} t_{ij} x_{ijp}) \le T_{Max}; \qquad \forall p = 1, \dots, F$$

N

Finally, we added new constraints to model the user's manual selection of POIs, to exclude from the outdoor paths sites in case of rainy days, and to exclude to visit a POI several times when more time-slots are available.

4 CASE STUDY

The CATReS outdoor recommendations approach is currently under deployment at the Uffizi Galleries (Italy), a museum complex in Florence comprising the Uffizi Gallery, the Pitti Palace, and the Boboli Gardens.

Those three sites are under the same administrative management and can be easily reached on foot. The Uffizi Gallery is the main museum, attracting several thousands of visitors per day. The Pitti Palace includes four museums: the Treasury of the Grand Dukes, the Palatine Gallery with the Imperial and Royal Apartments, the Modern Art Gallery, and the Museum of Costume and Fashion. Directly behind Pitti Palace are the marvelous Boboli Gardens.

The ongoing deployment process started in August 2019, uses the CATReS outdoor tour recommendation with a restricted set of contextual information including the timeslots, POIs, and Weather data (the three most right contextual information in Figure 2). By knowing the available entry time to access Uffizi and Pitti, the distance between those sites, the total time available for the visits, as well as the minimum reasonable visit time. In the optimization model, we considered the following parameters associated to the three sites: a museum score calculated as the average of user ratings on Google and Trip Advisor, the estimated time for visiting each site, and the time windows (timeslot in which the site can be visited).

Figure 1 shows an example of a resulting path. We assumed that the tourist buys the ticket at the Uffizi Gallery and that the first entry timeslot available is at 3:15 pm. The resulting path calculated by the optimization model implemented, considering the number of available tickets for the other museums is showed in figure.

5 CONCLUSIONS

In this paper we presented CATReS, a Context-Aware Tourist Recommender System that based on context, tourist preferences, and profiles, suggests indoor and outdoor tours. So far, we implemented a part of our model, that is being experimented in the Uffizi Galleries. We implemented a Team Orienteering Problem with a Time Windows optimization model that takes into account environmental context referred to weather conditions and site congestion. Future work will consider tourist preferences and profiles. KaRS 2019 Second Workshop on Knowledge-Aware and Conversational Recommender Systems, November 3rd-7th, 2019, Beinergta Kianauano, Henry Muccini, and Fabrizio Rossi

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REFERENCES

- C. Bin, T. Gu, Y. Sun, L. Chang, and L. Sun. A travel route recommendation system based on smart phones and iot environment. Wireless Communications and Mobile Computing, 2019.
- [2] C. Bolchini, C. A. Curino, E. Quintarelli, F. A. Schreiber, and L. Tanca. Context information for knowledge reshaping. *Int. J. Web Eng. Technol.*, 5(1):88–103, May 2009.
- [3] C. Emmanouilidis, R. Koutsiamanis, and A. Tasidou. Mobile guides: Taxonomy of architectures, context awareness, technologies and applications. J. Network and Computer Applications, 36(1):103–125, 2013.
- [4] D. Gavalas, V. Kasapakis, C. Konstantopoulos, G. Pantziou, N. Vathis, and C. Zaroliagis. A personalized multimodal tourist tour planner. In *Proceedings of the 13th International Conference on Mobile and Ubiquitous Multimedia*, MUM '14, pages 73–80, 2014.
- [5] D. Gavalas, V. Kasapakis, C. Konstantopoulos, G. E. Pantziou, and N. Vathis. Scenic route planning for tourists. *Personal and Ubiquitous Computing*, 21(1):137–155, 2017.
- [6] D. Gavalas, C. Konstantopoulos, K. Mastakas, and G. Pantziou. A survey on algorithmic approaches for solving tourist trip design problems. *Journal of Heuristics*, 20(3), June 2014.
- [7] A. Gunawan, H. C. Lau, and P. Vansteenwegen. Orienteering problem: A survey of recent variants, solution approaches and applications. *European Journal of Operational Research*, 2016.
- [8] L. Kzaz, D. Dakhchoune, and D. Dahab. Tourism recommender systems: An overview of recommendation approaches. *International Journal of Computer Applications*, 180(20):9–13, Feb 2018.
- [9] R. P. Punnarumol Temdee. Context-Aware Communication and Computing: Applications for Smart Environmente. Springer International Publishing, 2018.
- [10] I. B. Sassi, S. Mellouli, and S. B. Yahia. Context-aware recommender systems in mobile environment: On the road of future research. *Inf. Syst.*, 72:27–61, 2017.
- [11] P. Vansteenwegen, W. Souffriau, G. V. Berghe, and D. V. Oudheusden. The city trip planner: An expert system for tourists. *Expert Syst. Appl.*, 38(6):6540–6546, 2011.
- [12] P. Vansteenwegen, W. Souffriau, and D. V. Oudheusden. The orienteering problem: A survey. *European Journal of Operational Research*, 2011.