Automated Leisure Walk Route Generation for an Interactive Travel Planner

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ABSTRACT

This paper presents a study of the state-of-the-art approaches for traveler assisting systems with particular attention paid to the problem of travel itinerary automated construction. We describe an algorithm for creating a route for a leisure walk to be included to the OpenStreeMaps based interactive travel planner. We discuss the current implementation and analyze further requirements from the viewpoint of better personalization of a tourist recommendation system.

Categories and Subject Descriptors

H.4 [**Information Systems Applications**]: Miscellaneous; H.5.2 [**Information Interfaces and Presentation**]: User Interfaces—*human centered design*

General Terms

Automation, Human Factors

Keywords

Human-centric computing, Information systems, Travel, Route generation

1. INTRODUCTION

Path finding is a common problem in many areas of information processing. It occurs while solving problems of getting directions, mapping a route for a leisure walk, finding an optimal topology of a digital circuit, tracing a software run and many others. The focus of this short paper is an application of route generation algorithms to the purposes of planning a traveler itinerary, probably the most obvious route construction related problem.

With current level of computer-assisted tools and methods, tourists expect more facilities than simply finding a shortest (or quickest) path or getting a direction. They require taking into account many competitive factors of route construction, some of them (like sight attractiveness) aren't easily formalizable. The problems related to developing better personalized services for travelers are within the scope of the emerging domain of urban computing [13].

Tourists visiting some area for a certain period are unlikely able to visit every attraction. Effectively, they solve a kind of fuzzy optimization problem in order to select something more interesting to them personally. Tourists select the points of interest (POI) depending on their value from a certain point of view [11]. Hence, one of possible application of traveler advisory systems is to navigate the selection process by implementing the criteria representing a tourist attraction value by some formal schema.

In this work we describe an implementation of the algorithm supporting a travel itinerary generation which can be used as a component of an automated traveler recommendation and guide construction system.

2. PERSONALIZED SERVICES FOR TRAVELERS: STATE OF THE ART

Nowadays information services that can be used to support traveler needs include route and time planning, access to real-time information (alarms, traffic information, weather alerts, etc.), payment services, journey tracking via mobile and geo-navigation tools, access to relevant online resources, and transportation planning.

Today travelers require more than simply a nicely looking algorithm based on traditional salesman problem that isn't enough to leverage existing travel experience and to arrange planning with respect to requirements of delivering personalized cultural and historical information. Many research efforts are about developing some formalization of the traveler's degree of satisfaction. For example, in [4] the authors took steps toward better personalization while introducing a formal model for travel itinerary recommendation based on collaborative filtering and recommendations of other travelers with similar travel interests.

In [3] the authors proposed a near optimal daily route itinerary generation as an advanced version of known team orienteering problem. In contrast to this work, in our approach we try to work with an open list of POIs in order to detect the next POI to visit iteratively with having in mind the possibility to response to changes in traveler plans, environment conditioned changes nearly in real time.

The authors of [5] discuss a formal model with respect to such attributes as time, cost, distance and route infrastructure (including relief, signs, administrative restrictions,

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etc.). They represent the task as a multi-criteria decision making problem reducing the subjective influence in process of route planning. We dare to say that in our work we attempt to do the inverse: to increase the subjective influence while proposing an itinerary for both a traveler and a professional (or an amateur) travel guide.

The author of [6] lays emphasis on mentioning the difference between the tasks appearing in different traveling phases (before-visit, during-the-visit and after-visit) which could be periodically repeated. The above mentioned paper follows a conceptual technology-related discourse of Brown and Chalmers [1] where the authors argued over the importance of support for sharing visit experience with other travelers as well as the importance of post-visit retrospectives: *"Post-visiting is thus a powerful way of expanding the enjoyment of a tourist visit out beyond the visit itself"*.

We also have to mention two recent projects related to the scope of this research: *TAIS*, the mobile application for guiding tourist activity described in [7] and focused on step-by-step itinerary construction in response to user actions and movements with an interesting feature of collecting user impressions about visited POIs, and *Aurigo*, an interactive tour planner for personalized itineraries [12]. To a great extent, the latter is in the same direction as the project of ours. The authors described the idea of finding a balance between automated and purely manual approaches, together with the implementation of a tour planning system combining an algorithm for generating recommended itineraries with interactive visualized interface for better itinerary personalization. The authors pointed out three important aspects:

1. Algorithmic solutions for personalized itinerary generation often use approximation and heuristics.
2. While developing such algorithms and related tools, we have to learn from human behavior and experience.
3. The focus of such solutions is on creating technology which doesn't support only kind of time/cost/etc. optimization task but allows travelers to develop their own *memorable experience* (the latter term being borrowed from [10]).

3. AUTOMATIC TOURIST ROUTE GENERATION

Let us consider the problem of constructing a tourist route for a leisure walk within the limited period of time and/or tourist area region. The common steps required in order to construct a tourist route are the following (the simplified scenario):

1. Define a time slot, select the departure and destinations points. Define other constrains if required.
2. Explore potential locally accessible POIs for the current point on the route (initially the current point is departure poit).
3. Evaluate POIs by using some formalized model for taking into account the degree of POI popularity, interestingness, price to visit, location, etc.
4. Rank the POI and add the best ranked POIs to the part of the route in progress.

Steps 2–4 are repeated until the destination point is reached.

However, there are many issues to be resolved before the general schema would work. First, we have to think about time limitation for the whole walk and about more or less equal distribution of POIs along the route[1].

3.1 The Model

The standard task of tourist route generation is formalized by Souffriau [8] as follows:

Assume there are N POIs.

For every POI: $x_{ij} = 1$, if a path between the POIs marked as i and j exists, otherwise $x_{ij} = 0$.

Each POI i has a score $S_i \geqslant 0$, where for a departure point $i = 1$, for the destination point $i = N$.

The shortest path points i to j requires time t_{ij}, the total score S_{total} has to be maximized under constrain of time limit T_{max}.

This model set boundary of the future route and determinate criteria for the best tourist route that is the best suit of the tourist objects and the best path between this objects.

3.2 Exploring Locally Accessible POIs

Due to the fact that the POI score depends on its place along the route, each potentially accessible POI's score has to be recalculated at each iteration. In order to explore POIs locally we use the geometric model shown in Figure 1.

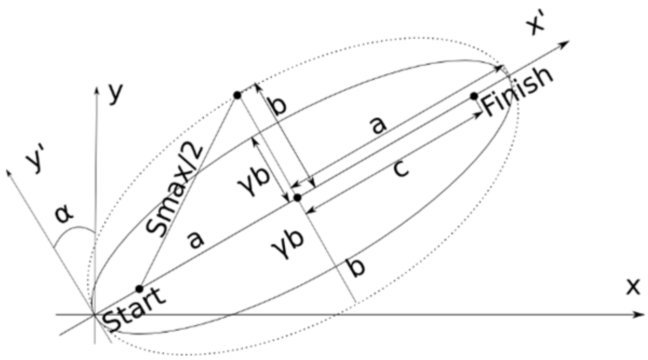

Figure 1: Exploring local area

This geometric model (Figure 1) has the following parameters: *Start*, *Finish* – the arrival and departure point within the route area, a – the semi-major axis of the search area, b – the semi-minor axis of the search area, c – half of the focal distance of the search area, $S_{max}/2$ – half of the maximum distance that can be covered for the remaining time, α – the search area angle of rotation, γ – the minimization coefficient of semi-minor axis.

Unlike to the model used in the earlier mentioned *Arigo* project, where the authors introduces a *Pop Radius* for exploring the POIs in the *circled* local area [12], we use an elliptic model for the local POI exploration area. The elliptic form of the local region, where the potential POIs to visit are explored, allows us to use ellipse particularity: the sum of the distances to the two focal points is constant for every point on the curve. It means that if this sum is equals to the distance to the most distant point a person can theoretically

[1]The serious problem which is out of scope of this paper is that there could be different criteria of such an equal distribution.

reach within the given time and speed limits, each point outside the ellipse couldn't be reached. So, corresponding POIs must be excluded from the short list for further analysis. POIs located close to the border of the ellipse may also be exclude from the search, otherwise it could happen that the resulting route is too sparse: most time will be spent not to see the sights but to walk in between.

3.3 Adding POIs to the Search Scope

In current implementation, we used an extension of a gradient descent algorithm for searching POIs to be included to the route. The extension is as follows: searching a new POI to be included occurs in the area with a maximum distance between two objects in the buffer route. This modification makes possible to reduce the maximum distance between the tourist objects and to exclude from the consideration unreachable objects and therefore to improve performance. Then the selected objects are evaluated in order to find the object with the maximum score.

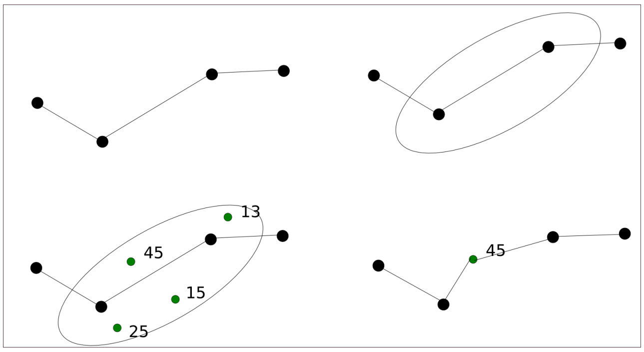

Figure 2: Iteration of adding the POI to the route

We also consider the greedy randomized adaptive search algorithm GRASP [9] as a good candidate to substitute the gradient descent stub in future implementation. One of the reasons is that GRASP uses randomized greedy heuristics in multistart-procedure and as a result generates different solutions even in equal conditions, and we believe it is rather interesting feature for a traveler route generation.

After adding a new POI to the route, we need calculate the path time.

If the path time is greater than the maximum limit, then the last added POI must be removed from the route, the process of finding POIs stops, otherwise we start new iteration.

The total time score is the sum of traveling time spent between POIs with addition of the time spent at each POI.

The last step is to minimize the traveling time between the POIs selected according to the above described procedure, and that means to solve the common task of finding a Hamiltonian path in a weighted undirected graph.

3.4 POI Evaluation

One of the most challenging problems is how to evaluate POIs and to obtain scores used in the route generation algorithm in order to have positive effect on creating interesting and personalized travel routes. Different characteristics of travel sights may compete with each other [2], they may depend on the personal preferences, and also (sometimes) on the other objects.

One of the possible approach for POI attractiveness evaluation is using photos associated with tourist objects and posted and updated by users in in different social networks. If we analyze photos carefully, we can select the most interesting tourist objects and analyze variations of their popularity in "real time". We are also able to extract other helpful information such as visit time, geo-coordinates, weather conditions, etc. [2].

After selecting photo series, we should create some area around every POI and analyze, how many photos are taken in the area, what is the period when most photos are taken, in order to select a period of minimum and maximum tourist activity.

In order to compute the score for each POI we use some type of linear convolution: each tourist object characteristic is measured at one-hundred units scale, from worst (0) to best (100). Here is the equation used to compute the score for some i-th POI:

$$\begin{cases} M_{totali} = \sum_{j=1}^{N_{metric}} k_j m_{ij} \\ m_{ij} = \frac{s_{ij}}{max(s_{ij})} * 100; i = 1..N \\ \sum_{j=1}^{N_{metric}} k_j = 1 \\ 0 \leqslant m_{ij} \leqslant 100; i = 1..N; j = 1..N_{metric} \end{cases} \quad (1)$$

where M_{totali} being the final score for i-th POI, m_{ij} being the normalized score for j-th characteristic of the i-th POI, k_j being the weight of j-th characteristic, s_{ij} being the score of the j-th characteristic, N_{metric} being the number of characteristics used.

3.5 Software Prototype

Figure 3 illustrates the architecture of the software prototype developed in order to arrange experiments on generating tourist routes with further integration with the interactive travel planner system.

Figure 4 shows the application interface using OpenStreetMap[3] API in order to visualize the route on the map.

4. CONCLUSIONS AND FUTURE WORK

To improve the quality of generated tourist routes, we have to extend the list of criteria used to select and evaluate tourist POIs, supporting such factors as price, time windows, importance of tourist object in culture, seasoning, etc.

The latter observation leads us to think of generating a set of itinerary trees (instead of a set of itineraries) as proposed in [3].

We also have to pay attention to the whole multi-day journey planning where we have to take into account the whole set of itineraries in order to avoid undesired intersections or repeated routes, as well as to support wider range of possible constrains (including budget, weather conditions, sanitary concerns, respect to the age and disabilities, etc.)

With regard to the content related improvements, we believe that automatic tourist route generation algorithms have to be extended in order to support an extremely useful feature like constructing the thematically linked journeys.

[2]For example, think of the popularity of a certain sight. "Popular" often means "interesting to see". However at the same time it might mean that many other visitor come and we spent much time to wait for an entrance ticket.

[3]http://www.openstreetmap.org

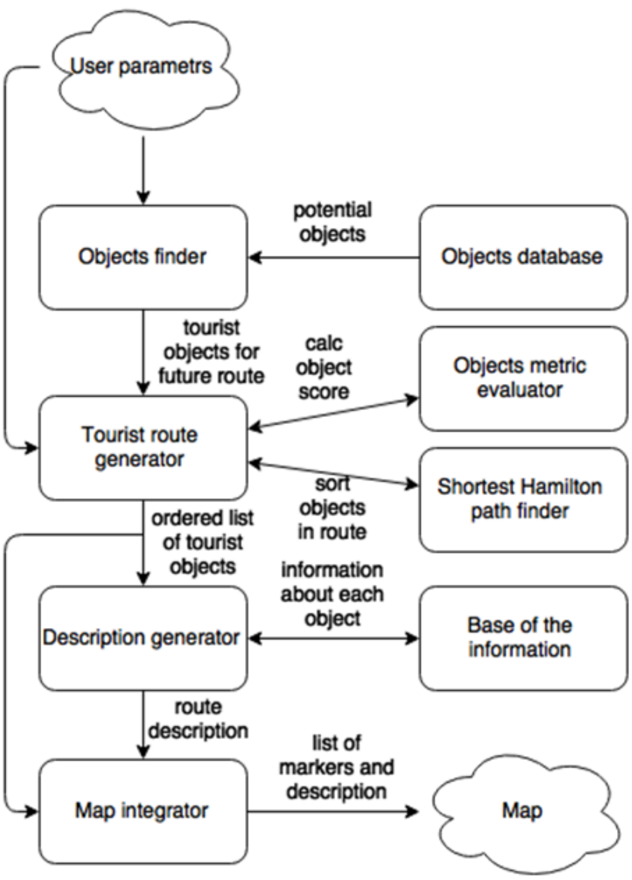

Figure 3: Architecture of the prototype.

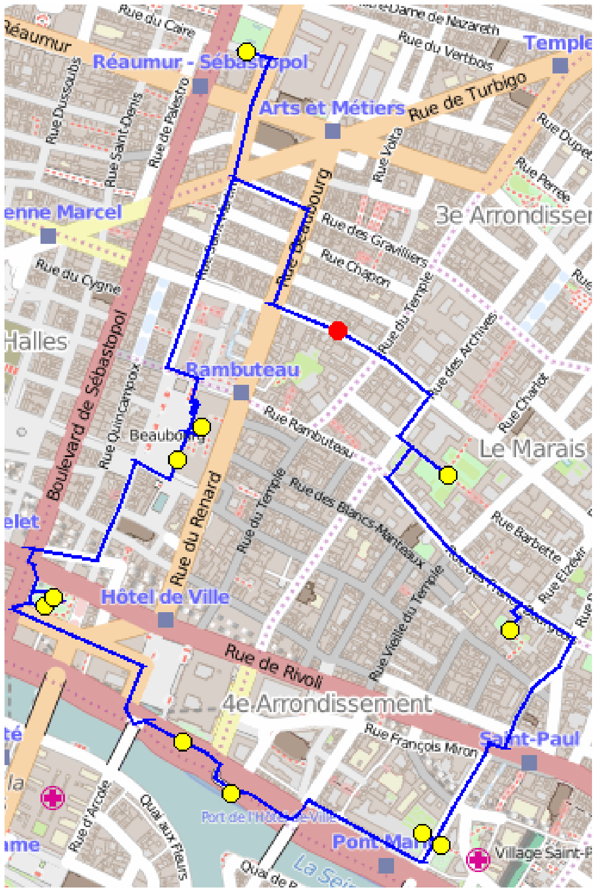

Figure 4: Example of auto-generated tourist route.

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