The On-Demand Tourist Paths Problem

Teodor Gabriel Crainic[†] Nicoletta Ricciardi* Giovanni Storchi*

[†] Université du Québec à Montréal and
Centre de Recherche sur les Transports, Université de Montréal
C.P. 6128, Succursale Centre-Ville
Montreal H3C 3J7, Canada
theo@crt.umontreal.ca

* Dipartimento di Statistica, Probabilità e Statistiche Applicate
Università di Roma "La Sapienza"
Piazzale Aldo Moro 5, 00185 Roma, Italy
{nicoletta.ricciardi, giovanni.storchi}@uniroma1.it

1 Introduction

The aim of this presentation is to introduce the *On-Demand Tourist Paths Problem (DTPP).* The aim of DTPP is to identify visit itineraries according to particular requests made by a tourist in a historic-artistic town.

Museums, churches and other places of interest must be considered, as well as particular streets and places that are places of attraction in their own right due to their cultural, historical or shopping interest. Parameters such as the importance and/or interest, popularity, type of place, average visiting time and so on of each place of interest must be considered in order to define its score of "desirability". More than one type of score must in fact be defined with respect to the interest, for example, to visit (rapidly, normal, or in depth) or only to pass in front and look. Several types of requests may be made based on these scores (e.g., maximize the number of monuments passed by or the interest of a normal visit within a given time), but they may be classified into two categories: *Sequential-activity paths*, where each of the main activities specified by the user have to be performed in the order given by the user (e.g., museum visiting, lunch, shopping) and *mixed-activity paths*, where there is no particular order on activities.

The city representation has to be processed to yield a graph that helps finding such paths rapidly. In the current approach, on each of the links of the resulting network, only one instance of each type of monument or activity is explicitly represented. Thus, for example, if three museums are located on the same street, this street will be represented as a sequence of three links, the two added nodes separating the museums. The resulting network is then composed of a set of nodes that includes street junctions and separating nodes, and a set of directed links. A set of attributes is associated to each link. Attributes are of two types: *descriptive*, such as length, walking travel time, global interest, main type of activity and so on; and *touristic*, such as type of attraction, the epoch of construction or architectural type, visit time for various types of visitors, etc. The user specifies one or several requests in terms of total time available, starting and finish location, and the desired type of itinerary. The goal of the system is to propose for each request a set of paths that answer the request by different path composition. The goal of DTPP is to find, simultaneously, the best path for each of the specified categories within the set of user-specified temporal constraints and preferences.

2 Scenario description

The scenario is composed of two groups of data. The first group describes the physical structure of the city, that is the network of the streets through which it will be possible to characterize different avenues, distances, public squares with their physical characteristics. The second group includes for all the sites considered a synthetic description of the characteristics.
Every arc of the graph is identified by its extreme nodes and is described by its physical characteristics. The arcs of the graph are then subdivided, if necessary, to insert the nodes representative of the places that may be visited. Thus, for instance, if on a street there are a church and a museum, then the arc is decomposed by inserting two new nodes. In an analogous way, if there are more than one point of interest at a given location (e.g., a plaza), a node can be split to allow independent visits. Museums, churches, archaeological sites, panoramic points, commercial streets or typical restaurants, are identified as places of tourist interest.

To every site is associated a set of qualitative and quantitative parameters, such as the relevance, time of visit for different types of tourists, the type of the site. Moreover, the main cultural or architectural characteristic must be identified, for example, if a church is baroque or gothic, or if a museum is modern or classic art. More refined classifications may be introduced, of course. The site capacity, the opening hours, the cost, and the normal congestion at various time periods of the day and year are other important characteristics. A scale is used for each parameter to determine the relative relevance of the site. Every site (node of the graph) therefore is characterized through the following parameters:

a) Type: church, museum, site archaeological, scenic view, ...
b) Class: classic, modern and ancient art, gothic, renaissance, …
c) Interest degree: average of the values (stars) present in the most common tourist guides.
d) Estimation of average visit time (by type of visit).
e) Opening hours.
f) Cost, etc..

Every link (arc of the graph) is characterized by:

a) Length
b) Walking and driving times
c) Type: pedestrian, one-way street, street in limited access zone, etc.
d) Characteristics: shopping, visit, connecting street, …
e) Relevance: degree of interest relatively to the characteristics.

A weighted combination of the site parameters determines a score of "attractiveness" or "desirability" that yields the parameter used to identify the optimal paths.

3 Problem definition

The On-Demand Tourist Paths Problem may be considered as a variant of the Traveling Salesman Problem, where one is not obliged to visit all the nodes of the graph. Rather, one collects rewards at the nodes and on the links visited. The objective is to select the nodes visited and to build a tour to maximize the total reward, while respecting the time available and a number of tour feasibility constraints. More than one selection/tour building must be performed at the same time.

The DTPP is addressed on a network $G=(N,A)$ composed of a set of nodes N of places of interest plus street junctions and separating nodes, and a set of directed links $a \in A$.

Attributes are associated to each node and link. Attributes are of two types: *Descriptive* (length, travel time by foot, global interest, main type of activity and so on) and *Touristic*. The latter are organized in a table indicating for each type of activity (e.g., museums, monuments, archeological places, etc.) the time to visit, the interest to visit, and the interest to "look at" (that is, to pass by and admire from the outside).

Two different types of paths may be requested:

- *Sequential-activity paths*, where each of the main activities specified by the user has to be performed separately and in the order specified by the user (e.g., museum visiting, lunch,

shopping). Approximate time durations for each activity are given.
- *Mixed-activity paths*, where there is no particular order on activities. A more complex problem considers constraints on the total time for some (all) activities or, alternatively, on their relative proportions.

For each type of path and site of interest, it is possible to do a complete visit or only to give a casual glance while passing by. The appropriate interest measure corresponding to each activity must therefore be used in the computation of the score of the site and path. The score of a path is determined as the sum of the scores obtained from the visit of the tourist places along the path. The scores of the sites and streets, may then be used to compute a set of paths to maximize:

- Total score of the preferences
- Total score of monuments visited
- Number of monuments visited
- Number of hits (monuments seen and visited, streets passed on)
- Total score of the hits
- Total score of hits forgetting the preferences

The goal is to find for each user request the best paths in each of these categories according to the user preferences.

4 Proposed resolution approach

We want to emphasize that the graph may become extremely large. First, there is the issue of the many types of tourist demands. Consider a tourist with some time on his or hers hands and a limited knowledge of the city. There are many types of tourists and many possible ways they envision how best to use the time. Some may be interested in particular artistic, technical, or social aspects, or in religious places or in selective shopping. They can make requests with various degrees of precision regarding the knowledge of the city and their own interest. In fact, there are many types of tourists, from those who only watch or photograph monuments and carry on to visitors who immerse themselves into every particular aspect of the visited city.

To reduce the graph considered when computing the paths, we use the starting point, ending point, and the time limit specified in the request to determine the area delimited by the longest elementary paths respecting the input data. All paths outside the area specified by these “extreme” paths are not feasible and we may thus reduce the graph dimension considerably.
We utilize this structure to build the paths in two phases: a construction phase and an optimization

phase. In the first phase, we build a set of paths that respect all the time constraints and other tourist requirements. These paths are improved in the optimization phase.

To determine a set of alternative paths, we use a labeling technique called A*. We selected the A* algorithm because it is one of the best and fastest methods to determine the shortest path between two nodes.

Extensive computational results on the network representing the central part of Rome will be presented and used to discus the performance of the algorithm. We will also plan to discus alternate graph representations and algorithmic structures.

References

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