Antourage: Mining Distance-Constrained Trips from Flickr

Saral Jain
Max-Planck-Institute Informatics
Saarbrücken, Germany
sjain@mpi-inf.mpg.de

Stephan Seufert*
Max-Planck-Institute Informatics
Saarbrücken, Germany
sseufert@mpi-inf.mpg.de

Srikanta Bedathur
Max-Planck-Institute Informatics
Saarbrücken, Germany
bedathur@mpi-inf.mpg.de

ABSTRACT

We study how to automatically extract tourist trips from large volumes of geo-tagged photographs. Working with more than 8 million of these photographs that are publicly available via photo-sharing communities such as Flickr and Panoramio, our goal is to satisfy the needs of a tourist who specifies a starting location (typically a hotel) together with a *bounded travel distance* and demands a tour that visits the popular sites along the way. Our system, named ANTOURAGE, solves this intractable problem using a novel adaptation of the *max-min ant system (MMAS)* meta-heuristic. Experiments using GPS metadata crawled from Flickr show that ANTOURAGE can generate high-quality tours.

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Keywords: Flickr, Geolocation, Graph Mining, Photo Collections, Trip Planning

1. INTRODUCTION

Photo-sharing sites such as Flickr and Panaramio are a great resource for photography enthusiasts and increasingly for travelers. Geo-tagged photographs available on these collections provide a quick overview of the interesting places at travel destinations [4]. The volume of such geo-tagged items has seen an explosive growth thanks to the introduction of GPS-enabled digital cameras during the summer of 2008. For instance, at the time of writing, well more than 90 million photos publicly available on Flickr are geo-tagged.

While an overview overlaid on a map is useful, planning a trip that visits interesting locations is still quite cumbersome. Some popular cities/regions are covered by online trip designing services (e. g. `http://www.homeandabroad.com/`), ignoring many less popular ones or those which have gained popularity only recently. In contrast, photographs shared on Flickr exhibit larger geographical coverage, and typically reflect the tourist trips of users sharing these images. Thus, it is intriguing to consider the possibility of utilizing the proverbial "wisdom of crowds" embedded in Flickr-like sources to mine sightseeing trips automatically.

We present a novel system, called ANTOURAGE[1], aimed towards achieving this goal. This system is designed to help a casual tourist, typically constrained by the time and distance spent on the trip, in quickly identifying the route. The only inputs that ANTOURAGE requires from the user are (i) the starting location (e. g. a hotel or a public-transit station), and (ii) an upper bound on the distance covered by the trip. The output of the system is a tour (a closed path) that covers popular nearby locations and does not exceed the specified distance constraint. Previous efforts along this line [5, 6] only manage to identify visit-durations and points of interest.

In the next section, we describe the data we operate on, and the algorithmic foundations of ANTOURAGE. Afterwards, we present some anecdotal example tours extracted for London and Rome to demonstrate the utility of the proposed system. Finally, we conclude with directions for future work that we plan on.

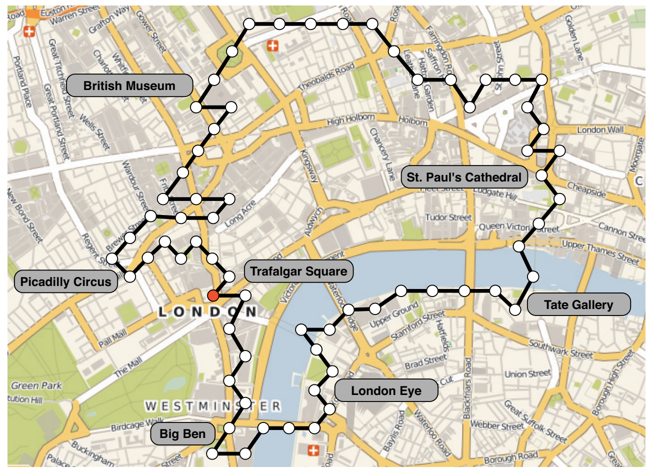

Figure 1: An example tour found by Antourage for London

2. MINING TOURIST TRIPS

Given the starting location for a trip, ANTOURAGE first extracts the photos taken in the surroundings from a large-scale Flickr-crawl [2], and transforms them into a vertex-weighted graph with fixed inter-node distance. On this graph, we compute tours that start from the specified location and visit popular places subject to given distance constraints. Finally, these tours are visualized using OpenStreetmap (`http://www.openstreetmap.org`).

2.1 Graph Construction

We use more than 8 million geo-tagged items available from a crawl of the popular photo sharing community site Flickr (obtained via [2]). For the purpose of simplicity, we use a hexagonal grid overlay over the map of the city of interest, and associate with each hexagon a weight derived from the photo collection – we use the number of pictures taken within the area of the cell. An example grid overlay derived for a region of the city of New York is shown in Figure 2. From this, we create an equivalent *vertex-weighted* grid graph where each vertex maps to a hexagonal cell in the overlay,

*corresponding author

[1]The name ANTOURAGE is derived from its choice of using a retinue of ants to help the user in navigating the surroundings.

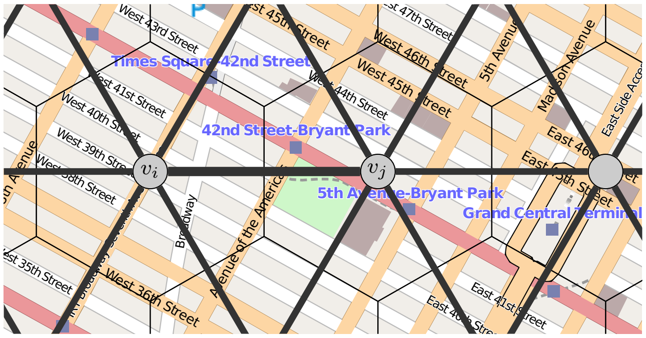

Figure 2: Hexagonal Grid overlay.

and two vertices v_i, v_j are joined by an edge (displayed in black in the figure) if they correspond to adjoining hexagons.

2.2 Distance-Constrained Tour Construction

Let $G = (V, E)$ be a grid graph derived as described above. Let $p : V \rightarrow \mathbb{Z}^+$ be a function that assigns to each vertex in the graph a value. Let $d : E \rightarrow \mathbb{R}^+$ be a function on the edges that assigns a (metric) distance to each edge $e_{ij} \in E$. As input, we have a special *starting node*, $S \in V$, and an upper bound on the distance, $D_{\max}$. The goal is to to obtain a *tour*, $\mathcal{T} := \langle S, v_1, v_2, \ldots, v_i, v_{i+1}, \ldots, S \rangle$, that begins at S, and maximizes the total profit collected from visited nodes, while not exceeding the total distance, $D_{\max}$. It has been shown that this problem, which is called as *orienteering problem* or *bank robber's problem*, is NP-hard and also APX-hard (i.e., hard to approximate efficiently) on general graphs [1]. Successful strategies for solving the orienteering problem in practice have mainly relied on meta-heuristics such as genetic algorithms, tabu search, and more recently, ant-colony optimization.

2.3 Solution Based on the Max-Min Ant System

We developed an efficient approach based on the powerful *max-min ant system (MMAS) meta-heuristic* [7] – an improvement over the classic ant-colony optimization (ACO) methods. The detailed description of the algorithm is beyond the scope of this paper, but we briefly outline its workings. In its basic form, ACO is based on the behavior of real ants and possesses features such as the memory of past actions, knowledge exchange amongst ants, etc. Ants perform random-walks in parallel, each starting from S, and choosing the next node to visit probabilistically as,

$$p(v_j|v_i) = \frac{\tau_j^{\alpha} \cdot p_j^{\beta}}{\sum_{v_k \in \mathcal{N}(v_i)} \tau_k^{\alpha} \cdot p_k^{\beta}},$$

where, τ_j is the quantity of pheromone left on the node v_j, p_j is the profit gained by visiting v_j and $\mathcal{N}(v_i)$ is the direct-neighborhood of node v_i. The values α and β are tuning parameters of the algorithm that balance the influence of the profit value and the "memory" of previous random-walks that have visited the target node. Each ant explores the graph, starting from node S, visiting nodes and collecting profits. At each stage we also check wether we can reach S from the current node without violating the distance constraint. Whenever we break the constraint, the ants backtrack and reach S via an optimal *backward path* computed using dynamic programming (which can be carried out efficiently on the grid graph), thus completing the tour. At the end of each round, when all ants have completed their tour construction, pheromone values on the visited nodes are updated so that the nodes in the best tour are biased to be visited in next rounds. We omit the details of the pheromone update models we have used due to lack of space.

Figure 3: Example tour for Rome

3. RESULTS AND FUTURE WORK

This algorithm was implemented in Java, and when run on the hexagonal grid-graph generated at 150 m cell distance for the city of London, tours were generated within 42 seconds on an out-of-the-box laptop with 2.4 GHz Intel Core 2 Duo processor, 4 GB RAM, running Mac OS X 10.6.2. We present two anecdotal results drawn from our experiments: (i) a tour for the city of London, shown in Figure 1, that starts at Trafalgar Square and (ii) a tour for the city of Rome, shown in Figure 3, that starts from Vatican. Both tours are limited to a 10 km overall length (starting points are shown as red dots: ●). In both cases, the tours generated by ANTOURAGE manage to cover most of the important landmarks [4]. Clearly, the distance constraint makes it impossible to cover *all* the major landmarks – for instance, in order to cover Buckingham Palace as well as St. Paul's Cathedral in London (refer Figure 1), the total tour length would be close to 9 km, thus a tour of 10 km may result in missing one of these two landmarks – as shown in the example.

While the results from the current approach are promising, it also opens a number of directions for future work. One of the drawbacks of the current approach is that the resulting tours do not take into account the time spent at any location as well as the reachability based on the road network. We could also allow for customization of tours based on the categorization of the landmarks as well as the social network information available from Flickr.

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