Potential-of-Interest Maps for Mobile Tourist Information Services

Yohei Kurata

Department Tourism Science
Tokyo Metropolitan University, Japan
ykurata@tmu.ac.jp

Abstract

To prevent tourists from being overwhelmed by a flood of tourist information, this paper proposes an alternative approach to tourist information services, namely *potential-of-interest maps*. Potential-of-interest maps visualize the sightseeing potential of each place in a tourist area, which is estimated from data about locations where previous visitors have found something impressive. Such maps provide visual aids for tourists and will save their effort at decision making. In this paper, we first compare five possible approaches for obtaining data about locations where previous visitors have been impressed, among which the use of photo geo-tags is concluded the most promising. We then construct an example of potential-of-interest maps making use of Flickr's photo data. Finally, we develop a prototype of a mobile tourist information tool which features a potential-of-interest map. In our user test, nine of twelve test users show an intention to use this tool again at other destinations.

Keywords: mobile tourist information services, potential-of-interest maps, photo-taking locations, kernel density estimation, user participation

1 Introduction

Tourism is an activity in which people need a large amount of information, as it is performed in unfamiliar environments. For this reason, many engineers and researchers have undertaken the challenge to provide information aids for tourists, making use of rapidly-advancing mobile information technologies (e.g., Zipf & Manaka 2001). In addition, AR and ubiquitous technologies, which bridge the real world and information in a more seamless way, are increasing the capabilities of mobile tourist information services. However, there is also a concern about mobile tourist information services, because they may confuse tourists by provide too much information through a tiny screen. To tackle this problem, computational techniques for selecting and reorganizing information based on user profiles, such as collaborative filtering (Resnick 1994), have been applied to the domain of tourist information services (for instance, Ricci *et al*. 2002). However, such techniques usually require a certain amount of time and effort to obtain the user's profile. In addition, depending on destinations and party members, a tourist's preferences may change from time to time, which makes the problem more difficult (Kurata 2011).

In this paper, we introduce an alternative approach for mobile tourist information services, called *potential-of-interest maps*. Our key idea is to visualize the sightseeing potential (or *potential-of-interest*) of places in a tourist area, based on data about locations where previous visitors have found something impressive. The map that illustrates potential-of-interest is highly useful for tourists, as they can visually identify which places will be worth visiting and on which route they can enjoy such places efficiently, without reading unnecessary text. In this paper, we discuss how we should construct such potential-of-interest maps, as well as how we can employ these maps in mobile tourist information services. The main contribution of this paper is to propose a new layer of a tourist map which promotes the users' *visual thinking* in their tour planning, while many of existing tourist information tools depends on textual information.

The remainder of this paper is organized as follows: Section 2 explains the concept and merits of potential-of-interest maps in detail. Section 3 compares five possible approaches for determining locations where visitors have found something impressive. Section 4 constructs a sample potential-of-interest map, with which we develop a prototype of a tourist information tool in Section 5. Section 6 reports the result of our user test. Finally, Section 7 concludes with a discussion of future work.

2 Potential-of-Interest Maps: A Visual Aid for Tourists

In a potential-of-interest map, each point is painted in deeper colours as more tourists found something impressive at and around the corresponding location in the real world. Potential-of-interest maps can achieve a certain level of tourist guides without textual information. For instance, a deeply-coloured spot probably indicates the presence of popular tourist attractions there. A linearly-stretched coloured area probably corresponds to a major corridor where many tourists come and go. Isolated coloured spots may indicate hidden places-of-interest which attract adventurous tourists. With such implications, tourists can think visually about where they should go and which route they should take, without reading unnecessary text.

The absence of unnecessary text, if it is carefully designed, may stimulate users' inquisitive spirits. People who visit a high-potential location will try to find what is interesting there, if it is not obvious, by awakening their five senses. Interesting findings will not only satisfy them, but also make them perceive a sense of community with previous visitors who have found that place. Such a tourist information service will attract adventurous tourists who consider other services officious and noisy.

It is also nice, especially for novice users, to supplement potential-of-interest maps with certain textual information. For instance, we can develop a digital version of a potential-of-interest map, in which information about each tourist attraction appears when the user clicks the corresponding point on the map. An important feature of such text-enhanced potential-of-interest maps is that the painted pattern of potential-of-interest helps the users to decide which tourist attractions they should consider in their tour planning; in other words, they can visually identify which attractions are not worth reading their information. In this way, potential-of-interest maps can be used as base maps for other tourist information.

3 Calculation and Visualization of Potential-of-Interest

To make a potential-of-interest map for a tourist area, we first need to know *visitor-interested locations* (the locations where previous visitors found something impressive) in this area. Here we consider the following five possible approaches for obtaining visitor-interested locations:

i. Annotation

This is a simple and inexpensive survey-based approach, in which tourists are asked after their sightseeing to point or encircle the locations where they have found something impressive.

ii. On-site manual recording

This is also a survey-based approach, in which tourists are asked to carry a GPS-equipped device and record their locations when they find something impressive. One possible method is to prepare an application for smartphones, which records the geo-coordinates when the user taps its display, analogous to giving applause. Another possible method is to apply existing micro-blogs, such as Twitter, in which the user can post a short message with location data.

iii. Use of photo geo-tags

In addition to GPS-equipped digital cameras, recent smartphones also allow users to record the locations where they take photos. When photos are taken by tourists with these devices, their photo-taking locations can be regarded as visitor-interested locations, because in many cases tourists take photos when they find something impressive there.

iv. Detection from GPS logs

During a walking tour, tourists typically reduce their speed when they find something impressive. Thus, by analyzing the trajectory of tourists recorded by GPS-equipped devices, we can detect visitor-interested locations with some degree of accuracy.

v. Text mining

In this approach, we extract the data of visitor-interested locations from a large amount of texts in travel blogs and reviewing sites. The extraction of such location data from text on web pages can be easily performed when the page shows geo-coordinates or mailing addresses (Kurashima *et al*. 2005).

In the next step, we compare these five approaches from the following viewpoints:

On-site workloads

It is not desirable to impose certain workloads on tourists during their sightseeing, because these workloads distract them and may affect their activities.

Off-site workloads

In *annotation*, the tourists have to recall the locations that have impressed them and then find them on a map. This task is difficult and error-prone, especially for people with low map-reading skills.

Accuracy

Spatial accuracy is a concern with both *annotation* and *text mining*, since these approaches rely on human memory.

Possibility of commission errors

In *detection from GPS logs*, such locations as traffic intersections and toilets may be mis-detected as visitor-interested locations, unless a certain data refinement process using facility location data is applied.

Possibility of omission errors

In *use of photo geo-tags*, visitor-interested locations in photography-prohibited areas are never detected. Similarly, in *detection from GPS logs*, visitor-interested locations where tourists cannot stop, such as scenery spots on a highway without lookouts, cannot be detected. In *text mining*, visitor-interested locations without any reference to their addresses are difficult to detect. Finally, *on-site manual recording* is also risky because the subjects may forget to record their locations, especially when they are devoted to sightseeing.

Technical challenge

At this moment there are no well-established techniques that realize detection of visitor-interested locations from tourists' GPS trajectories or their writings. Thus, *detection from GPS logs* or *text mining* are more technically challenging than others.

Device necessity

Survey-based approaches are costly, especially when we have to ask the subjects to carry certain devices. In addition, the devices' weight may affect their activities. This, however, becomes a less important issue, because many tourists nowadays carry their own smartphones and they can be used for experiments.

Table 1 summarises the above discussion. Which approach we should take depends on which viewpoints we decide to emphasizes. We, however, concluded that *use of photo geo-tags* is the most promising approach, considering its smallest number of problems (note that *device necessity* seems not critical as stated above). In addition, it is also nice that *use of photo geo-tags* imposes less workload on tourists than *annotation* and *on-site map recording*, as photo-taking is a tourists' natural activity.

Table 1. Comparison of five possible approaches for obtaining visitor-interested locations from seven viewpoints

	On-site Workload	**Off-site Workload**	**Accuracy**	**Possibility of commission errors**	**Possibility of omission errors**	**Technical challenge**	**Device necessity**
Annotation		×	×				
On-site manual recording	×				×		×
Use of photo geo-tags					×		×
Detection from GPS logs				×	×	×	×
Text mining			×		×	×	

Now let us assume that we have already obtained a large dataset of visitor-interested locations in a tourist area by one of the above five approaches. The next mission is to calculate the potential-of-interest of each location in this area. For this calculation, we can use a technique called *kernel density estimation* (Parzen 1962). Roughly speaking, kernel density estimation is a computational operation in which we assign a small hill for each data point, called a *kernel*, and measure the total height of all hills on each location. As a result, a location with a larger number of points around it has a higher value. Kernel density estimation is, in the original sense, a technique to estimate the probability distribution of a stochastic process from a large set of samples. If we take the *use of geo-tags* approach, for instance, tourists' photo-taking activities are considered a stochastic process that follows a certain two-dimensional probability distribution. This probability distribution should reflect the distribution of sightseeing potentials.

The estimated probability distribution can be represented by a continuous surface map. This surface map is sometimes called a *heat map* in analogy to a thermograph. Intuitively speaking, this surface map represents the density of sample points (in our case, visitor-interested locations) at each location. Thus, the surface map, constructed via kernel density estimation from a large dataset of visitor-interested locations, is considered a potential-of-interest map.

4 Demonstration

As a case study, a potential-of-interest map was made by the *use of photo geo-tags* approach in Section 3. Our target was Yokohama, a portside city near Tokyo. Yokohama's central area is a popular tourist destination, which attracts more than forty million tourists in a year.

In order to ease the labour of collecting data about photo-taking locations from tourists, we used Flickr photos for this study. Flickr (http://www.flickr.com/) is one of the most popular photo-sharing services on the web and is currently owned by Yahoo! USA. Flickr has many photos taken by tourists. In addition, Flickr has an open and powerful API with which we can perform geo-searching of Flickr photos in our own program. Therefore, Flickr is a suitable data source for collecting data about tourists' photo-taking locations. Indeed, there are already many researches which employ Flickr's photo data. For instance, Girardin *et al*. (2007) and Zheng *et al*. (2011) inferred tourists' movement patterns from spatio-temporal sequences of photo locations of individual photographers, while Hollenstein and Purves (2010) analyzed people's perception of areas in a city from the combination of location data and user-generated tags of Flickr photos. Use of

In our study, we first developed a JavaScript program which automatically collects the data of Flickr photos that have been taken within a certain rage of a specified address. The data include the Photo ID, the location (geo-coordinates) where the photo has been taken, the owner's ID, and the owner's place of residence (country and city names). With this program, we collected the data of 1061 photos of Central Yokohama (the photos taken within 3km from Yokohama City Hall). We then removed 38 photos taken by local residents, who were probably not tourist photos. The remaining 1023 photos were taken by 95 people (on average 10.8 photos per person); 34 live in Japan, 20 in other countries, and the place of the remaining 41 people were unknown.

Then, we imported the location data of these 1023 photos into ArcGIS 8.1 with Spatial Analyst and carried out kernel density estimation. The resulting map (Fig. 1) shows higher values at and around major tourist attractions in Central Yokohama, such as Minato-Mirai Waterfront Area, Akarenga Park, Ohsanbashi Wharf, and Yokohama Chinatown. This supports our intuition that the location data of Flickr photos, which include many tourist photos, can be employed as the data source for potential-of-interest maps.

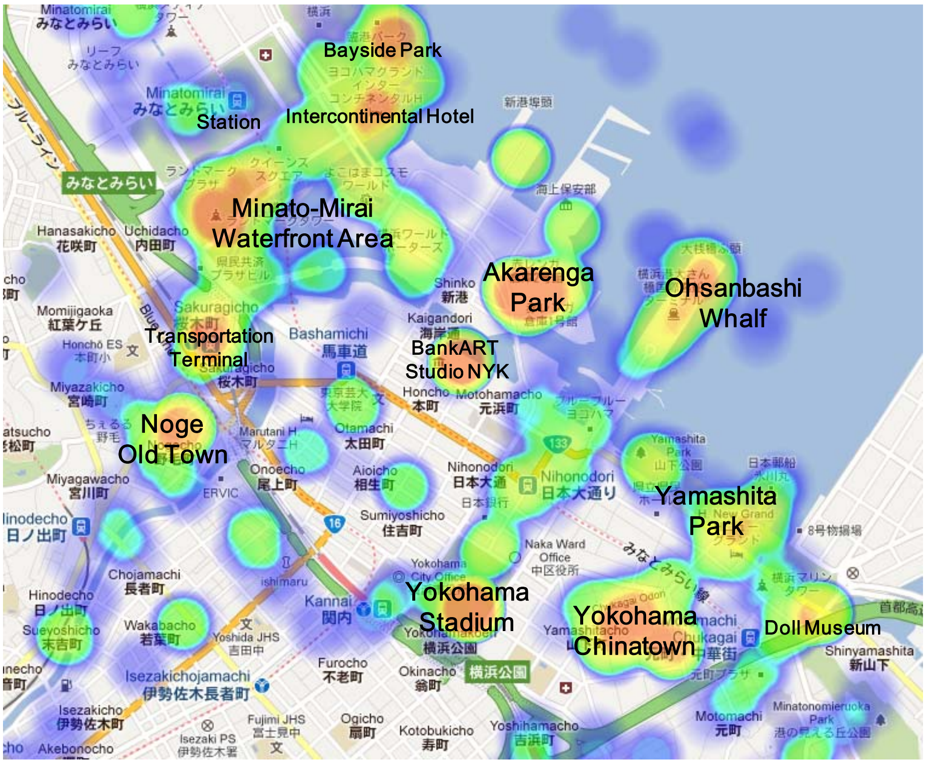

Fig. 1. A potential -of-interest map of Central Yokohama, made from photo-taking location data of Flickr photos

5 Potential-of-Interest Map-based Tourist Information Tool

Now that we have an example of a potential-of-interest map, we implemented a prototype of the mobile tourist information tool discussed in Section 2, which features a point-of-interest map. This tool first shows a Google map of Central Yokohama, which is enhanced with a layer showing the potential-of-interest map (Fig. 2-left). In this map, the darker areas represent the areas with higher potential-of-interest (i.e., the areas where many tourists have taken photos).

This map also contains blue markers, which represent the locations of major tourist attractions and train stations. In total 34 markers are prepared for this area. If you click a marker, a short description and a picture of the corresponding facility are shown in a balloon (Fig. 2-right). The description contains hyperlinks to the official site and Wikipedia page of this facility, if they exist.

The screen also shows a button named ‘Start Tracking.’ If this button is on, the map automatically scrolls such that the user’s current location comes to the centre of the map, together with a circle at the centre which shows possible measurement error of the current location.

Since this tool was developed with JavaScript and the Google Maps JavaScript API v3, it can be used on various platforms through web browsers. Its screen layout and user interface depends on the device, due to the specification of the Google Maps JavaScript API v3. For instance, on Android smartphones and iPhones, the user can scroll the map using one finger. In addition, on iPhones (but not Android smartphones at this moment) the user can change the map scale with two fingers.

The most remarkable feature of this prototype is its simplicity. The initial screen shows almost no text except labels. Nevertheless, the map is informative, as it visually tells the user which attractions are possibly worth visiting and which are not. If the user becomes interested in a certain area, he may browse the descriptions of tourist attractions in that area. These descriptions are valuable to judge quickly whether the attraction is interesting or not for him. If he needs more information for his decision, the user can obtain it from external sites via hyperlinks. We considered that tourist information tools should not be relying entirely on proprietary information, as it is difficult to keep updating the information up-to-date within individual tools.

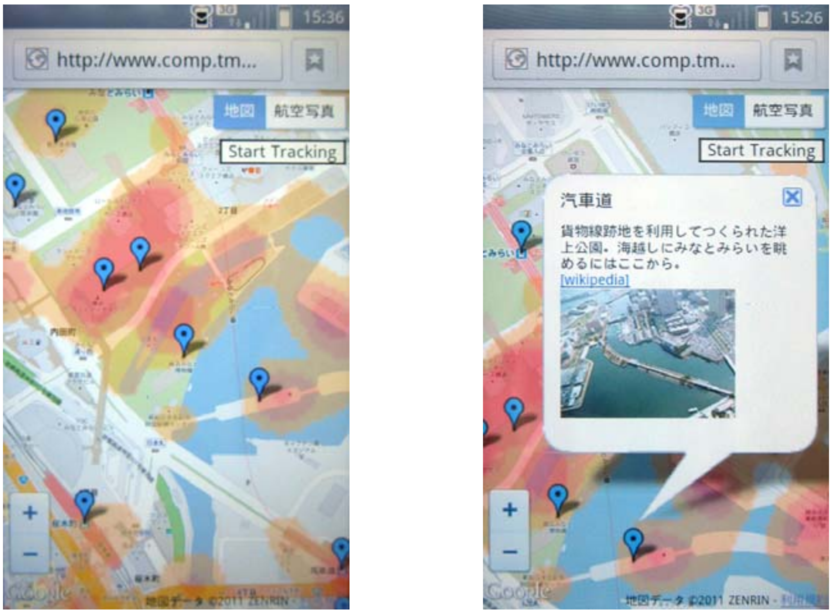

Fig. 2. Screenshots of our mobile tourist information tool which features a potential-of-interest map. The balloon in the right screenshot introduces *Kishamichi Promenade*, saying “A trans-bay promenade which was built on a former freight railroad. Visit here if you want to enjoy a nice view of Minato-Mirai Waterfront Area over a bay”.

6 User Evaluation

In order to evaluate the developed tool which featured a Flickr-based potential-of-interest map, we conducted a user test. In this test, we asked its participants to visit Central Yokohama and do sightseeing freely for at least two hours using our tool. After that, we asked them to answer an online questionnaire. We had twelve participants (eight males and four females; average age was 27.2). Nine participants used their own smartphones, while other three borrowed the Android smartphones we prepared.

Table 2 summarizes the major result of our user test. Unfortunately, the average scores of six evaluation items were not glorious. The major reason was that, as implied by the large standard deviation (S.D.) values, the participants were divided into sympathetic and anti-sympathetic groups. Particularly, the three participants who reported their poor map-reading skills were anti-sympathetic. For instance, the average score of Item 1 (ease-of-use) by these three participants was only 2.0. On the other hand, three participants who borrowed our Android smartphones gave a score of 3.4 for Item 1, even though they were not used to the smartphones.

Table 2. Test users' evaluations of our mobile tourist information tool featuring a potential-of-interest map (5: highest and 1: lowest, *n* = 12)

Question	**Ave. Score**	**S.D.**
1. Did you feel that it was easy to operate the system?	3.5	1.2
2. Did you find any new attractive spots while using the system?	3.1	1.1
3. Did you think that potential-of-interest is reliable?	3.3	1.1
4. Did you think that the information about each point-of-interest, shown in a balloon, was sufficient?	3.5	0.9
5. Do you want to use this tool on smartphones again when you visit other destinations?	3.7	1.2
6. Do you want to use this tool again on a PC when you plan a trip at home?	3.4	1.4

Among the six evaluation items, the average score of Item 2 (new findings) was the lowest. This was probably because most participants have already visited Yokohama many times. Item 3 (validity of potential-of-interest map) was given low scores by the participants who visited Yokohama on rainy days. Our potential-of-interest map seems unsuitable for rainy days, because it was made from the geo-tags of tourist photos mostly taken on sunny days. Lastly, Item 5 (use intention in other destinations) and Item 6 (use intention at home) are given high scores by nine and seven of twelve participants, respectively. This makes us confident of the presence of consumer needs for our new tool.

We also asked the participants to comment freely on our tool. Some participants gave positive comments on such features of our tools as the absence of unnecessary textual information, the presence of potential-of-interest data on unfamiliar districts, and easy access to the information around the user's current location. We also found complaints about slow data communication speed, inaccuracy of estimated current locations, and small displays, which were actually device-side problems (although there is still room for improvement in our side).

Several ideas for improvement were proposed by some participants. One nice idea was to prepare several potential-of-interest maps which correspond to different situations (e.g., day and night, sunny and rainy days, dating and solo trip) and to enable their switching or to represent them with different colours.

7 Conclusions and Future Work

It is difficult for tourists to process a large amount of text-base tourist information for finding which attractions, streets, and areas are worth visiting. This problem becomes more serious when the tourists are already at the destination and have to rely on their mobile device with a tiny screen. This paper, therefore, proposed the use of potential-of-interest maps in mobile devices as a visual aid for tourists. Potential-of-interest maps allow the tourists to understand the distribution of sightseeing values in a tourist area and accordingly, help the tourists to select the targets (attractions, streets, and areas) whose information should be looked carefully for their tour planning.

In this paper, we made a potential-of-interest map of Central Yokohama from the location data of Flickr photos. Geographic visualization of Flickr's photo-taking locations itself is not new, but the use of it as a source of tourist information seems a new idea. Zanker *et al*. (2010) also discussed the application of user-generated geo-tagged information on the Web to the tourism domain, although their focus was to use such information in extending the framework of information retrieval. On the other hand, we pursued a new presentation style of tourist information.

One remaining issue in the current approach is that we cannot assure that the photos we have used are taken by ordinary tourists. Thus, we are planning to revise our potential-of-interest map based on photo location data collected from actual tourists. In addition, in order to keep the potential-of-interest map up-to-date, we are planning to introduce a 'user participation' mechanism, in which photo location data are collected seamlessly from the users of our tool by building a camera function into our tool. A benefit of this mechanism is that the result of tourists' natural actions is utilized for guiding future tourists. Ultimately, we would like to evolve the tool into a dynamic system in which its users can see where other users are taking photos at each moment, because many season- and time-dependent attractions, such as festivals, flowers, and street performances, take place in a tourist area. Another merit of the user participation mechanism is that we can consider personalization by collaborative filtering (Resnick 1994); that is, we can customize potential-of-interest maps for each user, based on the photo location data of other *similar* users who have taken photos at similar locations.

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