Tourists Visit and Photo Sharing Behavior Analysis: A Case Study of Hong Kong Temples

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Abstract Travel statistics report published by the tourism board was one of the important sources that attraction managers used to plan for marketing strategies. However, only a limited number of famous attractions were involved in such reports, therefore rare information was gathered for 2nd or 3rd tier attractions, such as temples. These small attractions were kept away from many tourists' knowledge or travel plan so that it is also a difficulty to explore their visit behaviors. Fortunately, social media sites have been rapidly developed and widely used in our lives, to fill this blank with a large number of active users, who shared their travel experiences by writing textual comments and uploading travel photos. This provides scholars and managers with opportunities to understand tourists' behaviors and the potential attractions they are interested in, by analyzing the photos they uploaded and shared online. In this paper, we report a study of extracting geotagged photos uploaded by tourists to one of the popular social media sites, Flickr, for tourists' visit and sharing behavior analysis of Hong Kong temples. The results indicate four popular temples that attracted most tourists taking photos. The behavior analysis shows the difference preferences of tourists from various locations and the trend changes of their visits in the past 5 years.

Keywords Geotagging • Photos • Flickr • Tourists' behaviour • Temples • Hong Kong

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1 Introduction

Being the most popular city destination around the world in 2013 (Euromonitor International, 2015), Hong Kong attracted more than 60 million tourists visiting this tiny place in 2014 (HKTB, 2014a). *Hong Kong Tourism Board* (HKTB) has been promoting Hong Kong as a shopping and dining paradise. Statistics showed that tourists spend more than 60 % on shopping, 18 % on accommodations, and 12 % on dining (HKTB, 2014b). However, what other activities they involved in trips stay unclear to industry practitioners. Statistics in official reports only focused on popular attractions and major tourist's activities; anything beyond that was still undercover due to time and budget constraints for conducting comprehensive survey to gather information from every tourist. Moreover, tourists from different regions and cultures often behave differently (Leung et al., 2012). Therefore, attraction managers cannot easily obtain enough valuable data for analysis but only rely on their own observations on limited number of samples and information passed by others to prepare their marketing and business strategies (Lew & McKercher, 2006). According to HKTB (2014b), visiting temples was one of the popular tourists' activities in Hong Kong. However, no prior research or statistical report indicates which temples were in the top visited list or any details showing visitors' behaviors.

In the Internet era, many tourists posted their travel photos on social media and online photo albums to share their travel experiences with friends and relatives. Their selections of the photos to be uploaded and shared present their personal opinions of the past travels, which directly affect the peers' impressions and decision-making (Tham, Croy, & Mair, 2013). Many existing studies focused on analyzing textual information attached to the uploaded photos, such as hash tags (Zhang & Yun, 2014), photo captions (Pan, Lee, & Tsai, 2014), and review comments (Park & Nicolau, 2015). However, if the photo does not associate to any textual context, it is not easy to use those existing methods and obtain expected outcome.

GeoTagging (here after geotag) is a process of attaching geographical identification metadata into multimedia documents such as images and videos (Zheng, Zha, & Chua, 2012). Since digital cameras and small phones having built in GPS functions, when people taking photos with such devices, a large number of photos shared on social media websites contain GPS information as geotags. Together with the time of photo taking and the associated user profiles, geotags stored as the Metadata of photos shared can be used to outline tourists' travel paths and activities they participated during the trips. Even the tourist did not type in any comment for the photos, the users' profile and the photos themselves can provide certain details for behavioral analysis. Attraction managers therefore can analyze such information to get better understanding of tourists' preferences and behavioral differences. This study aims *to analyze tourists' visit behaviors using geotagged photo images shared on social media sites together with the associated Metadata*.

The rest of paper is structured as follows. Section 2 reviews existing literature on analyzing tourist behavior using GPS information. A framework for collecting and processing geotag data from photos is introduced in Section 3. Section 4 presents a case study of analysing tourists' visits and photo sharing behaviours in Hong Kong temples. Section 5 concludes our study and emphasizes on the current limitations.

2 Literature Review

After *Geographic Information System* (GIS) was firstly introduced in 2012, it was adopted in many studies to explore tourists' movement patterns (Lau & McKercher, 2006; Zakrisson & Zillinger, 2012). A common way to use GIS required tourists to carry a device to record their travel movement. It can precisely indicate the actual tourists' locations, but with many limitations including: (1) small data samples can be collected due to limited number of devices available; (2) time consuming to record the entire movement; and (3) low participation rate due to the inconvenience caused during the travel. With the popularity of media-sharing platforms (e.g. Flickr and Youtube), massive amount of photos and videos are publicly available on the Internet and have become an important data source for both academic and industry studies. Syed-Ahmad, Musa, Klobas, and Murphy (2013) used photos uploaded by normal users on Flickr to examine the geographic characteristics of Arab Countries. Pan et al. (2014) extracted the captions of tourists' photos to evaluate travel destinations' quality. They collected the relevant photos' descriptions and tourists' comments for a pre-determined destination to identify the relationships among travel motivations, resolutions of images taken at that destination, and other affective qualities.

With the introduction and popularity of *Global Positioning System* (GPS) in smart phones and mobile photo capturing devices, the geographical information are now automatically stored in a photo's geotag for location recording. In order to make use of those geotagged photos available on Internet, many automatic computing algorithms were developed to collect, store and organize those photos for further analysis (Crandall, Backstrom, Huttenlocher, & Kleinberg, 2009; Jaffe, Naaman, Tassa, & Davis, 2006). The collected geotagged photos could help attraction managers to understand users' visit behaviors and discover their travel patterns for future marketing planning. Zheng et al. (2012) extracted photos in four modern cities (*London*, *Paris*, *San Francisco*, and *New York City*) and examined 446 tourists' travel patterns. Vu, Li, Law, and Ye (2015) attempted to use geotagged data to analyze the tourists' travel preferences in Hong Kong. Their study identified the most popular attraction sites in Hong Kong, and the differences in travel patterns between Asian and Western tourists. However, from the recent studies, none of them focused on any 2nd or 3rd tier tourist attraction, but only the officially reported or tourist-known ones. It is unclear to industry practitioners what other tourists' activities or potential attractions are. This study determined *to fill the gaps*

by exploring the tourists' behaviors at the 3rd tier tourist attractions such as temple.

3 Methodology

Geotagged photos were made available on the web applications of Flickr for public view, but they were not directly downloadable. They must be accessed via Flickr's Application Programming Interface (API) (Flickr, 2015). In order to identify popular temples based on the number of tourists visited the temples and the photos taken, we proposed a framework to extract geotagged photos from Flickr and cluster both the tourists and the photos for popular temples.

3.1 Geotagged Photo Extraction Using Flick's API

Among the wide ranges of functions provided by Flickr's API, *PhotosSearch* function allows users to query Flickr's servers and retrieve information based on certain search criteria. The location of each geotagged photo p is referenced by a value pair $< x_p, y_p >$ for longitude and latitude coordinates. The region defined to extract geotagged photos can be specified by a bounding box, whose coordinates are defined by x_{min}, y_{min}, x_{max} and y_{max} for the minimum longitude, minimum latitude, maximum longitude, and maximum latitude, respectively. The *PhotosSearch* function allows for temporal information to be specified, such as the earliest time (t_{min}) and the latest time (t_{max}) of photo taking. Only photos taken between these periods are considered. The returned result contains all Metadata information carried by the photos including *PhotoID*, *GPS location*, *TakenDate*, *UploadDate*, *Tags*, *OwnerID* and owner's *demographic information*.

Basically, bounding boxes can be specified over the regions of interested temples to extract the geotagged photo data. However, no prior statistics report officially indicated any temple with potential attractions in Hong Kong. It is also a challenge to define the region for the bounding box of a temple. Some temples may not have clear boundaries with outside areas, while, visitors may take temple photos from either inside or outside of the temple. Therefore, this study adopt a special density clustering, named P-DBSCAN (Kisilevich, Mansmann, & Keim, 2010) to assists the identification of popular temples and specification of the bounding boxes as presented in Sect. 3.2.

3.2 Popularity Identification Using P-DBSCAN Clustering

The search process will return a large number of geotagged photos, but not all of them are useful and kept for further analysis. The collected data may be imbalanced that often causes misleading. For instances, one tourist can take many photos at a particular temple; while at another temple, there were many tourists visited but only few photos were taken. When identifying temple popularity, the number of visitors as an important parameter should have more weight than the number of photos taken. This issue can be tackled by using P-DBSCAN, a specifically developed clustering method for geotagged photos. P-DBSCAN takes the photo owner's information and its association to the photos taken into account for computation.

Suppose P is a collection of geotagged photo data relevant to temple. Photo relevant to temple can be retrieved by specifying keywords (for example, "*temple*") in the *PhotosSearch* function. Each photo p is referenced by a value pair $< x_p, y_p >$ for its coordinates. Let $Dist\ (p,q) = \sqrt{(x_p - x_q)^2 + (y_p - y_q)^2}$ denotes the direct distance between two photos p and q. The neighborhood of a photo p is defined as $N_\theta(p)$ using the following equation:

$$N_\theta(p) = \left(p \in P, Owner(q) \neq Owner(p) \middle| Dist(p,q) \leq r\right) \tag{1}$$

where $Owner(\bullet)$ is an ownership function to specify the owner of photo. Equation (1) means that a photo q is the neighborhood of another photo p if it belongs to a different user and its location is within a neighborhood radius r from photo p. Let $NeighborOwner(p)$ be the owner number of the neighbor photos $N(p)$ and δ is the owner number threshold. A photo p is called a core photo if its neighbor photos belong to at least minimum number of owners ($NeighborOwner(p) \geq \delta$).

The P-DBSCAN clustering process starts with a set of unprocessed photos $p_1, p_2, \ldots \in P$. For each photo p_i, it is a core photo, it is assigned to a cluster c. Otherwise, it is marked as noise and discarded. All neighbors $N(p_i)$ of the core photo p_i are put into a queue for further processing. Each neighbor photo $p_j \in N(p_i)$ was assigned to the current cluster c until the queue is empty. Such process is repeated for the rest of the unprocessed photo(s) in P. After all the clusters of photos are obtained, their geographical coordinates are examined to determine the name and the spatial extent of the area. The values r and δ are determined based on the scale of specific applications. If the region to be identified is at the macro level such as a country or a city, large values can be assigned to r and δ. If the region is at a micro level such as a temple, r and δ take small values. The implementation of this technique is discussed further in Sect. 4.

4 Experiment Implementation and Finding Analysis

A case study of Hong Kong temples was conducted using the above methods to analyse tourists' visits and photo sharing behaviours. In this section, we presented the process of the adopted experiments and reported the findings from the returned results.

4.1 Popular Temple Identification

To identify the popular temples for further analysis, we set the bounding box with parameter values shown in Table 1 to cover the entire Hong Kong geographical area, as suggested in recent work. The search was limited to recent five and half years from January 1 2010 till June 30, 2015. Keywords inputted into the search function were "*temple*" and "*buddha*" due to most of the temples in Hong Kong were built up for Buddhism. If the photo tag field contained one of the provided keywords, then certain photo was included in the returned results; otherwise, it was discarded.

The search returned *3767* photos about temples from *783* visitors over the entire Hong Kong area. The locations of the collected photos are shown as yellow dots on the satellite image as Fig. 1. P-DBSCAN was then applied to the collected dataset for clustering. In our case, the regions of interest were the temples at micro level, thus, r can take small values of *0.002* as recommended in, which is equivalent to approximately *150* m. The minimum owner δ was set to *5 %* of the total number owners in data collection. The clustering process returned four clusters as shown in Fig. 1b. After examining the locations, the clusters returned were marked using the names of the corresponding temples. These temples were *Tian Tan Buddha*, *Wong Tai Sin, Tin Hau* and *Man Mo*.

From Fig. 2a, b, we found that the photos taken at the *Tian Tan Buddha* and *Wong Tai Sin* clusters were mainly located within or close to the regions belonging to those temples. In this case, we can easily define bounding boxes (as shown in red rectangular), to cover the spatial extends of these temples to extract the data for further analysis. For the cluster shown in Fig. 2d, the photos were centered at *Man Mo* temple, but spread widely to the surrounding areas. The reason is because *Man*

Table 1 Photo search parameters

Parameter	Value	Description
x_{min}	113.887603	Minimum longitude of the bounding box
y_{min}	22.215377	Minimum latitude of the bounding box
x_{max}	114.360015	Maximum longitude of the bounding box
y_{max}	22.51446	Maximum latitude of the bounding box
t_{min}	1/1/2010	Earliest photo taken date
$t_{\max}$	30/6/2015	Latest photo taken date

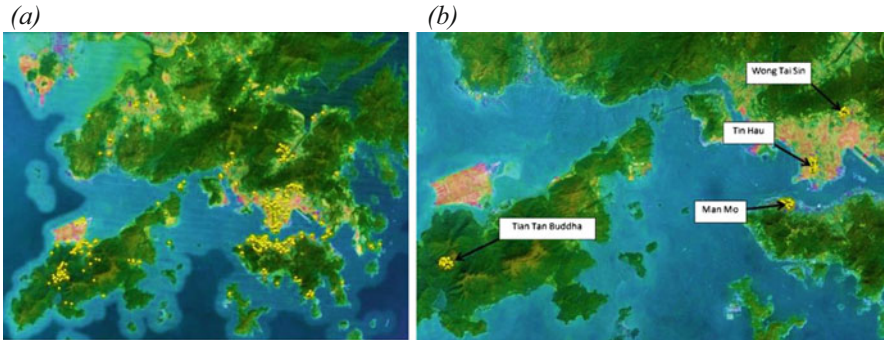


Fig. 1 (**a**) The locations of the temple photos and (**b**) clustering result of P-DBSCAN

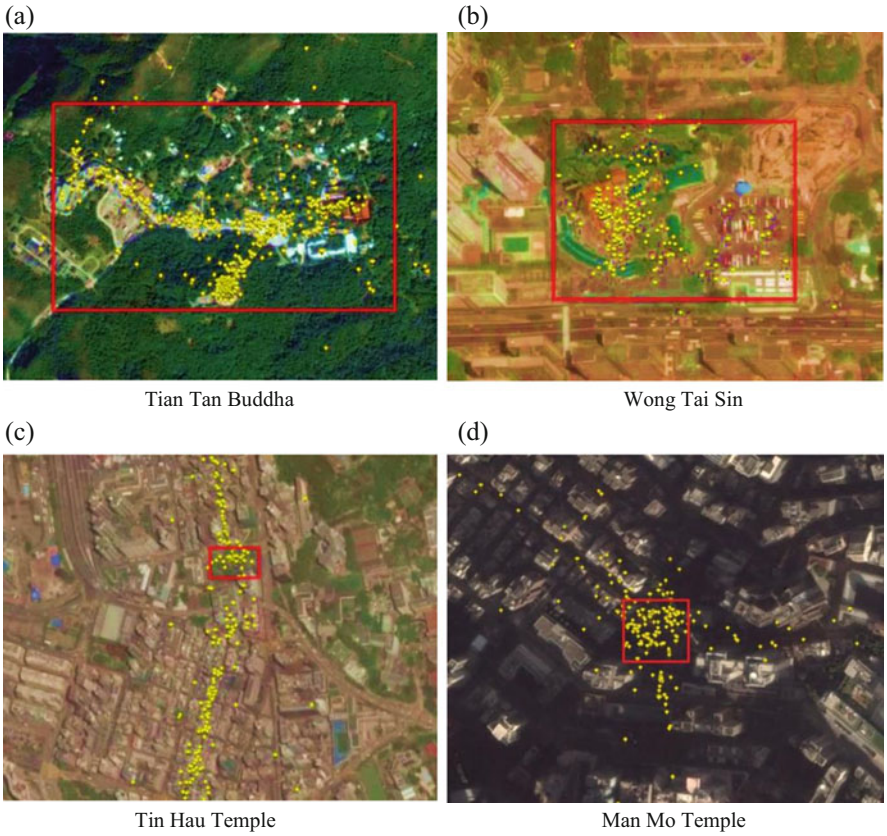


Fig. 2 Locations of photos for temple clusters (**a**) Tian Tan Buddha, (**b**) Wong Tai Sin, (**c**) Tin Hau Temple, (**d**) Man Mo Temple

Mo temple stays in the center of *Hong Kong* metropolitan area. Tourists usually take photos of *Man Ho* temple from high levels of the surrounding buildings in this area. In order to exam the behavior of temple visitors, this study set the bounding box to covered the region belonging to *Man Ho* temple only, which was at the center of the cluster. For *Tin Hau* cluster (Fig. 2c), many photos were actually not taken inside *Tin Hau* Temple, but along the "*Temple Street*". This is due to the specification of "temple" keyword during the photo search process. Many photos at "*Temple Street*" were included but indicated as irrelevant to our interest of temple visitors. However, "*Temple Street*" was named after *Tin Hau* temple. Therefore, *Tin Hau* temple was still included by setting a bounding box only covered the region belonging to the temple.

4.2 Geographical Differences on Tourists' Temple Visit Behaviors

Flickr enable users to fill in their residential country in their profile. In this study, out from the *343* visitors, *47 %* of them indicated their country of residence in the profile. As shown in Table 2, around *17 %* tourists were from USA and *70 %* of them visited *Tian Tan Buddha*. UK ranked second (13 %) and Mainland China tourists ranked third (*9 %*).

Table 3 indicates the trend in number of users uploading photos to Flickr about Hong Kong temples have been dropped from 2010 to 2014. The data collected for 2015 were discarded because they only covered the period of the first 6 months of the year. There was no solid evidence to proof the reason of the dropping. It could relate to the dropping of Flickr's popularity, the dropping of visitors' interest on temples, or the dropping of tourists' photo sharing behaviour. Moreover, Flickr is not popular in China. Therefore the number of photos upload from China may not reflect the actual tourists' interests in temples. The results shown one-third of the temple visitors were from Europe, *28 %* from Asia, and *20 %* from North America (Table 3).

4.3 Visit Behavior Analysis for the Identified Popular Temples

In order to avoid the case that some photos taken inside a temple were not tagged with any relevant keyword, so no keyword was used in the data collection process in Sect. 3.1. A second round of data collection was conducted for the identified popular temples with the regions shown in Fig. 2, but no keyword was used. As a result, we obtained a new data set with all the geotagged photos taken inside the selected areas for *Tian Tan Buddha*, *Wong Tai Sin, Tin Hau* and *Man Mo* temples.

Table 2 Geographical distribution of base on Flickr user profile

Country	Tian Tan	Wong Tai Sin	Man Mo	Tin Hau	Total
USA	40	10	5	2	57
United Kingdom	34	4	3	2	43
China	12	7	7	4	30
Australia	18	1	0	1	20
Singapore	14	2	0	2	18
Germany	11	1	3	0	15
Taiwan	10	1	2	1	14
Spain	7	2	1	0	10
Japan	5	1	1	2	9
Russia	7	0	0	1	8
Canada	6	2	0	0	8
Philippines	6	1	0	0	7
Netherlands	4	1	1	1	7
Italy	4	0	1	1	6
Switzerland	5	1	0	0	6
Malaysia	4	0	1	0	5
France	4	0	0	1	5
Brazil	3	1	1	0	5
New Zealand	4	0	1	0	5
Thailand	3	1	0	0	4
Sweden	2	1	1	0	4
Korea	0	1	2	0	3
Belgium	3	0	0	0	3
Argentina	3	0	0	0	3
India	2	0	0	0	2
United Arab Emirates	2	0	0	0	2
Finland	1	1	0	0	2
Mexico	2	0	0	0	2
Bangladesh	1	0	0	0	1
Estonia	1	0	0	0	1
Greece	1	0	0	0	1
Hungary	1	0	0	0	1
Luxembourg	1	0	0	0	1
Norway	0	0	1	0	1
Poland	0	0	1	0	1
Dominican Republic	1	0	0	0	1
Hong Kong Residents	17	7	3	5	32

Totally *6955* photos from *780* visits were returned. Table 4 shows the photos taken at each temple and its corresponding number of visitors.

From the data collected in the first round to identify the popular temples, the numbers of the tourists had a big drop of 40 % from 2013 to 2014 (see Table 3).

Table 3 Regional distribution of Flickr user profile per year

Region	Year					Total
	2010	2011	2012	2013	2014	
Europe	20	29	23	20	15	107 (33 %)
North America	17	7	13	16	10	63 (20 %)
Australia/New Zealand	5	6	5	6	1	23 (7 %)
South America	0	3	1	4	1	9 (3 %)
Asia	18	21	16	19	14	88 (28 %)
Hong Kong Residents	5	9	3	10	3	30 (9 %)
Total	65	75	61	75	44	320 (100 %)

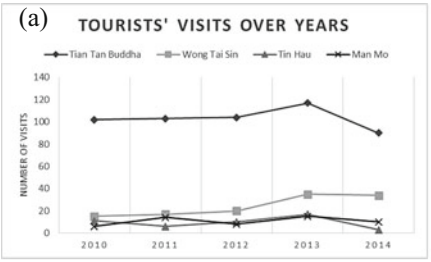
Table 4 Statistics of tourists and photos uploaded for the popular temples

Popularity	Temple	Photos	No. of visits	Average photos upload Per visitor
1	Tian Tan Buddha	4965	541	9.18
2	Wong Tai Sin	1372	126	10.88
3	Tin Hau Temple	362	60	6.03
4	Man Mo Temple	256	53	4.83
	Total	6955	780	8.92

After we analysed the data collected for the four popular temples, we found the same dropping trend for three of the temples: *Tian Tan Buddha*, *Tin Hau* and *Man Mo* temple; only Wong Tai Sin temple was visited in 2014 was close to that in the previous years (see Fig. 3a). From Fig. 3b, we found that June and July had least visitors in all four temples during the whole year. Unlike *Wong Tai Sin* temple that had a peak of visits in February, the other three attracted more visitors in January. However, the tourists' visits fluctuated frequently if we counted them on days (Fig. 3c). For the entire 4 years, there was no visitors uploaded any photos to Flickr on the last days of each month (28th, 29th, 30th or 31st).

The actual number of Flickr visitor was *734* as one person can visit multiple temples per trip (Table 5). *Tian Tan Buddha* was the most popular temple for tourists with *541* visits, followed by *Wong Tai Sin (126 visitors)*. *Tin Hau* and *Man Mo* temples had *60* and *53* visits respectively. Table 5 presents the statistics of tourists' visits. Among all *734* tourists, none of them has visited all four temples. Only five of them visited three temples, and *36* visited two. The remaining *94 %* tourists only visited one temple, and majority of them went to see the *Tian Tan Buddha*.

In order to have a clearer picture of the tourists' behaviour, we selected a set of users who visited multiple temples and/or visited temples in multiple years and summarized their visits in Table 6. Out from *343* tourists, *17* of them (*5 %*) matched these criteria, and only four of them visited the temples in different years. Except one visitor was a local resident in Hong Kong, the remaining three of them were from Asia. They visited different temples when they revisited Hong Kong in couple



Number of Photo Taken over Years

Number of Photo Taken over Months

Number of Photo Taken over Days

Fig. 3 The total number of photos taken in four temples from 2010 to 2014 (**a**) number of photo taken over years, (**b**) number of photo taken over months, (**c**) number of photo taken over days

Table 5 Distributions of tourists' visits

	Tian Tan	Wong Tai Sin	Man Mo Temple	Tin Hau Temple	No of visitors
Visited three temples	5	5	1	4	5
Visited two temples	30	26	8	8	36
Visited one temples	506	95	51	41	693
Total	541	126	60	53	734

of years. For those who visited two temples during the same trip, *Tian Tan* temple was the most popular one to tourists (over *92 %* of the tourists visited it); and *Wong Tai Sin* was the second popular with *61 %* of the tourists took photos. Interestingly, tourists only visited maximum two temples and none of them visited more than two. Besides, from the number of photos uploaded to Flickr indicated that the Asian tourists visited all temples randomly; while the tourists from Europe had rare visit to *Man Mo* or *Tin Hau* temple. For the North American tourists, *Man Mo* temple was the least temple they visited.

Table 6 Tourists visiting behaviour via photos uploaded

	Region	Tian Tan	Wong Tai Sin	Man Mo Temple	Tin Hau Temple
Tourist 1[a]	Hong Kong	0	2012, 2013 (33)	0	2013 (5)
Tourist 2[a]	Asia	2011 (2)	2010 (31)	0	0
Tourist 3[a]	Asia	2011 (2)	0	2012 (12)	0
Tourist 4[a]	Asia	0	2011 (10)	2015 (5)	0
Tourist 5	Asia	2010 (105)	0	0	2010 (6)
Tourist 6	Asia	2010 (11)	0	2010 (1)	0
Tourist 7	Asia	2013 (63)	0	0	2013 (10)
Tourist 8	Europe	2010 (13)	2010 (5)	0	0
Tourist 9	Europe	2011 (6)	2011 (8)	0	0
Tourist 10	Europe	0	2011 (1)	2011 (1)	0
Tourist 11	Europe	2013 (1)	2013 (2)	0	0
Tourist 12	Europe	2015 (2)	2015 (2)	0	0
Tourist 13	Europe	2015 (2)	2015 (3)	0	0
Tourist 14	N. America	2012 (2)	0	0	2012 (14)
Tourist 15	N. America	2013 (3)	2013 (41)	0	0
Tourist 16	N. America	2010 (29)	0	0	2010 (1)
Tourist 17	N. America	2014 (42)	2014 (25)	0	0

Note: Numbers in bracket indicated the number of photos uploaded
[a]Repeat visits

5 Conclusions

This study attempted to analyze tourists' visit behaviors by taking use of the geotagged photos uploaded by tourists to the social media sites. The data extraction method introduced in this paper impacts attraction managers could make uses of the widely available tourists' photos from online media-sharing sites to collected relevant photos about their attractions so as to understand the tourists' behavior and travel pattern. Moreover, they can also identify the behavioral difference among different among different countries. The more comprehensive data they have, their marketing strategies could be more precise.

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