

論文 / 著書情報
Article / Book Information

題目(和文)	
Title(English)	Spatiotemporal Analysis of Human Behavior in Urban Settings Based on Social Geotagged Photos with Emphasis on Differences Between Locals and Tourists
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出典(和文)	学位:博士(学術), 学位授与機関:東京工業大学, 報告番号:甲第12251号, 授与年月日:2022年9月22日, 学位の種別:課程博士, 審査員:大佛 俊泰,藤井 晴行,鍵 直樹,斎尾 直子,沖 拓弥
Citation(English)	Degree:Doctor (Academic), Conferring organization: Tokyo Institute of Technology, Report number:甲第12251号, Conferred date:2022/9/22, Degree Type:Course doctor, Examiner:,,,,
学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	要約
Type(English)	Outline

Thesis Outline

Understanding the disparities in human mobility behavior of locals and international tourists (LCL and TRS), during stable and unstable conditions alike, is of paramount importance in several domains, including urban planning, tourism, and disaster response management. This becomes even more critical in cities depending on tourism on one hand and vulnerable to recurrent extreme events on the other hand. Existing studies, however, often focus only on residents' behaviors and overlook those of international visitors. This is partly attributed to difficulties associated with collecting high-resolution mobility samples, including expensive budgets, lengthy surveys, and possible biased volunteers, to name a few. Furthermore, in the case of emergencies following a natural disaster, for instance, such a procedure would be quasi-impossible. For these reasons, researchers have relied increasingly on mobile phone data to investigate mobility choices and patterns in the last two decades. While such data presents several advantages over traditional field-survey-based data, obtaining mobile phone data is typically costly, and the rate varies depending on the study area's extent and the desired period. Furthermore, due to privacy issues, such data is normally offered as aggregated statistics rather than micro-scale samples, which lack relevant social attributes for users.

Driven by an expanded internet network worldwide and the apparition of geotagging-capable smartphones, the increased use of social networks witnessed since the beginning of the past decade has led to the generation of new sources of data which are referred to as geotagged social data in the form of text- and/or photo-based records. Taking advantage of the accessibility and the high spatiotemporal resolution offered by such data, researchers have investigated urban mobility-related studies on LCL and TRS, relying mainly on textual records. Few studies, on the hand, have used geotagged photos to explore disparities in human behaviors in urban settings, either during steady or perturbed circumstances, despite their potential to provide more insights. Also, there isn't a good way to tell the difference between records posted by both groups, which can make it hard to tell them apart.

In light of such challenges, the primary purpose of this research is to spatiotemporally investigate the urban human mobility of tourists using information extracted from their shared geotagged photos taken in steady and unsteady conditions, with a focus on the mobility disparities between LCL and TRS. To fulfill this objective, the following general questions guide the study:

- RQ #1: How to differentiate between LCL and TRS based on their online-shared geotagged photos?
- RQ #2: How do mobility patterns of TRS differ from those of LCL over time and across space?
- RQ #3: To what extent is human mobility disturbed by different natural disasters?

To meet these goals, we used geotagged photos collected between July 2008 and December 2019 from Flickr in Tokyo's 23 special wards, hereinafter referred to as Tokyo. Tokyo was selected as the target area for this study given that it is the most popular tourist destination in Japan for both international and domestic visitors due to its abundance of tourist attractions. Furthermore,

since this research is mostly based on geotagged images, there is a rather significant number of such photos in this region accessible on Flickr. Moreover, the target area is among the world's riskiest cities in which to live. Based on a recent report from Lloyd's City Risk Index, which estimates the economic output threatened by 18 man-made and natural disasters, Tokyo has the highest risk index of the 279 cities that were looked at.

In terms of the research questions, this dissertation's main conclusions are:

1. Based on digital traces extracted from geotagged photos, we developed a machine learning (ML)-based approach for distinguishing between LCL and TRS. The obtained accuracy (75.5%) is higher than that of the Shannon entropy approach—commonly used in the literature. The proposed method can also be used to divide users into specific groups, such as domestic tourists, foreign residents, etc., which makes it scalable.
2. Differences between LCL and TRS were investigated using linear and non-linear models:
 - a. The results of the first approach in combination with computer vision techniques indicate that TRS have a strong preference for amusement, while LCL are attracted to nature. In contrast to TRS, whose members are not followed by job obligations, LCL's photos are mostly taken during the weekends. Familiar with the area, LCL tend to spatially cover a wider extent compared to tourists, who are concentrated near the Yamanote railway loop line, connecting most of the touristic attractions.
 - b. The results of the second approach using non-linear models suggest that the itinerary total times (TM)- and traveled distances (DST)-based monthly routines of both LCL and TRS during bad, ideal, and mixed weather conditions are much more predictable than those obtained daily and weekly. Also, it is found that DST is the best proxy for predicting TRS's daily mobility behaviors, while TM is much better for predicting LCL's.
3. The comparative analysis of the impacts of several extreme events showed that all extreme events perturbed mobility patterns to different degrees. Furthermore, these patterns mostly followed a truncated power-law distribution during steady and unsteady states. Wet-weather-related disasters, particularly Typhoon Wipha and the 2015 heavy rain, disturbed human movements the most in terms of displacements, traveled distances, and trip characteristics. Initially, this research section was aimed at applying the proposed methodology to LCL and TRS. Nonetheless, because the sample size is so small, the effects are studied for all users instead.