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Understanding the tourist mobility using GPS: Where is the next place?

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HIGHLIGHTS

- This paper explores tourist mobility using GPS at the level of tourist attraction.
- A heuristic method is proposed to predict the next location of individual tourist.
- A case study at the Summer Palace is conducted to evaluate the method's performance.
- We further explore the potential applications of the proposed method.

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ABSTRACT

Understanding the mobility of tourists plays a fundamental role in the administration and design of tourist destinations, planning of on-site movement and marketing of attractions. In this paper, we focus on how to accurately predict the tourist's next location within a given attraction. A heuristic method based on data mining is proposed, which considers the trajectory of a focal tourist and the movements of past visitors. To evaluate the performance of the proposed method, a case study was conducted at the Summer Palace in Beijing, China. We collected movement information from tourists using GPS tracking technology, and the results of an independent samples *t*-test indicate that the proposed method indeed performs significantly better than existing methods. We further explore the potential applications of the proposed method. Our results significantly contribute to enhancing the level of personalized location-based service, tourist attraction administration, and real-time crowd control.

1. Introduction

Tourism is generally regarded as separate from daily life; therefore the study of tourism has often been seen as peripheral to the social sciences. However, the mobility paradigm arguably allows us to place tourism at the core of social and cultural life rather than at the margins (Coles & Hall, 2006). The formation, development and disappearance of mobility in physical space is an important way for humans to experience the world, the sense of space production and the progress of place formation, including the social forces associated with almost all complex and related information, such as the mobility of people, objects and information (Cresswell, 2006). The focus on mobility allows us to show how the discourses and practices of freedom implied by driving underline the contemporary tourism experience in some contexts (Hannam, Butler, & Paris, 2014). Proponents of the mobility paradigm argue that the concept of mobility is concerned with mapping and understanding not only the large-scale movements of people, objects, capital and information across the world, but also the more local simultaneous processes of daily transportation, passage through public space and the movement of material things in everyday life (Hannam, Sheller, & Urry, 2006).

Understanding tourist mobility plays a fundamental role in the administration and design of destinations, planning of on-site movement and marketing of attractions (Xia, Zeephongsekul, & Packer, 2011). In the past few years, academics and practitioners

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have increasingly studied the movement patterns of tourists (De Cantis, Ferrante, Kahani, & Shoval, 2016; Xia, Zeephongsekul, & Arrowsmith, 2009; Xia et al., 2011), and how to guide practice based on this movement pattern, for example, by using market segmentation (Xia et al., 2010) and behavior analysis (Huang & Wu, 2012; McKercher, Shoval, Park, & Kahani, 2015).

With the recent development of mobile Internet technology and geographic information technology, it is possible to track and record the space-time path of individual tourists accurately (Shoval & Isaacson, 2007). However, tracking and recording is not the ultimate purpose; the application of new technology should provide new knowledge to better understand tourist activities and optimize travel behavior. Recently, GPS tracking technology to obtain travel spatial-temporal trajectory data has been applied in the study of tourist behavior, but its use has been limited to description at the level of clustering and pattern analysis (De Cantis et al., 2016; Lew & McKercher, 2006; McKercher, Shoval, Ng, & Birenboim, 2012; Shoval, McKercher, Ng, & Birenboim, 2011). The accurate and constructive description of tourists' spatial-temporal behavior could help with proposed diagnosis, analysis, and countermeasure issues to better analyze what has already happened. If forestalling actions are considered, then studies about what will happen in the future become much more important. Thus, the answer to this research question is valuable for optimizing the behavior of both tourists and attractions/destinations, which are the essential areas of visitor management and destination management.

Although predicting and recommending the potential location of a newcomer based on the person's preferences and the experiences of past tourists makes sense for both tourists and tourism product suppliers (Tsai & Chung, 2012), until recently few studies have attempted to predict tourist movement trends at the level of a tourist attraction (Xia et al., 2009; Xia et al., 2011). This study seeks to fill this research gap by meeting three objectives. First, we collect movement data using GPS technology to ensure high data quality. Second, we apply a grid-based clustering method to reduce data-processing complexity and retain only the most important information. Third, we design a heuristic algorithm based on data mining to predict the potential location of a focal tourist based on the person's current trajectory and the experience of previous tourists. To evaluate the performance of the proposed method, a case study was conducted at the Summer Palace in Beijing, China. We collected the movement information of 117 tourists using GPS, and obtained 111 valid trajectories. The results of an independent-samples *t*-test indicate that our method performed significantly better than existing methods. Furthermore, we discuss the potential applications of the proposed method, such as personalized location-based service, tourist attraction administration, and real-time crowd control.

This study will contribute by expanding the application of tourist movements in the mobile Internet era, in which movement data can be collected more easily; by proposing a new method that improves prediction accuracy compared with current methods; and by achieving a beneficial trade-off between prediction accuracy and efficiency.

The remainder of this paper is organised as follows. Section 2 gives an overview of the related work, which extends beyond tourism to include transportation. In Section 3, we propose several definitions and the methodological framework, after which the heuristic prediction algorithm (HPA) is described in detail. Section 4 provides the experimental results and the performance of the algorithm. Section 5 discusses the application of the prediction method in personalized location-based service, attraction/destination planning and management and real-time crowd control. We conclude the paper in Section 6 and propose a possible direction for future research.

2. Literature review

2.1. Movements of tourists

The study of this issue began with (Campbell, 1967). However, most such studies have involved mapping and modelling of movements between destinations (Mckercher & Lau, 2008), as tourist destinations are not independent, but exist within a competing and complementary relationship (Wall, 1978). A potential tourist is likely to visit multiple destinations on a single trip to reduce the time and cost associated with travel (Ben-Akiva & Lerman, 1985). The study by Lue, Crompton, and Fesenmaier (1993) supports this notion, and summarised five movement patterns. Oppermann (1995) also proposed various models for travel itineraries, two for single destinations and five for multiple destinations. Hwang, Gretzel, and Fesenmaier (2006) examined the multicity trip patterns of international tourists in the United States, while Li, Meng, and Uysal (2008) revealed the spatial patterns of travel flows and travel propensity in the Asia-Pacific region over a 10-year period. Yang, Fik, and Zhang (2013) analysed the decisions of tourists with respect to sequential destinations using a dataset from an on-site tourist survey in Nanjing, China.

In recent years, the movement of tourists within a destination has received greater attention. Tideswell and Faulkner (1999) focused on the travel pattern of international visitors in Queensland, Australia, and explored the synergy between these patterns and destination development. Fennell (1996) studied tourist movements in the Shetland Islands using measures of space, time, perception, region and core/periphery. McKercher and colleagues did considerable exploration of tourist movements within an urban destination, using an inductive approach to identify factors that influence such movements in Hong Kong (Lew & McKercher, 2006). They then identified 78 discrete movement patterns, which they categorised into 11 movements styles (Mckercher & Lau, 2008).

Compared to inter- and intra-destination movements, the study of intra-attraction movements (e.g., in national parks, protected areas, theme parks, etc.) has been inhibited by the diversity of tourist movements (Mckercher & Lau, 2008) and the difficulties of gathering accurate location information from tourists at the micro level (Lau & McKercher, 2006). Recently, benefiting from advances in tracking technology, e.g., GPS, GIS, RFID, APPs, etc., new studies are constantly emerging. For example, Connell and Page (2008) revealed a variety of itinerary patterns at Loch Lomond and the Trossachs National Park in Scotland through a map-based questionnaire and GIS; Orellana, Bregt, Ligtenberg, and Wachowicz (2012) explored visitor movement patterns in the Dwingelderveld National Park using GPS; Smallwood, Beckley, and Moore (2012) analysed visitor movement patterns using travel networks in a large marine park and revealed that visitor movements were highly dependent on the road network.

These studies make up for the inadequacy of previous tourist movement research at the micro level; however, most of them have particularly emphasised qualitative factors affecting tourist movements. Xia et al. have explored this issue using models (Xia & Arrowsmith, 2005; Xia et al., 2009; Xia et al., 2011), broadening perspectives on tourist movements.

2.2. Movement prediction

Although a number of studies have mapped and modelled tourist movements, to date few have attempted to predict trends in tourist movements. Xia et al. (2009) analysed tourist movement data and then predicted tourist movements using Markov chains. Two years later, they proposed the semi-Markov processes that incorporate the time dimension (Xia et al., 2011). To our knowledge,