Characterizing Urban Structure Using Taxi GPS Data

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ABSTRACT

Scholars have explored urban structure from many perspectives. Developments in ICT have made it possible to discover spatial patterns in activities using big data. The identified patterns allow us to better understand urban structure. This chapter reports the collection of taxi GPS records for a single day in the inner city of Guangzhou, China. Taxi trips are connected to urban space by defining travel intensities. The spatial-temporal distribution of trips shows differences between three time periods (daytime, evening, before dawn). Different types of spatial facilities provide different activity places, the importance of which depends on their location and time of day. The study illustrates how descriptive analyses of taxi GPS data can enhance our understanding of urban space from the perspective of activities.

INTRODUCTION

Cities are spatial representations of human settlement (Hillier, 2002). The rapid pace of life makes big cities colorful and attractive; people may enjoy various lifestyles in big cities. City spaces become different as individuals’ activities are continuously changing. Personal activities need physical space as a container, while a good transportation system is a prerequisite for interpersonal communication, so as to attract more people to visit these places. People’s activities shape urban spaces (Jiang, Ferreira, & Gonzalez, 2012; Yuan, Zheng, & Xie, 2012). Social and economic activities are the basis of spatial facilities, resulting in traffic flows that that be considered as manifestations of functional linkages between subareas of cities (Bento, Cropper, Mobarak, & Vinha, 2005). Understanding people’s spatial-temporal behavior is therefore an important perspective to understand the configuration of urban space (see Lucas Jr. & Rossi-Hansberg, 2002; Wang, 2000; Garcia-López, 2012; Le Néchet, 2012; Giuliano & Small, 1993; Rofe, 1995).

It is not easy to uncover patterns of individuals’ behavior because of the large differences (social background, lifestyle, cultural differences, etc.) between people, privacy issues and limitations in data collection. However, at an aggregate level, some patterns tend to emerge when large amounts
of individual travel data can be processed. New information technology makes it possible to collect such data. Location-aware technologies (such as GPS and smart mobile phones) provide an opportunity to collect individuals’ location data (Miller, 2005). Using taxis’ GPS data is an efficient way of collecting individuals’ travel behavior data (Liu, Kang, Gao, Xiao, & Tian, 2012). It has advantage of objectivity, exact positioning, avoiding any privacy issues. The main disadvantage of using taxi data is that the recorded trips only cover part of the trips and trip patterns, and therefore of people activity-travel patterns. Still, in cities where a substantial share of trip is made by taxi, an analysis of taxi GPS data is useful in better understanding the functioning of cities.

To demonstrate this contention, this chapter describes the collection and use of taxi GPS data to identify individuals’ activities and investigate urban structure from the perspective of individual activity-travel patterns. Urban spatial structure can be described from the perspective of scale, form, network and internal organization (Anas, Arnott & Small, 1998), and measured by economy, labor, housing market, social classes, etc (Arnott, 1998; M.-A. García-López & Muñiz, 2013; Gaubatz, 1999; Greene, 1980; Gu & Shen, 2003; Sasaki, 1990; Thisse & Wildasin, 1992; Wildasin, 1985; Wu & Yeh, 1999). In this chapter, we connect taxi trips to communities, exploring travel intensities of communities to uncover the spatial structure of the city.

DATA

The study area is the inner city of Guangzhou, China (Figure 1). Guangzhou is in the process of rapid urbanization and globalization. The inner city consists of Yue Xiu, Tian He, Hai Zhu, Li Wan, Huang Pu and Bai Yun Districts. These are the main transportation areas of the city. The inner city has a population of 7.73 million inhabitants, an area of 1210.2 km$^2$, and 1337 communities. Data used in the study are taxi GPS records, collected on Monday, May, 11, 2009. The data is stored in an Oracle database, which is provided by the traffic research center of Sun Yat-sen University. Every taxi is installed with a GPS collector, which refreshes location information, jointly with time, speed, and carrying status, every 20 seconds (Table 1).

The database includes 24.4 million GPS records in total. These records contain a large...