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Research on Collective Human Mobility in Shanghai Based on Cell Phone Data

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ABSTRACT

The high-frequency mobility of a massive population has caused an enormous influence on the urban internal structure, which is unable to be described by traditional data sources. While recent advances in location-based technologies provides new opportunities for researchers to understand daily human movements and the structure as a whole. The article aims to explore human spatial movements and their aggregate distribution in Shanghai using large-scale cell phone data. The trajectory of each individual is extracted from cell phone data after data cleansing. Then, an indicator system which includes mobility intensity, mobility stability, influential range, and temporal variation is developed to describe collective human mobility features in census tracts scale. Finally, spatial elements are extracted using the indicator system and the structure of human mobility in Shanghai is discussed.

KEYWORDS

Cell Phone Data, Human Mobility, Indicator System, Shanghai, Urban Structure

INTRODUCTION

With the development of traffic information technology and acceleration of life and work rhythm, the high-frequency mobility of massive population has caused enormous influence on the urban internal structure, which has brought a new challenge to urban spatial policy. How to measure the intensity of human mobility and explain its dynamic structure is of great significance to understand the law of intra-urban dynamic structure and support real-time population management. Traditional population surveys such as national censuses are conducted every ten years, which reflect only long-term changes. While human activities often result in large-scale population movements within a short period. Such rapid and irregular changes in urban space exceed the scope of traditional census data, and thus challenge population management in recent years. How to describe, measure and evaluate collective human mobility in urban space? Does the distribution of human behavior fit into the urban spatial form? These two problems are difficult to be solved with the traditional urban structure model and static spatial analysis method.

The developing succession of the urban spatial structure is influenced not only by the external influences of the region's natural and humanistic environment but also by factors such as internal division of functions and land use. Relative researches have reached a considerable depth in the evolution and morphology of urban spatial structure with a series of empirical research by like

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Zhang (2001), Wang and Sun (2011), and Lee (2007). However, limited by the research data and methods, there is always a certain distance between macroscopic scale structure and the real human behavior. Whether our urban structure conforms to the real law of urban life, there isn't a quantitative explanation that can be generally accepted.

In the era of big data, an increasingly broad array of user-generated data like cell phone data derived from location-based services and the Global Positioning System (GPS) provides new possibilities to analyze human behavior and their spatial distribution. Mobile positioning big data have opened up the interaction between human behavior and urban spatial structure, which not only enables quantitative analysis of urban structure under greater spatial and temporal granularity, but also breaks the long-term research barrier of "interpreting space with space", revealing the spatial law behind complex form of the city from the perspective of collective human activity. Relative research has proved that the cell phone data can be used to identify these daily activities, such as commuting, traveling, and the whole space-time path (Ahas et al., 2015; Widhalm et al., 2015; Phithakkitnukoon et al., 2010; Song et al., 2010; Doyle et al., 2014). However, cell phone data still have great potential that needs to be exploited to advance human behavior studies further.

Therefore, the paper aims to explore urban spatial structure from the perspective of collective human mobility. Two-week cell phone data of 2G users in Shanghai are used. By revealing the intensity, stability, spatial influence and temporal variation of daily human mobility, we extracted spatial elements and concluded them into a spatial structure. The remainder of this paper is organized as follows. "Literature Review" gives a panorama of relevant research on the urban structure and human behavior. In the part of "Methodology", a detailed introduction to how cell phone data can be applied to urban spatial structure research is described. Section 4 illustrates the results of the case study performed, which shows collective human behavior in Shanghai. In Section 5, the paper discusses about the results and possibilities for application. The final part presents a conclusion of this article and provides insights for further research. The results can provide a reference for the formulation of urban space policy and population management strategy.

LITERATURE REVIEW

Definition of Human Mobility

In China, human mobility tends to be confused with population mobility since the Chinese household registration system makes the movements of people more complicated than other countries. Definitions in relevant researches can be divided into three types. First, "Population Migration", which is defined as movement that crosses the boundaries of certain jurisdictions, usually brings changes in household registration (Zhao, 2005). Then, "Population Movement", which is referred to the change of residence or working place within a certain period, includes short-term, long-term and permanent relocation (Zhao et al, 2013). Thirdly, "Human Flow/Mobility", which is defined as residents' locational changes in a short period, usually occurs inside the city and continuously changes over time (Wen et al., 2000; Kwan et al., 2008). The last concept is more closed to "human mobility" in this research.

Human Mobility Researches Based on Traditional Data

Spatial features of human mobility are always an essential topic in the field of population geography and urban planning. Gaining spatial-temporal information of residents' travel behavior is the basic step of these researches. Trip survey data and activity-daily-record data are the two main data sources. For example, Pan et al. (2009) and Zhang et al. (2008) used trip survey data to explore residents' travel patterns in Shanghai and Beijing. Kwan (1998) and Shaw et al. (2000) used activity-daily-record data to show specific individual travel information within the city like commuting and shopping.

Based on these two types of data, researchers focus on the description of individual travel patterns, the explanations of decision-making mechanisms, and the build of a comprehensive activity