Spatial Behavior and Healthy Aging

A GPS-based study of the older residents in Shanghai

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Abstract

The spatial behavior of elderlies is essentially the result of interactions between people and the environment. In order to explore a demand-responsive spatial intervention through new types of data from the perspective of urban planning, this study attempts to identify the differentiated trip features within the aged group, and proceed to gain a further understanding of their daily trip pattern, trip chain, and daytime activity sequence. 76 older residents from a typical public housing neighborhood in Shanghai were asked to carry an Android Phone for 102 consecutive days. By collecting and analyzing the trajectory data, we found that even in a highly consistent social and physical environment, there are still significant differences among the elderlies' daily activities, mainly existing in the age and gender aspects. The research indicates that elderlies' daily trip patterns are related to the starting point, effective interval, travel time, and the physical conditions of the individuals.

Keywords

Elderly, GPS, Spatial Behavior, Built Environment, Age, Gender, Demand-responsive, Planning intervention

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1.Introduction

The living environment is an important resource for Chinese cities to response the challenge of aging. In an ideal living environment, aged people can obtain necessary support when their physical functions gradually decline due to aging. Although there is a weakening in self-care ability and sharp decline in family care resources, the elderlies' need can be satisfied in a timely manner. The loneliness that might be caused by transformation of social roles can be appropriately eased.

In order to further implement the *Healthy and Active Aging Strategy* (WHO, 2007), an increasing number of countries and cities attach great attention to the age-oriented improvement of the built environment and explore spatial strategies to improve the community and home to a more age-friendly environment through planning and design. Planning designers and community service providers should re-examine the existing living environment from the standpoint of specific groups and think about the rigid practices of traditional planning, such as allocating service/land resources based on administrative divisions, static demographic statistics, and planning indicators. They should also explore innovative planning methods and tools. Therefore, our study attempts to explore a demand-responsive spatial intervention through new types of data from the perspective of urban planning and public services.

The built environment in urban-rural areas in China have a relatively weak foundation for building age-friendly facilities(Yu et Tian, 2019). The planning practices, corresponding policies, and technological innovations fall behind the rapidly growing demand for elderly services. Firstly, the practices carried out in

various places mainly focus on addressing the shortage of elderly care institutions. There is also a lack of attention to the construction of public living environments which are suitable for the elderly. Secondly, the aged population is a group that has great differences within, such as the different stages of aging, the gender, and the condition of the living environment. Since these differences are hard to discover through general statistics, it is difficult to achieve policies for a refined spatial governance that is based on specific conditions using traditional planning methods. To achieve the development goals of improving residents' quality of life and to promote healthy and active ageing, we should pay more attention to the spatio-temporal behavior of the older residents, as well as their trip pattern and decision-making mechanism.

2. Data collection

2.1 Equipment and application

Under the premise of available backstage data, we chose Redmi Smartphones, which are supported by the Android system. The GPS+A-GPS location function allow us to record samples' trajectory, obtain the longitude and latitude coordinates of measured objects in real time.

The project independently developed the "Community Residents' Behavior Monitoring Software V1.0" (software copyright obtained from the National Copyright Administration of the People's Republic of China: 201610014870.3) to receive GPS satellite location information and acquire location data. The functional modules of the software include: a) GPS data acquisition and storage module which we use to record and store location data; b) The uploading the stored GPS location data to the server.

2.2 Site and samples

TJ neighborhood is a typical public housing community, which adopted the standardized housing design and community planning system (Figure 1). This type of neighborhood was built in large quantities across China from the 1950s to 1980s, laying a foundation for the applicability of findings. In addition, these houses were mostly distributed to residents by their institutions (单位) as a welfare. Since the residents' degree of ageing has been increasing over half a decade, the public houses will become the main objects of the age-friendly transformation project of urban communities in China. The percentage of ageing in TJ neighborhood is 38%, which means that more than one third of the community's residents have either reached or surpassed the age of 60.

Figure 1 Aerial view of TJ neighborhood

The project team organized publicity activities with Neighborhood Committees and building leaders to recruit volunteers in different building. By doing this, it not only helped to enhanced the participation enthusiasm of residents, but more importantly, it could ensure that the research samples were evenly distributed in the different locations in the neighborhood (Figure 2). We eventually invited 80 volunteers (55 +) using stratified random sampling approach. The reason for counting from the age of 55 is that it is the retirement age for most Chinese. During the study, 4 volunteers quit or stopped for different reasons. So the complete data of the project was obtained from 76 volunteers (mean age=70.1, SD=7.7)(Figure 3). It should be noted that according to the research question, this study doesn't involve elderlies who are in need of counselling or nursing services.

Figure 2 Study site and spatial distribution of participants

Figure 3 Age and gender structure of sample population

2.3 Data collection

The older residents participating in this study were asked to carry an Android Phone from September 18th to December 28th, 2015. The sampling rate of the GPS loggers was three seconds a point and the positioning accuracy was four meters. In a dataset, a GPS trajectory is a sequence of GPS points, where Lng, Lat and Time represents the longitude, latitude and timestamp. The data generated by the Redmi smartphones we mentioned before is uploaded to the PostgreSQL database via Internet real time, which would be recorded and classified by the system that works backstage. We established a personal information file for each participating volunteer, including personal information, information from the survey taken before and after the research, and related information of corresponding equipment. Also, the denoising and compression of trajectory data were completed at the data pre-processing stage combined with multi-source data (such as POI data and auxiliary geographic data). As of the end of the study, the preliminary dataset contained over 37.2 million GPS points collected by 76 volunteers in a period of 102 days. Apart from the data we acquired from the volunteers, we obtained POI dataset from Gaode Map (a Chinese web mapping service), and road datasets from Open Street Map (OSM).

3. Findings

3.1 Trip characteristics

Among all the travel methods we normally use, the elderlies mainly choose to walk, and only a small proportion choose to travel by motor vehicles, non-motor vehicles, or a combination of both and walking. As a person gets older, the possibility of them choosing mixed travel methods increases too, which confirms the fact that a person's physical strength decreases as they get older. Based on our study, we found that men in different age groups tend to choose to walk more often than women, and the number of women choosing mixed travel is significantly higher than men.

Figure 4 Trip frequency per capita by age and gender

According to the total walking trajectory data of the 76 participants during the entire study period, we have obtained the trip frequency after the standardization of the sample numbers within the group. It is found that the elderlies' trip frequency shows a declining trend as they get older. Among the age group of 55-74, the per capita trip frequency of men are higher than that of women. However, in the age group 75 and above, the per capita trip frequency of the elderly male is similar to that of the elderly female. (Figure 4)

In addition, different starting points for travel time are found in different age groups. Specifically, younger elderly tend to head out earlier than the older elderly. (Figure 5)

Figure 5 Travel time characteristics by age group

3.2 Travel range

We studied the age group of volunteers with travel range, and found that the age group 75-84 has the biggest walking range, followed by the age group 65-74. Both groups greatly exceeded the age group 55-64. Obviously, this result does not match the common knowledge that the range of activities is inversely proportional to age increase. Through the interpretation of the survey information, we might get a possible explanation - some young-olders are still working on the campus, whose daily travel pattern showed the characteristics of pendulum. Also, it is quite common for younger elderly people to take care of their grandchildren. Therefore, their daily travel range becomes more limited. Consistent with the general inference, people who are 85 years or older have the minimum travel range. (Figure 6)

Figure 6 Travel range by age

3.3 Trip Chain

Trip Chain refers to the whole process of people organizing their travel base on time and space for completing one or more activities. The information in the trip chain includes space, time, methods and purposes. It creates a link between different travels as well as between travel and activities. It does not only have the potential to reveal the travel decision-making mechanism, but also directly affect the travel demand forecast and the spatial allocation of POIs. By identifying the length of the trip chain, the number

of stops, and the complexity of activities, people can better understand how the space structure and amenities layout in the built environment affect the elderlies' daily activity pattern. We used the data of a single travel trajectory of the elderlies to collect the high-frequency GPS information from the starting point to the ending point. It is found that the daily needs and lifestyles of individuals have a significant impact on the formation of the trip chain. In this study, some elderly people made over ten stops on their travel chains (Figure 7).

Figure 7 Length of the trip chain and its occurrence frequency of the elderly in the sample

x axis: Number of trip chain destinations; y axis: Length of the trip chain for a single trip

We divided the trip chains into the single-purpose trips and multi-purpose trips, according to the number of stopping points during the trip. By comparing the number of trip chains of single-purpose and multi-purpose trips, it's found that single-purpose trips account for more than 50% of all trip chains. The older-elderly is the main age group in the single purpose travel population.

4. Discussion

The lifestyle of elderlies, especially their behaviors and concepts, are formed during the interaction with the physical and social environment. This interaction presents a human's needs and values (Hägerstrand, 1970). It also serves as a medium for people to intervene, understand, and transform the environment. People can find improvements and strategies through identifying the contradiction between a human and his/her environment (Kwan MP, Weber J., 2008).

(1) Deepening of understandings

Under the condition of high-density human settlement as in Shanghai, the surrounding environment of the communities provides places to fulfil most of the elderlies' needs, such as shopping, transportation, leisure, fitness, and so on. However, there are always barriers that prevent people from getting healthy activities in the neighborhood. The existence of these constraints may be attributable to the ignorance of the activity needs of specific groups or the misjudgment on activity patterns and behavior characteristics. This study uses the data generated by smart devices to reproduce the behavior model and decision-making process of individuals and groups in a truthful and three-dimensional way. It helps to reveal the structural relationship between spatial behavior and behavioral space under high-density living environment conditions.

Results also show that even under the highly consistent social and environmental conditions, there are still significant differences among the elderlies' daily life activities, mainly existing in the age and gender aspects. This indicates that the age-friendly construction and renewal of the built environment should pay attention to the similarities and differences of the elderly people, as well as the applicability and safety of environmental facilities.

(2) Methods implications

By presenting the internal space structure and people's behaviors intuitively, we can carry out recognizable features and patterns of massive data, such as the visualization of spatial elements. For traditional methods of describing human behavior based on two-dimensional maps, it's a huge leap forward. The geographic information system (GIS) expands spatial knowledge from geographical concepts, such as location and distance, to structural relationships, such as proximity, aggregation, and isolation. The GPS trajectory data creates potential conditions for exploring the formation process of these structural relationships (Kleinberg, 2000; Zenk S. et al., 2018). Through understanding the process, we tried to explain why and how spatial behavior occurs, as well as to explore the measurement model and innovative algorithm for the spatial-behavioral interaction mechanism.

By exploring the patterns, we can simulate various possibilities of daily activities in a specific environment. In addition to time and space limits, relative analysis should also consider the influencing factors such as the rationality of travel range and trip chain. It should be noted that the simulation of adding human factors to activity sequences is much more elaborate and complex than previous spatial analysis methods. The range of travel, activity patterns, activity types, spatial preference, and travel decision which are revealed in this study all play a great role in simulation and prediction for future environment planning and intervention. These information are useful references when optimizing resource allocation, planning age-friendly environment, and promoting elderlies' health behavior.

(3) Planning suggestions

In this study, we explore how the elderly use different sites and amenities inside and outside the neighborhood, how they choose and respond to environment, and how they arrange the activities accordingly. Based on these findings, we can better evaluate and discover the policies and measures that can improve the age-friendly performance of the built environment.

The daily activities of elderly residents constitute a dynamic social and behavioral space superimposed on the substantial space. They do not only reflect the structural characteristics of built environment, but also show many important topics, for instance the daily activity space, Spatio-temporal utilization restriction, service accessibility, and social exclusion. They can be used as the practice guide for the action, as well as the empirical basis for carrying out simulations and predictions. The contributions it can make are but not limited to:

- a) Evaluate the allocation of public resources based on voting with the feet;
- b) Provide a new measurement method for individual study based on the refined Spatio-temporal data;
- c) Change static substantial space planning into dynamic life space planning, and guide the community planning to pay more attention on the health-oriented needs.

Spatial behavior is the result of choices made by the behavior subject in the built environment. The study on Spatio-temporal behavior does not only offer a scientific basis for urban planning and social governance, but also feeds back the knowledge and information to residents. The study could be expended to provide personalized services for residents and assists senior residents, for example the personalized information release service, the personal decision-making support services, and the activity guidance.

5. Conclusion

The study proposes to build a multi-functional neighborhood which could satisfy elderlies' needs for their healthy life. It also suggest understanding the built environment through different types of activities, the duration of stays, and the scatter of destinations, instead of through the types of construction land and the facility allocation from the traditional planning. The characteristics and patterns of the elderlies' daily activity trajectory, sequence, and their allocation of time are important dimensions to evaluate the applicability of the built environment, the performance of the amenities. The conclusions drawn from analysis on specific built environments, as well as the sequence and mechanisms obtained after in-depth summary can also provide important evidence for measuring and putting forward policies of the built

environment.

Different from the perspectives when conducting research on the economy, society, and management, the behavior-based study emphasizes the understanding of behavioral selection and restriction process of individuals at the non-aggregate level. This is conducive for the study to reveal the process and mechanisms of interactions between individuals and the built environment.

6. References

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