Evaluation and Improvement Strategies for Slow Traffic Systems Based on Multi-source Big Data: A Case Study of Shijingshan District of Beijing City

LI Yiwen
(North China University of Technology, Beijing 100144, China)

Abstract The slow traffic system is an important component of urban transportation, and the prerequisite and necessary condition for Beijing to continue promoting "green priority" are establishing a good urban slow traffic system. Shijingshan District of Beijing City is taken as a research object. By analyzing and processing population distribution data, POI data, and shared bicycle data, the shortcomings and deficiencies of the current slow traffic system in Shijingshan District are explored, and corresponding solutions are proposed, in order to provide new ideas and methods for future urban planning from the perspective of data.

Keywords Multi-source data, Slow traffic system, Shijingshan District
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In order to deeply implement the development concept of "slow traffic priority, public transportation priority, and green priority", Beijing released the 2023 *Quality Improvement Action Plan of Beijing Urban Slow Traffic System* in May 2023. The *Work Plan* has identified 24 key work tasks, continuously promoting the development of the urban slow traffic system, continuously improving the quality of slow traffic travel, encouraging and supporting citizens to more adopt "walking+cycling" travel methods, and improving their sense of achievement in slow traffic travel[1].

1 Research meaning

Slow traffic generally refers to transportation that is carried out manually, such as walking or cycling, with a travel speed of 5-15 km/h. As a short-distance travel method, slow traffic has positive effects such as low energy consumption, no pollution, alleviating motor vehicle traffic congestion, and improving the urban appearance. In the actual operation process of the city, slow traffic can directly reach the interior of the community, covering the "last kilometer" of urban transportation. The construction of slow traffic network affects the demand for humanization in the city, making the urban environment more livable, urban transportation smoother, and urban life healthier.

Against the backdrop of the rapid development of big data, it has become a more innovative and scientific research method by using big data for urban planning. The problems existing in the city can be more intuitively expressed, thereby strengthening the planning and governance capabilities of urban workers to the city. At present, the widely used data types in urban planning include: mobile signaling data, GPS data, check-in data, POI data, and public transportation IC card swiping data[2]. It is mostly research on single source data and lack integrated research of multiple source data. This paper explores the safety of slow traffic and its connection with public transportation by obtaining parking data, shared bicycle location data, population distribution data, and traffic station data, in order to compare with existing slow traffic system and identify issues.

2 Current situation of slow traffic system in Shijingshan District

The urban green coverage rate of Shijingshan is 47.09%, and the per capita area of public green space has reached 73.89 m^2, ranking first in the urban area of Beijing. Shijingshan is the area with the highest green coverage rate and the highest per capita ownership of public green space in the urban area of Beijing. Large areas of urban green space should be organically combined with slow traffic system to improve the overall accessibility and organicity of urban transportation system, making urban transportation more reasonable and efficient.

At present, sidewalks in Shijingshan District account for 21% of the total roads, but the overall separation facilities between motor vehicles and non motorized vehicles are not perfect. There are still significant problems in the current situation, such as a high proportion of on-road parking on the road, 20% of the total parking lots on the roadside, and a large number of road intersections without improved channelization measures. The connection between slow traffic system and bus stops has problems such as long distance, poor environment, and outdated connection facilities.

3 Acquisition and processing of multi-source big data

3.1 Data acquisition

① Shared bicycle data. Based on the possibility of obtaining data, the location data of shared bicycles in Shijingshan District of Beijing is selected. ② Population data. According to the Bulletin of the Seventh National Population Census in Shijingshan District of Beijing, the number of permanent residents in each street of Shijingshan District is obtained, and the area of each street is obtained based on the 2022 Beijing Shijingshan Statistical Yearbook to obtain the population density of each street. ③ POI data. The main types of POI data required for analysis are transportation spatial distribution data, including distribution data of bus stops, subway stations, parking lots, etc.

3.2 Data processing

Based on the preliminary data obtained, 202 items of bus stop data, 128,129 items of shared bicycle location data, and 532 items of parking lot distribution data are selected and imported into ArcGIS for research. The data uniformly

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uses the WGS84 coordinate system. The data analysis method mainly adopts the nuclear density analysis method, and the nuclear density calculation formula is as follows:

$$Density = \frac{1}{(radius)^2}\sum_{i=1}^{n}\left[\frac{3}{\pi}\cdot pop_i\left(1-\left(\frac{dist_i}{radius}\right)^2\right)^2\right]$$
$$For\ dist_i < radius$$

where $i = 1, 2, \cdots, n$ and is input point. If they are within the radius distance of position (x, y), only the points in the sum are included. pop_i is population field value at point i and an optional parameter. $dist_i$ is the distance between point i and (x, y).

4 Current problems of slow traffic system

4.1 Slow traffic safety issues

The safety hazards of non motor vehicles mainly come from conflicts with motor vehicles. Therefore, the rationality of isolation measures between motor vehicles and non motor vehicles is a direct condition that affects the safe driving of non motor vehicles in the design of slow traffic system[3]. Using ArcGIS to perform nuclear density analysis on the on-road parking lots in crawl data, the spatial distribution of on-road parking could be obtained (Fig.1).

It can be concluded that the density of parking lots on the roads of Babaoshan Street and Lugu Street is the highest, reaching about 20 parking spaces/km^2, and the actual number of parking spaces is likely to be greater than the collected data itself. Due to the actual situation of Babaoshan Street and Lugu Street, most of the parking spaces on the road are arranged on narrow side roads with mixed traffic of motor and non motorized vehicles. This phenomenon makes the already narrow slow traffic space even more crowded, further expanding the conflict between motor and non motorized vehicles. Due to the competition for space between on-road parking lots and slow traffic system, pedestrians and bicycles have no right of way, which directly leads to a decrease in the safety and accessibility of slow traffic.

4.2 Connection issues between slow traffic and bus

According to the local standard *Regulations for the Setting of Non-motorized Vehicle Parking Facilities* in Beijing, the non motorized vehicle parking facilities in rail transit stations should be set up separately in conjunction with the entrances and exits. It is advisable to utilize the roadside and outer partition spaces on both sides of the entrances and exits, as well as the space behind the entrances and exits, and the connecting distance should be less than or equal to 100 m. 80 m of service radius is taken as the buffer zone of parking lot, and bus stops outside the buffer zone are selected, and 137 bus stops that do not meet the service radius are obtained. By conducting nuclear density analysis on these bus stops (Fig.2), it can be seen that the density of unreasonable bus stops on Jindingjie Street, Pingguoyuan Street, and Lugu Street in Shijingshan District is relatively high. The connection distance between the slow traffic system and the bus station is too far, and passengers need to walk a long distance to reach the public transportation they want to transfer to during the connection process. If the walking distance is too long, it will increase the pressure on the station and transfer efficiency, causing traffic congestion, which is not conducive to improving travel efficiency and also causing safety issues for passengers' travel. For special passengers such as those carrying luggage and those who are elderly, weak, sick, or disabled, long shuttle distance can also bring more burden and trouble[4].

5 Optimization strategy for slow traffic system

5.1 Security optimization strategy for slow traffic system

5.1.1 Related strategies of non motor vehicle.

(1) On secondary roads with larger road width and better road conditions, such as Lugu Street, Shixing Street, Lugu Road, etc., hard isolation measures are adopted to spatially eliminate safety issues caused by speed differences between motor vehicles and non motor vehicles.

(2) For roads with narrow road width that are difficult to adopt hard isolation measures, such as Bajiao South Road, Yuquan South Road, Jingyang Street, etc., strict control should be implemented to strictly control the number of parking spaces on the road, and the parking spaces on the road should be arranged only on one side of the road as much as possible to avoid the presence of parking spaces in different directions on the same section of the road. The parking spaces should be arranged as discontinuous as possible and not too close to the intersection.

(3) For road sections that can be designed in conjunction with urban green space systems, such as Jingyuan Road, according to cognitive theory in environmental psychology, after people develop awareness of the boundaries of the road, they unconsciously regulate themselves within the boundaries when entering again[5]. Different materials and colors could be used to significantly distinguish non motorized lanes from motorized lanes, help travelers to psychologically differentiate space, and improve the accessibility and continuity of the slow traffic system.

5.1.2 Related strategies of pedestrian system. Starting from the standardization of street crossing facilities, the road grade, purpose, and pedestrian flow are estimated. For roads mainly composed of motor vehicles with low pedestrian traffic flow, safety islands can be set up to improve the safety of slow traffic[6]. Some roads, such as residential main roads, have both transportation functions and the daily needs of residents, and pedestrian traffic volume is large. These roads can adopt the form of overpasses and be equipped with accessible facilities to ensure the passage of special populations. For roads dominated by slow traffic, it is recommended to adjust the proportion of traffic light time while meeting the requirements of motor vehicle traffic, giving pedestrians more time to cross the street. Moreover, wider roads with higher pedestrian flow should be equipped with crossing warning devices to increase the vigilance of vehicles and pedestrians when crossing the street.

5.2 Optimization strategies for transfer between slow traffic and bus

From the population density of each street in Shijingshan District, the population density of Bajiao Street, Babaoshan Street, and Lugu Street has reached over 10,000 persons/km^2; next are Jindingjie Street, Pingguoyuan Street, and Laoshan Street, and population density in Gucheng Street, Guangning Street, and Wulituo Street is lower (Table 1). From the distribution data of shared bicycles (Fig.3−4), it can be seen that the density of Laoshan Street, Bajiao Street, and Lugu Street is relatively high.

By utilizing population density and shared bicycle density, the demand for public transportation transfer is classified into three levels: high, medium, and low. Among them, high-

demand streets include Bajiao Street, Lugu Street, Babaoshan Street, and Laoshan Street; medium-demand streets include Gucheng Street, Pingguoyuan Street, and Laoshan Street, and low-demand streets include Guangning Street and Wulituo Street. Non motorized vehicle parking spaces in high-demand streets should reach a coverage rate of 100% at 80 m; non motorized vehicle parking spaces in medium-demand streets should reach a coverage rate of 70% with a service radius of 80 m, and the maximum does not exceed 100 m; non motorized vehicle parking spaces in low-demand streets should reach a coverage rate of 80% with a service radius of 100 m[7].

Table 1 Land area and permanent population of each street in Shijingshan District

region	Land area//km^2	Population	Population density//persons/km^2
Whole region	85.74	567,851	6,623
Babaoshan Street	4.32	61,211	14,169
Laoshan Street	6.10	40,023	6,561
Bajiao Street	6.30	110,929	17,608
Gucheng Street	15.41	67,685	4,392
Pingguoyuan Street	13.13	97,543	7,429
Jindingjie Street	7.30	67,734	9,279
Guangning Street	6.11	14,684	2,403
Wulituo Street	21.50	41,249	1,919
Lugu Street	5.57	66,794	11,992

6 Conclusions

The rapid development of multi-source big data provides strong theoretical support for urban planning research[8]. The research work in the early stages of preparation, analysis and research during the preparation process, and management work after implementation can all be carried out more effectively and scientifically using big data. However, urban transportation planning is more suitable for research using big

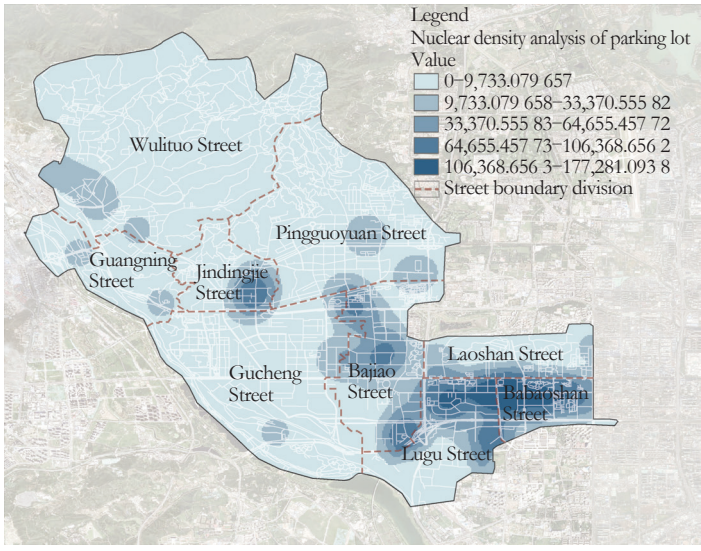

Fig.1 Nuclear density of on-road parking lots

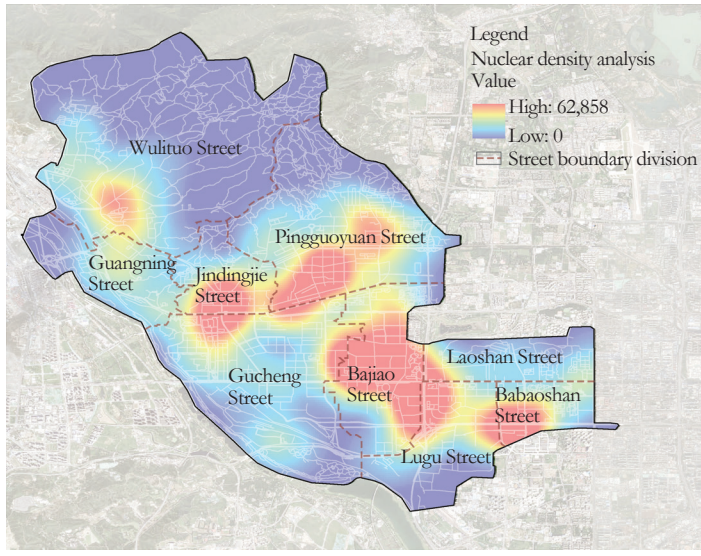

Fig.2 Nuclear density of unreasonable bus stops

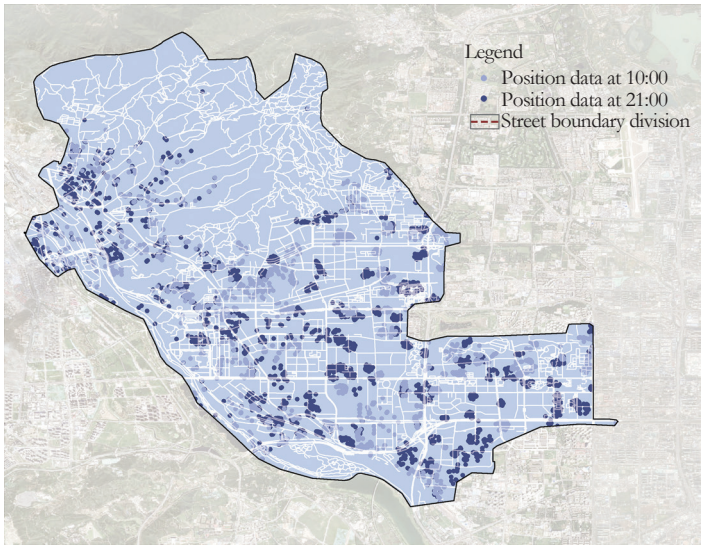

Fig.3 Location of shared bicycles in Shijingshan District

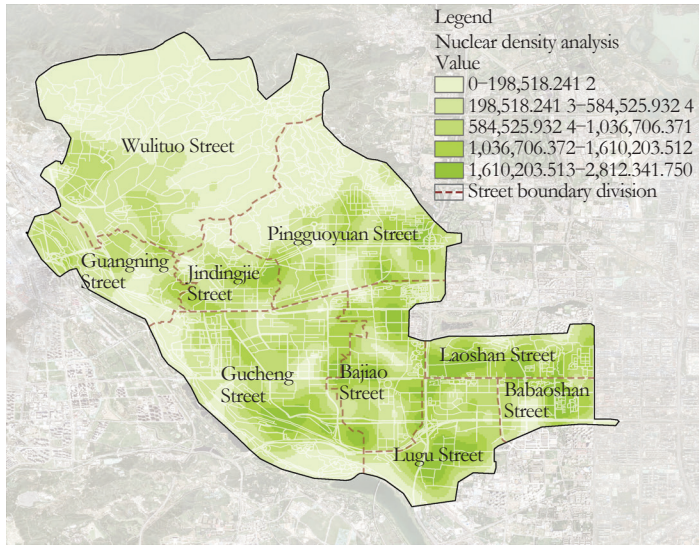

Fig.4 Nuclear density of shared bicycles distribution in Shijingshan District

(To be continued in P68)

Agricultural cultural heritage projects should be established in key research plans, and it should encourage interdisciplinary and multi-dimensional integration of research, and form long-term research mechanisms through platforms such as workstations and cultural centers. At the same time, it is also necessary to actively integrate with the achievements of the world agricultural cultural heritage, actively build a world cultural heritage community, and enhance China's influence in the field of world agricultural cultural heritage. Demonstration zones for the protection and development of agricultural cultural heritage should be developed in areas with good development levels, to exchange experiences in protection and development. Scientific and systematic education should be conducted for grassroots management personnel and practitioners to improve their professional skills and management abilities.

5 Conclusions

Agricultural cultural heritage, as a product of social development and a carrier of civilization inheritance, occupies an important position in the long history of China. Today, with the rapid development of modern agriculture, retaining the imprints of these times and preserving the memories of these times make the protection and development of agricultural cultural heritage particularly important. The protection and development of agricultural cultural heritage is not the work of any individual or government. It requires everyone to actively make their own contributions and the attention of society.

In the current protection and development of agricultural cultural heritage, there are many problems such as imbalanced development, insufficient funds, and talent shortage, which hinder the protection and development process of agricultural cultural heritage. These problems put forward higher requirements, and it requires more efforts to face these challenges. People are required to actively explore the disciplinary system and protection and development models of agricultural cultural heritage protection in the process of continuous exploration. It is worth noting that it should always adhere to promotion in the essence of agricultural cultural heritage when guarding innovation, and always prioritize protection in the process of protection and development.

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(Continued from P64)

data due to its high demand for data[9]. Multi-source data is used to study the current situation of slow traffic system in urban areas, and corresponding solutions are proposed, further proving the feasibility and effectiveness of using multi-source data analysis methods. It could provide suggestions for planning and improve the level of planning services.

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