

Spatial and Temporal Distribution Characteristics of Street Vitality based on Baidu Heatmap: Taking Wenjiang District of Chengdu City as an Example

Chenlin Yuan¹, Zhihui Jing^{2,*}, Tingting Su²

¹ College of Economics of Sichuan Agricultural University, Chengdu, Sichuan, China

² College of Resources of Sichuan Agricultural University, Chengdu, Sichuan, China

*Corresponding Author.

Abstract: Street vitality has long been a topic of concern in urban planning theory and practice, and it is important to study the spatial and temporal distribution characteristics of street vitality in the region for urban renewal and development. Using the Baidu Heatmap and taking Wenjiang District of Chengdu City as an example, we analyze the crowd gathering degree of each street at different time periods during weekdays and rest days with the help of ArcGIS software, quantitatively evaluate the current street vibrancy levels of Wenjiang District, identify the high vibrancy streets, and put forward suggestions for the regional development of each dynamic street. The results show that the medium and high vitality streets on weekdays and rest days are mainly Liutai Avenue East and Haike Road East, while the low vitality streets are mainly Ecological Avenue Guanwen Road and Wenyu Road. The factors affecting the vitality of the street are closely related to whether the surrounding traffic is convenient and whether the facilities are perfect. Based on the crowd data provided by Baidu's heat map, it clearly reflects the information of crowd gathering and the situation of space being used in any street space at any time, which can replace the traditional method of crowd data statistics.

Keywords: Baidu Heatmap; Street Vitality; Spatiotemporal Distribution; Urban Planning; Regional Development

1. Introduction

The current society is one of rapid development, advanced technology, and widespread information exchange. Big data is

a product of this high-tech era. With the increased attention on big data from society, it has been widely applied, its advantages gradually revealed, and its areas of influence expanded. In the era of big data, the development of cities has become particularly important, and the development of urban areas directly affects the overall development of the city. As the basic components of the urban system, streets not only bear the function of passage but also serve as carriers of people's daily lives and are an important source of the city's vitality [1]. The vitality of streets is one of the important factors affecting urban renewal and protection [2,3].

Most foreign studies on urban development are based on the vitality characteristics of streets: Jacobs pointed out that short lengths, high population density, and a mix of functions and architectural ages are the characteristics of vibrant streets [4]. Katz believes that factors affecting street vitality include compactness, scale, function, and building density [5]. Montgomery mentioned that fine texture, reasonable scale, mixed functions, and street connectivity are the characteristics of good street vitality [6]. Jan Gehl concluded in "Life Between Buildings" that factors influencing street vitality include diverse functions, slow traffic systems, and developed spaces [7]. However, there are almost no foreign studies using Baidu Heatmap to analyze street vitality. Domestic scholars have conducted research on the characteristics and influencing factors of street vitality through evaluation indicators or big data. Using Baidu Heatmap, studies and analyses have been conducted on the distribution characteristics of the population, the degree of aggregation, the vitality of urban streets, spatial structure, urban job-housing balance, and more in various cities across the

country. He Yulin pointed out that Baidu Heatmap can assist in forming a diversified and multifunctional urban spatial structure [8]. Mr. Wu Zhiqiang studied the spatial structure of the central city of Shanghai based on the heat map, and believed that the utilization of the urban space can be seen by using the dynamic visualization form of the heat map [9]. Mr. Wang Licang also analyzed the agglomeration degree and distribution of the number of people in the main urban area of Wuhan and believed that the agglomeration degree of people will also change with the change of time [10]. Domestic scholars have laid a solid foundation for Baidu Heatmap in the research of urban planning. Compared with the vitality and development status of a city from the street scale, compared with the large and medium-scale urban research, it takes a more micro perspective to examine people's living space, which has a stronger practical significance [11].

Therefore, this study, based on Baidu Heatmap, analyzes the current street vitality levels of Wenjiang District from both temporal and spatial dimensions. On the one hand, it can dynamically analyze the characteristics of changes in street vitality within Wenjiang District, and on the other hand, it can provide reference for the vitality, development, renewal, and protection of Wenjiang District.

2. Regional Overview of Wenjiang District

The Wenjiang District has simple landforms and topography, located in a plain area with very fertile soil. Within the Wenjiang area, there are numerous water resources from river systems; the Jinma River, Qingshui River, Jiang'an River, and Yangliu River are the four major rivers that run through Wenjiang, along with many tributaries. In addition, due to the water quality, soil, and climate, the growth of flowers and trees is very suitable in the Wenjiang area. These well-grown flowers and trees have brought about the unique Sichuan-style bonsai, making Wenjiang the largest production and trading center for Sichuan-style bonsai.

Wenjiang District, north latitude 30°36' -30°52', east longitude 103°41' -103°55', is surrounded by Qingyang District, Shuangliu District, Chongzhou City, and the southeast and northwest of Pidu District. With a total area of 277 square kilometers, the Wenjiang

area is roughly shaped like a broom.

3. Data source and data processing

3.1 Data Source

The crowd data provided by Baidu Heatmap can replace traditional methods of crowd data statistics. It not only speeds up the statistical process but also compensates for the lack of dynamism in traditional statistical methods. Since Baidu Heatmap is based on data records left by users of Baidu Maps, these are traces left unconsciously by users. The participation of these unconscious public crowds increases the accuracy of research on street vitality and provides more authoritative suggestions and strategies for the subsequent development and construction of urban areas. Because the data of Baidu Heatmap is represented based on users of Baidu Maps and cannot replace population data, the research focuses more on the degree and distribution of crowd gathering on streets from different perspectives, and then analyzes the spatiotemporal characteristics of street vitality changes.

Baidu Heatmap is to show the location of users in the form of different colors, for different location interface, will be distinguished by different colors [12]. Different colors represent different representatives. If the Baidu Heatmap is shown in red in a certain area, it indicates that the population flow in this area is large, and the concentration degree is high. If it is shown in blue, it is vice versa.

The data is from the heatmap feature of Baidu Maps. Using this feature, it is possible to capture images of the entire area at different points in time. The data is time-sensitive, with updates occurring every 15 minutes. Therefore, in this study, images are captured at intervals of every two hours. Due to the large volume of collected data and its certain similarity and periodicity, only the most characteristic and representative time periods are selected. Specifically, Sunday and Monday are chosen to represent weekends and weekdays, respectively. Images are captured every two hours from 6:00 to 24:00 on both weekends and weekdays. A total of 20 Baidu Heatmaps are captured, which serve as important data for subsequent visual analysis.

3.2 Data Processing

3.2.1 Baidu maps Heatmap Capture and Compilation

Captured screenshots of Baidu Heatmaps of the study area are organized chronologically and spatially. ArcGIS software is utilized for projection and geographic registration [13]. Organize and perform basic visual analysis on the collected Baidu Heatmap data for Sundays and Mondays, representing weekends and weekdays respectively. Classify the heatmap values into 1-9 levels based on attribute characteristics. Simultaneously, categorize the concentration of people, with the highest level being 9 indicating the highest concentration, and the lowest level being 1.

3.2.2 Mask Extraction using ArcGIS

On the basis of the above, further spatial visualization analysis was made. Using the mask extraction function of ArcGIS, the heatmap was extracted from the road buffer zone to generate the street heatmap and classified the street into levels 1-9. The darker the color, the higher the degree of crowd concentration, the greater the thermal value. The street with thermal value of 7-9 is defined as high vitality street, the street with thermal value of 4-6 is defined as medium vitality street, and the street with thermal value of 1-3 is defined as low vitality street.

3.2.3 Calculate the spatiotemporal-varying feature values of street vitality

Based on the aforementioned processing and analysis, further examine the spatiotemporal characteristics of street vitality, as well as the temporal variations of streets of different levels [14]. This involves computing the relative proportions of spatial clustering for each street level, which represents the relative proportions of highly active, moderately active, and low-activity streets among all streets at each time point. This analysis captures the spatiotemporal dynamics of street vitality. A higher relative proportion indicates greater vitality for the street.

Vitality characteristics of streets at different levels:

$$X_1 = H_i/T, X_2 = M_i/T, X_3 = L_i/T \quad (1)$$

Where x_1 , x_2 , x_3 respectively represent the vitality characteristic values of high, medium, and low-level streets, represents the spatial clustering quantity of high-vitality streets at time point i , represents the spatial clustering

quantity of medium-vitality streets at time point i , represents the spatial clustering quantity of low-vitality streets at time point i , which $i = 6:00, 8:00, \dots, 24:00$, T represents the number of all streets.

3.2.4 Superimposed and comparative analysis

In order to accurately correlate the vitality of streets with specific locations within the area, a comparative analysis is conducted by overlaying regional maps, street heatmaps, and prominent features such as major roads, landmarks, and rivers. This process associates street vitality with the spatial distribution within the area, ultimately providing insights into the distribution of streets of various vitality levels within the region. By analyzing the surrounding facilities, environment, transportation, and other factors of streets with different vitality levels, important factors influencing street vitality can be identified.

4. Results and Analysis

4.1 Street status of Wenjiang District

Streets are the most important part of a city, and the vitality of the streets can fully show the vitality of the city. By analyzing the street space through urban spatial architecture, the current situation of urban streets can be analyzed, and the vitality of streets can be further analyzed, so as to provide a prerequisite for the optimization of urban spatial structure and urban public service facilities. Current analysis of the study area presents the following problems:

1. Due to the promotion of urbanization, the lifestyles of different groups are differentiated and diversified, leading to some differences in the vitality level of the streets in the region.

2. At present, there is unbalanced development of urban streets, the distribution of high vitality streets is concentrated, and the distribution of medium and low vitality streets is scattered.

3. At present, the functions of urban streets are chaotic, and there are many functional types in the high vitality streets, so that the streets with high vitality streets are more and more dynamic, while the functional types in the low vitality streets are too single, resulting in the streets with low vitality are still in a state of low vitality.

4.2 The Spatiotemporal Variation Characteristics of Street Vitality

Based on the data of heat map, it is found that the change of agglomeration degree in Wenjiang District changes significantly with the passage of time. In order to intuitively represent the dynamic changes of the dynamic streets of each level in different times during rest days and working days, the agglomeration degree and change characteristics of the population in space will be displayed in the form of charts, so as to reflect the dynamic changes of the street vitality.

4.2.1 The spatiotemporal variation characteristics of street vitality in Wenjiang District on weekends

The variation of street vitality in Wenjiang District on weekends can be observed from the above figure (Figure 1). At each time point, the streets in Wenjiang District exhibit different vitality characteristics, and the proportion of each vitality level street also changes over time.

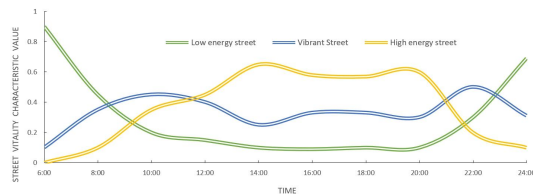


Figure 1. Map of Wenjiang District on March 20, 2022 (Sunday)

Among them, high-vitality streets are significantly more numerous than medium-vitality and low-vitality streets, and the time is concentrated from 12:00 to 20:00, indicating that the streets in Wenjiang District are more lively on weekends, and people's gathering intensity is relatively high. Each level of street vitality exhibits some fluctuations: from 6:00 to 10:00, the vitality of low-vitality streets continues to decrease, while both medium-vitality and high-vitality streets show a clear upward trend; from 10:00 to 14:00, the vitality of high-vitality streets continues to rise, reaching its peak during weekends. In contrast, the vitality of medium-vitality streets suddenly declines, and the vitality of low-vitality streets also continues to decrease. From 14:00 to 16:00, there is a slight decrease in the vitality of high-vitality streets, while the vitality of medium-vitality streets shows an increasing trend. From 16:00 to 20:00, streets of all three

levels show a relatively stable trend, indicating that the vitality of streets and the concentration of people in Wenjiang District are most stable during this time period. From 20:00 to 22:00, high-vitality streets begin to decline, while medium- and low-vitality streets begin to gradually rise. From 22:00 to 24:00, the vitality of high- and medium-vitality streets starts to decline, while the vitality of low-vitality streets experiences a significant increase.

In summary, on weekends, the concentration of the active population in Wenjiang District remains relatively stable. Low-vitality streets exhibit a "U"-shaped variation, while high-vitality streets show an inverted "U" shape. The peak of population aggregation is mainly around 14:00. It is inferred that during the daytime, people may transition from indoor activities at home to outdoor activities, leading to an increase in the number of people on the streets. This continues until the arrival of the evening at 20:00 when the vitality of high-vitality streets gradually begins to decline, persisting until midnight. After 22:00, the vitality of high- and medium-vitality streets begins to decline, while the vitality of low-vitality streets starts to rise, indicating that people are returning home to rest, and the spatial aggregation on the streets begins to decrease.

4.2.2 The characteristics of street vitality changes in Wenjiang District on workdays

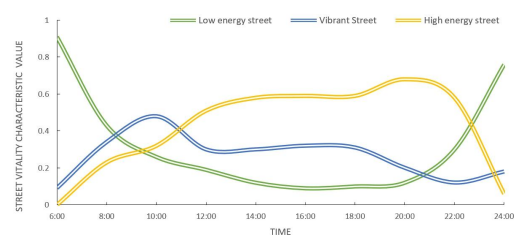


Figure 2. Map of Wenjiang District on March 21, 2022 (Monday)

From the above graph (Figure 2), it can be observed that on workdays, the overall vitality changes of streets in Wenjiang District are relatively smooth. The vitality of low-vitality streets still exhibits a "U"-shaped variation, while the vitality of medium and high-vitality streets fluctuates. From 6:00 to 10:00, there is a noticeable upward trend in the vitality of medium and high-vitality streets, with the ratio of medium-vitality streets consistently higher than that of high-vitality streets. From 10:00 to

12:00, the vitality of high-vitality streets continues to rise, while the vitality of medium-vitality streets shows a slight decline. From 12:00 to 18:00, the vitality changes of low, medium, and high-vitality streets all remain relatively stable, until 20:00 when the ratio of high-vitality streets reaches its peak. During this time, the vitality of medium-vitality streets decreases slightly, while the vitality of low-vitality streets gradually increases. Finally, from 22:00 to 24:00, the vitality of high-vitality streets rapidly decreases to its lowest point, while the vitality of medium-vitality streets shows a slight upward trend, and the vitality of low-vitality streets continues to rise.

In summary, on workdays, people's activities are more stable compared to weekends. The vitality of low-vitality streets still follows a "U"-shaped variation, with the peak of population aggregation mainly around 10:00 and 20:00. Based on these time points, it can be inferred that people are commuting to and from work. People transition from indoor activities at home to outdoor activities and then to their workplaces. Moreover, in areas where people gather more densely, the attributes of the locations can be inferred, such as shopping malls, schools, and office buildings, which serve as places capable of accommodating crowds.

4.2.3 Comparison of the change characteristics of street vitality

A comparison will be made between the vitality changes of streets in Wenjiang District on weekends and workdays, focusing on the vitality changes of streets at different levels. Since the vitality changes of low-vitality streets follow a "U"-shaped variation on both weekends and workdays, the comparison will only be conducted for medium-vitality streets (refer to Figure 3) and high-vitality streets (refer to Figure 4).

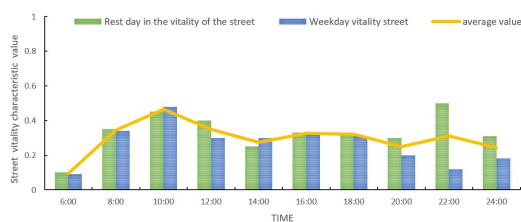


Figure 3. Comparison of Dynamic Characteristic values of Dynamic Streets during Rest Days and Working Days
Comparing the vitality changes of active

streets on weekends and weekdays as shown in Figure 3, it can be observed that there is not a significant fluctuation in the vitality of active streets between weekends and weekdays, both remain relatively stable throughout the day. During different time periods of the entire day, the proportion of active streets on weekends is mostly greater than that on weekdays. The time points with the greatest variations between these two days are 12:00, 20:00, 22:00, and 24:00. At these four time points, the vitality changes of active streets on weekends are consistently greater than those on weekdays, with the largest disparity occurring at 22:00. At this time, the concentration of people on active streets during weekends is significantly higher, far exceeding the average values of both weekends and weekdays. Hence, it can be inferred that people are freer during weekends, leading to a higher presence of crowds on streets, especially at 22:00, whereas the opposite holds true for weekdays.

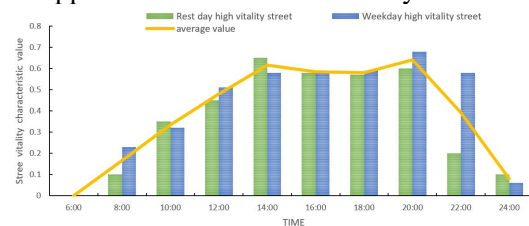


Figure 4. Comparison of Vitality Characteristic values of High Vitality Streets between rest Days and Working Days

Comparing the proportions of highly active streets on weekends and weekdays as depicted in Figure 4, it can be observed that the proportions of highly active streets on both weekends and weekdays are quite high. Particularly between 12:00 and 20:00, the proportion of highly active streets averages close to or above 0.5. From this, it can be inferred that regardless of whether it is a weekend or a weekday, during this time period, there is a high concentration of people. At 14:00, the proportion of highly active streets on weekends exceeds that of weekdays because it is during working hours. During weekends, people have more free time, leading to a higher concentration of people on the streets during this time period compared to weekdays. From 20:00 to 22:00, the proportion of highly active streets on weekdays exceeds that of weekends. This is because residents on weekdays go out for a walk or leisure after

dinner, resulting in gatherings.

In summary, through the comparison of the street vitality characteristics on weekends and weekdays, the change of the street vitality in Wenjiang District has the following characteristics:

Whether on weekdays or weekends, the changes of street vitality are similar, especially the low vitality streets, showing a trend of "U" shaped change, while the middle and high vitality streets show a trend of rising, gentle and decreasing in different time periods.

On weekdays and weekends, there is no great difference in the overall degree of population spatial agglomeration, and the middle and high vitality streets are evenly distributed in different dimensions of space and time. Among them, the degree of crowd concentration and the time of the crowd activity and the nature of the activity on the street are greatly related. For example, the vitality of the street on weekdays is closely related to the commuting time, while the vitality of the street on weekends reflects the free time of the crowd.

4.3 Identify the Distribution status of High-Vitality Streets

Can be seen from figure 4, weekends of high dynamic street proportion is at 14:00, weekdays high dynamic street proportion is in 20:00, the high dynamic street area and Salween area map location, make the street vitality corresponding to the regional spatial distribution, finally get high dynamic streets in the position of the area

On weekends, areas with high concentrations of people are mainly concentrated in the eastern section of Liutai Avenue, the northern section of Xuefu Road, the eastern section of Haiko Road, the eastern section of Xingke Road, Yangliu East Road, the third section of Guanghua Avenue, and Qingquan North Street. These streets are near Chengdu University of Traditional Chinese Medicine, Southwest University of Finance and Economics, as well as some commercial areas, hospitals, and residential areas. Public facilities are relatively well-equipped, and transportation conditions are convenient. Therefore, it can be inferred that on weekends, people's activities mainly occur near university campuses, commercial plazas, and large residential areas.

On weekdays, areas with higher concentrations

of people are located in the eastern section of Liutai Avenue, the eastern section of Haiko Road, Fengxi Avenue, the eastern section of Xingke Road, and the third section of Guanghua Avenue. These streets are situated near universities, hospitals, commercial areas, and office buildings. Additionally, the surrounding areas have relatively well-established infrastructure and convenient transportation conditions. Therefore, it can be inferred that on weekdays, people's activities primarily occur near university campuses and commercial office buildings.

In summary, through comparing the distribution of highly active streets on weekends and weekdays, the vitality distribution of streets in Wenjiang District exhibits the following characteristics:

Low-vitality streets are situated at the periphery of Wenjiang District, with less convenient transportation and farther from metro lines. Conversely, all highly active streets are concentrated in the central urban area of Wenjiang District, primarily along the axis of metro line 4. Most highly active streets are located in bustling transportation areas, suggesting a significant correlation between crowd aggregation and whether streets are positioned at crucial transportation hubs.

Throughout Wenjiang District, moderately to highly active streets are concentrated predominantly in the southeastern direction, while other areas consistently remain low in vitality. Observing the surroundings of low-vitality streets, they are often located within villages or towns with a lack of large-scale commercial facilities. Therefore, it can be inferred that moderately to highly active streets have a strong correlation with the presence of universities, hospitals, shopping malls, office buildings, and large residential areas in the vicinity. Consequently, the level of crowd aggregation is closely related to the surrounding environment and the availability of public facilities.

5. The Conclusions and Recommendations

5.1 Conclusion

Through the function of Baidu Heatmap, we identified the vitality of each street in Wenjiang District, analyzed the change characteristics of street vitality, compared the changes of street vitality in Wenjiang District

on weekends and weekdays, identified the main distribution areas of high vitality streets, and the following conclusions are drawn:

The moderately to highly active streets in Wenjiang District are primarily concentrated in the area east of Jinxiu Avenue North, south of Zhanbei Canal Road, west of Linqun North Street, and north of Kesheng Road. Streets in other areas within the district are classified as low-vitality streets.

There is obvious unbalanced development in the vitality of Wenjiang District, and the distribution of middle and high vitality is concentrated.

Wenjiang District has a variety of street functions, mainly commercial streets, life service streets and landscape leisure streets. Moreover, the commercial and life service streets are mostly medium and high vitality streets, while the landscape leisure streets are generally low vitality streets.

Although there are differences in street vitality between weekends and weekdays, street vitality has no large direct connection with weekends and weekdays, while there is a strong connection with whether the traffic is developed and in an important transportation hub node, the surrounding environment and the nature of public facilities.

5.2 Suggestions

After the analysis of the vitality of the streets, according to different levels of vitality street put forward corresponding strategies and Suggestions, which in the street vitality promotion suggestion, should be people-oriented, respect history, maintain regional characteristics, create diversified street space, improve the street environment quality, attract people in the streets, communication, walking, rest, display, trading and other diversity activities.

5.2.1 Suggestions for medium and high vitality street areas

The high vibrant streets in Wenjiang District are mainly commercial streets and life service streets, and most of them are located in commercial, schools, hospitals, residential and other areas with convenient transportation.

Commercial streets

Due to the fact that commercial streets are primarily characterized by retail and dining activities that involve consumer behavior, notable examples being Jinqiang University

City Commercial Street, Amber Commercial Street, Meilihua Commercial Street, Guanghua Avenue Section Three, Tianbao East Street. Such streets should maintain their convenient road advantages by appropriately widening roads, adding pedestrian bridges, or other infrastructure, ensuring there is sufficient pedestrian space. This not only ensures the safety of crowds at major traffic hubs with high vehicle flow, but also ensures strong connectivity on both sides of the street. It is advisable to increase activities where people can rest and linger, not only focusing on the experiential activities of consumer groups but also considering the stay of non-consumer groups. Only in this way can the crowd aggregation on commercial streets be ensured, thereby enhancing the vitality of the streets.

Service streets

Service streets are usually located near residential areas, schools, and hospitals, primarily serving as the fundamental activity streets for daily life in the region. Notable examples include the east section of Haike Road, the north section of Xuefu Road, the north section of Jinxiu Avenue, and Liuhe Road. Such streets should emphasize the interaction and lingering of people. It is advisable to appropriately beautify the green belts on both sides of the street and to add amenities such as shared bicycle parking points, public seating, and children's playgrounds to provide the crowd with good rest spaces. This not only brings a pleasing and tidy environment to the street but also ensures that activities on both sides of the street can attract people to rest and linger, thereby maintaining or enhancing the street's high vitality.

5.2.2 Suggestions for low vitality street areas

Due to the fact that low-vitality streets are primarily scenic and leisure streets located on the outskirts of Wenjiang District and in historically and culturally rich villages, notable examples being Yufu Road, Guanwen Road, and Chunjiang South Road. To enhance the vitality of low-vitality street areas, it is necessary to improve the surrounding environment and infrastructure while maintaining the authenticity and integrity of the original streets. This includes maintaining good street hygiene, beautifying the green belts on both sides of the street, creating a favorable historical and cultural atmosphere,

protecting and renovating surrounding historical buildings, and organizing some commercial camping activities to create a good resting and lingering environment. This will attract people to visit or rest here, thereby increasing the vitality of the street.

References

- [1] Ding month. Study on the spatial distribution characteristics and influencing factors of street vitality in Urumqi city J *Statistical Theory and Practice*, 2021 (03): 23-27.
- [2] Niu Xinyi, Wu Guanshu, Li Meng. Research on the influence of built environment on street vitality and its spatial and temporal characteristics based on LBS location data J *International Urban Planning*, 2019, 34 (1): 28-37.
- [3] Zhong Hongbin, Qian Hairong. Review on foreign Urban Street Reconstruction and Renewal Research J *Modern Urban Research*, 2009, 24 (09): 58-64.
- [4] Jacobs J. *The Death and Life of Great American Cities* M New York: Vintage, 1992.
- [5] Katz P, Scully V J, Bressi T W. *The New Urbanism : Toward an Architecture of Community* M New York: McGraw-Hill, 1994.
- [6] Yan Lei, Xu Qianli, Zhou Weiran. Looking for the lost space. Take the typical lot as the entry point to reshape the vitality of urban streets J *New Building*, 2005, 23 (03): 72-74.
- [7] Young Gail. *Communication and space* M Who can be, the translation. Beijing: China State Engineering and Construction Press, 2002.
- [8] He rain. Research on multicenter cities in China based on Baidu Heatmap J *Residence*, 2018, 38 (13): 157.
- [9] Wu Zhiqiang, Ye Zhongnan. Research on urban spatial structure based on Baidu map thermal map. Take the central city of Shanghai as an example J *Urban Planning*, 2016, 40 (4): 33-40.
- [10] Wang Lu warehouse. Space and temporal characteristics of urban population gathering in the main urban areas of Wuhan based on Baidu Heatmap J *Western Journal of Habitat Environment*, 2018, 33 (02): 52-56.
- [11] Long Ying, Zhou Yin. Quantitative evaluation of street vitality and analysis of influencing factors. Take Chengdu as an example J *New Building*, 2016, 34 (01): 52-57.
- [12] Zhou Xiaoling, MAO Jiangxing, Li Qingxiang, Jiang Lijuan. Analysis of the spatial and temporal characteristics of population agglomeration in Nanning city based on Baidu Heatmap J *Journal of Nanning Normal University (Natural Science Edition)*, 2020, 37 (04): 134-139.
- [13] AnJieYu. Study on population aggregation in urban scenic spots based on big data of heat map. Take the main urban area of Nanchang city as an example J *Information and Computers*, 2020, 32 (20): 3.
- [14] Min Zhongrong, Ding Fan. Analysis of the spatial and temporal distribution characteristics of street vitality based on Baidu Heatmap. Take the historic city of Nanchang city in Jiangxi Province as an example J *Research on Urban Development*, 2020, 27 (02): 31-36.