Journal of Landscape Research 2023, 15(4): 21–30

Evaluation of Recreation Service Quality of Slow Traffic Space in Urban Parks Based on IPA–Space Syntax Model

ZHOU Xi[1], CHU Zuoyong[1*], JI Xiang[2]

(1. School of Civil Engineering and Architecture, Anhui University of Science and Technology, Huainan, Anhui 232001, China; 2. School of Mechanics and Civil Engineering, China University of Mining and Technology/Jiangsu Collaborative Innovation Center for Building Energy Saving and Construction Technology, Xuzhou, Jiangsu 221116, China)

Abstract To build an "ecological and livable city", it is important to figure out the relationship between human activity and urban park space and create a high-quality urban park through the integration of "people" and "park". Taking Longhu Park in Huainan Province as an example, the study quantitatively analyzed and evaluated the characteristics and service quality of slow traffic space using importance-performance analysis (IPA) and space syntax, clarified the key indexes and areas to be optimized, and put forward corresponding design countermeasures and suggestions in combination with human activity demand. The results suggest that: ① The mean performance of park recreation service quality is 3.63, less than the mean importance (3.95). Tourists pay special attention to the safety and convenience of slow traffic space, and the diversity and identiability of site functions is the focus "to be improved". ② The accessibility of Longhu Park shows a strong irregular shape in the southwest. The dead-end roads in the far lake area and the flora and fauna area on the northwest side have weak spatial perception, and the composite function carrying potential of slow traffic space is better reflected in a small range. Therefore, an optimization strategy for slow traffic space is proposed to enhance the continuity of road network, site identifiability, and functional diversification. The results will provide new thoughts of governance based on spatial humanism for the high-quality renewal of urban parks in the new era.

Keywords IPA analysis, Space syntax, Urban park, Slow traffic space, Recreation service quality

DOI 10.16785/j.issn 1943-989x.2023.4.005

The rapid development of urbanization leads to urban problems such as the loss of urban public activity space and the decline of urban vitality[1-2]. Urban park is an important part of urban public activity space, and reasonable park design can guide residents to carry out activities such as rest, communication and exercise, promote tourists' active participation in public space experience, and enhance the vitality and recreation quality of parks[3]. To meet the current demand for the construction of livable cities, it has become an important issue that needs attention in current urban planning and design by providing residents with high-quality urban park space[4].

In recent years, many scholars have conducted relevant spatial studies on urban parks. For example, scholars at abroad have conducted research and evaluation on the relationship between park space perception and human criminal behavior[5]; Cristina et al.[6] studied and analyzed the accessibility of parks and its impact on the use of parks; Bae et al.[7] studied and evaluated the park's spatial environmental quality through users' spatial perception. In China, Yu Bingqin et al.[8-9] studied and evaluated the current quality of park space through IPA evaluation model; Wang Shan et al.[10-12] studied and evaluated the accessibility and perceived accessibility of urban park green space and its correlation with spatial vitality; Zhai Yujia et al.[13-15] conducted a quantitative study on the spatial characteristics and quality of parks from the perspective of spatial scale. Existing studies mostly evaluate the image perception and service quality of park space from the perspective of users, or evaluate the characteristics and quality of park space through accessibility and safety from the perspective of spatial scale, and lack the research and analysis of the interactive relationship between objective space and subjective behavior. In order to design the slow traffic space of urban parks that can meet the needs of tourists, we should consider not only the structural characteristics and quality of slow traffic space of urban parks, but also the satisfaction and comfort level of tourists. As a more mature method for evaluating the recreation service quality of urban parks, IPA analysis method is combined with space syntax to build a quantitative analysis model integrating mathematical statistics and spatial topology, and it will be more scientific and reasonable to study and evaluate the slow traffic space quality of urban parks by combining the two methods.

Taking Longhu Park in Huainan City as an example, this paper studied and evaluated the recreation quality and influencing factors of slow traffic space based on IPA and space syntax, and revealed the coupling relationship between the distribution characteristics of slow traffic space and human activity behavior, in order to provide a useful reference for the diagnosis and optimization design of slow traffic space vitality of urban parks.

1 Research objects and methods

1.1 Research objects

Longhu Park is located in Tianjia'an District, Huainan City, Anhui Province, covering an area of 65.4 hm^2. It was built in 1957 and officially opened to the public as a closed park on October 1, 1980. With the development of economy and society and the improvement of people's living standards, old facilities and attractions of Longhu Park can not keep up with the pace of the times, and are far from meeting the high-quality needs of the general public for urban parks. As an indispensable comprehensive park in the old city, Longhu Park bears the historical memory, hometown feelings and cultural characteristics of Huainan people. Therefore, to optimize the urban function, improve the ecological environment and

Received: May 20, 2023 Accepted: June 25, 2023

Sponsored by National Key Research and Development Project (2018YFD1100203); Research Topics of Huainan Municipal People's Government Development Research Center, Innovation Topics of Huainan Urban Renewal Strategy Research (K2110098).

* Corresponding author.

urban taste, and meet the citizens' pursuit of higher quality of urban environmental space, it is of great practical significance to study the renovation and optimization of Longhu Park.

1.2 Research methods

1.2.1 IPA analysis. IPA analysis, namely importance-performance analysis[16], mainly includes two stages: ① Issuing importance and performance questionnaires based on recreation service quality, to obtain the mean value of each evaluation index in these two aspects; ② Constructing IPA quadrants according to the mean values of importance and performance obtained from the survey (Fig.1)[17]. The recreation service quality is evaluated according to the distribution of each index in 4 quadrants. Quadrant I is the "keep up the good work" zone with high importance and performance; quadrant II is the "possible overkill" zone with high performance but low importance; quadrant III is the "low priority" zone with low importance and performance; quadrant IV is the "concentrate here" zone with high importance but low performance[18].

1.2.2 Space syntax theory. As a tool for quantitative analysis of space, space syntax mainly adopts three methods, namely axis analysis, isovist analysis and convex space analysis, to study urban space problems at different scales[19]. Axis analysis is often used to study the layout of streets or urban road network; convex space analysis is often used to study the architectural space where the room is clearly defined; isovist analysis is mostly used to study the free and open architectural plane[20]. Compared with axis analysis, line segment method proposed by Turner takes into account the influence of metric distance and deflection angle of park roads on the travel of people (vehicles)[21], which is more suitable for the quantitative study of the slow traffic space of urban parks. Spatial syntax analysis includes many indexes; connectivity, integration and selectivity are used to reflect spatial accessibility; intelligibility and synergy degree are used to reflect the identifiability of space; symbiosis degree reflects the composite functional carrying capacity of space.

(1) Connectivity C_i represents the number of spaces intersecting a certain space. The greater the connectivity, the stronger the permeability and accessibility of the space[22]. The formula is as follows:

$$C_i = K \qquad (1)$$

where K represents the number of spaces intersecting the i-th space.

(2) Integration I_i represents the degree of concentration or dispersion of a space. The 3-step depth radius is used to measure the local integration and the depth radius n is used to measure the global integration. The greater the integration, the more concentrated the space and the stronger the accessibility[23]. The formula is as follows:

$$I_i = \frac{n\left[\log_2\left(\frac{n+2}{3}\right) - 1\right] + 1}{(n-1)(MD_i - 1)} \qquad (2)$$

$$MD_i = \frac{\sum_{j=1}^{n} d_{ij}}{(n-1)} \qquad (3)$$

where I_i represents the integration; MD_i represents the mean depth; n represents the total number of connections.

(3) Selectivity $CH(a_x)$ represents the frequency of an element as the shortest topological distance between two nodes[24]. The higher the selectivity, the greater the possibility that the space is selected as the shortest path, and the greater the potential for crossing traffic. The formula is as follows:

$$CH(a_x) = \frac{\log\left[\frac{\sum_{i=1}^{n}\sum_{j=1}^{n}\sigma(x, y, j)}{(n-1)(n-2)} + 1\right]}{\log\left[\sum_{i=1}^{n} d(x, i) + 3\right]} \qquad (4)$$

where $CH(a_x)$ stands for the selectivity of road segment a_x after standardization; n stands for the total number of segments; $d(x, i)$ stands for the minimum intersection angle distance from segment x to i; $\sigma(x, i, j)$ stands for the minimum path length of segment i to j via x.

(4) Intelligibility R^2 represents the correlation between connectivity and global integration[25]. The higher the intelligibility, the stronger the perception of segment i to the whole space, that is, the higher the identifiability of the space. The formula is as follows:

$$R^2 = \frac{\left[\sum(C_i - \bar{C})(I_i - \bar{I})\right]^2}{\sum(C_i - \bar{C})^2 \sum(I_i - \bar{I})^2} \qquad (5)$$

where R^2 stands for the intelligibility; C_i stands for the connectivity of space i; $\bar{C}$ stands for the mean connectivity; I_i stands for the integration of the i-th step; $\bar{I}$ stands for the mean integration.

(5) Synergy degree R^2 represents the relationship between local integration and global integration[26]. The greater the synergy degree, the stronger the correlation between the walking accessibility of segment i and the accessibility of the segment in the whole system, the higher the identifiability of the space. The formula is as follows:

$$R^2 = \frac{\left[\sum(I_3 - \bar{I}_3)(I_n - \bar{I}_n)\right]^2}{\sum(I_3 - \bar{I}_3)^2 \sum(I_n - \bar{I}_n)^2} \qquad (6)$$

where R^2 is the synergy degree; $\bar{I}_3$ is the integration of any three steps; I_3 is mean integration of three steps; I_n is the global integration; $\bar{I}_n$ is the mean value of global integration.

(6) Symbiosis degree R^2 represents the interrelationship between integration and selectivity. The greater the symbiosis degree, the greater the composite function carrying potential of the space[27]. The formula is as follows:

$$R^2 = \frac{\left\{\sum(I_i - \bar{I})\left[CH(a_x) - \overline{CH(a_x)}\right]\right\}^2}{\sum(I_i - \bar{I})\sum\left[CH(a_x) - \overline{CH(a_x)}\right]^2} \qquad (7)$$

where R^2 is the symbiosis degree; I_i the integration of the i-th element in the system; $CH(a_x)$ is the selectivity of road segment a_x after

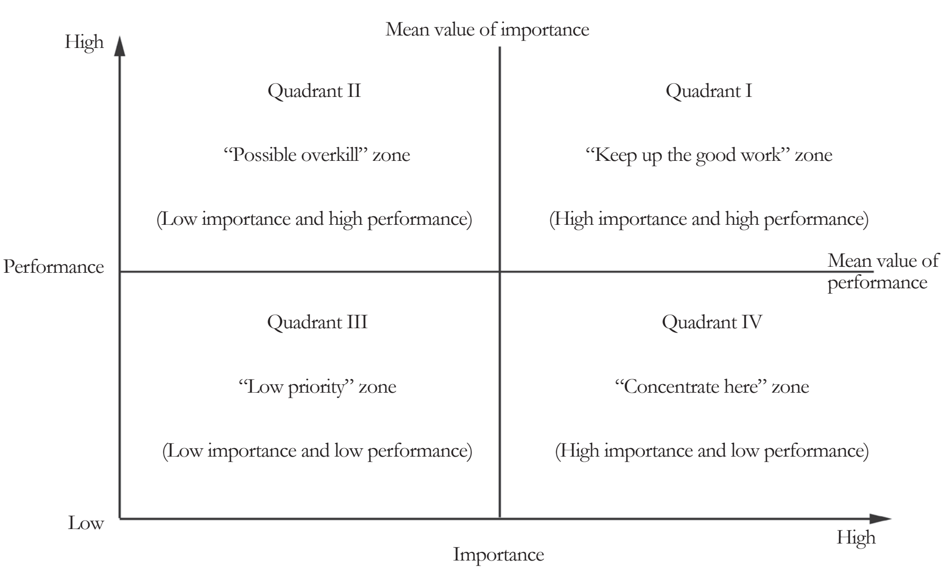

Fig.1 IPA quadrant diagram

standardization; $\overline{I}$ is the mean integration of the system; $\overline{CH(a_x)}$ is the mean selectivity of road segment a_x after standardization.

1.2.3 Complementarity of IPA analysis and space syntax analysis. IPA analysis obtains people's perception process of environment characteristics of slow traffic space in urban parks through questionnaires. The analysis result is a subjective demand of people, but it can not explain the specific objective reasons. Space syntax theory, on the contrary, pays more attention to quantitative analysis at the objective level, and can explain the influence of park spatial organization characteristics on individual behavior from an objective perspective. In order to achieve the unity of subjective evaluation and objective quantification, this study introduced IPA and space syntax into the evaluation of slow traffic space quality of Longhu Park, and clarified the coupling relationship between human activities and spatial organization characteristics to optimize the research method (Fig.2).

1.3 Data sources and processing

An empirical analysis was conducted with the tourists of Longhu Park in Huainan City as the main objects. From February 12, 2022 to May 12, 2022, two working days and two rest days were selected every month to issue questionnaires to the tourists of Longhu Park. The questionnaire was composed of two parts: basic information of users, importance of park use and performance evaluation[28-29]. Tourists rated the importance and performance of various indexes in Longhu Park according to their own needs. The questionnaire adopted a standard 5-level Likert scale[30]. Ratings ranged from "very unimportant/very dissatisfied" to "very important/very satisfied" on a scale of 1-5, and a higher score indicated that users considered one aspect of the park as more important or more satisfying. A total of 150 questionnaires were distributed and 136 were recovered, with an effective recovery rate of 90.66%. The authenticity and validity of the data were ensured by interviews with tourists.

Based on the space syntax line segment method, the vector road base map was drawn in CAD using the satellite map of Longhu Park in 2022, and imported into Depthmap to generate line segment model automatically (Fig.3), so as to quantitatively analyze the features of the slow traffic space in Longhu Park.

2 Results of activity requirements analysis

2.1 Research design based on IPA

First of all, the gender, age structure, visiting means, visiting frequency, staying time and visiting purpose of tourists were investigated to understand the basic information of tourists. Referring to previous studies on the spatial quality evaluation of urban parks[31-35], the evaluation criteria were selected from the user's point of view to establish a recreation perception evaluation system of slow traffic space in urban parks based on human activity needs. The evaluation indexes were composed of six criteria layers, namely safety, convenience, comfortableness, interestingness, attractiveness and communicativeness, with a total of 20 indexes. By analyzing and sorting out the corresponding data, this paper studied and evaluated the recreation service quality of slow traffic space in urban parks.

2.2 Data analysis

2.2.1 Basic information of tourists. According to the questionnaire (Table 1), among the 136 tourists, males accounted for 47.05% and females accounted for 52.95%. The proportion of females participating in park activities was slightly higher than that of males. In terms of age structure, children, young people, middle-aged people and the elderly accounted for 11.76%, 21.32%, 48.53%, and 18.38%, respectively, and the middle-aged and elderly groups accounted for a large proportion of park tourists. In terms of visiting means, walking accounted for 67.65% of the total. As for visiting frequency, the number of tourists visiting more than once a day and

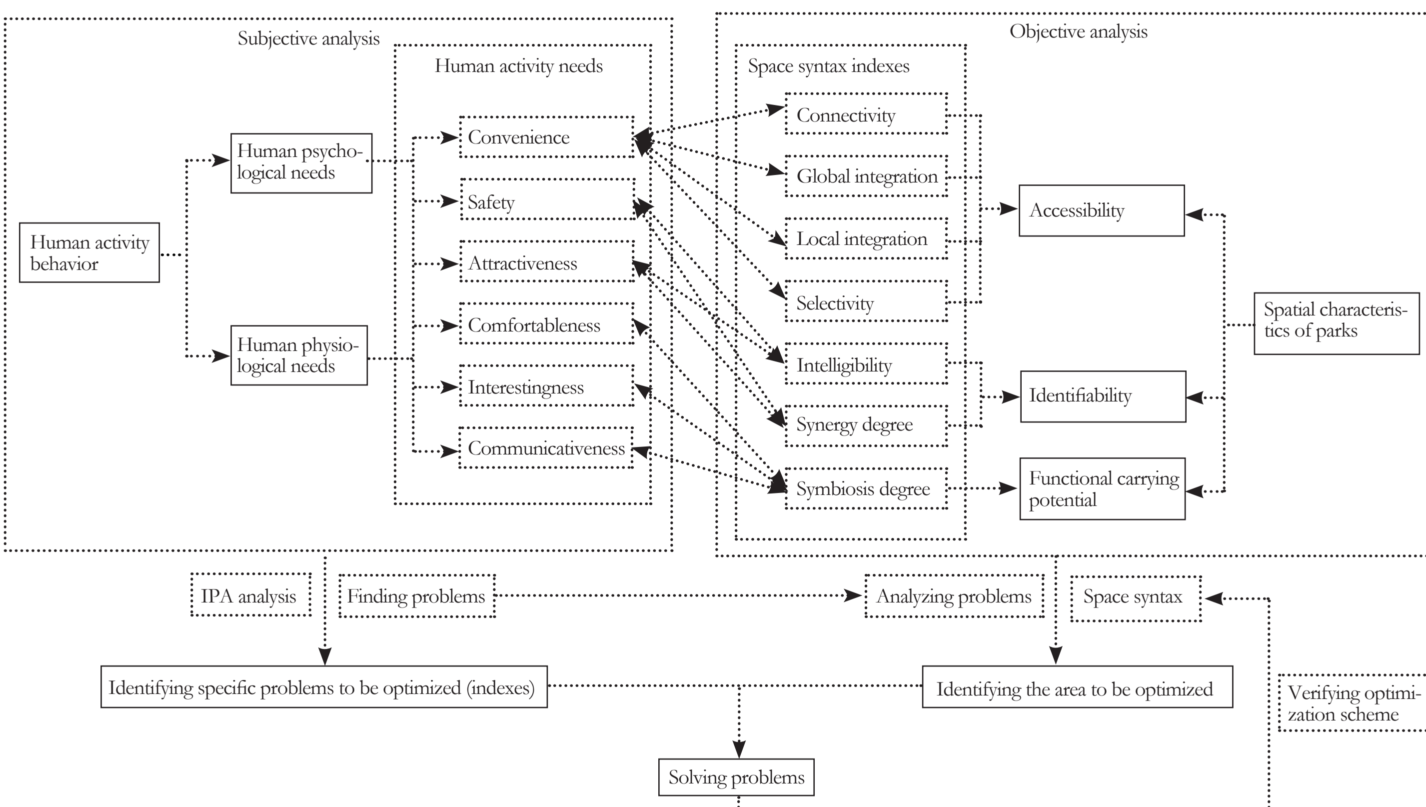

Fig.2 IPA–spatial syntactic analysis idea

more than once a month was larger, accounting for 74.79% of the total. The staying time of 1–3 h accounted for 56.62%, followed by less than 1 h, accounting for 28.68%. With regard to visiting purpose, sightseeing accounted for 30.15%, followed by exercise, accounting for 25.00%, indicating that most of the tourists were nearby residents who walked to the park for sightseeing and exercise, and had high requirements for the path planning and service facilities of slow traffic space.

2.2.2 Importance and performance analysis. From the importance evaluation of tourists to the park (Table 2), the top 5 in scoring were: safety of activity facilities, accessibility of the park, safety of spatial layout, improvement of barrier-free facilities, and convenience of service facilities, indicating that tourists pay particular attention to the safety and convenience of the park. In terms of performance, the top 5 in scoring were: accessibility of the park, environmental sanitation and greening, convenient and striking entrances, safety of activity facilities, safety of spatial layout and safety of plant species, and the bottom 5 in scoring were: richness of activity facilities, identifiability of the site, diversity of functions, comfortableness of the site size and attractiveness of activity facilities. The former are the key factors of park space design, and the latter are the contents that need to be improved. The mean overall performance of the slow traffic space of Longhu Park was 3.63, which was less than the mean importance (3.95), indicating that the slow traffic space of Longhu Park can not meet the needs of tourists to a certain extent, and needs to be further optimized and improved.

2.2.3 IPA quadrant analysis. With importance as the *X*-axis and performance as the *Y*-axis, the IPA quadrant diagram was plotted by setting the mean importance (3.95) and mean performance (3.63) as the coordinate origin (Fig.4), and the differences in the mean value of importance and performance among 20 quality evaluation indexes were analyzed (Fig.5). According to the IPA quadrant diagram, the indexes located in the "keep up the good work" zone of Quadrant I included safety of activity facilities (N_1), safety of spatial layout (N_2), accessibility of the park (N_5), convenient and striking entrances (N_6), and improvement of barrier-free facilities (N_8) (Fig.4). There were 2 safety quality factors and 3 convenience quality factors, indicating that tourists have high degree of performance and importance to the safety and convenience of slow traffic space. However, the performance value of 5 indexes was actually still lower than the importance value, and there was a significant difference between importance and performance (Fig.5), which needs to be further improved.

The indexes located in the "possible overkill" zone of Quadrant II were safety of plant species (N_3), environmental sanitation and greening (N_9), beauty of the landscape (N_{16}), and diversity of space types (N_{19}) (Fig.4), involving 1 safety quality factor, 1 comfortableness quality factor, and 2 attractiveness quality factors. Tourists did not pay attention to the above 4 indexes, and showed high value of performance on these 4 indexes. In terms of actual individual indexes, there was no significant difference in importance and performance (Fig.5), indicating that the environmental sanitation and greening landscape of slow traffic space can better meet the needs and expectations of tourists, and planners do not need to pay too much attention.

The indexes located in the "low priority" zone of Quadrant III included safety of architectural ornaments (N_4), comfortableness of the site size (N_{10}), interestingness of the park (N_{11}, N_{13}), richness of activity facilities (N_{14}), diversity of site functions (N_{15}), experience of the site (N_{18}), and privacy of interaction space (N_{20}) (Fig.4), involving 1 safety quality factor, 1 comfortableness quality factor, 3 interestingness quality factors, 3 attractiveness quality factors and 1 communicativeness quality factor. The above 9 indexes are the quality factors of the sub-optimal development of Longhu Park. From the specific value, the importance value of the 9 indexes was greater than the performance value, indicating that tourists have certain expectations of the above indexes, but they have not been satisfied. There were great differences in the importance and performance of diversity of site functions (N_{15}) (Fig.5), which needs to be further improved.

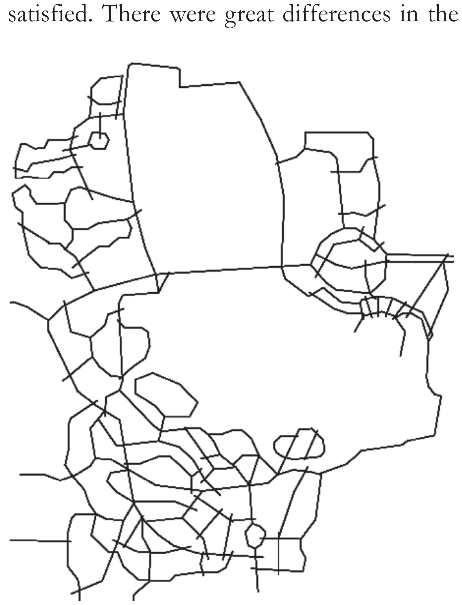

Fig.3 Line segment model of slow traffic space in Longhu Park

The indexes in the "concentrate here" zone of Quadrant IV were identifiability of the site (N_{17}) and convenience of service facilities (N_7) (Fig.4), which were convenience and attractive quality factors, respectively. Moreover, the two indexes are quite different in importance and realistic performance (Fig.5), which are the "key points to be improved".

3 Spatial feature analysis

3.1 Accessibility analysis

The accessibility of the slow traffic space of Longhu Park was quantitatively analyzed in Depth Map (Fig.6), and the level of index value was reflected by the change in cold and warm color of line segment, that is, the level of spatial accessibility. It was found that the maximum connectivity (8) appeared in mid lake road, and the maximum local integration (2.34) appeared in south gate recreation area. Both the maximum global integration (0.78) and maximum selectivity (50,477) appeared in the primary main park road in the southeast side. As the walking frame of the park, the primary main park road has strong crowd gathering and guidance. South gate recreation area is located at the entrance of the park, and the space is strongly permeable and has good walking accessibility. The mean connectivity of slow traffic space was 2.82; the mean value of global integration was 0.53; the mean value of local integration was 1.30; and the mean selectivity was 4,287.73 (Table 3). The overall accessibility of the park shows the characteristics of agglomeration development around the "east-west-south" primary main park road. As the road network form of Longhu Park shows a strong irregular grid shape in the southwest, the 4 parameter indexes of the southeast side of the park and the far lake area connected by secondary roads or paths show warm color with small values, indicating weak spatial accessibility. Such spaces are the key areas to optimize the accessibility and convenience.

3.2 Identifiability analysis

With connectivity as the *X*-axis and global integration as the *Y*-axis in Depth Map (Fig.7a), according to the linear formula: $y = 0.038\,538\,6\,x + 0.426\,73$, the intelligibility was calculated as 0.177 (Table 3). With local integration as the *X*-axis and global integration as the *Y*-axis, according to the linear formula: $y = 0.155\,145\,x + 0.333\,025$ (Fig.7b), the synergy degree was obtained as 0.304 (Table 3). The intelligibility and synergy degree of the slow traffic space in Longhu Park are both less than 0.5, and the identifiability of the slow traffic space in the park is low, which is not conducive to tourists' perception of the overall spatial site in the park. The road network on the southwest side of the park is well connected, with clear road classification, and there is strong correlation between local space and overall space system, with good identifiability of space, which can better meet the safety and attractiveness needs of tourists in the park. However, the road network structure on the southeast side of the park is simple, and tourists have weak ability to perceive the whole park space through the locally known road space. The closed spaces in the far lake area such as dead-end roads, cul-de-sac and the flora and fauna area in the northwest side have low connectivity and integration, and are not well integrated into the slow traffic system of the whole park. Tourists are easy to produce visual obstruction, disorientation or insecurity in such space, which can not meet the attractiveness and safety needs of tourists in the park. The safety and identifiability of such spaces are the focus of "to be improved".

Table 1 Basic information of tourists

Basic information	Category	Number of tourists	Proportion//%
Gender	Male	64	47.05
	Female	72	52.95
Age structure	Children (0–8 years old)	16	11.76
	Young people (18–34 years old)	29	21.32
	Middle-aged people (35–59 years old)	66	48.53
	The elderly (60 years old and above)	25	18.38
Visiting means	Walking	92	67.65
	Public transport	17	12.50
	Self-driving or riding	27	19.85
Visiting frequency	More than once a day	38	29.94
	Several times a week	61	44.85
	Several times a month	29	21.33
	Other	8	5.88
Staying time	< 1 h	39	28.68
	1–3 h	77	56.62
	3–5 h	16	11.76
	> 5 h	3	2.22
Visiting purpose	Tour	41	30.15
	Recreation	23	16.91
	Exercise	34	25.00
	Social communication	23	16.91
	Other	15	11.02

Table 2 Importance and performance evaluation of tourists on Longhu Park

Criterion layer	Index layer	No.	Importance (I)	Performance (P)	I–P
Safety	Safety of activity facilities	N_1	4.63	3.89	0.74
	Safety of spatial layout	N_2	4.49	3.88	0.61
	Safety of plant species	N_3	3.86	3.88	−0.02
	Safety of architectural ornaments	N_4	3.86	3.53	0.33
Convenience	Accessibility of the park	N_5	4.52	4.31	0.21
	Convenient and striking entrances	N_6	4.20	3.98	0.22
	Convenience of service facilities	N_7	4.27	3.62	0.65
	Improvement of barrier-free facilities	N_8	4.29	3.87	0.42
Comfortableness	Environmental sanitation and greening	N_9	3.61	4.07	−0.46
	Comfortableness of the site size	N_{10}	3.49	3.29	0.20
Interestingness	Attractiveness of activity facilities	N_{11}	3.79	3.32	0.47
	Particularity of the site	N_{12}	3.68	3.43	0.25
	Exploratory nature of the site	N_{13}	3.81	3.53	0.28
Attractiveness	Richness of activity facilities	N_{14}	3.36	2.98	0.38
	Diversity of site functions	N_{15}	3.80	3.23	0.57
	Beauty of the landscape	N_{16}	3.84	3.69	0.15
	Identifiability of the site	N_{17}	4.01	3.22	0.79
	Experience of the site	N_{18}	3.87	3.59	0.28
Communicativeness	Diversity of space types	N_{19}	3.90	3.80	0.10
	Privacy of interaction space	N_{20}	3.72	3.54	0.18
	Mean		3.95	3.63	0.32

3.3 Analysis of composite function carrying potential

Line segment models with different topological radius scales R=3, R=5, R=7, and R=9 were selected, and the values of symbiosis degree under different topological radii of the slow traffic system in Longhu Park were obtained by setting integration as the *X*-axis and selectivity as the *Y*-axis in Depth map (Fig.8). Thus, the symbiosis degrees of Longhu Park were 0.63, 0.53, 0.48 and 0.43 when R=3, R=5, R=7 and R=9 (Table 3). With the gradual increase of topological radius, the symbiosis degree gradually decreases, and the topological radius R represents the size of the functional influence radius R. The larger the R, the greater the composite function carrying potential will be reflected in a larger scope, indicating that the composite function carrying potential of the park is better reflected in a smaller scope. The results suggest that the development mode of Longhu Park has changed from the original high number coverage of functions to the high-quality creation of various function spaces. The future planning and design of slow traffic space should focus on enhancing the complex and diversified functions of the park, the characteristics and richness of communication space, and the optimization of facilities and services.

4 Optimization strategies

Through quantitative analysis of data results based on IPA-space syntax, this paper proposes the optimization ideas of the slow traffic space in Longhu Park from the following three aspects.

4.1 Appropriately increasing road connections to improve the continuity of slow traffic space

Tourists come to the park mainly for recreation and exercise, and pay special attention to the convenience and continuity of slow traffic space. Meanwhile, the space with improved accessibility can better attract tourists to gather, which will improve the vitality and utilization rate of slow traffic space. A reasonable road network planning and design mainly includes the following two aspects. ① Main park roads are increased to attract crowd assembling, to improve the space utilization rate of low accessible areas. ② By strengthening the connection between secondary roads and main roads, crowds in high-accessibility areas are dispersed, thus reducing safety accidents and space congestion. According to the irregular road network structure of low traffic space in Longhu Park, local roads should be adjusted as follows. ① The roads with weak accessibility such as dead-end roads and cul-de-sac should be appropriately reduced. ② In the southeast side of the park with weak accessibility, a new primary park road can be built to form a continuous and convenient primary green fitness loop with the original "east-west-south" primary park road, to improve the accessibility of the road network in the southeast side of the park. ③ It is suggested to add two secondary lake roads to form two secondary waterfront sightseeing zones with the original secondary lake ring roads, so as to relieve the crowd gathering pressure and space congestion of the original mid lake road. ④ The primary fitness loop and the secondary waterfront sightseeing belt can form a "one-ring and two-belt" ring network structure, strengthening the internal connectivity of slow traffic space and balancing the local accessibility of the park. As shown in Fig.9, the connectivity increased from 2.82 to 3.22 after optimization, the mean value of global integration increased from 0.53 to 0.59, and the mean value of local integration increased from 1.30 to 1.45. However, with the agglomeration development of road network structure, the mean selectivity decreased from 4,287.73 to 3,743.48 (Table 3). The result indicates that the optimized slow traffic space in Longhu Park has enhanced accessibility and balanced distribution, which is conducive to meeting the accessibility and convenience needs of tourists in slow traffic space for recreation and exercise in Longhu Park.

4.2 Increasing the site identification construction to enhance the identifiability and attractiveness of the park

As the main body of park tourists, the middle-aged and elderly people have increased requirements for the identifiability of sites due to the gradual decline in memory and vision. Thus, specific suggestions for improving the identifiability of slow traffic space in Longhu Park are as follows. ① Roads should be reasonably classified, and the difference among main park roads, secondary roads and tourist walkways should be clearly reflected through width or paving style, thus making the structure of road network clear to meet tourists' wayfinding needs. ② The road network space "blind areas" such as dead-end roads, cul-de-sac, winding roads and far lake closed spaces with weak identifiability should be properly inserted with activity spaces and recreation sites or installed with pilot identifiers, so as to enhance the identifiability of the space, activate the space and activate the dead corners. ③ Different functional spaces can be implanted with diverse cultural elements, so as to create functional spaces integrating different cultural characteristics and enhance spatial memory. For example, the pavement and landscape sketches in the south gate amusement area can implant animation elements that children like; some animal statues can be appropriately added to the northwest flora and fauna area; combined with the current situation of the park, the south gate of the park can be supplemented with dragon gallery frame and dragon signboard, highlighting the "dragon" cultural theme of the park. As shown in Fig.10, the intelligibility of the slow traffic space of Longhu Park increased from 0.177 to 0.213 after optimization, and the synergy degree increased from 0.304 to 0.346 (Table 3). The result suggest that the Longhu Park after optimization has enhanced spatial perception of slow traffic space, which is conducive to meeting tourists' wayfinding needs, eliminating visual obstacles, enhancing the safety of tourists' recreation, and satisfying users' needs for site identifiability.

4.3 Enhancing the function diversification and service optimization of slow traffic space

The development mode of Longhu Park has changed from the original high number coverage of functions to the high-quality creation of various functional spaces. It is necessary to strengthen the functional complexity of slow traffic space, the characteristics and richness of interaction space and the optimization of services to meet the needs and expectations of tourists of different activity types in terms of attractiveness and interestingness. Specific suggestions are as follows. ① Function zoning is carried out reasonably, and dynamic and static zoning is carried out according to the travel degree; the near lake area close to the primary

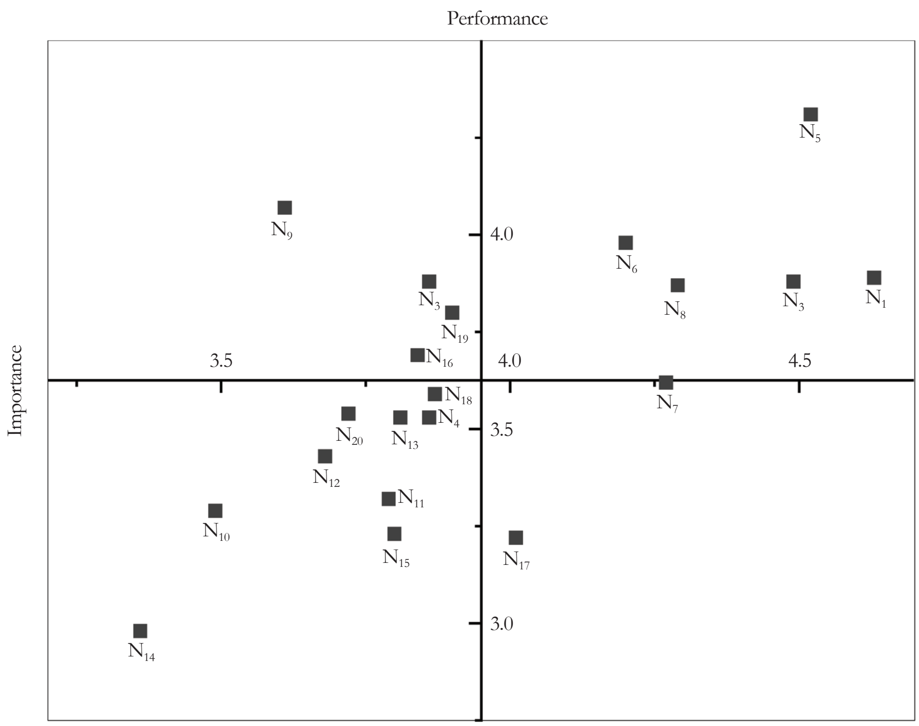

Fig.4 IPA quadrant of Longhu Park

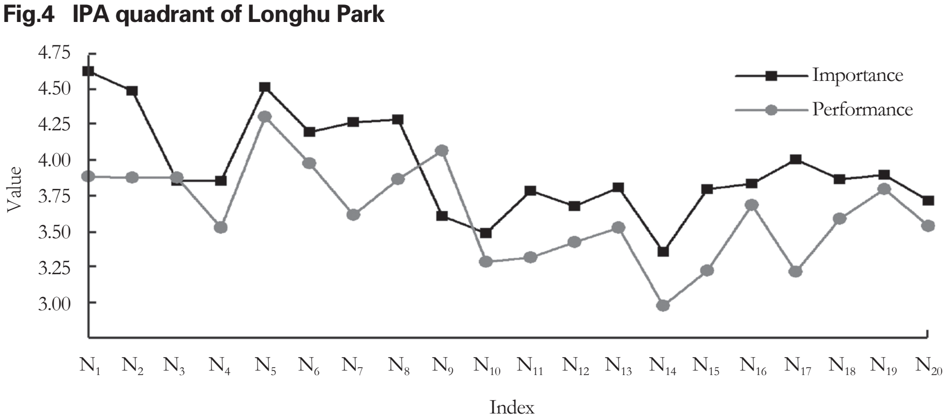

Fig.5 Differences in importance and performance

main park road with high travel degree bears dynamic activities; the distal area from the lake bears static activities. ② As the main spaces for recreation and exercise in parks, entrances and main park roads of the park should add recreation and service facilities appropriately, such as seats, sanitation facilities and public toilets; there are more children in the south gate amusement area, and interestingness and safety should be emphasized when setting up children's pleasure ground. ③ In the southeast area of the park with low accessibility, recreation space and rest space can be appropriately inserted to enrich the sense of walking space and attract tourists to stop, so as to activate the space and improve the utilization rate of the slow traffic space in the southeast side. ④ The middle-aged and the elderly are the main users of the park, so the safety and comfortableness of barrier-free and recreational facilities should be focused in the design. ⑤ The interaction space between different age groups can be increased. For example, an atmosphere of intergenerational integration of different age groups can be created through appropriate combination of children's activity space and entertainment and leisure space, to meet the diversified needs of tourists to talk, learn, rest, entertainment, etc. As shown in Fig.11, the symbiosis degrees of different topological radii R = 3, R = 5, R = 7, and R = 9 after optimization were 0.62, 0.49, 0.39, and 0.36, respectively (Table 3). After optimization, the symbiosis degree of different topological radii decreased, indicating that the functional layout of the park space after optimization is more perfect, which is conducive to meeting the tourists' needs of interestingness and communicativeness in park recreation and the high-quality development needs of the functional space of Longhu Park.

To sum up, the optimization of slow traffic space of urban parks mainly includes three aspects: adjusting local road network structure, enhancing site identifiability, function diversification and service optimization. The optimized Longhu Park was evaluated quantitatively by using space syntax, and it is found that the slow traffic space of optimized Longhu Park has improved accessibility, convenience and site identifiability and realizes function and service optimization, consistent with the design intention. This not only makes people's activities in Longhu Park more convenient, but also improves the recreation perception and service quality of the whole slow traffic space.

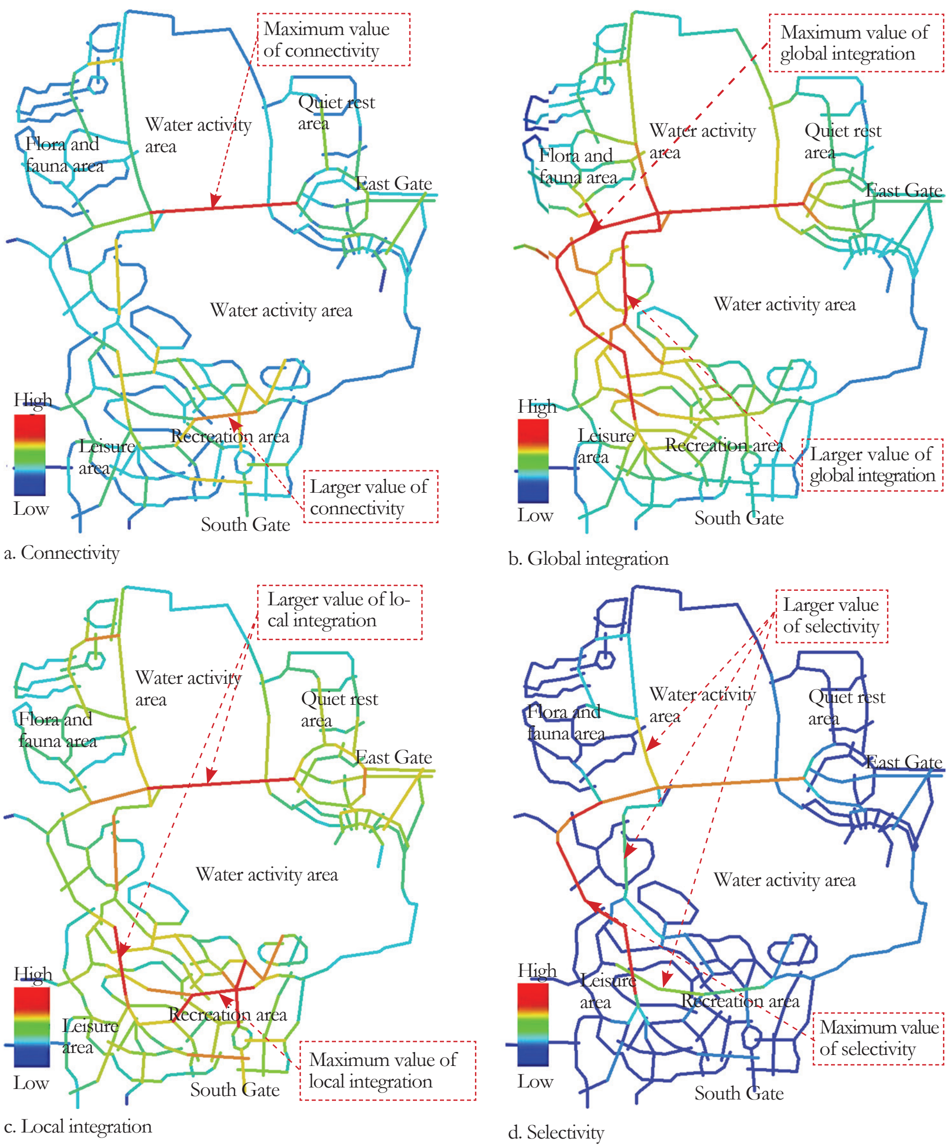

Fig.6 Accessibility analysis

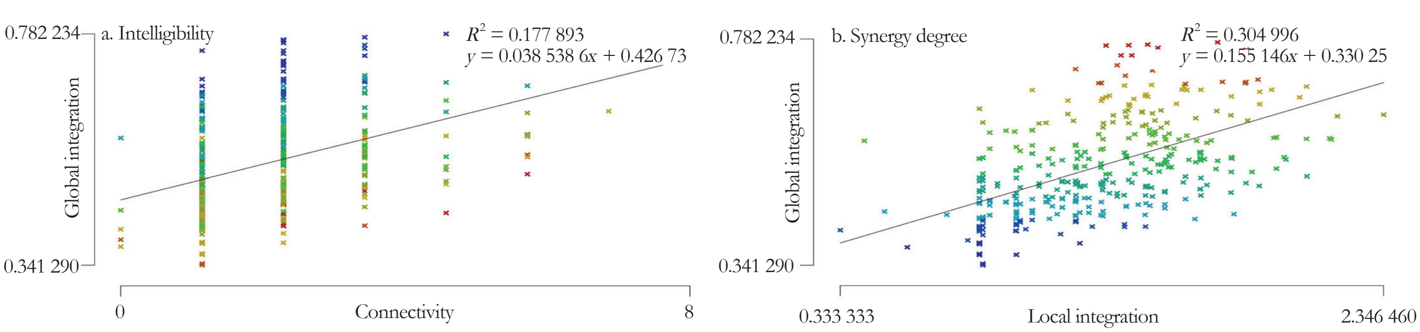

Fig.7 Identifiability analysis

5 Conclusions

Improving the quality of slow traffic

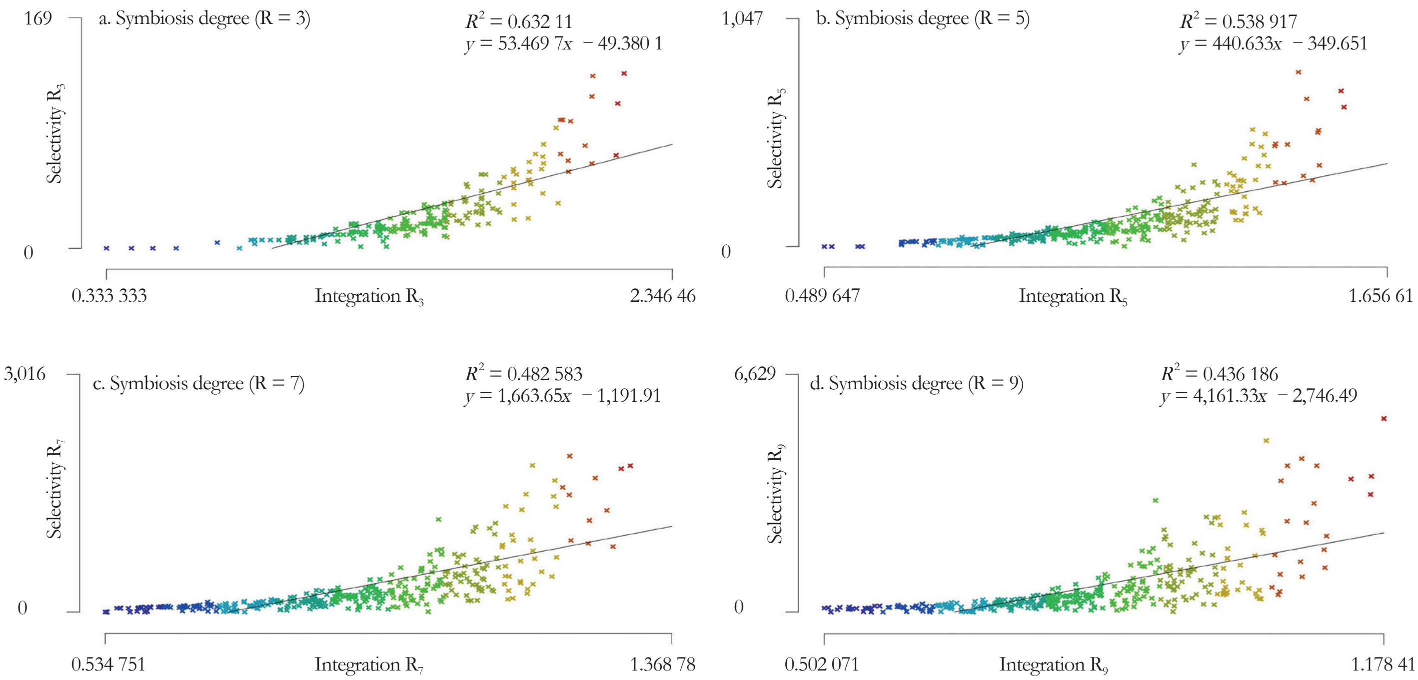

Fig.8 Accessibility analysis of optimized slow traffic system

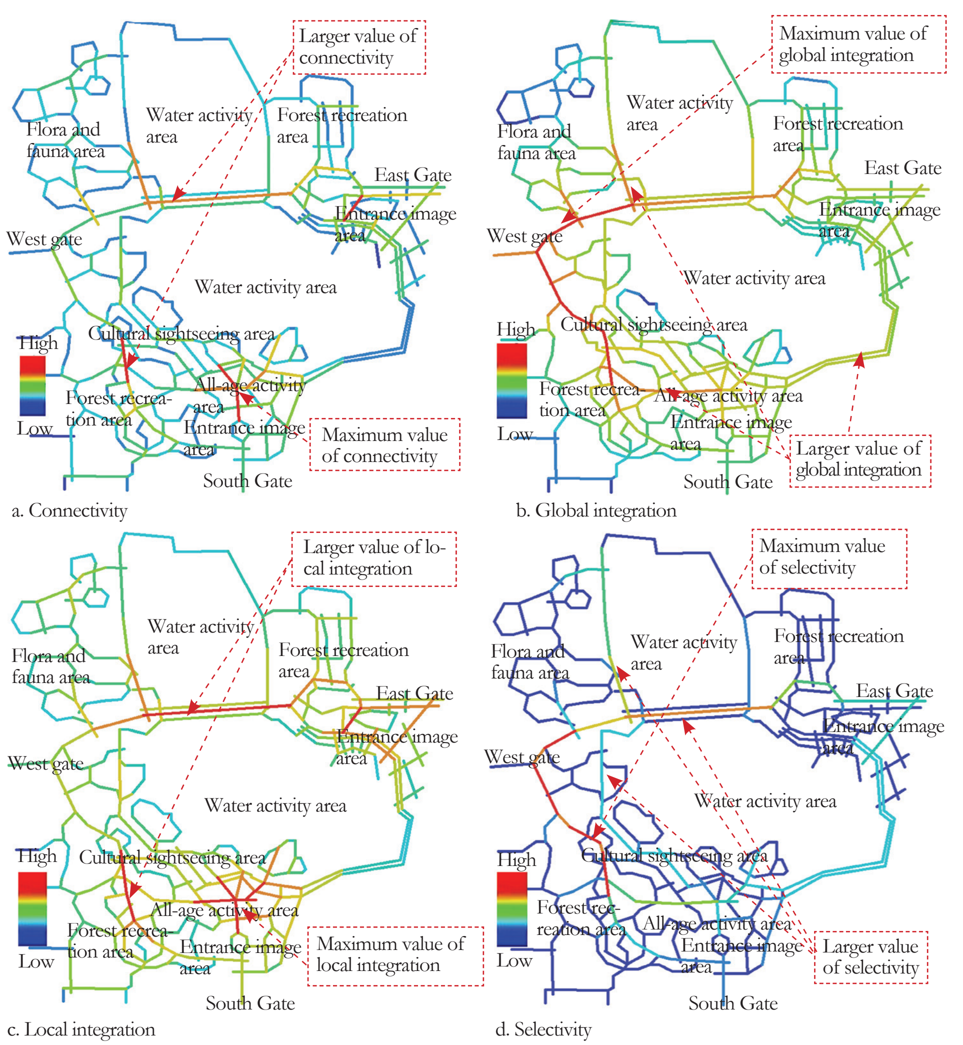

Fig.9 Accessibility analysis of optimized slow traffic system

space of urban parks can extend the leisure time of tourists, increase the frequency of activities, and improve the vitality and use level of urban parks, which is of great significance to the construction of "ecological and livable city". Taking Longhu Park in Huainan City as an example, this study quantitatively analyzed the quality of slow traffic space of urban parks through IPA and space syntactic analysis model, and studied the activity and behavior needs of tourists and the matching situation of the vitality and function of slow traffic space. The practical problems existing in slow traffic space were summarized, and the corresponding improvement countermeasures were proposed. The main conclusions are as follows. ① The safety of activity facilities, safety of spatial layout and accessibility of space in slow traffic space are highly valued; there is a big gap between the expectation and real performance in functional diversity and identifiability of site space, which is the key content that needs to be improved urgently. ② Secondary roads, distal lake area connected by paths and single road network in the southeast side of the park have weak spatial accessibility, low spatial vitality and use level; the closed spaces such as dead-end roads, cul-de-sac, turning road with excessive curvature and flora and fauna area in the northwest side have low identifiability, resulting in idle and inefficient use of space. The functional development mode of Longhu Park has changed from the original high number coverage of functions to

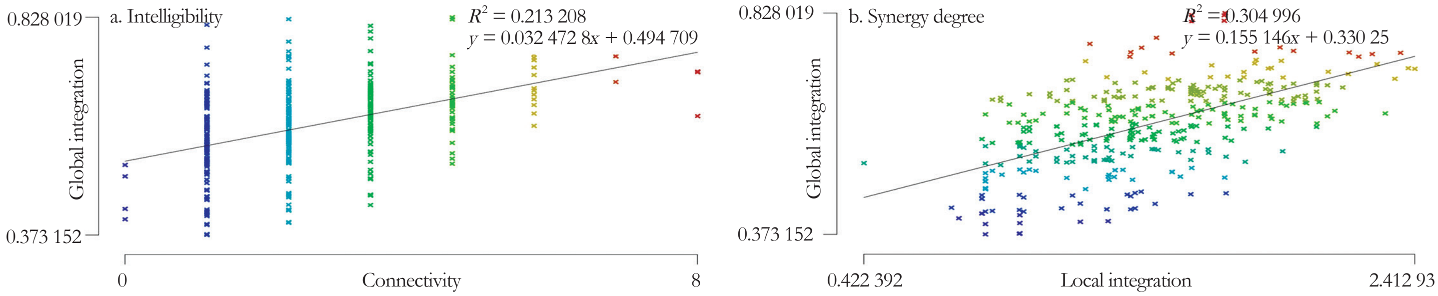

Fig.10 Spatial identifiability after optimization

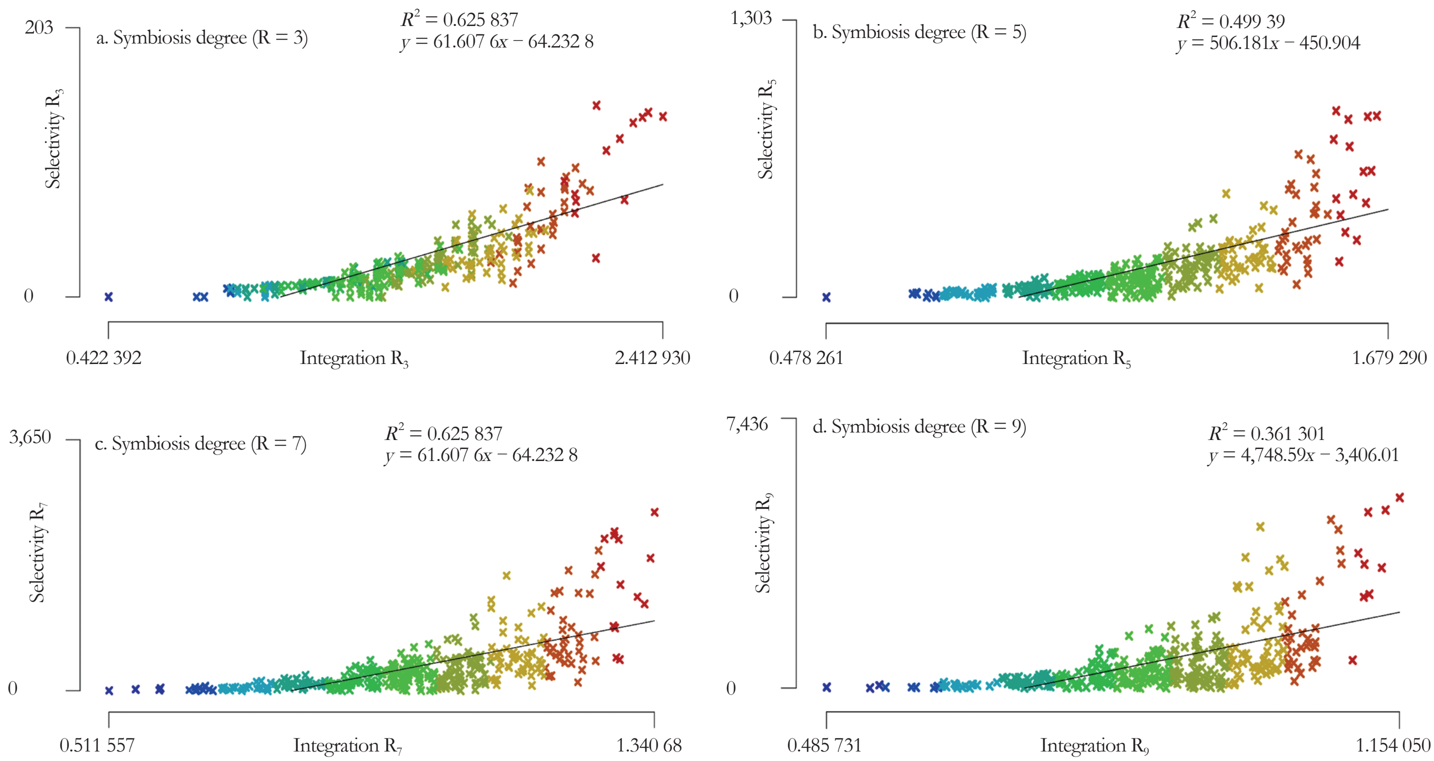

Fig.11 Functional carrying potential after optimization

Table 3 Parameter indexes of space syntax

Parameter index		Before optimization	After optimization
Connectivity	Minimum	1.00	1.00
	Mean	2.82	3.22
	Maximum	8.00	8.00
Global integration	Minimum	0.34	0.37
	Mean	0.53	0.59
	Maximum	0.78	0.82
Local integration	Minimum	0.33	0.42
	Mean	1.30	1.45
	Maximum	2.34	2.41
Selectivity	Minimum	0	0
	Mean	4,287.73	3,743.48
	Maximum	50,477	39,760
Intelligibility	R = n	0.177	0.213
Synergy degree	R = n	0.304	0.346
Symbiosis degree	R =3	0.63	0.62
	R = 5	0.53	0.49
	R = 7	0.48	0.39
	R = 9	0.43	0.36

the high-quality creation of various functional spaces. Finally, combined with the behavioral needs of space users, this paper puts forward the strategy of improving the slow traffic space of Longhu Park in the following three aspects: ① Appropriately increasing or decreasing road connections to improve the continuity of slow traffic space; ② Appropriately inserting pilot identifiers, signage and leisure and entertainment scenes, to activate the space, activate the dead corners, and improve the identification of the site; ③ Adding interactive activity facilities and space sites to meet the diverse needs of tourists of different activity types such as conversation, learning, rest and entertainment. The research results can provide new ideas and methods for the diagnosis, function positioning and renewal design of urban park space in the new era, and help designers to explore the optimal solution of humanized design of urban park space more efficiently and improve the rationality of design schemes.

References

[1] Yu, L., Liu, J. M. & Li, T. (2019). Important progress and future prospects for studies on urban public recreational space in China. *Journal of Geographical Sciences*, *29*(11), 1923-1946.

[2] Zhang, W. Z., Xu, J. X. & Ma, R. F. et al. (2019). Basic connotation, current situation, and development orientation of high-quality development of Chinese cities: Based on the survey of residents. *City Planning Review*, (11), 13-19.

[3] Zhao, Y., Xu, F. & Wan, Y. L. (2022). Spatial accessibility and supply-demand balance analysis method of park green space based on modified gravity model. *Journal of Geo-information Science*, *24*, 1993-2003.

[4] Huang, T., Wei, M. & Zhi, Y. T. (2022). Reconstruction of aging adaptability of walking space network in urban leisure green space based on behavior simulation: A case study of Huqiu Wetland Park in Suzhou. *Geography and Geo-Information Science*, *38*(2), 80-88.

[5] Aziz, N. A. A. E. (2020). Space syntax as a tool to measure safety in small urban parks: A case study of Rod El Farag Park in Cairo. *Landscape Architecture Frontiers*, *8*(4), 42-59.

[6] Cristina, A. A., Daniel, D. & Luis, Z. (2019). Characteristics of urban parks and their relation to user well-being. *Landscape and Urban Planning*, *189*, 27-35.

[7] Bae, Yeon, H. & Byun. (2019). Study on environmental project factors in peripheral spaces around children's parks within low-level housing areas by using IPA analysis-focusing on user consciousness survey. *Journal of the Architectural Institute of Korea Planning & Design*, *35*(1), 73-81.

[8] Yu, B. Q., Xie, C. K. & Yang, S. B. (2014). Correspondence analysis on residents' perceived recreation satisfaction and importance in Shanghai urban community park. *Chinese Landscape Architecture*, *30*(9), 75-78.

[9] Yu, B. Q., Che, S. Q. & Xie, C. K. (2018). Understanding Shanghai residents' perception of leisure impact and experience satisfaction of urban community parks: An integrated and IPA method. *Sustainability*, *10*(4), 1064.

[10] Wang, S., Cheng, L. L. & Qiu, W. et al. (2023). Research on the accessibility of park green space in Jinan District of Fuzhou City based on multi-source data. *Journal of Northwest Forestry College*, *38*(1), 257-265.

[11] Hao, F. L., Zhang, H. R. & Wang, S. J. (2021). Spatial accessibility of urban green space in central area of Changchun: An analysis based on the multi-trip model. *Scientia Geographica Sinica*, *41*(4), 695-704.

[12] Zhang, J. Y., Chen, P. Y. (2021). Reviewing the research development of perceived accessibility to urban parks and its application inspirations in the trend of human-oriented planning. *Urban Planning International*, *36*(5), 96-103.

[13] Zhai, Y. J. (2016). Applying space syntax theory in measuring urban park configurational attributes and implications in design and management: Based on convex map analysis. *Chinese Landscape Architecture*, *32*(3), 80-84.

[14] Zhang, Y. Y., Sun, Y. T. & Yao, C. H. (2019). The application of spatial syntax in the accessibility study of urban parks: A case study of Wuhan. *Chinese Landscape Architecture*, *35*(11), 92-96.

[15] Ma, J., Cheng, Y. N. (2021). Research on optimization of urban park design based on swarm intelligent simulation and spatial syntax analysis. *Chinese Landscape Architecture*, *37*(4), 69-74.

[16] Martilla, J. A., James, J. C. (1977). Importance-performance analysis. *The Journal of Marketing*, *41*(1), 77-79.

[17] Riali, A., Riali, J. & Jesus, V. et al. (2008). An application of importance- performance analysis (IPA) to the management of sport centers. *Managing Leisure*, *13*(3-4), 179-188.

[18] Chen, D. J., Wang, Y. X. & Guo, Y. R. (2021). Research on the development of forest tourism experience products based on tourist satisfaction: A case study of 49 national forest parks in Shandong Province. *Forestry Economics*, *43*(8), 62-79.

[19] Song, J. S., Sun, Y. & Hou, X. C. (2017). Analysis of spatial environment characteristics of community park in densely populated district based on activity classification of elderly. *Architectural Journal*, (5), 116-120.

[20] Hillie, R. B. (1996). *Space is the machine*: *A configurational theory of architecture*. England: Cambridge University Press.

[21] Ding, C. B., Gu, H. Y. & Tao, W. (2015). Progress in the application of space syntax in human geography research in China. *Tropical Geography*, *35*(4), 515-521, 540.

[22] Dai, X. L., Yu, W. B. (2015). Exploration of natural movement principle of space syntax in Chinese context: The discussion of construction method of space syntax street network model as a strategic model. *Modern Urban Research*, (4), 118-125.

[23] Peponis, J., Feng, C. & Green, D. et al. (2015). Syntax and parametric analysis of super block patterns. *The Journal of Space Syntax*, (1), 109-141.

[24] Chen, M. X., Shen, F. & Zha, L. S. et al. (2005). A research on urban traffic network based on space syntax: A case study on Wuhu City. *Geography and Geo-Information Science*, *21*(2), 39-42.

[25] Shen, F., Zha, L. (2005). A research on urban traffic network based on space syntax: A case study on Wuhu City. *Geo-Information Science*, *21*(2), 39-42.

[26] Hillier, B., Iida, S. (2005). *Network and psychological effects in urban movement*. Berlin, Heidelberg: Springer, 475-490.

[27] Hillier, B., Yang, T. & Turner, A. (2012). Normalising least angle choice in Depthmap and how it opens up new perspectives on the global and local analysis of city space. *Journal of Space Syntax*, *3*(2), 155-193.

[28] Duan, J., Hillier, B. (2007). *Spatial studies 3: Space syntax and urban planning*. Nanjing: Southeast University Press.

[29] Wang, Z. Y., Liu, L. (2020). A study of the spatial morphological changes of city and unprotected historic block from the perspective of spatial syntax: A case study of Wenfeng Ancient Street in Hechuan. *Journal of Southwest University* (*Natural Science Edition*), *42*(1), 142-150.

[30] Albayrak, T., Caber, M. (2016). Destination attribute effects on rock climbing tourist satisfaction: An asymmetric impact-performance analysis. *Tourism Geographies*, *18*(3), 280-296.

[31] Um, S., Chon, K. & Ro, Y. H. (2006). Antecedents of revisit intention. *Annals of Tourism Research*, *33*(4), 1141-1158.

[32] Zhai, Y. J., Wu, C. Z. (2021). Identification of main influencing factors on urban park overall satisfaction: Based on analysis of users of different age groups. *Landscape Architecture*, *28*(5), 57-62.

[33] Yao, X. J., Chen, L. (2022). Service quality evaluation of urban park green space in northern Anhui Province: A case study of Bengbu City. *Journal of Northwest Forestry University*, *37*(6), 242-249.

[34] Voigta, A., Kabischn, N. & Wrsterd, D. et al. (2014). Structural diversity: A multi-dimensional approach to assess recreational services in urban parks. *Ambio-A Journal of the Human Environment*, *43*(4), 480-491.

[35] Lee, Y. C., Lim, K. H. (2015). Attitudes of citizens towards urban parks and green pace for urban sustainability: The case of Gyeong-san City, Republic of Korea. *Sustainability*, *7*(7), 8240-8254.