Urban street network from the perspective of complete streets Multidimensional feature measurement and empirical research based on the analysis framework of transportation, society, and nature

Han Ruina and Yang Dongfeng

Abstract: As a continuous, large-scale, and multi-attribute network system, streets can be accurately controlled by finely characterizing their network measurement system to plan intervention directions in stock updates. At the same time, the network type classification mode can also guide the refinement design strategy of streets. Taking residents' mobility, interaction, and ecological behavior as the core, using the concept of complete streets as the medium, and multi-attribute street network elements as the guarantee, establish a multi-attribute street network measurement system covering transportation, society, and nature. Selecting Dalian City as the research area, principal component analysis, case comparison, and cluster analysis were used to evaluate the characteristics of street networks with different attributes. Research has found that convenient transportation networks have relatively high levels of density, form, and proximity to bus stops, which can ensure the safety needs of mobile behavior and are in line with the goal of safe streets; Social service-oriented networks have a relatively high level of location advantages, functional complexity, and interface quality, which can to some extent meet the requirements Rich demands for social interaction behavior, reaching consensus with the goals of dynamic streets; The blue-green level and accessibility of natural dominant networks are relatively high, which can guide ecological behavior and better match the goals of green streets; However, the deficient network is seriously inadequate in terms of traffic safety, social vitality, and environmental quality. It is urgent to improve the quality of the street network through measures such as improving station proximity, functional support, and green quality. Finally, suggestions and references are provided for the refinement of street design and the revitalization of existing street networks in the context of urban renewal.

Keywords street network; Transportation; society Nature; Complete street; Behavioral needs

Chinese Library Classification Number: TU984 Document Identifier: A
DOI: 10.16361/j.upf.202401012
Article Number: 1000-3363(2024)01-0100-1

Han Ruina, PhD Candidate at the School of Architecture and Art, Dalian University of Technology, hrncd@foxmail.com
Yang Dongfeng, Professor and Doctoral Supervisor at the School of Architecture and Art, Dalian University of Technology, Corresponding author: yangdongfeng@dlut.edu.cn

Revised based on the winning papers from the 6th "Jin Jingchang Chinese Urban and Rural Planning Graduate Student Paper Competition"; National Natural Science Foundation of China General Program: "Identification of Interactive Effects of Residential Built and Social Environment on Elderly Mental Health and Planning Intervention" (Project No.: 52078095).

With the high-quality development of new urbanization, the focus of urban construction has shifted from incremental expansion to stock renewal, and refined street design has become a key approach to urban renewal in the new era. The street network, as an important way to understand the structure and texture of the city, not only ensures mobile safety, but also undertakes the functions of urban social and ecological benefits. In recent years, the drive of big data and new technologies has provided a new perspective for the study of urban street space. Most street research work mainly focuses on two aspects: visual quality and topological form. Some scholars [2-6] are dedicated to the human scale street visual quality features, mainly based on street view photos and deep learning technologies, to characterize interface quality features by measuring street penetration rate, green visibility rate, sky visibility, interface transparency and openness, etc; At the same time, some scholars [7-9] have also paid attention to the study of street morphology, using spatial syntax and sDNA analysis of axis or line segment models to measure indicators such as integration, selection, centrality, and proximity to characterize network morphology features. It can be seen that a large amount of research has laid a solid theoretical foundation for refined street design.

However, existing research has mostly focused on the quality or morphological characteristics of street interfaces at the micro level, with less attention paid to the refined measurement of street network systems at the overall level, and the proportion of research on network type recognition is relatively low. Hillie [10] believes that the most important factor in shaping pedestrian movement patterns is the structural relationship of the street spatial network itself. As a continuous, large-scale, and multi-attribute network system, the precise characterization of the network measurement system of streets can help to accurately control the planning intervention direction in stock updates. At the same time, the network type classification pattern can also guide the refinement design strategy of streets.

Therefore, the study attempts to start from the behavioral needs of residents and take how to accurately characterize complete streets using quantitative methods as the research question, attempting to construct a refined network measurement system that covers multiple attributes of transportation, society, and nature, aiming to provide a preliminary foundation for the measurement and practice of street networks. Taking Dalian City as the research area, the street network is selected as the research object, and principal component analysis and empirical research are used to explore the main characteristics of street networks with different attributes. In addition, cluster analysis methods are used to further clarify the types of street networks, in order to provide reference and guidance for the refinement design of streets and the revitalization of the rationality of street networks in the context of urban renewal.

1. Theory and Framework

1.1 Theoretical Basis: Behavioral Needs - Complete Streets - Multi Attribute Networks

The research attempts to construct a theoretical framework for multi-attribute street networks (Figure 1), taking residents' behavioral needs as the core, using a complete street concept as the medium, and multi-attribute street network elements as the guarantee, to establish a multi-attribute street network system measurement system. Among them, resident behavior mainly includes three dimensions: mobility, interaction, and ecological behavior; The goal of a complete street refers to the construction of safe streets, vibrant streets, and green streets; The multi-attribute street network mainly covers transportation, social, and natural networks.

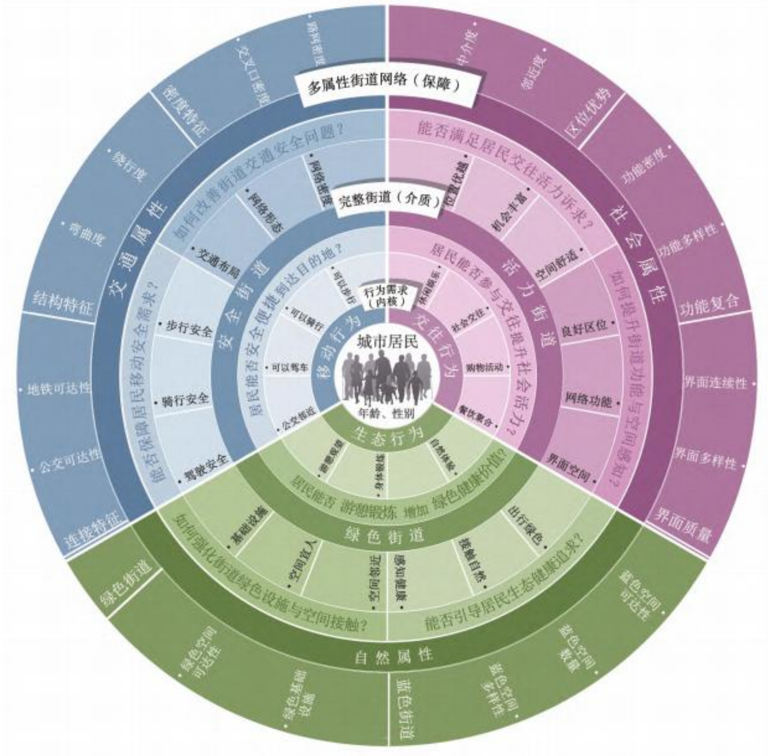

Fig.1 Theoretical framework

1.1.1 Resident behavioral needs (core): mobility communication ecology

According to Maslow's hierarchy of needs theory, the satisfaction of residents' behavioral needs is an increasing process from lower to higher levels. The existing research has relatively matured in the construction of activity behavior theory. Yang Gail divided outdoor activities into three categories: necessity, spontaneity, and social activities. Chai Yanwei et al. [12] divided residents' behavior into daily activity patterns, commuting behavior, shopping behavior, and leisure behavior. In addition, Zhou Suhong et al. [13] divided daily activities into three categories: maintenance activities that meet the needs of family life, work-related survival activities such as work and school, and leisure activities such as entertainment and exercise. Based on the above, the study divides resident behavior into three dimensions: mobility, interaction, and ecology as the core. Mobile behavior mainly includes walking, taking subways, buses, and motor vehicles, and street safety is the basic guarantee for the occurrence of mobile behavior; Interpersonal behavior mainly includes leisure and entertainment, social interaction, shopping and dining, and street vitality is the internal driving force for sustained interpersonal behavior; Ecological behavior mainly includes natural experiences, physical exercise, and recreational observation, and green streets are the external driving force for the increase of ecological behavior.

1.1.2 Complete street (medium): safety vitality green

The United States has proposed the "Complete Streets" policy, aimed at ensuring the right of way for all modes of transportation, meeting travel and safety needs. The main objectives of a complete street design are three: ① Safe streets. Ensure the safety of users of all modes of transportation on the street Vitality Street. Increase the public space of the street to promote social interaction among residents, enhance the attractiveness of the street to serve people Green streets. Enhance the greening rate of streets, improve rainwater infiltration and reuse, and encourage residents to choose green and healthy modes of transportation. In this study, "complete street" serves as a medium for measuring residents' behavior and streets, mainly including two levels: at the resident level, it refers to meeting the needs of all residents' complete behavior; At the street network level, it refers to solving the problems faced by residents' behavior by measuring the complete multi-attribute network elements (traffic, society, and nature), namely how to improve street traffic safety, enhance street vitality and spatial perception, and strengthen street green facilities and spatial contact opportunities.

1.1.3 Multi attribute Network (Guarantee): Transportation Society Nature

Based on the above residents' behavioral needs and the complete connotation of the street, the street network is divided into three attributes: transportation, society, and nature. At the same time, it conforms to the goals of safety, vitality, and green streets in the complete street, and corresponds to the residents' mobility, communication, and ecological behavioral needs. Research on street networks has gradually focused on their multidimensional properties, proposing to view streets as an integrated network of multiple public benefit systems. For example, the Regional Plan As of New York (RPA) calls for a reconsideration of streets as "three interconnected network systems that can work together to improve quality of life," mainly involving the following three attributes: street networks will carry transportation systems, street networks will also serve social systems, and street networks should also be part of natural ecosystems.

Based on this, the study further selected sub indicators through three attribute features to accurately characterize the complete street. Firstly, the transportation network is the spatial carrier for mobile behavior, and it is necessary to ensure the safety needs of residents' movement in terms of network density, morphological characteristics, and public transportation level [17]; Secondly, social networks determine the duration and occurrence of social interactions, and they need to meet residents' demands for vitality in terms of location advantages, functional complexity, and interface quality; Finally, natural networks influence the frequency of ecological behavior and guide residents towards a green and healthy lifestyle at the level of green and blue spaces on streets [19-23].

1.2 Measurement System: Transportation, Social, and Natural Networks

The transportation network system is mainly reflected in density characteristics, structural characteristics, and connectivity characteristics, and mainly focuses on traffic safety, walkability, and accessibility. Specifically, density features refer to the comprehensive level of street segment density divided by intersections and intersection density. Research has shown that [24] road network and intersection density can affect the number of traffic accidents, resilience level [25], traffic organization, and walkability of streets [26]; The structural features are represented by the degree of detour (detour rate) and the degree of curvature (line curvature rate). The former refers to the ratio of the actual distance based on the network to the distance in a straight line, while the latter refers to the ratio of the length of the network's connections to the distance in a straight line at the endpoints [27]. Research [28]] shows that the greater the degree of network detours, the greater the possibility of covered destinations, which is more conducive to walking activities. Compared with curved networks, linear networks are more conducive to convenient movement [29]. The connection feature is represented by the distance between the subway and bus stop, which reflects the proximity between the subway station and bus stop. Ye Yu et al. [30]

believe that the distance from bus and subway stations has a significant impact on the accessibility of pedestrian spaces on streets and the convenience of community life.

The social network system mainly includes location advantages, functional complexity, and interface quality, and focuses on street centrality, pedestrian flow distribution, street vitality, and social activities. Specifically, at the level of location advantage, betweenness centrality (intermediary centrality) and proximity centrality (proximity centrality) are used to represent it. The former refers to the number of times the shortest path appears in any street network as a starting and ending point, while the latter represents the average sum of distances from the starting point to all endpoints within the search radius. Ye Yu et al. [5] believe that intermediary degree can help enhance the potential of streets to carry traffic and determine whether the network is suitable as a center. Che Guanqiong et al. [28] also suggest that streets with higher proximity are more likely to attract pedestrian traffic. At the level of functional complexity, characterized by functional density and diversity, it mainly covers service facilities such as healthcare, education, commerce, transportation, and leisure. A large number of studies have shown that service facilities can help increase social stopping behavior [31], and enhance street vitality and walkability [26, 32-34]. At the interface quality level, interface continuity and diversity are used to characterize it. The former is represented by the building line sticking rate index, while the latter is represented by the mixed height types of buildings on both sides of the street. Most studies have found that interface continuity has a positive effect on nighttime street vitality and social activity [6]. Ashihara Yoshinobu believed that the facades along the street enclosed by buildings on both sides of the street were very necessary, and Jacobs also emphasized that a great street must have clear boundaries, and therefore the building interface plays a key role in the degree of enclosure of the street space.

The natural network system is mainly represented by street green and blue levels. Among them, green streets are represented by green space accessibility and green infrastructure. The former is measured by the two-step mobile search method to calculate the AOI accessibility of parks and green spaces, while the latter is measured by the normalized vegetation cover index NDVI value; Blue streets are represented by the distance from the blue space, the number and type of blue spaces, which mainly include beaches, rivers, and water systems. Most studies [35-36] have shown that blue-green spaces, as important places for residents to actively engage in activities, are more likely to make residents feel happy and have a stress relieving effect [37-38]. Exposure to blue-green spaces also helps to improve public health, happiness, and cohesion [39-42]. Moreover, studies [23, 43-44] indicate that compared to green spaces, blue spaces are more effective in leisure and relaxation, while green spaces have a more significant effect on physical exercise.

1.3 Technical roadmap

The research is generally divided into four steps: data collection, indicator calculation, principal component analysis, and cluster analysis (Figure 2). Firstly, the study defined the section of road sandwiched between two intersections as a street, forming a network of 26246 streets, and established a 25 meter buffer zone based on this to measure multidimensional feature indicators within the buffer zone; Secondly, the principal component analysis method is used to extract dominant feature features, and ArcGIS is used for spatial visualization analysis. At the same time, typical cases are selected for specific analysis of spatial features; In addition, the study used clustering analysis to classify the network types of urban street networks based on multiple indicators, and obtained the characteristics of different types of street networks by grouping them; Finally, an attempt is made to describe and summarize the overall patterns and divisions of different street networks in Dalian, and to propose suggestions for improving the quality of multi-attribute street networks from a complete street perspective.

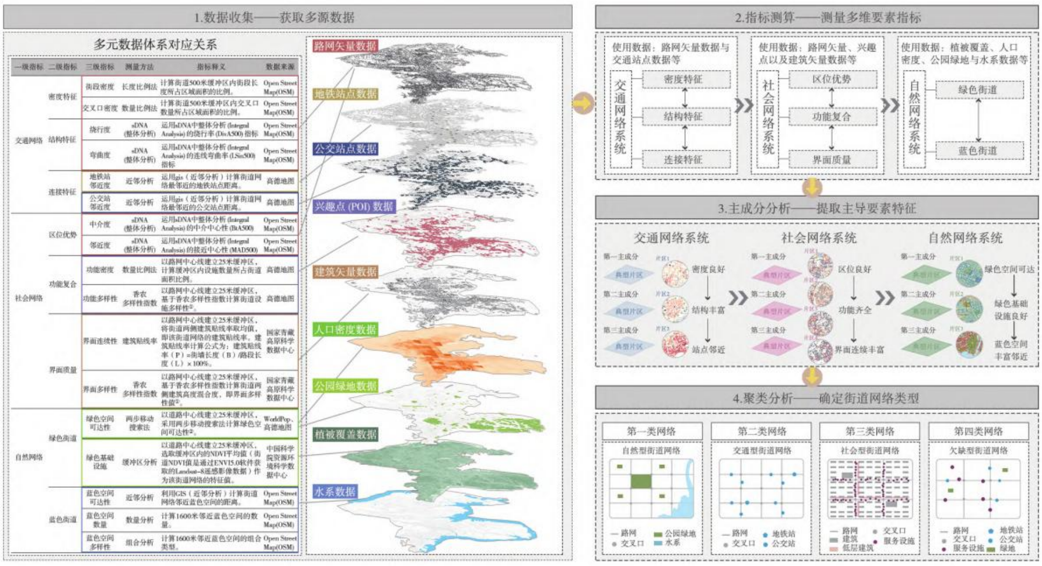

Fig.2 Technical route

2 Data and Methods

2.1 Research Object

The study takes the central urban area of Dalian as the empirical research area and selects the urban street network as the research object [Figure 3 (a)]. As a typical mountainous city, Dalian has complex terrain, winding street networks, and significant spatial heterogeneity. Therefore, conducting research on the street network system in Dalian has typical characteristics and practical significance.

2.2 Data measurement

The street network data measurement mainly includes 9 multivariate datasets, including road network vector data, subway stations, bus stations, points of interest (POI), building vectors, population density, park and green space AOI, NDVI, and water systems. The measurement methods and data sources are shown in Figure 2. It is worth noting that the study used Shannon diversity index ① to calculate functional diversity and interface diversity based on existing research on diversity [45-46]. In addition, based on existing literature on measuring the accessibility of parks and green spaces, two-step mobile search method ② was used to calculate the accessibility of green spaces [47]. The specific calculation formula can be found in the annotations.

2.3 Measurement Results

The measurement results of different attribute street networks in Dalian city show significant differences in spatial distribution. At the level of transportation network system, the spatial distribution of measurement results is shown in Figure 3 (b). Due to the fact that street networks with different analysis radii can match corresponding distances for travel, usually 500 meters is a comfortable walking distance for residents [48]. Therefore, the study selected a 500 meter buffer zone for street segment density and intersection density. In addition, the overall analysis of sDNA also selected a 500 meter angle distance as the index for detour and curvature; Finally, according to the "Standard for Urban Comprehensive Transportation System Planning"

GB/T 51328-2018 and the distance of residents' travel, the distance between adjacent public transportation stations is divided into three levels. The distance between adjacent subway stations is: Level 1 is distance ≥ 800 meters; The second level is 500 m ≤ distance ＜ 800 m; Level 3: Distance ＜ 500 m; Distance from nearby bus stop: Level 1 requires a distance of ≥ 500 meters; The second level is 300 m ≤ distance ＜ 500 m; The third level is a distance of less than 300 meters. At the level of the social network system, the spatial distribution of measurement results is shown in Figure 3 (c). As mentioned earlier, based on 500m as the optimal distance for residents' travel, the search radius for the betweenness centrality and proximity indicators in the overall analysis of sDNA also selects an angular distance of 500m; In addition, to improve the refinement and differentiation of indicators, the diversity of street facilities is calculated based on POI subcategories; At the same time, a 25 meter buffer zone is established based on the centerline of the road network for interface continuity, and the building alignment rate is calculated. Shannon diversity index is used to calculate interface diversity based on building height mixing.

At the level of natural network systems, the spatial distribution of measurement results is shown in Figure 3 (d). At the level of blue streets, according to Wang Lan et al. [23], "neighborhoods" are divided into "small neighborhoods (800m) and large neighborhoods (1600m)", and the accessibility of blue spaces is divided into three levels: level one is distance ≥ 1600m, level two is 800 m ≤ distance ＜ 1600m, and level three is distance ＜ 800m; Divide the number of blue spaces within the search range into four levels: level zero is no blue space, level one is only one blue space, level two is two blue spaces, and level three is three blue spaces; Divide the diversity of blue spaces within the search range into five categories: Level 1 refers to no blue space, Level 2 refers to only small water systems, Level 3 refers to riverbanks or riverbanks and small water systems, Level 4 refers to at least one or two types of blue spaces along the coast, and Level 5 refers to the coexistence of coastal riverbanks and small water systems.

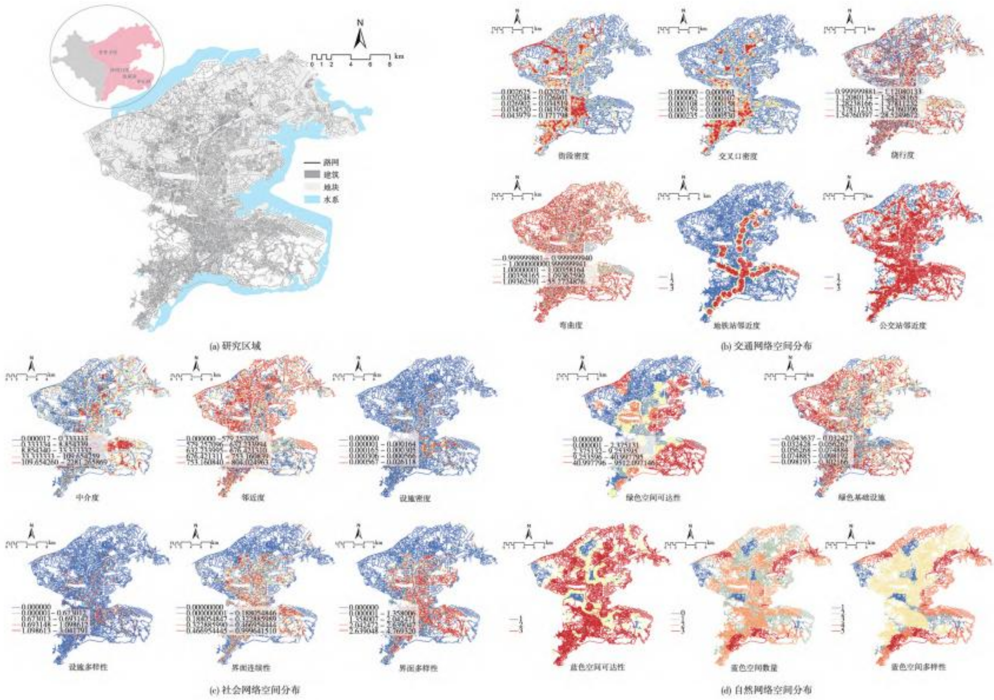

Fig.3 Area of study and spatial distribution of street networks

3 Feature extraction of street network elements

3.1 Feature Extraction

Perform principal component analysis on street network indicators (Table 1) to explore the dominant factors in multidimensional and multi indicator analysis. Firstly, in order to eliminate the possible impact of dimensional differences, the data was standardized. At the same time, to verify the feasibility of principal component analysis of the data, KMO and Bartlett's sphericity tests were conducted separately. The KMO values for the transportation, social, and natural network systems were 0.545, 0.563, and 0.626, all of which were greater than 0.5

Sig<0.05 indicates that the data supports principal component analysis. The transportation, social, and natural network systems extracted three principal components, with cumulative contribution rates of 76.24%, 70.17%, and 85.05%, respectively, all greater than 70.00%. This indicates that the dimensionality reduction analysis method is effective and that these principal components can comprehensively reflect the main situation of the comprehensive evaluation of street network features. Finally, based on the eigenvalues and component matrices of each principal component, calculate the scores of each principal component factor. See Table 2.

At the level of transportation network system, the first principal component has high load values for detours and curvatures, and positive factor coefficients, indicating that the first principal component can reflect the information of both indicators and has a positive effect, which can represent structural characteristics; The high load values and positive factor coefficients of street segment density and intersection density in the second principal component indicate that the second principal component can represent both indicators and is positively correlated, which can represent density characteristics; The high proximity load value and positive factor coefficient between subway stations and bus stations in the third principal component indicate that the third principal component is a comprehensive reflection of the two indicators and is positively correlated, reflecting the connectivity characteristics.

At the level of social network systems, the first principal component has high loadings of interface continuity and diversity with positive factor coefficients, indicating that the first principal component is mainly determined by the positive effects of two indicators, which can express interface quality; The higher factor coefficients of functional density and diversity loading values in the second principal component are positive, indicating that the second principal component mainly reflects the information of two indicators and has a positive effect, which can express the degree of functional complexity; The third principal component has higher loadings for mediation and proximity, but the mediation factor coefficient is positive and the proximity coefficient is negative, indicating that the third principal component can reflect two indicators, with the former having a positive effect and the latter having a negative effect, which can indicate location advantage.

At the level of natural network systems, the blue space accessibility, quantity, and diversity loadings in the first principal component are relatively high and positively correlated, indicating that the first principal component can reflect the three indicators of blue space and has a positive impact. It represents the blue level of streets; The green space accessibility load value in the second principal component eigenvalues is relatively high and positively correlated, indicating that the second principal component is mainly determined by the positive impact of green space accessibility, which represents the level of green accessibility in the street; The green infrastructure load value in the third principal component is relatively high and positively correlated, indicating that the third principal component is determined by the positive effect of green infrastructure and can represent the green level of the street.

Table 1 Results of principal component analysis

Transportation Network System					Social Network System					Natural Network System				
Indicator		Principal Component			Indicator		Principal Component			Indicator		Principal Component		
		1	2	3			1	2	3			1	2	3
Density Features	Segment Density	0.014	0.877	0.032	Location Advantage	Betweenness Centrality	0.091	0.151	0.736	Green Street	Green space accessibility	-0.010	0.997	0.045
	Intersection Density	0.005	0.819	0.240		Proximity	-0.025	0.054	-0.813		Green infrastructure	0.006	0.045	0.997
Structural Features	Detour Degree	0.948	0.017	0.005	Functional Compound	Functional Density	0.035	0.861	0.079	Blue Street	Blue Space Accessibility	0.768	-0.022	0.048
	Curvature Degree	0.948	0.002	-0.007		Versatility	0.164	0.833	0.021		Number of blue spaces	0.916	-0.065	0.035
Connected Features	Proximity to Subway Stations	0.001	-0.001	0.826	Interface Quality	Interface continuity	0..861	0.080	0.049		Blue space diversity	0.900	0.105	-0.045
	Proximity to Bus Stops	-0.003	0.282	0.676		Interface variety	0.855	0.115	0.080	—	—	—	—	—
Eigenvalue		1.797	1.519	1.258	Eigenvalue		1.511	1.481	1.218	Eigenvalue		2.238	1.012	1.003
Contribution		29	25	2	Contribution		25.	24.	20.	Contributi		44.7	20.	20.

Rate%	.951	.323	0.963	Rate%	176	691	298	on Rate%	65	239	050
Cumulative Contribution Rate%	29.951	55.274	76.237	Cumulative Contribution Rate%	25.176	49.867	70.165	Cumulative Contribution Rate%	44.765	65.003	85.054
KMO Sampling Adequacy Measure = 0.545 > 0.5; Sig = 0.000				KMO Sampling Adequacy Measure = 0.563; Sig = 0.000				KMO Sampling Adequacy Measure = 0.626; Sig = 0.000			

Tab.2 Matrix table of factor score coefficients

Transportation Network System					Social Network System					Natural Network System				
Indicator		Principal Component			Indicator		Principal Component			Indicator		Principal Component		
		1	2	3			1	2	3			1	2	3
Density Features	Segment Density	0.010	0.712	0.029	Location Advantage	Betweenness Centrality	0.074	0.124	0.667	Green Street	Green space accessibility	-0.007	0.991	0.045
	Intersection Density	0.004	0.665	0.214		Proximity	-0.020	0.044	-0.737		Green infrastructure	0.004	0.045	0.996
Structural Features	Detour Degree	0.707	0.002	0.004	Functional Compound	Functional Density	0.028	0.707	0.072	Blue Street	Blue Space Accessibility	0.513	-0.022	0.048
	Curvature Degree	0.707	0.014	-0.006		Versatility	0.133	0.684	0.019		Number of blue spaces	0.612	-0.065	-0.035
Connected Features	Proximity to Subway Stations	0.001	-0.001	0.769	Interface Quality	Interface continuity	0.700	0.066	0.044		Blue space diversity	0.602	0.104	-0.045
	Proximity	-0.	0.22	0.6		Interface	0.696	0.094	0.072	—	—	—	—	—

	to Bus Stops	002	9	03		variety								

3.2 Feature Evaluation

Based on the score coefficients of principal component factors (Table 2), expressions for the scores of each principal component were constructed. Using different street network score functions and variance contribution rates as weights, comprehensive evaluation models for street network systems were constructed. The larger the comprehensive score of each street network element, the more prominent the feature. In addition, ArcGIS was used to perform spatial visualization analysis on the scores of each principal component, and typical areas were selected as case studies based on the three attribute features of transportation, society, and nature to deeply evaluate the characteristics of the street network.

The evaluation results of the street traffic network show an overall characteristic of being high in the west and low in the east, with scattered points around. This indicates that the traffic characteristics of the network are significantly influenced by its density, morphological structure, and public transportation distribution, with the central area having the highest evaluation value (Figure 4). The study selected three areas, Donglian Road, Zhongshan Road, and Southwest Road, for case analysis. Specifically, in the first principal component, the overall street network spatial distribution is relatively homogeneous, and all three areas are at a medium to high level, indicating that the street structure has prominent advantages, mainly manifested as rich and diverse structures; In the second principal component score, the high scoring areas are mainly concentrated in the central western part, while other areas are at a medium to low level. Among them, the Donglian Road and Zhongshan Road areas have moderate scores and average density, while the Southwest Road area has a higher score, showing characteristics of high density and small streets; In the third principal component, it mainly exhibits a decreasing trend towards the outer circle centered around subway and bus stations. The scores of the three districts are all high, indicating that the connectivity characteristics of the street network are obvious, manifested as being closer to the subway station and bus station.

The evaluation results of the street social network show an overall characteristic of decreasing from the center to the outer circle. This indicates that the social characteristics of the network are significantly influenced by location conditions, street facilities, and interface quality, with high evaluation values mainly concentrated in the western central region (Figure 5). The study selected four important commercial districts for case analysis, namely the South China Plaza commercial district in Ganjingzi District, the Xi'an Road commercial district in Shahekou District, the Olympic commercial district in Xigang District, and the Qingniwaqiao commercial district in Zhongshan District. Specifically, in the first principal component, the overall network evaluation is at a moderately high level, and the scores of the four commercial districts are also high, indicating that the quality of the street interface is good, reflected in the continuity and richness of the interface; In the second principal component, the evaluation results are similar to those of the first principal component, both at a high level, indicating a good degree of functional complexity in the street, reflected in the rich and diverse service facilities; In the third principal component, high evaluation values are often found in the eastern region, while other regions are at a moderate to low level. Among them, only the Xi'an Road commercial district scored low, and the street location advantage is not obvious, while the other three major commercial districts are moderately high, manifested by high proximity and centrality of the street network.

The evaluation results of the street natural network show a hollow overall feature of increasing in a circular pattern, with low inside and high outside. This indicates that the natural features of the network are greatly influenced by the blue-green spatial level, and the high evaluation values are concentrated in peripheral water bodies, forests, and other areas. The study selected three park square areas for case analysis, namely Zaoyuan Park area in the north, Zhongshan Park area in the south central part, and Xinghai Square area in the south (Figure 6). Specifically, in the first principal component, the evaluation values are generally higher in areas adjacent to water systems and lower in areas farther away from water systems. Among them, the Zaoyuan Park and Zhongshan Park areas have moderate to low scores, indicating a lack of blue level in the network. The Xinghai Square area has a higher score, manifested by diverse blue spaces and proximity to the coast and Malan River; In the second principal component, the overall evaluation value is high for areas adjacent to parks and green spaces, and low for areas farther away from parks and green spaces. Among them, Zaoyuan Park and Xinghai Square have higher scores, indicating higher accessibility of green spaces, manifested as adjacent parks and green spaces, while Zhongshan Park has the lowest score and is farther away from parks and green spaces; In the third principal component, the overall spatial distribution is relatively homogeneous, and all three areas are at a medium to high level, indicating that the green infrastructure is relatively complete, mainly manifested by a high vegetation coverage rate in the streets.

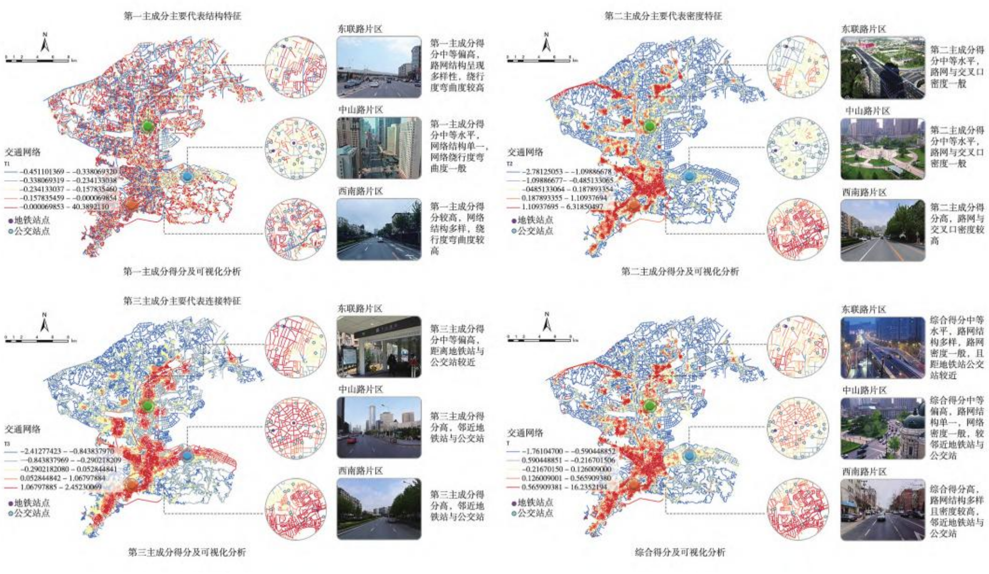

Fig.4 Comprehensive scores and visualization analysis of the transport network systems

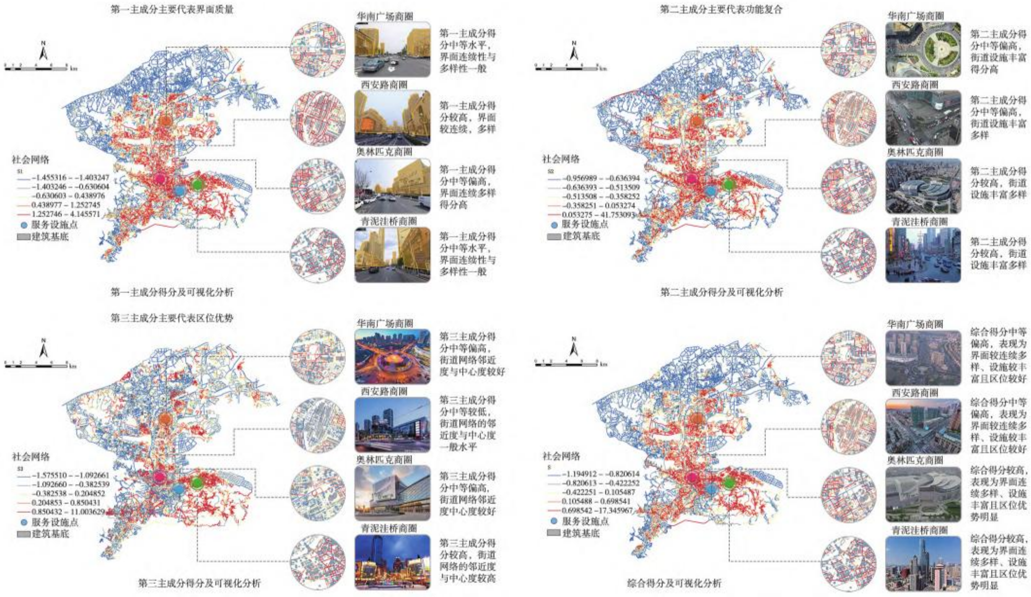

Fig.5 Comprehensive scores and visualization analysis of the social network system

4 Analysis of Street Network Types

Perform K-means clustering analysis based on the above comprehensive scores (Table 3), and perform spatial visualization analysis based on the classification results (Figure 7) to explore the spatial distribution characteristics of the street network. Divide the types of street networks in Dalian into four categories: natural dominant (A1), convenient transportation (A2), social service (A3), and deficient (A4).

Nature dominated networks refer to networks with significantly higher natural attribute evaluations than the other two attributes. These networks are mainly distributed in areas such as mountains, forests, and water bodies around cities, and are characterized by good accessibility to green spaces in streets, high levels of green infrastructure, and rich types of adjacent blue spaces; Convenient transportation type refers to a network with significantly higher scores in transportation attributes than the other two attributes. This type of network is mainly distributed in the central western region, characterized by smaller street scales, richer forms, and closer proximity to subway and bus stations; Social service type refers to networks with prominent social attribute characteristics that are higher than the other two attributes. This type of network is mainly distributed in old city areas and scattered in surrounding areas, showing good location conditions, complete facilities, and continuous and diverse interface spaces; Deficiency type refers to a type of street network with low scores in all three attributes, scattered in urban centers and peripheral areas, mainly characterized by high network density, distance from public transportation stations, insufficient facilities, discontinuous interfaces, and a lack of blue-green spaces. It has no promoting effect on residents' travel and may even have a negative impact. There is great room for improvement in this type of street network.

Tab.3 Cluster analysis of the street network system

Dimension	Type			
	Nature-Dominated Type（A1）	Traffic-Convenient Type（A2）	Social Service Type（A3）	Deficient Type（A4）

Traffic Network Score	-0.639	0.5%	0.122	-0.220
Social Network Score	-0.635	-0.075	1.383	-0.361
Natural Network Score	0.471	0.241	-0.079	-1.267
Number of Streets	8301	8245	5383	4317
Total Number of Streets	26246			

5 Conclusion and Discussion

5.1 Main research conclusions

The street network, as a spatial carrier of resident behavior, has a guiding role in the refined design of streets under the background of urban renewal through its multi-attribute measurement system and type classification model. The study takes residents' mobility, interaction, and ecological behavior as the core, uses the concept of complete streets as the medium, selects multi-attribute elements of transportation, society, and nature as guarantees, and attempts to provide new ideas for the measurement system of street networks. The specific conclusions are as follows: ① Convenient transportation network. This type of network has a relatively high density, morphological structure, and proximity level to public transportation, which can ensure the safety needs of residents' mobile behavior and is in line with the goal of safe streets Social service-oriented network. This type of network has a high level of location, functional complexity, and interface quality, which can to some extent meet the rich demands of residents' social interaction behavior and reach consensus with the goal of dynamic streets Nature dominated network. The blue-green level and accessibility of such networks are relatively high, which can guide residents' ecological behavior and better match the goals of green streets Lack of network. This type of network accounts for a relatively small proportion and is sporadically distributed in urban centers and peripheral areas. Measures such as improving site proximity, functional support, and green quality are still needed to improve the quality of street networks.

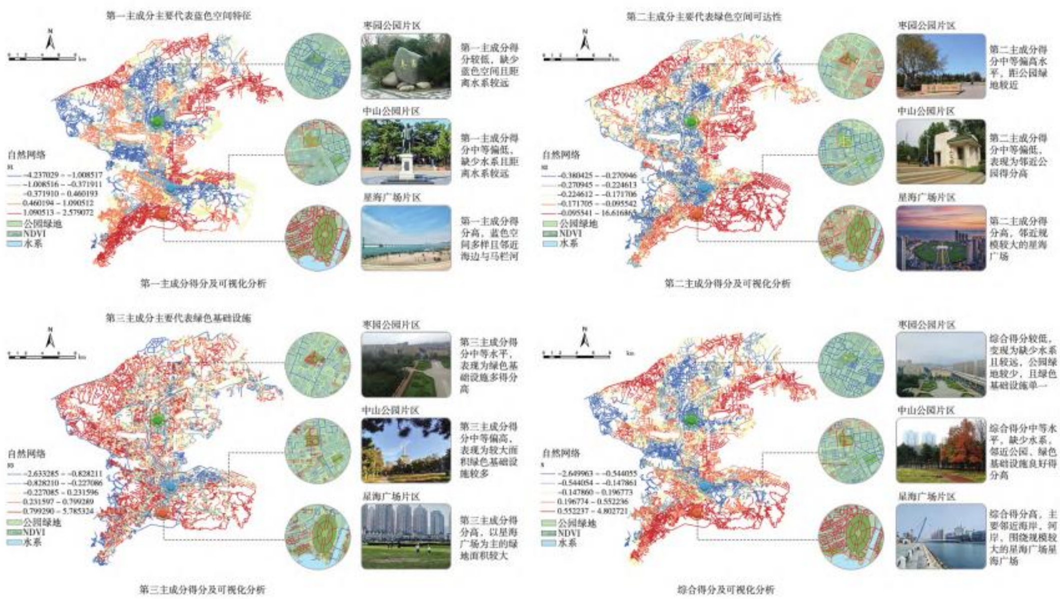

Fig.6 Comprehensive scores and visualization analysis of the natural network system

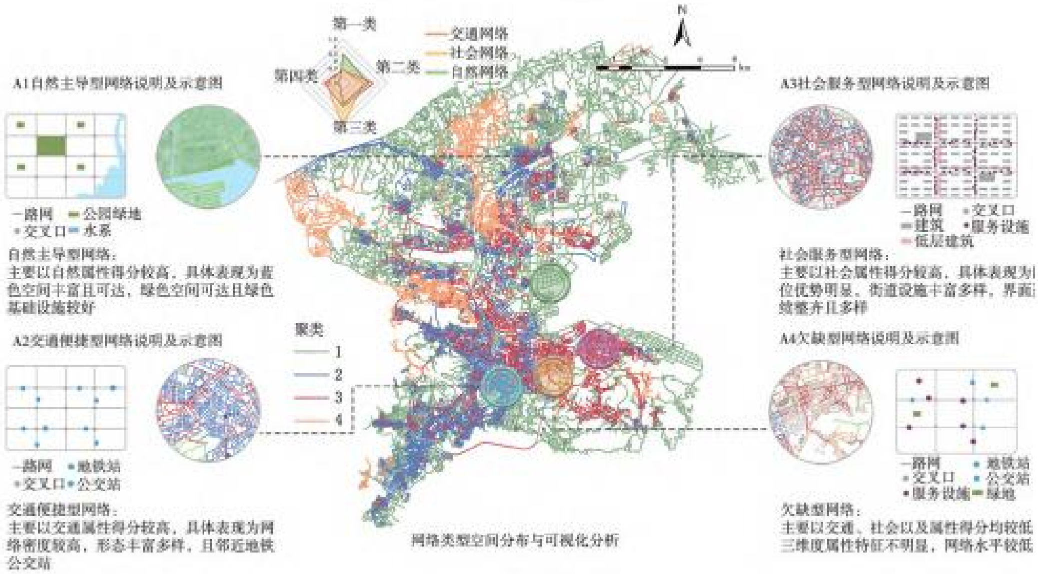

Fig.7 Clustering and visualization analyses of street networks

5.2 Extended Discussion

Based on the accurate diagnosis of street network types mentioned earlier, this study proposes matching improvement suggestions for four types: ① Convenient transportation type. Despite having a safe and convenient transportation system, there is still a lack of vitality and landscape environment in the streets due to the influence of location and function. It is recommended to continue improving the level of transportation services while increasing the diversity of street businesses, vegetation planting on both sides of the street, and street green spaces to improve the level of street services [49-51] Social service-oriented. The good vitality of the street also makes the street network slightly inadequate in terms of traffic safety and environmental quality. It is recommended to improve the hierarchical structure of the street network [52], adopt traffic diversion methods to reduce the frequency of accidents [53], and add green facilities on both sides of the street to collect rainwater, appropriately increase blue-green spaces and their guiding signs to improve the quality of the street Natural dominant type. The unique natural resources provide the street network with environmental advantages, but also bring problems such as inconvenient transportation and insufficient social vitality. It is recommended to increase the coverage of public transportation facilities [54], improve the number of service facilities [55] and interface quality [56] to increase transportation convenience and street vitality, thereby enhancing the material support of the street network for residents' activities and travel Lacking type. Affected by various factors, this type of street network has many problems. However, on the premise of ensuring street safety, improving social vitality first and then improving the quality of the street environment can help efficiently enhance the refined design of streets under the background of stock renewal.

5.3 Insufficient research

This study aims to accurately measure and characterize complete streets, but there are still shortcomings and areas for improvement. Firstly, in the current context of multi-source big data, different data choices can lead to instability in research conclusions to a certain extent, and this difference has a certain impact on the universality of research conclusions. Secondly, research on street networks still needs to explore the relationship with residents' activity behaviors, especially the correlation between different types of activity behaviors involved in different attribute networks. However, due to space limitations, the relationship between street networks and residents' activity behaviors has not been included in the analysis. Based on this research, further in-depth exploration of the intrinsic correlation with residents' activity behaviors will be conducted in the future.

Notes

① The formula for calculating Shannon diversity index is as follows: $S = -\sum_{i=1}^{m} P_i ln P_i$。 In the calculation of functional diversity, M represents the number of facility types, Pi represents the proportion of i-th type facilities in the total number, and when there is only one type of facility, its value is 0; In the diversity of interfaces, M represents the number of building floors and Pi represents the proportion of the i-th type of building height to the total. When there is only one type of building height, its value is 0.

② Two step mobile search method: The first step is to extract the population of the park and green space as the supply point j for the park and green space. A search domain is established with the maximum distance d0 to the park and green space as the half longitude, and all the population numbers in the search domain are summarized. The Gaussian function is used to assign values according to the decay law, and the weighted population is added and summarized to calculate the supply-demand ratio Rj

$$R_j = \frac{S_j}{\sum_{k \in \{d_{kj} \le d_0\}} G(d_{ij}) D_k} \quad (1)$$

Dk represents the population of each network buffer zone, dkj is the road network distance between positions k and j. For parks with multiple entrances, the road network distance from the demand unit to the nearest entrance is selected, and unit k needs to fall within the search domain (i.e. dkj ≤ d0); Sj is the area of park green space j; G (dij) is a Gaussian decay function that considers spatial friction problems, and its specific form can be expressed as:

$$G(d_{ij}) = \frac{e^{-\frac{1}{2} \times \left(\frac{d_{ij}}{d_0}\right)^2} - e^{-\frac{1}{2}}}{1 - e^{-\frac{1}{2}}} \ (d_{ij} < d_0) \qquad (2)$$

The second step is to use any entrance location i as the demand point and the maximum distance d0 of the road network for people to go to the park and green space as the radius, establish a search domain I, and then search for all parks and green spaces j within the search domain. The supply-demand ratio Rj of these parks and green spaces is summarized and summed on the basis of a Gaussian decay function to obtain the distance cost based park and green space accessibility A of residential area i. The larger the value, the higher the accessibility level.

$$A_i^D = \sum_{j \in \{d_i \le d_0\}} G(d_{ij}) R_j \qquad (3)$$

③ Principal component score expression for transportation network system:

T1 =0.01X1 -0.004X2 +0.707X3 +0.707X4 + 0.001X5 -0.002X6；

T2 =0.712X1 +0.665X2 +0.002X3 +0.014X4 - 0.001X5 +0.229X6；

T3 =0.029X1 +0.214X2 +0.004X3 -0.006X4 + 0.769X5 +0.603X6。
Social network system:
S1=0.074X1-0.020X2+0.028X3+0.133X4+0.700X5+0.696X6
S2=0.124X1+0.044X2+ 0.707X3+0.684X4+0.066X5+0.094X6；
S3=0.667X1-0.737X2+0.072X3+0.019X4+
0.044X5+0.072X6 natural network system
N1=-0.007X1+0.004X2+0.513X3+ 0.612X4+0.602X5；
N2=0.991X1+0.045X2-0.022X3-0.065X4+ 0.104X5；
N3=0.045X1+0.996X2+0.048X3-0.035X4-0.045X5。
Comprehensive evaluation model:
Transportation network=0.230/0.762 × T1+0.253/0.762 × T2+0.210/0.762 × T3; Social network=0.252/0.702 × S1+0.247/0.702 × S2+0.203/0.702 × S3; Natural network=0.448/0.851 × N1+0.202/0.851 × N2+0.201/0.851 × N3。

参考文献

References

[1] 卓健, 曹根榕 . 街道空间管控视角下城市 设计法律效力提升路径和挑战[J].规划师, 2018, 34(7): 18-25.
ZHUO Jian, CAO Genrong. Path and Challenges for Enhancing the Legal Effectiveness of Urban Design from the Perspective of Street Space Control [J]. Planner, 2018, 34(7): 18-25.
[2] 唐婧娴, 龙瀛, 翟炜, 等 . 街道空间品质的 测度、变化评价与影响因素识别: 基于大规 模多时相街景图片的分析[J]. 新建筑, 2016 (5): 110-115.
TANG Jingxian, LONG Ying, ZHAI Wei, et al. Measurement, Evaluation of Changes, and Identification of Influencing Factors of Street Space Quality: Analysis Based on Large-Scale Multi-Temporal Street View Images [J]. New Architecture, 2016 (5): 110-115.
[3] 江浩波, 卢珊, 肖扬 . 基于街景技术的上海 历史文化风貌区城市色彩评价方法[J]. 城 市规划学刊, 2022(3): 111-118.
JIANG Haobo, LU Shan, XIAO Yang. Method for Evaluating Urban Colors in Shanghai's Historical and Cultural Scenic Areas Based on Street View Technology [J]. Urban Planning Journal, 2022(3): 111-118.
[4] 邵源, 叶丹, 叶宇 . 基于街景数据和深度学习的街道界面渗透率大规模测度研究: 以 上 海 为 例 [J/OL]. 国 际 城 市 规 划 : 1-13 [2022-09-07]. https://doi.org/10.19830/ j.upi.2021.241.
SHAO Yuan, YE Dan, YE Yu. Research on Large-Scale Measurement of Street Interface Permeability Based on Street View Data and Deep Learning: A Case Study of Shanghai [J/OL]. International Urban Planning: 1-13 [2022-09-07]. https://doi.org/10.19830/j.upi.2021.241.
[5] 叶宇, 张昭希, 张啸虎, 等 . 人本尺度的街 道空间品质测度:结合街景数据和新分析 技术的大规模、高精度评价框架[J]. 国际城 市规划, 2019, 34(1): 18-27.
YE Yu, ZHANG Zhaoxi, ZHANG Xiaohu, et al. Measurement of Street Space Quality at Human Scale: A High-Precision, Large-Scale Evaluation Framework Combining Street View Data and New Analytical Techniques [J]. International Urban Planning, 2019, 34(1): 18-27.
[6] 徐磊青, 康琦 . 商业街的空间与界面特征 对步行者停留活动的影响: 以上海市南京 西路为例[J]. 城市规划学刊, 2014(3): 104- 111.

XU Leiqing, KANG Qi. Influence of Spatial and Facade Characteristics of Commercial Streets on Pedestrian Staying Activities: A Case Study of Nanjing West Road in Shanghai [J]. Urban Planning Journal, 2014(3): 104-111.
[7] 胡扬, 王雷 . 街道空间平面指标对步行者 路径的影响: 四个步行街区的比较分析[J]. 新建筑, 2021(2): 31-36.
HU Yang, WANG Lei. Impact of Street Space Planar Indicators on Pedestrian Path Selection: Comparative Analysis of Four Walking Districts [J]. New Architecture, 2021(2): 31-36.
[8] 王伊倜, 杨滔 . 空间句法在城市规划实施 评估中的应用探索: 以云南省玉溪市总体 规划为例[J]. 城市规划, 2018, 42(11): 71- 78.
WANG Yiti, YANG Tao. Exploration of the Application of Space Syntax in the Implementation Assessment of Urban Planning: A Case Study of Yuxi City Master Plan in Yunnan Province [J]. Urban Planning, 2018, 42(11): 71-78.
[9] HE S W, YU S, WEI P, et al. A spatial de- sign network analysis of street networks and the locations of leisure entertainment activities: a case study of Wuhan, China[J]. Sustainable Cities and Society, 2019, 44: 880-887.
[10] HILLIER B. Natural movement: or con- figuration and attraction in urban pedestri- an movement[J]. Environment and Plan- ning B: Planning and Design, 1993(20): 29-66.
[11] MASLOW A H. A theory of human moti- vation[J]. Psychological Review, 1943, 50 (4): 370-396.
MASLOW A H. A Theory of Human Motivation [J]. Psychological Review, 1943, 50 (4): 370-396.
[12] 柴彦威, 沈洁 . 基于居民移动—活动行为 的城市空间研究[J]. 人文地理 , 2006(5): 108-112.
CHAI Yanwei, SHEN Jie. Urban Space Research Based on Residents' Mobility-Activity Behavior [J]. Human Geography, 2006(5): 108-112.
[13] 周素红, 彭伊依, 柳林, 等 . 日常活动地建 成环境对老年人主观幸福感的影响[J]. 地 理研究, 2019, 38(7): 1625-1639.
ZHOU Suhong, PENG Yinong, LIU Lin, et al. Impact of the Built Environment of Daily Activity Sites on Elderly Subjective Well-Being [J]. Geographical Research, 2019, 38(7): 1625-1639.
[14] JOHN R. “Complete streets” program gives more room for pedestrians, cyclists [N/OL]. 2007. [2014-02-26]. http://usa- today30.usatoday. com/news /nation/2007 -07-29-complete-streets_N.htm.
[15] Regional Plan Association. Re-envision- ing the right-of-way[R]. New York, 2021.
[16] Transportation Alternatives. NYC 25x25: a challenge to New York city's next lead- ers to give streets back to people[R]. New York, 2021.
[17] 卓健, 吴卓烨, 徐逸菁 . 路权共享导向的开 放街区规划设计策略[J]. 规划师, 2017, 33(7): 19-25.
ZHUO Jian, WU Zhuoye, XU Yijing. Open Block Planning and Design Strategies Oriented by Shared Right-of-Way [J]. Planner, 2017, 33(7): 19-25.
[18] 施澄, 袁琦, 潘海啸, 等 . 街道空间步行适 宜性测度与设计导控: 以上海静安寺片区 为例[J]. 上海城市规划, 2020(5): 71-79.
SHI Cheng, YUAN Qi, PAN Haixiao, et al. Measurement and Design Guidance of Street Space Walkability: A Case Study of the Jing'an Temple Area in Shanghai [J]. Shanghai Urban Planning, 2020(5): 71-79.

[19] HUANG B , FENG Z , PAN Z , et al. Amount of and proximity to blue spaces and general health among older Chinese adults in private and public housing: a na- tional population study[J]. Health & Place, 2022, 74: 102774.
[20] YEN H Y , CHIU H L , HUANG H Y . Green and blue physical activity for quality of life: a systematic review and meta-analy- sis of randomized control trials[J]. Land- scape and Urban Planning, 2021, 212. DOI:10.1016/j.landurbplan .2021.104093.
[21] 谢波, 伍蕾, 王兰 . 基于自然实验的城市绿 道对居民中高强度体力活动的影响研究 [J]. 风景园林, 2021, 28(5): 30-35.
XIE Bo, WU Lei, WANG Lan. Study on the Impact of Urban Greenways on Residents' Moderate to Vigorous Physical Activity Based on Natural Experiments [J]. Landscape Architecture, 2021, 28(5): 30-35.
[22] 王兰, 廖舒文, 赵晓菁 . 健康城市规划路径 与要素辨析[J]. 国际城市规划, 2016, 31(4): 4-9.
WANG Lan, LIAO Shuwen, ZHAO Xiaojing. Identification of Healthy Urban Planning Paths and Elements [J]. International Urban Planning, 2016, 31(4): 4-9.
[23] MCDOUGALL C W , HANLEY N, QUILLIAM R S, et al. Neighbourhood blue space and mental health: a nationwide ecological study of antidepressant medica- tion prescribed to older adults[J]. Land- scape and Urban Planning, 2021, 214(4): 104132.
[24] 谢波, 凌昌隆, 王兰 . 城市街道模式对交通 安全的影响研究: 以武汉市主城区为例[J]. 城市规划, 2022, 46(8): 75-83.
XIE Bo, LING Changlong, WANG Lan. Study on the Impact of Urban Street Patterns on Traffic Safety: A Case Study of the Main Urban Area of Wuhan [J]. Urban Planning, 2022, 46(8): 75-83.
[25] 颜文涛, 卢江林, 李子豪, 等 . 城市街道网 络的韧性测度与空间解析:五大全球城市 比较研究[J]. 国际城市规划, 2021, 36(5): 1-12.
YAN Wentao, LU Jianglin, LI Zihao, et al. Resilience Measurement and Spatial Analysis of Urban Street Networks: A Comparative Study of Five Global Cities [J]. International Urban Planning, 2021, 36(5): 1-12.
[26] 龙瀛, 赵健婷, 李双金, 等 . 中国主要城市 街道步行指数的大规模测度[J]. 新建筑, 2018(3): 4-8.
LONG Ying, ZHAO Jianting, LI Shuangjin, et al. Large-Scale Measurement of Street Walkability Index in Major Chinese Cities [J]. New Architecture, 2018(3): 4-8.
[27] 宋小冬, 陶颖, 潘洁雯, 等 . 城市街道网络 分析方法比较研究 : 以 Space Syntax、sD- NA 和 UNA 为例[J]. 城市规划学刊, 2020 (2): 19-24.
SONG Xiaodong, TAO Ying, PAN Jiewen, et al. Comparative Study of Urban Street Network Analysis Methods: A Case Study of Space Syntax, sDNA, and UNA [J]. Urban Planning Journal, 2020 (2): 19-24.
[28] 车冠琼, 仇保兴, 杨滔 . 街道网络结构与土 地利用布局对人流分布的影响[J]. 西部人 居环境学刊, 2021, 36(2): 87-94.
CHE Guanqiong, QIU Baoxing, YANG Tao. Impact of Street Network Structure and Land Use Layout on Pedestrian Distribution [J]. Western Journal of Human Settlements, 2021, 36(2): 87-94.
[29] 宋小冬, 李晓晗, 齐文菲, 等 . 城市道路网 络拓扑结构对常规公共交通的适宜性评价 [J]. 城市规划学刊, 2020(4): 43-50.
SONG Xiaodong, LI Xiaohan, QI Wenfei, et al. Evaluation of the Suitability of Conventional Public Transport to Urban Road Network Topology [J]. Urban Planning Journal, 2020(4): 43-50.

[30] 叶宇, 黄鎔, 张灵珠 . 多源数据与深度学习 支持下的人本城市设计: 以上海苏州河两 岸城市绿道规划研究为例[J]. 风景园林, 2021, 28(1): 39-45.

YE Yu, HUANG Rong, ZHANG Lingzhu. Human-Oriented Urban Design Supported by Multi-Source Data and Deep Learning: A Case Study of Suzhou River Greenway Planning in Shanghai [J]. Landscape Architecture, 2021, 28(1): 39-45.

[31] 曹根榕, 卓健 . 城市老年人步行购物对商 业设施选择的空间影响因素分析:基于上 海中心城区 3 个典型居住区的实证研究 [J]. 上海城市规划, 2017(4): 101-106.

CAO Genrong, ZHUO Jian. Spatial Impact Factors of Urban Elderly Walking Shopping on Commercial Facility Selection: An Empirical Study Based on Three Typical Residential Areas in the Central Urban Area of Shanghai [J]. Shanghai Urban Planning, 2017(4): 101-106.

[32] 郝新华, 龙瀛, 石淼, 等 . 北京街道活力:测 度、影响因素与规划设计启示[J]. 上海城市 规划, 2016(3): 37-45.

HAO Xinhua, LONG Ying, SHI Miao, et al. Beijing Street Vitality: Measurement, Influencing Factors, and Planning and Design Implications [J]. Shanghai Urban Planning, 2016(3): 37-45.

[33] 杨俊宴, 吴浩, 郑屹 . 基于多源大数据的城 市街道可步行性空间特征及优化策略研 究: 以南京市中心城区为例[J]. 国际城市规 划, 2019, 34(5): 33-42.

YANG Junyan, WU Hao, ZHENG Yi. Study on the Spatial Characteristics and Optimization Strategies of Urban Street Walkability Based on Multi-Source Big Data: A Case Study of the Central Urban Area of Nanjing [J]. International Urban Planning, 2019, 34(5): 33-42.

[34] 惠英, 廖佳妹, 张雪诺, 等 . 基于行为活动 模式的儿童友好型街道设计研究[J]. 城市 规划学刊, 2021(6): 92-99.

HUI Ying, LIAO Jiamai, ZHANG Xuenuo, et al. Research on Child-Friendly Street Design Based on Behavioral Activity Patterns [J]. Urban Planning Journal, 2021(6): 92-99.

[35] ASHBULLBY KJ, PAHL S, WEBLEY P, et al. The beach as a setting for families health promotion: a qualitative study with parents and children living in coastal re- gions in southwest England[J]. Health Place, 2013, 23:138-147.

[36] 干靓, 杨伟光, 王兰 . 影响亲自然活动多样 性的城市滨江绿地空间特征识别与设计优 化: 以上海黄浦江沿岸为例[J].城市发展研 究, 2022, 29(7): 67-73.

ASHBULLBY KJ, PAHL S, WEBLEY P, et al. The Beach as a Setting for Families’ Health Promotion: A Qualitative Study with Parents and Children Living in Coastal Regions in Southwest England [J]. Health & Place, 2013, 23: 138-147.

[37] BRAY I, REECE R, SINNETT D, et al. Exploring the role of exposure to green space in preventing anxiety and depression among young people aged 14-24 living in urban settings: a systematic review[J]. 2021.DOI:10.21203/rs.3.rs-255123/v1.

[38] DEMPSEY S, DEVINE M T, GILLESPIE T, et al. Coastal blue space and depression in older adults. [J]. Papers, 2018. DOI: 10.1016/J.HEALTHPLACE.2018.09 .002.

[39] 陈玉洁, 袁媛, 周钰荃, 等 . 蓝绿空间暴露 对老年人健康的邻里影响: 以广州市为例 [J]. 地理科学, 2020, 40(10): 1679-1687.

CHEN Yujie, YUAN Yuan, ZHOU Yuquan, et al. Neighborhood Effects of Blue-Green Space Exposure on the Health of the Elderly: A Case Study of Guangzhou [J]. Scientia Geographica Sinica, 2020, 40(10): 1679-1687.

[40] 西蒙·贝尔 . 公众健康和幸福感考量的城 市蓝色空间: 城市景观研究新领域[J].风景 园林, 2019, 26(9): 119-131.

SIMON BELL. Urban Blue Space for Public Health and Well-being: A New Field of Urban Landscape Research [J]. Landscape Architecture, 2019, 26(9): 119-131.
[41] WHITE M P, PAHL S, WHEELER B W, et al. Natural environments and subjective wellbeing: different types of exposure are associated with different aspects of wellbe- ing[J]. Health & Place, 2017, 45: 77-84.
[42] 王兰, 蒋希冀, 汪子涵, 等 . 绿色空间对呼 吸健康的影响研究综述及综合分析框架 [J]. 风景园林, 2021, 28(5): 10-15
WANG Lan, JIANG Xiji, WANG Zihan, et al. Review and Comprehensive Analysis Framework of the Impact of Green Space on Respiratory Health [J]. Landscape Architecture, 2021, 28(5): 10-15.
[43] KUEHN S, DUEZEL S, MASCHEREK A, et al. Urban green is more than the ab- sence of city: structural and functional neu- ral basis of urbanicity and green space inthe neighbourhood of older adults[J]. Landscape and Urban Planning, 2021.DOI: 10.1016/j.landurbplan .2021.104196.
[44] 王兰, 张雅兰, 邱明, 等 . 以体力活动多样 性为导向的城市绿地空间设计优化策略 [J]. 中国园林, 2019, 35(1): 56-61.
WANG Lan, ZHANG Yalan, QIU Ming, et al. Optimization Strategies for Urban Green Space Design Oriented by the Diversity of Physical Activities [J]. Chinese Landscape Architecture, 2019, 35(1): 56-61.
[45] 赵广英, 宋聚生 . 城市用地功能混合测度 的方法改进[J]. 城市规划学刊 , 2022(1): 51-58.
ZHAO Guangying, SONG Jusheng. Methodological Improvement for Measuring Urban Land Use Function Mix [J]. Urban Planning Journal, 2022(1): 51-58.
[46] 郝新华, 龙瀛, 石淼, 等 . 北京街道活力: 测 度、影响因素与规划设计启示[J]. 上海城市 规划, 2016(3): 37-45.
HAO Xinhua, LONG Ying, SHI Miao, et al. Beijing Street Vitality: Measurement, Influencing Factors, and Planning and Design Implications [J]. Shanghai Urban Planning, 2016(3): 37-45.
[47] 仝德, 孙裔煜, 谢苗苗 . 基于改进高斯两步 移动搜索法的深圳市公园绿地可达性评价 [J]. 地 理 科 学 进 展 , 2021, 40(7): 1113- 1126.
TONG De, SUN Yiyu, XIE Miaomiao. Evaluation of Park and Green Space Accessibility in Shenzhen Based on Improved Gaussian Two-Step Floating Catchment Area Method [J]. Progress in Geography, 2021, 40(7): 1113-1126.
[48] 樊钧, 唐皓明, 叶宇 . 街道慢行品质的多维 度评价与导控策略:基于多源城市数据的 整合分析[J]. 规划师, 2019, 35(14): 5-11.
FAN Jun, TANG Haoming, YE Yu. Multidimensional Evaluation and Guidance Strategy for the Quality of Slow Traffic in Streets: An Integrated Analysis Based on Multi-Source Urban Data [J]. Planner, 2019, 35(14): 5-11.
[49] 张晓春, 邵源, 安健, 等 . 数据驱动的活动 规划技术体系构建与实践探索: 以深圳市 福田中心区街道品质提升为例[J]. 城市规 划学刊, 2021(5): 49-57.
ZHANG Xiaochun, SHAO Yuan, AN Jian, et al. Construction and Practice Exploration of Data-Driven Activity Planning Technology System: A Case Study of Street Quality Improvement in Futian Central District, Shenzhen [J]. Urban Planning Journal, 2021(5): 49-57.
[50] 童明, 王澍, 王世福, 等 .“高品质公共空间 的协同营造机制”学术笔谈[J].城市规划学 刊, 2021(1): 1-9.
TONG Ming, WANG Shu, WANG Shifu, et al. Academic Discussion on the Collaborative Creation Mechanism of High-Quality Public Spaces [J]. Urban Planning Journal, 2021(1): 1-9.

[51] 吴志强, 王凯, 陈韦, 等 .“社区空间精细化 治理的创新思考”学术笔谈[J].城市规划学 刊, 2020(3): 1-14.
WU Zhiqiang, WANG Kai, CHEN Wei, et al. Academic Discussion on Innovative Thinking in the Fine Governance of Community Spaces [J]. Urban Planning Journal, 2020(3): 1-14.
[52] 潘海啸, 刘冰 . 关于“小街区”规划设计的几 点探讨[J]. 城市规划学刊, 2019(S1): 220- 226.
PAN Haixiao, LIU Bing. Some Discussions on the Planning and Design of "Small Blocks" [J]. Urban Planning Journal, 2019(S1): 220-226.
[53] 刘珺, 王德, 王昊阳 . 上海市老年人休闲步 行环境评价研究:基于步行行为偏好的实 证案例[J]. 上海城市规划, 2017(1): 43-49.
LIU Jun, WANG De, WANG Haoyang. Evaluation of Shanghai Elderly Leisure Walking Environment: An Empirical Case Based on Walking Behavior Preferences [J]. Shanghai Urban Planning, 2017(1): 43-49.
[54] 黄晶, 王磊, 贾新锋, 等 . 公交友好导向下 的步行路径选择评价与街道空间优化[J]. 城市规划学刊, 2021(2): 87-93.
HUANG Jing, WANG Lei, JIA XinFeng, et al. Evaluation of Walking Path Selection and Street Space Optimization under the Orientation of Bus Friendliness [J]. Urban Planning Journal, 2021(2): 87-93.
[55] 黄建中, 胡刚钰, 李敏 . 老年视角下社区服 务设施布局适宜性研究:基于步行指数的 方法[J]. 城市规划学刊, 2016(6): 45-53.
HUANG Jianzhong, HU Gangyu, LI Min. Research on the Appropriateness of Community Service Facilities Layout from the Elderly Perspective: A Method Based on Walking Index [J]. Urban Planning Journal, 2016(6): 45-53.
[56] 奚婷霞, 匡晓明, 朱弋宇, 等 . 基于人感知 维度的街道更新设计引导探索: 以上海市 静安区彭浦镇美丽街区更新改造为例[J]. 城市规划学刊, 2019(S1): 168-176.
XI Tingxia, KUANG Xiaoming, ZHU Yiyu, et al. Exploration of Street Renewal Design Guidance Based on Human Perception Dimensions: A Case Study of the Beautiful Street Update and Transformation in Pengpu Town, Jing'an District, Shanghai [J]. Urban Planning Journal, 2019(S1): 168-176.