Research on the Relationship between Urban Public Space Behavior and Landscape Morphology Based on Big Data of Social Networks

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Abstract: In this paper, the interaction between landscape environment and spatial behavior is taken as the research background. From the assessment of landscape, the network big data-behavioral thermodynamic diagram is used to collect the behavioral data, which is quantitatively analyzed with landscape morphological characteristics. The crowd-landscape morphology correlation under modern life mode is explored, together with the interaction between human and environment, to optimize the design decision. This study started with the case of the typical urban public landscape space in the middle and lower reaches of the Yangtze River in China. It conducted a correlation analysis of behavioral research and dual-quantitative-data of landscape morphology. The research results were applied to the case of waterfront landscape design of a city in Jiangsu Province to explore the spatial behavior and the interaction of landscape morphology, providing some rationalized references and suggestions for the user-oriented landscape design.

Keywords: Social media, big data, spatial behaviour, thermodynamic diagram, landscape morphology indicators

1 Introduction

With the development of urban construction and the enhancement of emphasis on the landscape environment, the urban public landscape space in China has been transformed from "incremental development" to "stock optimization" in the past. Improved in both quantity and quality, it provides citizens more comfortable spaces for outdoor recreation and social interaction. However, there are still many problems in the use of space: low utilization rate, deviated use from the original design and so on. There are many causes for such problems. Limited studies by the designers on the behavior patterns and characteristics are one of the important factors. Many designers pay more attention to design style, conception and aesthetics form. Usually, they will determine design viewpoint, view surface and path based on their past experience and qualitative analysis in design practice. There is not much analysis, prediction and simulation of behavior. It makes the designed landscape environment fail to accommodate people's activities or effectively engage people's participation.

Understanding the behavior needs of public space users has always been one of the most important research topics in the field of landscape design. At the same time, it is also a subject that is difficult to quantify objectively. After a long period of research, the behavioral research methods advanced from the conventional ways of interviewing, cognitive mapping, behavioral maps, behavioral logging, direct observation, participatory observation, time-lapse photography, photography, questionnaires, psychological tests, adjective checklists, dynamic image analysis. Up to nowadays, such conventional research methods get further expanded to include doing experiments to collect physiological and psychological data. It is clear that

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scholars have been exploring from the qualitative to quantitative behavioral research methods. However, traditional research methods and the physiological and psychological experiments all share the same weakness of heavy workload, time-consuming and man-power-consuming. Besides, it is very difficult to rapidly display the crowd use intensity of different landscape spaces at the same time (CHENG YU-NING 2010).

The interaction between landscape morphology and usage behavior is the basic problem in the study of landscape humanization design (CHENG YU-NING & YUAN YANG-YANG 2015). For example, the path as a key element of behavioral guidance is interwoven with the actual use of landscape space and the crowd behavior pattern. Therefore, it is very important to analyze the relationship between path morphology and crowd behavior characteristics. With the development of social media and network technology, landscape designers now can record and analyze crowd distribution patterns and fluctuations in landscape space in different time periods via third-party observation and social-medial-based big data analytics. Based on the analysis of big data from social media and quantitative analysis of landscape morphology related to spatial behavior, this paper analyzes the interaction between landscape morphology and spatial behavior. With the new perspectives and methods, the paper probes into the user-oriented characteristics and behavior matchup of landscape design under modern life mode.

2 Data and Methods

2.1 Data Source

Based on China Tencent real-time information big data and Location Based Service (LBS) of Tencent thermal map, the study collected and processed the screened data samples. The data is mainly generated from the data feedback of Tencent's smartphone apps. Although it is impossible to completely cover all the age and income groups, in the case of big data obtained so far, compared with other data (cognitive mapping, behavioral maps, behavioral logging and so on), the real-time grid population data still has absolute advantage. This study selects the peak value of the National Day holiday passenger flow. From the real-time data from 9:00 am to 5:00 pm, it plotted the changes of population density and population flow in all regions. Thermodynamic diagram ranges from blue, green, yellow, orange to red, indicating a gradual increase in population density. It clearly shows the densely populated and sparsely populated areas.

2.2 Sample Screening

The samples were selected by the criteria of popular and representative historic public landscape space in the three regions of Jiangsu Province, namely the Southern Jiangsu, Central Jiangsu and Northern Jiangsu. The selected cases are continuously updated on the basis of historical scenic spots. They can reflect the incorporation into the changing landscape spatial structure and the modern lifestyles over time. Six scenic spots were finally screened out. They are Nanjing Yuhuatai Scenic Spot in Nanjing, Hanshan Temple Scenic Spot in Suzhou, Hongmei Park in Changzhou, Jinshan Lake Scenic Area in Zhenjiang, Daming Temple in Yangzhou and Langshan Park in Nantong.

2.3 LBS Data Processing

First of all, a representative day is selected for data collection (as shown in the Figure 1) from the chart of traffic flow trend. Six scenic spots of the landscapes and parks are sampled separately from 9:00 am to 5:00 pm to observe, at different times, tourists intensive areas, sparse areas and changes in population flow. After that, the study superimposed the data of nine time periods and integrated the distribution pattern of the population flow in nine periods into a single data graph. The paper observed the overall distribution of population flow and started the preliminary analysis (Figure 2).

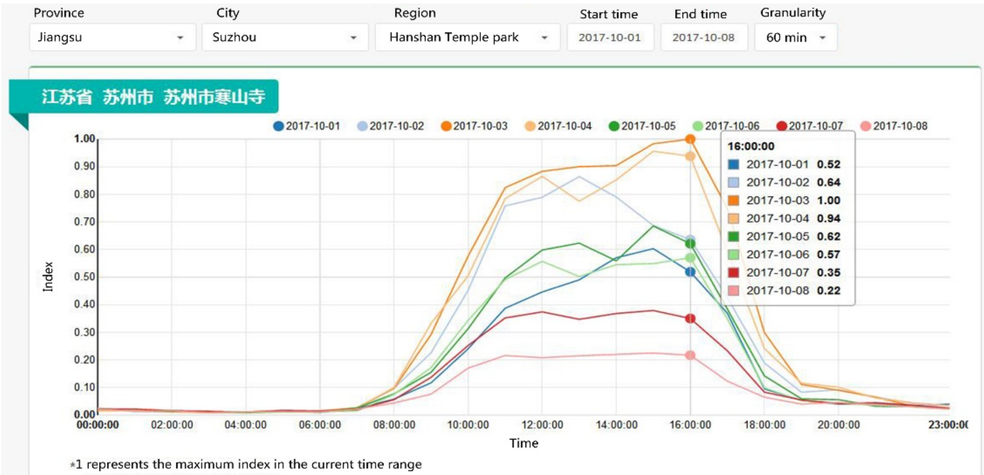


Fig. 1: Tendency chart of visitors flowrate

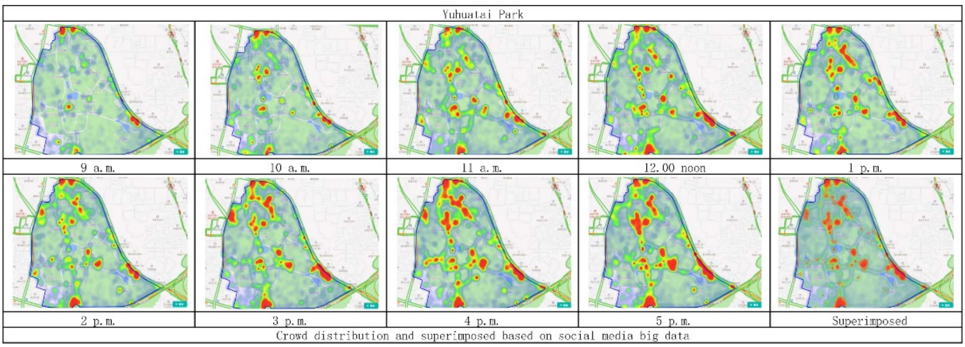


Fig. 2: Thermodynamic diagram

2.4 Selection of Morphological Indicators

Paths and nodes constitute the basis of the landscape spatial form. Its rationality is closely related to the spatial behavior initiation, patterns and spatial dynamics. Reasonable path morphology design and node distribution can give a positive spatial guidance to tourists' behavior, facilitate the interaction and match-up between tourists and landscapes, make full use of landscape resources, and avoid the dead space and idling landscape nodes. Therefore, this paper selects the following seven morphological indicators – namely, node morphology (number of spatial nodes, spatial node density, and spatial node density characteristics) and path morphology (path density, path node density, path integration and path intelligence) (Table 1).

Table 1: description of indicators

Category	Indicator	Method
Node morphology	number of node	N
	density of node	N/S
	analysis of node density	Kernel density analysis by Arcgis
Path morphology	density of path	L/S
	density of path crossing	Nc/s
	path integration	Depthmap
	path intelligence	Depthmap

L:the length of path; S:the area of park; Nc:the number of crossing

2.5 Comparative Analysis of LBS Behavioral Thermodynamic Diagram and Morphological Indicators

Firstly, the LBS superimposed data is compared with the spatial node density distribution to observe the difference between the passenger flow distribution and the spatial node distribution. On this basis, this paper further elaborates and analyzes, from the following four aspects, causes of mismatched landscape morphology and actual behavior. Such analysis was done in four aspects namely the density node characteristics and path integration degree, LBS data and path integration, LBS data and path intelligence, LBS data and road density. The paper also summarizes advantages of superior cases in morphological indicators and weakness of inferior cases.

3 Outcome and Issues

3.1 Density Distribution of LBS and Space Nodes

Nodes are the areas where passenger flow converges, maintains and circulates in landscape space. The distribution patterns of nodes are often arranged in the environment with better environment quality and reachability by the designers' ideas. Meanwhile, the node distribution should be stretched out to cover the entire site. The distribution of ideal space nodes should have a good matchup with the spatial distribution of tourists. The space where nodes are relatively concentrated is also the most attractive area for tourists to visit. Based on the kernel density analysis of ArcGIS, the space nodes distribution profile was studied and compared with LBS data. Among the six comparative cases analyzed, Nanjing Yuhuatai Scenic Spot, Suzhou Hanshan Temple Park, Changzhou Hongmei Park and Yangzhou Da Ming Temple Park were good in distribution of nodes; among which Yangzhou Daming Temple and Changzhou Hongmei Park had thermodynamic diagrams better matched with the distribution of spatial nodes. Spatial nodes distribution of Zhenjiang Jinsha Lake Park matched well with the spatial distribution of passenger flows. Nevertheless, its node distribution was over concentrated, producing very low site utilization efficiency.

3.2 Spatial Node Distribution and Path Integration

Path morphology and spatial distribution of nodes are the backbone to the park space system. They guide the occurrence and distribution of behaviour. Spatial nodes are the areas with most intensive planning and designing in the site. The appropriate spatial node distribution should correspond to the degree of path integration. This means the relatively more critical spatial nodes should be distributed in areas with good accessibility, otherwise it's not conducive to direct the passenger flow via roads to space nodes, compromising the node dynamics and behavioral comfort as a result. In the six cases, the best match between spatial node distribution and path integration is Yangzhou Daming Temple Park. The main space node areas are in a reachable area. The worst case is Zhenjiang Jinshan Lake Park whose nodes are not connected to the most reachable lakeside ring road to produce a good matchup; in the other four cases, there were some space nodes connected to weakly accessed roads.

3.3 LBS and Path Integration

The path integration is study for the reachability of landscape path system (YUJIA ZHAI 2016).The place which has much better integration would not only lead to other area conveniently, but also gather more crowd of people. From best level to general level, the relationship between thermodynamic diagram and path integration rank is Yangzhou Daming Temple Park, Suzhou Hanshan Temple Park, Nantong Langshan Park, Changzhou Hongmei Park, Nanjing Yuhuatai Scenic Spot and Zhenjiang Jinsha Lake Park.

3.4 LBS and Path Intelligence

Path intelligence is the tourists' comprehensibility of park's overall space morphology. The more intelligent the morphology is, the easier it is for tourists to reach their destination and reduce the blurred selectivity and fuzziness of their behavior process. Among the six comparative cases, the best path intelligence was observed in Yangzhou Daming Temple Park, Hanshan Temple Park, Changzhou Hongmei Park and Nantong Langshan Park. By contrast, Nanjing Yuhuatai Scenic Area and Zhenjiang Jinshanhu Park were lower in that area.

3.5 LBS and Road Density

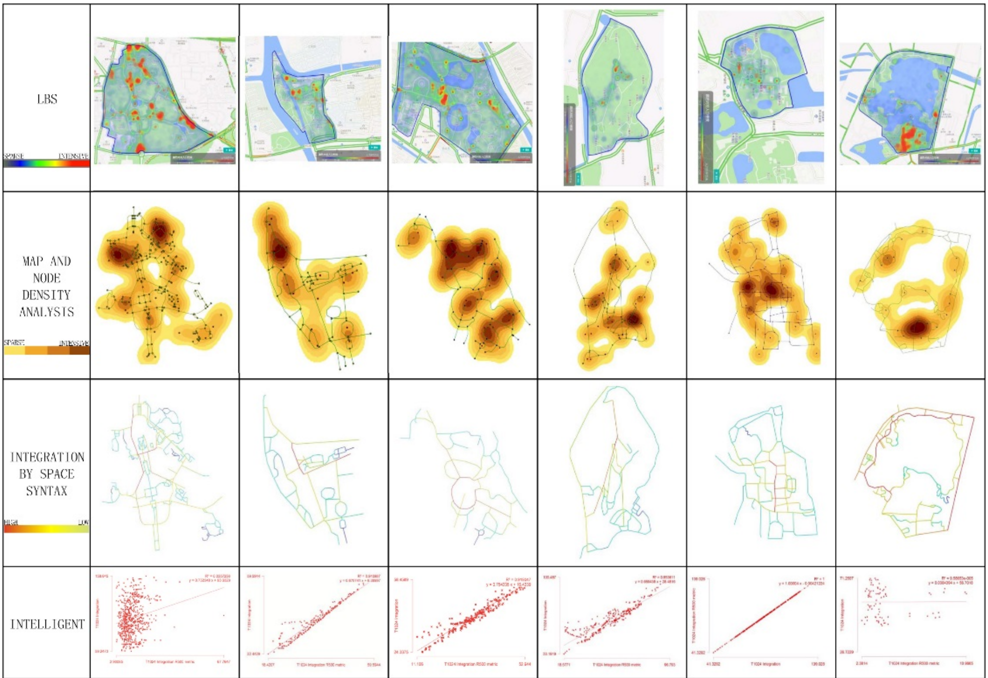
Road density covers two facets: i. the road length to the unit area, ii. the number of road intersections to the unit area (LIU YINGZI & ZONG YUEGUANG 2010). The relatively high road density produces more pleasant spatial scale of the site, which gives room to more behavior possibilities and a more active spatial distribution of tourists. Yangzhou Daming Temple had the most evenly distributed passenger flow, followed by Hanshan Temple, Hongmei Park and Nanjing Yuhuatai. Langshan Park and Jinshan Lake were the lowest in this aspect. The ranking of LBS passenger flow distribution was basically the same as that for the road density ranking among the six cases studied.

3.6 The Interaction between Morphological Indicators

The above analysis proved that various indicators are intricately connected and correlated to each other. Insufficiency on one aspect might be caused indirectly by other indicators. For example, in the analysis of LBS data and road density, although Nantong Langshan Park has certain advantages in road density, its actual passenger flow distribution on the behavioral thermodynamic diagram feedback is not quite good. The reason for that is the weak match between the node density and the degree of path integration.

3.7 LBS Data and Morphological Indicators Corresponding to the Results

Through the comparison of six cases, it was found that the correspondence between the spatial form and the actual activity in Yangzhou Daming Temple was outstanding. It had some advantages over the other cases in all aspects. Its morphological indicators can be used as the landscape space Design reference values to improve the human landscape design space.



NAME	Yuhuatai park	Hanshan Temple park	Hongmei Park	Langshan Park	Daming Temple Park	Jinshan Lake Park
AREA	101	8	29	18	9	118
N.N	38	16	23	37	30	22
D.N	0.38	2	0.79	2.1	3.3	0.19
L.P	14761	3567	5400	4667	2972	15354
D.P	146.15	445	186	259	330	130
INTELLIGENT	0.035	0.94	0.92	0.85	1	0
N.C	238	66	55	46	65	90
D.C	2.37	8.25	1.89	2.56	7.2	0.76

N.N:Number of Node; D.N:Density of Node; L.P:Length of Path ; D.P: Density of Path; N.C:Number of Crossing; D.C:Density of Crossing;

Fig. 3: Thermodynamic diagram and morphology indicators of six comparative cases

4 Case Study

A case analysis of a city waterfront green landscape in Jiangsu Province: this project is currently under construction. As a landscape and urban linked bonds, this waterfront green space planning and design have a lot of unknowns, the challenges which are faced with people not close to the water. People cannot enjoy the water view from the road. As showed in Figure 4 is the analysis of the status of the site elevation, slope. Therefore, creating the right dynamic route, spatial form, and visual corridor is particularly important.

Due to the segmented urban traffic, the design site is divided into three parts, of which the site #2 corresponds to the urban space axis and is designed with large-area square connected to the urban roads to guide the crowd to the waterfront. Site #1 and site #3 served as the two wings of the central axis with the path setting mode of step-changing scenery in traditional Chinese gardens. Nodes for sports, rest and landscape viewing are embedded into the free-curved path.

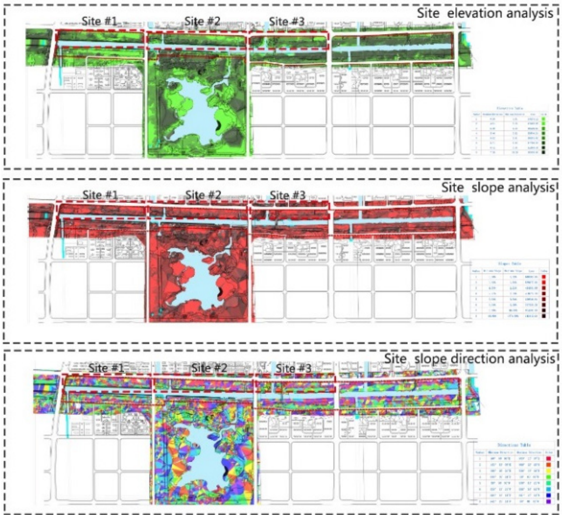
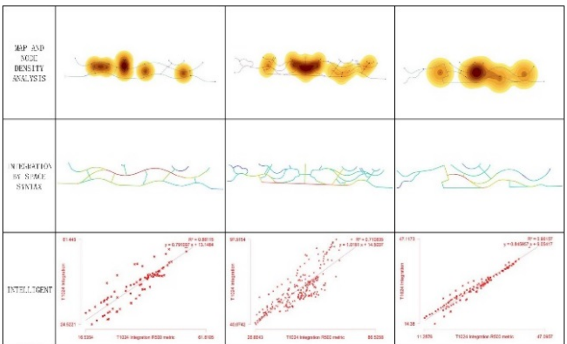


Fig. 4:
Site terrain analysis



NAME	2	1	3
AREA	9.9	10.8	5.6
N.N	6	16	5
D.N	0.61	1.49	0.58
L.P	2486	3993	2415
D.P	251	369.7	281
INTELLIGENT	0.88	0.71	0.96
N.C	23	57	20
D.C	2.5	5.3	2.3

Fig. 5:
Morphology indicators statistics

Based on the analysis of the above six cases, this paper studied the matching between the waterfront landscape morphology and spatial behavior. Through the describing and analyzing four indicators including spatial node density, path density, intelligence degree and road node density, the research identified investigation cases with similar readings to that of the three sites and forecasted their passenger flow distributions. In this way, the behavioral prediction simulation was done at the designing stage to improve the design outcome. According to the above mentioned research methodologies, we conducted statistics review and analysis to the spatial morphology indicators of the three sites (Figure 5). Benchmarked to the analytic data of Yangzhou Daming Temple Park, it was found that the node distribution profile of the three plots match well with their path integration. Site #2 is better on indicators like node density, path density and road node density whereas inadequate in path intelligence, indicating that there is a certain deviation between the partial path structure and the overall path structure in this site. Such deviation may result in the over concentration of passenger flow in central node area with the best path accessibility whereas leaving the other nodes spatially idling due to the insufficient tourist distribution. Site #1 and site #3 have their problems converged mainly on the space node density. They have large site area but insufficient number of nodes. It is forecasted that the space nodes of these two areas can be fully utilized in the future, but the passenger flow will stagnate, to some extent, in the space nodes. There is a lack of mobility in both the path and the entire space area at large, resulting in the compromised space dynamics of large space area (Table 2).

Table 2: Morphology indicators comparison

Indicator	1	2	3
D.N	Hongmei Park	Hanshan Temple	Hongmei Park
D.P	Langshan Park	Daming Temple	Langshan Park
INTELLIGENT	Langshan Park	Langshan Park	Hanshan Temple
D.C	Langshan Park	Daming Temple	Langshan Park

5 Conclusion and Outlook

Compared with the current common behavioral research methods, network-big data-based environmental behavioral research is more advantageous as it is relatively easy to obtain data in a short period of time. The generated visual analytic graph can produce more objective presentation of the use of the space from the macro perspective. At the same time, it is more time-sensitive, easy to guide more intuitive analysis of the conclusions. In this paper, through the thermodynamic diagram, we can describe the crowd intensity and its fluctuation in landscape space over time. Data such as the fluctuation trend of tourist quantity could be calculated. Designers would be able to understand the actual tourist's behavior more quickly and intuitively to adjust and improve their design.

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