

Correlation Analysis of Space Morphology and Way-finding Perception of Large-scale Theme Park Based on Multivariate Data

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Abstract: The influence of space morphological factors on the way-finding perception in public space way-finding research is the focus of current research. The large-scale theme park is a landmark place for the city to promote the tourism economy and the city vitality. This kind of place has the characteristics of large-scale spatial structure and complex local node route. It is easy to cause the problems that the space is difficult to be perceived, difficult to choose when seeking the way, time-consuming to choose, and even lost direction to reduce the playing experience. In order to explore that mutual effect of the law between the characteristic space morphology of a large-scale amusement park and the tourists' way-finding perception, this article takes the outdoor public space of the theme park of HB town as the object, based on Kevin Lynch's theory of environmental behavior related to space cognition of way-finding, use an on-site questionnaire and software simulation and 3D modeling of built environment. In the theme park of the HB town, 10 spatial feature points were selected to obtain the data of way-finding perception questionnaire, space morphological element modeling and measured oblique photography modeling. The three kinds of data were coupled by using the spss software regression analysis. The correlation among the spatial structure, the node interface enclosure and the subjective feeling of the tourists is obtained. Furthermore, the three are checked to find the difficult multi-direction nodes in way-finding. Finally, on the basis of this, the paper points out the space organization design suggestions of the large-scale theme park.

1. Introduction

Scholars in different disciplines have different research directions on way-finding. In the 1960s, the environmental behavior research scholar Kevin Lynch first used "way-finding" to describe the way-finding of the city scale in *The Image of City*. Taking the city as the research object, he

introduced how human beings can identify the space and direction through the physical space morphology such as the "boundary, region, node, path and sign" of the city so as to achieve the purpose of finding the way. According to Kevin Lynch's definition of way-finding, it is a process of organizing clear sensory cues from the external environment [1], which emphasizes the importance of the perception and cognitive process of cues. The identifiability of the environment refers to the possibility and easiness of the environment to be identified by human beings. It is a characteristic of a place that is easy to understand. It includes various meanings: the intention ability of the environment and the ability to locate and orient in the environment. From the perspective of the research direction of environmental psychology, there are two main factors that influence way-finding: external factors and internal factors. The external factors mainly refer to environmental information, while the internal factors mainly refer to individual differences and gender differences, etc. This thesis mainly studies the theme park, which is the external factor of path-finding in space morphology, including its space morphology and spatial difference. This paper probes into the influence of space characteristics such as the number of physical enclosure surfaces and aspect ratio on space vitality and space envelopment feeling. By analyzing the correlation between aspect ratio and space envelopment feeling, probes into the influence of physical space morphology on way-finding in HB town. Professor Bill Hillier of Bartlett Faculty of the Built Environment at University College London (UCL) translates the city into a complex self-organizing system under the long-term influence of multiple social and economic factors, namely "Space Syntax" [2]. This method has been widely used in planning, architecture and other related fields, in which the axis model and line model in space syntax, are applied in urban design. Wen Ning et al. had pointed out that the axis model was more suitable for the study of abstract problems of relevant cities [3], and many researches have shown [4-6], that the space syntax can maximize the value of the public space in the city by analyzing the urban space by means of graph theory method, which also provides the basis for the quantitative study of the public space [7]. In this study, the axis model in space syntax is used to obtain the theoretical accessibility, integration and selectivity of each spatial node in HB town. At the same time, the 10 feature nodes of the movie town are randomly distributed to the tourists to obtain the recognition degree of different nodes and obtain the subjective perception data of the tourists on the environment identifiability in the theme park. Finally, we use spss to couple the software simulation results, the oblique photography simulation real scenarios and questionnaire data to form the key points of space morphology design in the way-finding perception of the built environment. (Figure 1)

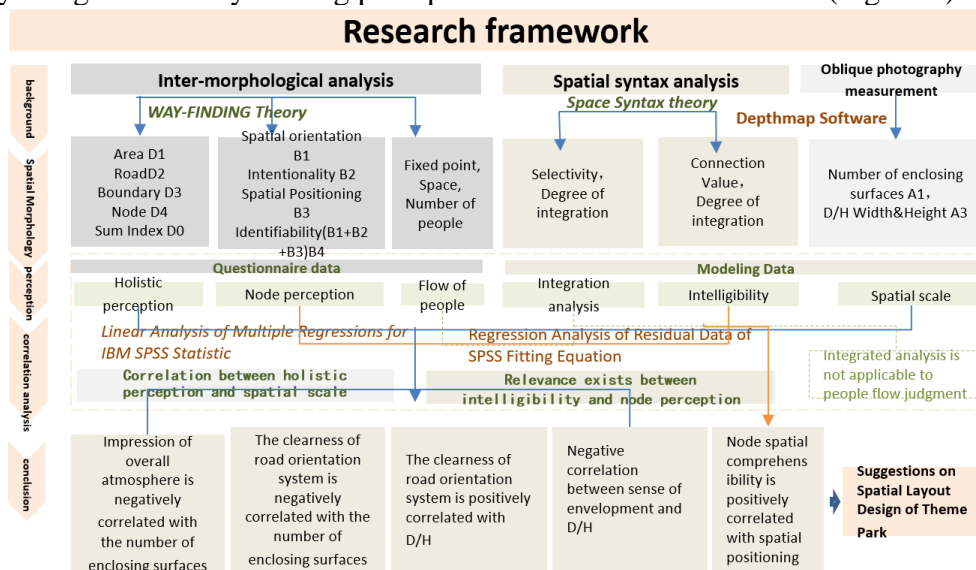


Figure 1: Research Framework

2. Research Object

Theme park (amusement park) is a relatively closed urban block in space, with one or more specific cultural tourism themes, which provides tourists with paid leisure experience, cultural entertainment products or services. It mainly includes amusement parks with large-scale amusement facilities as the main body and various movie and television cities with scene simulation and environmental experience as the main contents. The total number of visitors to TOP 25 theme parks in the world is 141 million. There are six finalists in China, with more than 28 million visitors, accounting for one in five [8]. Located in the Dawangshan Tourist Resort Center of Xiangjiang New District, Huayi Brothers Film Town has a planned total land area of about 1,000 acres and a total building area of about 150,000 square meters. It is an important experiential tourist area integrating multiple elements, such as leisure and entertainment, film theme exhibition, film scenarios implantation, children education and training, catering and shopping. Since the park opened on December 22, 2018, Huayi Brothers Film Town has received more than 600,000 tourists [9]. It is a landmark place for the city to promote tourism economy and urban vitality. Such a space with large area and complex spatial function and structure is a typical representative research object of way-finding.

3. Research Methods

3.1. Field Investigation

Taking a typical theme Huayi Brothers movie town as an example, in order to quantify the overall way-finding status of the theme park space and the perception of intentionality, polarization and orientation of each node space, subjective scoring data of tourists' way-finding perception outside the town was obtained by means of field questionnaire survey. The data mainly reflect the impressive degree (D1) of the town's overall atmosphere related to the town's space morphology when the tourists stay in the selected 10 spatial feature point spaces during the journey, the clearness of the road orientation system (D2), the sense of spatial envelopment (D3), characteristic element impressive degree (D4) and the index data. Then, the subjective evaluation index data and the building enclosing surfaces and building width-height ratio data obtained by oblique photography modeling are modeled by IBM SPSS Statistics, and the model is subjected to multiple regression linear analysis [10].

3.2. Quantitative Analysis of Space Morphology

Aiming at Huayi Brothers Film Town, we use Depthmap software to analyze the space syntax, and quantitatively grasp the intrinsic essence of its spatial structure [11]. The data provides quantitative basis for the analysis of convex space, horizon, axis and line segment model of nodes, and further estimates the relevant parameter basis of space morphology identifiability and accessibility such as integration degree, selectivity and connection value of the whole theme park space, and provides data basis for the study of the whole morphology.

3.3. Measuring Technique on Oblique Photography

Based on the flight records of unmanned aerial vehicles for Huayi Brothers Film Town, this paper collects the data of node people flow and applies them to the study of tourists' way-finding behavior. [12] At the same time, based on the joint utilization of DJI UAV and Reality Capture, the real-scenario restoration Rhino model of theme park space is constructed. Based on this model, the measured data of the number of enclosing surfaces A1 and the width/height ratio (D/H) A3 of the nodes are obtained,

and the correlation analysis is conducted with the questionnaire data [13].

4. Data and Analysis

4.1. Analysis of Measured Data and Overall Questionnaire

The enclosing degree of buildings in the environment, i.e. the number of enclosing surfaces, is related to the way-finding. The vitality of the urban public space in the construction of the vitality elements of the urban public space is affected by its reachability and accessibility. The space vitality can be measured by the number of enclosing surfaces and the spatial accessibility [11]. In addition, space vitality, spatial accessibility, overall atmosphere impression, road system pointing clearness, feature element impression degree all belong to the way-finding factors, so this study thinks that there is a correlation between the measured enclosing surface data and the way-finding (road system pointing clearness) in movie towns.

In the quantitative study on the space scale of the street, the influence of aspect ratio on spatial cognition and experience is probed into. In the quantitative analysis and research of urban space morphology, different width-height ratios can change people's visual feeling. When the street width-height ratio is between 0 and 0.6, the spatial relationship is too comfortable and open, and the sense of spatial enclosing is not strong. When the street width-to-height ratio is between 0.6 and 3.0, the space has mutual inclusive symmetry, pleasant, comfortable and moderate enclosing. When the street height ratio is between 3 and 4.0, the spatial relationship is moderately tense. Slightly oppressive. [14] Therefore, the applicability of Huayi Brothers movie town will be explored by analyzing the relationship between aspect ratio and the sense of space envelopment.



Figure 2: Model of oblique photography of movie town

The questionnaire data of the perception situation of each feature node of the visitor is obtained by issuing the questionnaire on site, and the enclosing surface number and aspect ratio data of each spatial node are obtained by the method of on-site measurement and oblique photography scenario model restoration (Figure 2). According to the relationship between the outdoor space and the building interface in the general layout of the site, and in combination with the above-mentioned field research experience, 61 spatial nodes with characteristic properties in the general plan are selected for the statistics of the number of enclosing surfaces. Most of the nodes are enclosed by 1-2 surfaces, 15% of which are not enclosed by four sides and the least number of nodes enclosed by three surfaces. Moreover, combining with the D/H theory, the width-height ratio of each node is calculated. It is found that the width-height ratio of the nodes on the narrow paths in the town is lower, mainly because

of the higher building height, which makes the tourists more close to the buildings of the town. The node buildings located on the main roads have moderate width-height ratio, so the approaching feeling is relieved, which is more comfortable than the former. Some nodes located on the spacious roads have higher width-height ratio. Make visitors feel more spacious.

Ten feature points are selected from the 61 sets of data as shown in Table 1 below. According to the above assumptions, this study considers that there is a relationship between the measured number of bounding surfaces (A1), the geometric shape of aspect ratio (A3) of the feature node and the impression degree of the whole town atmosphere (D1), the clearness of the road orientation system (D2), the sense of spatial envelopment (D3) and the impressive degree of feature elements (D4).

Table 1: Measured data of town space and survey index data of on-site questionnaire

Feature Node Number	A1 Number of enclosing surfaces	A3 Aspect Ratio	D1 Impression of overall atmosphere	D2 Clearness of Road Orientation System	D3 Space Envelopment	D4 Impression degree of feature elements	D0 sum index
A	3	0.886	8.300	6.450	4.125	7.825	26.700
B	1	1.358	5.650	7.075	4.400	4.575	21.700
C	0	2.177	5.525	6.250	3.100	5.100	19.975
D	1	0.686	5.475	5.250	3.750	5.025	19.500
E	2	1.096	4.650	5.750	6.775	4.875	20.725
F	0	0.655	4.775	5.375	5.700	4.525	20.375
G	3	0.211	4.750	4.225	8.275	5.050	22.300
H	0	0.301	3.025	5.050	5.450	4.575	19.425
I	2	0.414	6.925	5.000	7.925	6.775	26.625
J	2	0.575	5.925	4.575	5.500	6.675	22.675

Based on the data of A1 and A3 as independent variables and the index data of D1, D2, D3, D4 and D0 as dependent variables, the analysis models 1-5 were constructed and analyzed by using IBM SPSS Statistics. The validity and fitting test results of each model (Table 2) show that the models A1 and D1, A1 and D2, A3 and D2, A3 and D3 have good linear fit and effectiveness, and the linear fit of other models is crossed and not effective.

Results of correlation analysis (Table 3), the degree of impression of the whole atmosphere is negatively correlated with the number of enclosing surfaces, which indicates that the higher the degree of the enclosure of the space in the outdoor space of a small town, the lower the degree of impression of tourists on the space, and vice versa.

Table 2: Fitting Degree and Validity Check Results

Analysis Model Name	R2		Sig	
Model 1(Dependent Variable: D1)	0.410	-0.094	0.027	0.646
Model 2(Dependent Variable: D2)	0.388	0.501	0.032	0.013
Model 3(Dependent Variable: D3)	0.245	0.358	0.083	0.040
Model 4(Dependent Variable: D4)	0.128	-0.101	0.167	0.690
Model 5(Dependent Variable: D0)	0.008	-0.067	0.330	0.529

The clearness of the road orientation system is negatively correlated with the number of enclosing surfaces, which indicates that the higher the enclosure degree of the space in the outdoor space of a small town, the more blurred the direction of the road orientation system is, otherwise, the reverse;

However, the clearness of the road orientation system is positively correlated with the aspect ratio, which indicates that the bigger the aspect ratio of the space in the outdoor space of the town is, the more openness the visitors feel, the clearer the direction of the road orientation system is to the space, and vice versa, otherwise, the reverse;

There is a negative correlation between the sense of space envelopment and the aspect ratio, which indicates that the bigger the aspect ratio of the space in the outdoor space of the town is, that is, the more spacious the visitor's sense of space is, the lower the sense of space encirclement is, otherwise, the reverse;

Table 3: Regression Analysis of the Spatial Measured Data of the Town and the Survey Index Data of the Field Questionnaire

	Number of enclosing surfaces of A1		A3 Aspect Ratio	
	Significance	Standard Bate coefficient	Significance	Standard Bate coefficient
D1 Impression of overall atmosphere	0.027	-0.690	0.646	-
	Relevant	Negative correlation	No correlation	-
D2 Clearness of Road Orientation System	0.032	-0.676	0.013	0.746
	Relevant	Negative correlation	Relevant	Positive correlation
D3 Space Envelopment	0.083	-	0.040	-0.655
	No correlation	-	Relevant	Negative correlation
D4 Impression degree of feature elements	0.167	-	0.690	-
	No correlation	-	No correlation	-
D0 sum index	0.330	-	0.529	-
	No correlation	-	No correlation	-

3.2. Verification of Integrated Analysis

Through inductive research on the basic principle of axis model and relevant application cases, it is found that the axis model is more suitable for the study of abstract problems of related cities. Therefore, this research chooses to establish the axis model in the space syntax for further analysis [14].

The degree of selectivity in space syntax indicates the potential of traversing traffic in the space system, that is, the larger its value is, the node in the space is more likely to be traversed by pedestrians, and the relative pedestrian flow will be higher and the traffic volume will be larger. At the same time, the integration degree of space syntax can predict the arrival traffic potential of nodes. According to this, some scholars have integrated and analyzed the integration degree and selectivity in the research to obtain the maximum traffic volume area of the research base.

Furthermore, predecessors have pointed out the correlation between space morphological elements and human behavior perception. For example, spatial accessibility elements and attraction elements affect the vitality of blocks. The more attractive elements in space, the better accessibility, the higher the interaction of human behavior in space [15]; the integration and selectivity of space syntax have a strong pertinence to the action characteristics of attraction and accessibility [16]. However, there is a difference between passenger flow and spatial analysis results. It is speculated that the reason is that people's activities are not only affected by space limitation, but also guided and controlled by activities to a greater extent. Therefore, it is reasonably speculated that in the film town axis model, the higher the integration level is, the space is easier to be recognized and identified by tourists. This kind of space is also the intersection of lines of sight. In theory, there is also a high flow of people [17]. Therefore, the applicability of the above-mentioned theory in Huayi Brothers movie town will be verified by exploring the relationship between the node people flow in the movie town and the integrated analysis results obtained by space syntax analysis.

The outdoor space of the town is simulated and analyzed by depthmap software. In the process of analysis, the axis model (C3) is established, and the spatial integration degree (C3.1), the connection value (C3.2) and the selectivity (C3.3) of 61 spatial nodes are obtained respectively. After the data

processing, the integration analysis of the integration degree and the selectivity in the axis model is obtained (C3.4). Based on the above theories, this study will explore the correlation between the 10 feature nodes (A-J) flow selected by of movie towns and the analysis data of the axis model in spatial syntax (table 4) (Figure 3).

Table 4: Passengers Flow and Integration Analysis Data of Axis Model Nodes

Feature Node Number	Corresponding node number	Number of people passing in 2min	Integrated Analysis Values (C3.4)
A	4	57	5.288138414
B	9	7	6.852143692
C	18	52	6.979517781
D	25	13	10.9427503
E	26	23	12.35667983
F	28	22	8.750344874
G	32	7	3.173198945
H	33	10	6.446315953
I	37	41	9.026117306
J	62	63	8.461348909

In the study, the number of people passing in 2min for each node of A-J obtained in the field research is taken as an independent variable, and the integrated analysis value (C3.4) of each node obtained by formula calculation is taken as a dependent variable to construct an analysis model 6. The correlation analysis of the model is carried out by using IBM SPSS Statistics. The validity and fitting test results of the model (Table 5) show that the Sig of the model 6 is greater than 0.05, this indicates that there is no obvious correlation between the above data.

Firstly, the selection of the feature nodes is determined in accordance with the actual measured data, and the same type of each other is small. From the result of the traffic flow statistics, the minimum traffic flow is G point, the average passing person in 2 minutes is 7 people, the maximum is J point, and the average passing person in 2 minutes is 63 people, and the data difference is significant. Secondly, through the introduction above, the collection process is reasonable. It is concluded that the translation of the axis model is not completely consistent with the actual condition.

Table 5: Validity and Fitting Test Results of Model 6

Analysis Model Name	R2	Sig
Model 6	0.23	0.95



Figure 3: Location of feature nodes



Figure 4: Axis model optimization

In the generation of the space syntax model, there is no function of setting the site entrance. However, for the real movie town, the entrance is an important place where people pass through,

which also influences the integration degree, the selectivity and the connection value to a certain extent; moreover, the function setting of different spaces, as well as the occurrence of various events dominated by late-stage people, it also has a great influence on the space pedestrian flow. According to the actual observation, Point A is close to the main entrance, with large pedestrian flow, but its integrated analysis value is only 5.29, ranking 9th among the 10 node data, which is inconsistent with reality. Point J is located on the main road from the central axis of the movie town to the square, and the connection value, selectivity and integration degree of this point should be high. In the survey, the passenger flow at Point J is indeed the highest, with 62 people passing through the area in 2min on average. However, in the integrated analysis value of the axis model, the value of Point J is 8.46 while the value of Point D and Point E1 at the boundary of the movie town is 10.94 and 12.36, respectively, and which are not in accordance with reality. (Figure 4) Therefore, we think that the method of judging the flow of people through integration analysis is more suitable for urban spaces with no special function settings. For theme space parks such as movie towns, the non-naturally formed functional layout and human-manipulated activities make the conclusions of the computational model based solely on the spatial structure lose the accuracy.

3.3. Correlation Analysis between Intelligibility and Node Questionnaire

With the help of dethmap axis model, the outdoor space of the town is analyzed, and the connectivity and integration degree of each space node are obtained. The R2 of the connection degree and integration degree fitting curve reflects the intelligibility degree of the town outdoor space as a whole. The intelligibility reflects the intelligence of spatial composition, that is, the degree of perception of the whole space through the local space.

Evaluate the degree of difficulty of perceiving the whole space through local space with the aid of intelligibility [18]. When $0.7 < R^2 \leq 1$ of the fitting curve of the ratio of continuous interpretation and integration degree, it indicates that the degree of fitting is high, the spatial local and global relations are close, and the spatial intelligibility is good; when $0.5 < R^2 \leq 0.7$, the degree of synergy is low, and the degree of spatial intelligibility is general; when $R^2 \leq 0.5$, the degree of fitting is low, indicating that the degree of spatial intelligibility is poor. Global space is difficult to perceive through local space [19]. The purpose of the research is to generalize the relationship between the local space and the whole space of such space. In this research, we hope to further refine the analysis to obtain the perception degree of human to the whole space at different nodes, and calculate the residual error of the actual value and the fitting value of the ten feature nodes, namely the degree of calculating the data offset fitting curve, and the larger the residual error of the node intelligibility degree which represents the node space. The lower the node space intelligibility. In the nodal space, man perceives the whole space mainly through three aspects: "positioning", "orientation" and "intentionality". (Figure 5)

Based on site axis model:

Intelligibility (ratio of integration to connection value) integration degree is independent variable, connection value is dependent variable

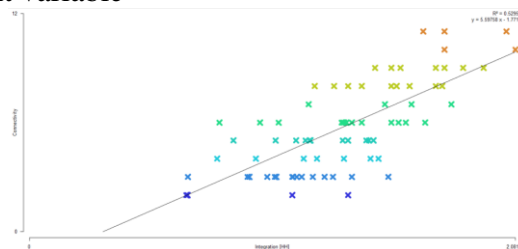


Figure 5: Fitting equation

Table 6: Statistics of Axis Model Data

S/N	Degree of integration (actual value)	Connection Value		
		Fitting value (y=5.59x-1.77)	Actual value	Residual (absolute value)
A	1.29	5.44	5.3	0.14
B	1.45	6.34	6.8	0.46
C	1.31	5.55	7.5	1.95
D	1.83	8.46	8.7	0.24
E	1.88	8.74	9.7	0.96
F	1.63	7.34	7.5	0.16
G	1.12	4.49	2	2.49
H	1.39	6.00	5.3	0.70
I	1.69	7.68	9	1.32
J	1.62	7.29	8.5	1.21

Table 7: Regression Analysis of Residual Data of Small Town Space Node Questionnaire and Intelligibility Fitting Equation

	Residual. absolute value	
	Significance p-value	Standard Bate coefficient
B1 Orientation	0.223	-
	No correlation	-
B2 intentionality	0.528	-
	No correlation	-
B3 Positioning	0.043	-0.648
	Relevant	Negative correlation
B4 Identifiability	0.135	-
	No correlation	-

Table 8: Small Town Space Node Questionnaire and Test Results of Fitting Degree by Regression Analysis of Residual Data of Intelligibility Fitting Equation

Analysis Model Name	R ²	Significance p-value (sig)
B3	0.420	0.043

It is obtained that $R^2=0.53 \geq 0.5$ the intelligibility is general. The fitting equation is $y=5.59x-1.77$. Further, for the 10 special attention points, the residual error is obtained as shown in the following table 6, and then the correlation analysis is conducted with "orientation", "intentionality", "positioning" and "identifiability" respectively.

The data were analyzed with SPSS software and the results are as follows, (Table 7, Table 8) The analysis shows that there is a negative correlation between the residual error and the positioning of the node space. Therefore, there is a positive correlation between the intelligibility of the node space and the positioning of the node space. That is to say, the better the tourist's perception of the direction in the node space of the town is, the more accurate his judgment of the whole space is, the more ideal the way-finding situation when walking in the town.

5. Conclusion

Based on the correlation analysis and fitting analysis of the spatial geometric features of the large-scale theme park and the perception and evaluation of the environment when the tourists find their way, the above-mentioned relationships are verified. At the same time, the conclusion is modified in combination with the actual condition, and the validation data of the influencing factors of the way-finding behavior are obtained. And the coupling between the multivariate data is realized so that the

conclusion has better reliability. In addition, the built environment modeling of UAV oblique photography technology is used to create a relatively reliable three-dimensional model for the scenario of a small town, so that accurate measurement data and 3D model of the enclosing surfaces of the building body can be obtained under the conditions of large site scale, large terrain change and complex built environment [20].

The following conclusions and design considerations can be drawn from the correlation analysis of the influential factors of tourists' way-finding behaviors in large-scale theme parks:

1) The higher the number of enclosing surfaces of the spatial nodes, the lower the "impression degree" of the overall atmosphere of the space will be, and the lower the "clearness" of the nearby road system will be experienced by the tourists. It can be seen that the nodes with higher bounding surfaces will cause the tourists to experience worse and more difficult way-finding experience.

Therefore, in the design of this type of outdoor space, the number of "enclosing surfaces" of the main popular core space and the important functional space should be relatively low, so as to optimize the tourist's spatial experience and improve the tourists' efficiency of way-finding in these spaces; Souvenir sales spaces and other spaces can appropriately increase the number of "enclosing surfaces" in order to enhance the tourists' fun to find their way or make them stay there for a longer period of time.

2) The higher the "width-to-height ratio" of the space node, the more openness the visitors feel the space. Therefore, the tourists think that the clearer the road orientation system here is, and the emptiness also means that the visitors feel less envelopment in the space. Therefore, in the design of this type for outdoor space, more spaces with high aspect ratio can improve the tourists' way-finding experience in the park. Considering the most pleasant and comfortable space envelopment when the "width-to-height ratio" is in the range of 0.6-3, it is advisable to set the width-to-height ratio to be 2~3.

3) The higher the intelligibility of the spatial nodes, the better the tourists' perception of the direction in the space, the better the way-finding experience, which is helpful for the tourists to estimate the overall space. Therefore, in the design of the type in an outdoor space, the "intelligibility" method in the space syntax theory can not only evaluate the "intelligibility" of the whole space, but also predict the direction perception condition of tourists at different space nodes according to the "intelligibility" method, and adjust the space morphology or arrangement function in the design based on this, and the node space with high node intelligibility is uniformly distributed in the type space.

Besides, we also get the findings about the accuracy of software simulation. In this paper, we find that the flow distribution predicted by the typical method of space syntax is quite different from that obtained by actual statistics, which means that the conclusion may not be completely credible and reliable when the designer uses simulation software to conduct auxiliary design due to the incompleteness of the limitation of calculation model and the limitation of software algorithm. Therefore, the designer should not completely rely on and believe the simulation results, but should have their own thinking.

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