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Evaluating Experiential Qualities of Historical Streets in Nanxun Canal Town through a Space Syntax Approach

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Abstract: Many studies have been conducted to measure the experiential qualities of historical streets using the standards and principles released by many global organizations. However, little attention has been paid to the effect of spatial characteristics of historical heritage. This study proposes a space syntax-based methodology, first developed by Bill Hillier and Julienne Hanson with colleagues from the Bartlett School of Architecture, while introducing factors such as complexity, coherence, ‘mystery’, and legibility from the work of environmental psychologist Stephen Kaplan and the urban designer Gordon Cullen. Our intention is to help inform urban designers in understanding people’s spatial cognition of historical streets, and thereby assist designers and managers in identifying where cognitive experiences can be improved. The proposed method is applied to Nanxun, which is a developed canal town currently in decline in Zhejiang Province, China. This will be treated as the case study in order to explore the implication of the space syntax analysis. The impact from spatial characteristics on the evaluation is indirect and largely determined by the road-network of the canal town. As for Nanxun, the findings of this research suggest that the government’s priority is to solve current negative tourist perception based on a conservation restoration plan. The findings of this research provide a reference for policymakers to better understand the experiential qualities of historical streets in townscapes.

Keywords: space syntax; experiential qualities; spatial analytics; design cognition; computational design



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1. Introduction

1.1. Research Aim

The Beijing–Hangzhou Grand Canal is recognized by the United Nations Educational, Scientific and Cultural Organization (UNESCO) as a World Heritage Site (WHS). It is the longest artificial river and one of the oldest canals in the world [1]. Many of the cities along the Grand Canal are undergoing rapid economic growth, and there are increasing numbers of both large and small developments impacting the heritage significance of these areas.

In order to help mitigate the loss of the spatial experience of the historic character of the Grand Canal towns, this research adopts a space syntax-based analysis method to assist in evaluating the experiential qualities of their historic streets. The aim of the research is to help public authorities, developers, urban designers, planners, architects, and landscape architects in possibly extending these experiences in new developed areas through sensitively designed interfaces and extensions to the heritage protected Grand Canal townscapes.

1.2. Research Background and Context

Buildings, open spaces, or other features, which contribute positively to the character of a conservation area in a historic townscape [2] (defined as the visual appearance of a town or urban area), require a systematic analysis of their spatial characteristics in order to

help evaluate the influence of these characteristics on user/visitor experience [3]. Experiential qualities of historical streets have been recognized as a major indicator to evaluate whether or not various sites need to be conserved and ways in which this can be realized. Townscapes have been a major concern for many researchers who study architecture, landscape architecture and urban design. The protection of historical and cultural heritage is an important cause to promote national unity, strengthen the national image and improve the quality of life of a nation's residents. However, economic globalization has brought an effect of 'compression' to the cultures of ethnic groups and regions around the world, as described by Yang and Yu [4], and this effect has quietly infiltrated into all aspects of society, especially for the preservation of historical heritage. Current trends in protection of historical heritage testify to increasing attention to the research on evaluating experiential qualities of historical streets which is widely recognized as a significant indicator when exploring experiential qualities of historical streets [2].

Space syntax aims to represent and analyze a diverse range of spatial layouts and to assist in explaining possible relationships between human behaviors and space characteristics [3,5]. Griffiths and Vaughan [6] in their paper, 'Mapping spatial cultures: contributions of space syntax to research in the urban history of the nineteenth-century city', applied historical data from maps to establish a mapping model applying space syntax theory on historical areas of 19th Century industrial cities with the use of HGIS (Historical Geographical Information Systems). Griffiths and Vaughan's [6] paper serves as an example of how the application of Space Syntax may yield informed insights as to why certain sociopolitical patterns of behavior may have been able to occur in different historic urban settings. Hence this paper begins to explore how the structure and morphology of many of China's historic Canal Town's provide a unique and intriguing visitor experience which is gradually being eroded with increasing development pressures.

The following paper is divided into five distinct sections. Following the introduction, the second part, Literature Review, appraises the previous research on space syntax and spatial cognition. The Third section, Methodology, discusses the process of the research which focuses on two subsections: Stage 1-Data Acquisition, the application of six Space Syntax indicators to measure the detailed information of the case study canal town of Nanxun 'Stage 2: Data Inference' reinterprets the data from stage 1, that is, the high and low value results of the six indicators, with low and high cognitive inference, and applies both serial vision theory and visual graph analysis (VGA) to assess the perceptions of Nanxun. The fourth Section Case Study: Nanxun, presents the application of Space Syntax and Visibility Graph Analysis (VGA) to provide an informed understanding of the spatial cognition of the town of Nanxun canal town. It elaborates on the limitations and future research, and presents a range of conserved and rebuilt suggestions to help improve people's spatial cognition in the historic districts of Nanxun. The final section, Conclusion, lists a number of important considerations is drawn in the fifth section.

2. Literature Review

2.1. Overview of Space Syntax

Space syntax was formulated by Bill Hillier and Julienne Hanson with colleagues from the Bartlett School of Architecture, University College London during the late 1970s and early 1980s. It involves a set of concepts and procedures for the study of spatial formations in order to advance understanding regarding the relationship between human spatial behavior and the form of the built environment, be it at an architectural building scale or the morphological structure of a city [7]. Two capstone moments in the development of space syntax occurred with the publication of Hillier's and Hanson's book 'The Social Logic of Space' in 1984 [8], and 'Space is the Machine [9]: A configurational Theory of Architecture', authored by Bill Hillier in 1999 (both were published by Cambridge University Press) [10]. The development of space syntax since the 1980s has undergone numerous advancements and applications, not only within architectural and planning practice submissions, but also in other research fields such as archaeology and human geography [11].

Scholars and researchers in the field of urban design have argued that architectural and urban morphology could be applied to spatial cognition. Zhao and Zou studied spatial characteristics in townscape and applied design cognition [12]. Penn [13] reviewed previous research work on syntax space and environmental cognition from his group, especially multiple doctoral degree dissertations. Penn [13] and his students utilized computer computation modelling to simulate the individual decision-making processes at the level of the individual. In Penn's opinion, cognitive space should be a topological terminology. Montello [14] studied on "thinking about thinking". He explored how significance is the cultural differences in spatial cognition. He reviewed the "Standard Social Science Model" which is often mentioned and implemented in studies related to the differences at that time and held a similar opinion with other scholars that a set of assumptions prevents observing universal aspects of human cognition. Ishikawa and Montello [15] reviewed two theories that hold the opinion that the cultural differences are significant: the carpentered-world hypothesis and the ecological hypothesis. Yu and Liu [16] combined an axis and image map to explore the special forms of Gulangyu of Xiamen in China. Based on their analysis, the authors put forward that ignoring the social and cultural environment cannot be ignored for the spatial pattern of the urban morphology. Wang and Bramwell [17] took the historical city block of China as an example and conducted a comparison using space syntax analysis. It was found that the space syntax analysis performed outstanding in research on the cognitive map due to its high degree of correlation. Additionally, the results of comparison of space syntax analysis and image map analysis indicates that the coherent structure and organization and the continuity are major elements to understanding a city [18].

Previous research results mainly focus on the comparison and analysis of relationships among the space syntax analysis, cognitive maps and space pictures [19,20]. In light of the large number of studies, Boeing [19] proved the relationship between isovist and visibility graphs. Gerald and Jan [20] study was based on established methods and published experimental data. The study investigated space syntax in different scales based on isovist and place graph. Since the architectural theory includes many complex factors which are difficult to numerically represent, the prediction as well as the accuracies of the spatial qualities would be doubtful. Initially, Gerald and Jan [20] discussed theories and methods in translating spatial qualities into isovist measurements. However, some navigation experiments where space properties are well represented by isovist and visibility graph measurements could benefit the responses and navigation behavior prediction. Meanwhile, according to the statistical results in the study, the measurements from a selected single position could be used for prediction purposes. Previous research has been conducted to modify the space syntax model by analyzing tourists' behaviors and big data analysis [20]. For example, Lebendiger and Lerman [21] aimed to find the correlations between urban spatial configurations and human emotions in an urban area to offer initial evidence that certain space sequences do cause positive and negative emotional arousal. However, there are few studies in which the questionnaire survey method, a classical method of acquiring people's space cognition information, corresponded to the spatial characteristics represented by the analysis variables in the space syntax model, or systematically discussed the spatial characteristics of historical city blocks and the interpretation level of the space syntax model.

Space syntax could be applied on historical districts. It also aims to represent and analyze a large range of spatial layouts and to assist in explaining the relation between human behaviors and space characteristics on historical streets [22]. The major contribution of the combination of space syntax analysis and geographic information system lies in improving the efficiency of expressing the competence of space [23–25]. In addition, space syntax mainly focuses on the open space which can express the representation patterns of a certain spaces [26]. Kubat et al. [27] investigated pedestrian and vehicular activity in Sharjah's historical center in order to understand current movement patterns in an attempt to provide suggestions on the conservation of historical areas based on the

understanding of spatial configuration. Space syntax analysis is favored in previous research on historical districts, since this research method provides a visualized and quantitative approach to exploring and researching historical districts in the fields of management, conservation and planning. For example, Li et al. [28] applied space syntax analysis to a historical district in China in order to explore the relationship between the street network and tourism preferences, while providing suggestions on tourism management. Additionally, Sheng et al. [29] considered Chaoyang in China as a case study and analyzed the traffic situation and visual integration of the central block using space syntax in order to provide a basis for the planning and re-design of historical districts. The study presented in this paper will provide a reference for policymakers to better understand the experiential qualities of historical streets in townscapes.

2.2. Main Analysis Factors of Spatial Morphology Information

Space syntax is a calculative method to understand the spatial patterns and configuration in order to assist in capturing user experience and reflecting visual and compositional attributes within a given space [30]. Figure 1 shows the Topological analysis methods of space syntax based on axial lines with additional consideration of shortest physical paths.

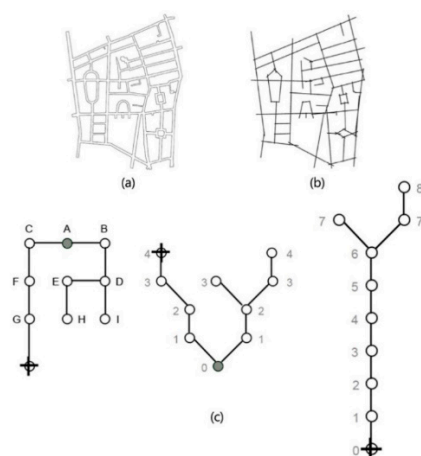


Figure 1. Topological analysis methods of space syntax based on axial lines (a), (b) with additional consideration of shortest physical paths (c).

Topological and geometrical analysis of space applies VGA. In addition, metric analysis which uses metric distance, the distance in metres from one space to another. Different spatial patterns are generated by assessing the three types of distance. In Figure 1, the major definitions used in Space Syntax can be concluded as follows:

- (1) Topological (paths with fewest turns)
- (2) Geometrical (paths with least angle change)
- (3) Metric (shortest physical paths)

Space syntax is one of the computational analytical methods. Metric distance belongs to the wider theoretical and methodological field of space syntax. Figure 1 illustrates three types of distance metrics including topological, geometrical and metric. Topological, geometrical, and metric measures in space syntax draw a theoretical distinction between three types of spatial analysis.

2.3. Main Theories of Experiential Qualities of Historical Streets

Stephen Kaplan [31], writing in the 1970s within the emerging field of environmental psychology, is still considered relevant today, and while his research discussed factors that influence peoples' preferences of landscapes, the authors believe that many of his ideas could offer valuable insight regarding tourist's preferences in the experience of townscapes and historical streets. Kaplan [31] listed certain misunderstandings and misconceptions

about preferences and perception and helped researchers, especially young scholars in architecture and urban planning, in thinking about four factors (as shown in Table 1) from two persisting purposes: ‘making sense’, which denotes the knowing or understanding of the things that happened in the space within a large time and space scale; and ‘involvement’, which denotes a learning activity. These two purposes are not contradictory since ‘making sense’ refers to the perceived structure of the environment and peoples’ involvement with it, and references a supportive environment as being a place rich in possibility. The four factors are separately presented as blow:

- Complexity belongs to the involvement element at the initial analysis stage. This concept is similar to ‘diversity’ or ‘richness’ which relates to how much is ‘going on’ or ‘there is to see’ in a specific scene.
- Coherence is the initial analysis stage concept for making sense. This concept would require that all the objects in people’s views should keep some kind of harmonic or internal consistency to deliver the message or story of a scene to people.

(Kaplan notes that many people often only hold a certain amount of information in their ‘working memory’ at any one time, and that this appears to be between five and seven major units or ‘chunks’ of information. Working memory is important for reasoning and the guidance of decision-making and behavior as distinct from short term memory [32]. Thus, if a scene possesses a high degree of complexity, it may require more structure to organize visual information, in a way that helps to realize coherence.)

- Mystery is different from surprise or novelty, rather, according to Kaplan [31], it is a spatial factor that represents the promise of new information offered by the scene, as one moves through a place. This would seem to align with the ‘journey’ oriented experience along a streetscape. The close connection and continuity between the observation and what is expected should bring in a high mystery feeling. Mystery raises curiosity rather than ambiguity or uncertainty [31].
- Legibility, this concept is similar to coherence and deals with the space structure with its variation and readability. The high legibility space will easily minimize the difficulty in finding one’s way (Wayfinding). A highly legible scene is simple enough for people to oversee and generate a cognitive map. This factor focuses on the influences on the moving within the space. Kaplan writes “legibility entails a promise, a prediction, but in this case not of the opportunity to learn but to function . . . it deals with the structuring of space, with its differentiation, with its readability . . . Coherence concerns the conditions for perceiving while legibility concerns the conditions for moving within the space” [31].

Table 1. Four factors of preference matrix (Source: Kaplan, 1979).

Level of Interpretation	Making Sense	Involvement
The Visual Array	Coherence	Complexity
Three Dimensional Space	Legibility	Mystery

Based on the four concepts, Kaplan’s research generated a 2 by 2 matrix in terms of the visual array as shown in Table 1, with respect to form, line, color, and texture, and of three-dimensional space with respect to spatial experience. He also discusses confusion in the idiosyncrasy of perception. Since perception and interpretation are combined together, the difficulty in separating these two indicators in the research is anticipated. Hence it is probably more appropriate for the researcher to use ‘preference’ rather than ‘judgment’ in their research and when conducting participatory interviews. Kaplan also suggests that the four factors: form, line, color, and texture, which are often used in the landscape analyses may conflict with the realities of human perception since they only work for a two-dimensional picture plane and provide a limitation on the sampling of the properties of the spatial experience. Kaplan’s matrix may provide a way to evaluate the townscape

experience. The challenge in adopting aspects of Kaplan's work is how to numerically illustrate the issues in the 2 by 2 matrix so as to create a symmetrical rating methodology which can be applied in conjunction with spatial syntax.

3. Methodology

The methodology is divided into two stages which are applied to the case study analysis of the Canal town Nanxun (see Section 4): 'Stage 1—Data Acquisition' and 'Stage 2—Data Inference'.

Stage 1: Data Acquisition, introduces the main analysis factors of spatial morphology information on the topological, geometrical, and metrics of the Space Syntax model [32]. Working with the software Depthmap, which is a multi-platform software designed to perform a set of spatial network analyses, data from six Space Syntax indicators were applied to measure detailed spatial information of Nanxun canal town's street network, and include: 1. connectivity value, 2. control value, 3. mean depth value, 4. local integration value, 5. global integration value, and 6. unintelligibility value.

1. Connectivity is treated as an indicator to explore the degree of the connection of a given space with other spaces.
2. Control value is widely used to measure the control effect of a given space on other spaces.
3. Mean depth is an important feature to draw the degree of convenience from a given space to other space.
4. Local Integration value is favored in literature in illustrating the centrality of a given space in remaining spaces of a certain region and
5. Global integration relates to the integration of a line towards all the other lines of the axial map
6. Intelligibility value relates to "the degree to which what can be seen and experienced locally in the system allows the large-scale system to be learnt without conscious efforts" [5].

With respect to the relationship between the space syntax model and subjective analysis methods, the research will measure Nanxun's spatial topological relationship under a walking scale ($k = 3$, as mentioned in Table 2) by employing the connectivity value, control value, mean depth value, integration value and intelligibility value in the space syntax model. If a space has a high connectivity value, this means many other spaces connect with this space [33]. The control value can reflect the spatial connectivity [24]. Furthermore, the mean depth value refers to the shortest topological distance of the space from all other spaces. The higher the integration value, the higher the accessibility and commonality of the space [28]. The intelligibility value is used to measure whether the local spatial structure helps to establish understanding of the entire inter-spatial system, indicating spatial identifiability [34].

'Stage 2: Data Inference', reinterprets the data from stage 1, that is, the high and low value results of the six indicators, with low and high cognitive inference based on the visual experiential qualities of Nanxun's historic street network and morphology derived from the writings of Gordon Cullen [2] and Stephen Kaplan [31]. This is conveyed in Table 2 Analysis variables in space syntax model and indicators of spatial cognition.

While previous studies have been conducted to attempt to evaluate the experiential qualities of spaces via questionnaires, the second stage of the methodology uses both Serial Vision theory and Visual Graph Analysis (VGA) to assess the perceptions of Nanxun canal town. The first stage of the visibility analysis addresses a serial vision approach which was first developed by the urban designer Gordon Cullen in his influential work *Townscape* first published in 1961 [2]. The concept of serial vision is significant to this study as it appears to reflect the rates of perception being experienced by an observer, which can be explained as a sequence of visual images captured by an observer when walking through a town at a uniform speed [2]. This may have a significant correlation to the analysis of space

syntax, especially regarding connectivity value, control value and integration value and also appears to share interesting parallels with the work of Kaplan [31].

Table 2. Formula and description of analysis variables in space syntax model (Duan, J. & Hillier, B. 2007. Urban Space 3: Space Syntax and Urban Planning, Nanjing, Southeast University Press).

Variable	Formula	Scale	Description of Variables
Connectivity value	$C_i = k$	The 'i' space	Refers to the number k of spaces connected to the 'i' space; the higher the value, the closer the space is to the surrounding space, the stronger the influence on the surrounding space and the better the space permeability.
Control value	$C_{1i} = \sum_{j=1}^k \frac{1}{C_j}$	The 'i' space	Refers to the reciprocal sum of other spatial connection values connected to the 'i' spatial node; the larger the value, the greater the degree of control the 'i' space has over the space it intersects.
Mean depth value	$D_i = \frac{\sum_{j=1}^n d_{ij}}{n-1}$	The 'i' space	Refers to the shortest topological distance of the 'i' space from all other spaces; the lower the value, the more convenient the space is.
Integration value	$I_i = \frac{n(\log_2((n+2)/3)-1)+1}{(n-1)(D_i-1)}$	The 'i' space	The most commonly used and important analysis variable, refers to the degree of spatial aggregation or dispersion between the 'i' space and other spaces. The higher the value, the higher the accessibility and commonality of the space. It is divided into the global integration value I_i and the local integration value $I_i(k)$. The global integration value refers to the relationship between the 'i' space and all other spaces and the local integration value refers to the relationship between the 'i' space and other spaces within the K steps (usually K = 3 at the walking scale).
Intelligibility value	$R^2 = \frac{\sum(C_i - \bar{C})(I_i - \bar{I})^2}{\sum(C_i - \bar{C})^2 \sum(I_i - \bar{I})^2}$	The whole space	Indicates the degree of correlation between local integration and global integration, used to measure whether the local spatial structure helps to establish understanding of the entire inter-spatial system (\bar{C} is the average of the Connectivity value of all units; \bar{I} is the average value of the global integration of all units in space); the larger the value, the stronger the spatial comprehensibility.

4. Case Study: Nanxun

4.1. Overview of Nanxun

Nanxun is located in Nanxun District, Huzhou, intersecting with Jiangsu, Zhejiang and Shanghai. In the Ming and Qing Dynasty, Nanxun was a famous town producing silk, and it is also an ancient town enriched with diverse people and combining both Eastern and Western architecture. Within the ancient towns in Jiangnan, the reputation of Nanxun is not accounted for the greatest, but the richness of Nanxun residents is remarkable. The rivers and streets in Nanxun are quite similar to other Jiangnan canal towns, as dwellings are crossed with each other, teahouses and restaurants are particularly prosperous. All dwellings are sitting next to rivers by connection of masonry steps, hence people normally conduct daily activities on the bank shore, such as washing clothes and vegetables. If there were boats parking in there, people could also get into the town through the dock. From aesthetic perspective, the white wall and grey tiles are reflected on the surface of river, and the flags hung over teahouses and restaurants could bring people the unique experience of Jiangnan river town. Within the Nanxun planned protection area of the ancient town, at

two sides off general traditional building area and important river streets, it is allowed to upgrade, rebuild, demolish and build various architectures and rectify the environment. However, all construction activities shall be continuously under the principle of continuity and logic of urban texture. It is not allowed to implement demolishing and construction engineering in large scale.

4.2. Data Acquisition—The Spatial Syntax Analysis of Nanxun

To measure the spatial characteristics objectively, this research employs space syntax to systematically reflect the spatial characteristics of Nanxun canal town, as outlined in Section 3—Methodology.

Figure 2 displays the road-network and waterway system plan in Nanxun.

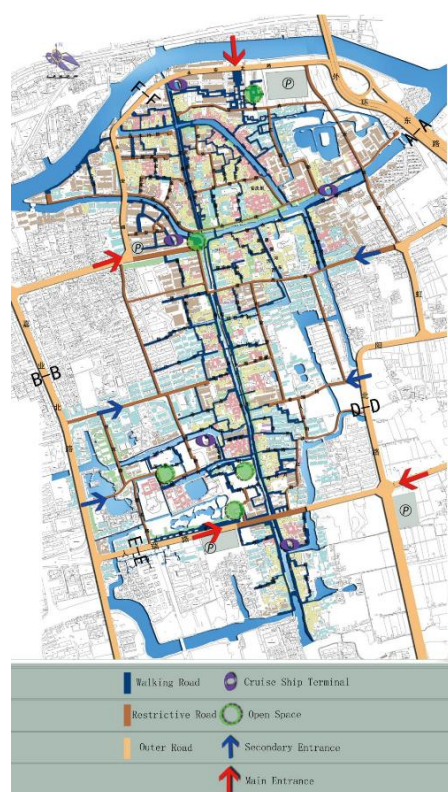


Figure 2. Road-network and waterway system plan in Nanxun.

Walking road, restrictive road, open space, main entrance and secondary entrance are shown in the Figure 2. On the whole, the axis structure of the ancient town area in Nanxun is not relatively simple. However, the spaces which have weak connectivity may increase mystery, mystery raises curiosity rather than ambiguity or uncertainty. In addition, historical and cultural blocks are social spaces in which a connection can be established between the urban context and social activity, containing unique emotional experiences and place attachments. Therefore, when studying the spatial characteristics of historical districts in order to optimize their development, we should not only take into account the spatial organization, but also consider the experiences of people's spatial cognition. Table 3 displays the spatial characteristics applied main analysis factors of space syntax of twenty-two major tourist streets in the Nanxun ancient town area.

Table 3. Space syntax analysis variables of ancient town area in Nanxun.

Road Name	Connectivity Value	Control Value	Mean Depth Value	Local Integration Value	Global Integration Value
Nanshan Street	4	1.250	503.820	61.482	144.248
Xiangshan Street	8	2.430	447.064	78.161	177.863
Renrui Road	5	1.726	341.369	75.074	178.014
Naxi Street	8	3.000	529.911	76.449	179.394
Wangshan Road	4	1.250	623.082	51.999	143.830
Wangjin Road	5	1.726	593.174	60.266	144.499
Hongshuo Road	6	2.000	495.372	70.366	157.337
Hongfeng Road	8	2.500	500.074	73.483	161.042
Baoshan Street	5	1.726	475.293	74.050	181.519
Bianmin Road	5	1.726	381.320	74.584	183.228
Hongyang Road	6	2.000	376.238	60.753	163.024
Nanfeng Street	5	1.726	373.797	65.942	183.368
Jiahe Road	5	1.726	355.918	43.901	146.679
Jiaye Road	5	1.726	317.762	51.432	166.219
Xida Street	5	1.726	427.487	69.349	183.058
Fengzhou Road	6	2.000	562.447	68.111	167.891
Dongda Street	5	1.726	610.750	69.860	143.203
Renshou Street	8	2.500	683.029	57.210	119.598
Fengtiao Street	5	1.726	656.531	71.724	141.614
Kaolaowan Street	5	1.726	657.381	73.291	143.335
Average value	5.65	1.900	495.591	73.247	160.448

As shown in Table 3, the integration value in the central historic block is higher than that in other regions of Nanxun town. The local integration value of these streets in this area clearly indicate that Xiangshan Street has the highest value, which is 78.161. It is also worth noting that Xiangshan Street is the main tourist street intersecting in the middle of the block, and is also the street with an elevated global integration value. With significant public exposure Xiangshan Street is the main passageway of the ancient block space organization [35]. Xiangshang street also presents the greatest connectivity value of 8 which is significantly higher than all of the 10 streets in ancient Nanxun, its control value of 2.430 is also much higher than that of other streets. The average local integration value of the main tourist streets of Nanxun is 61.482.

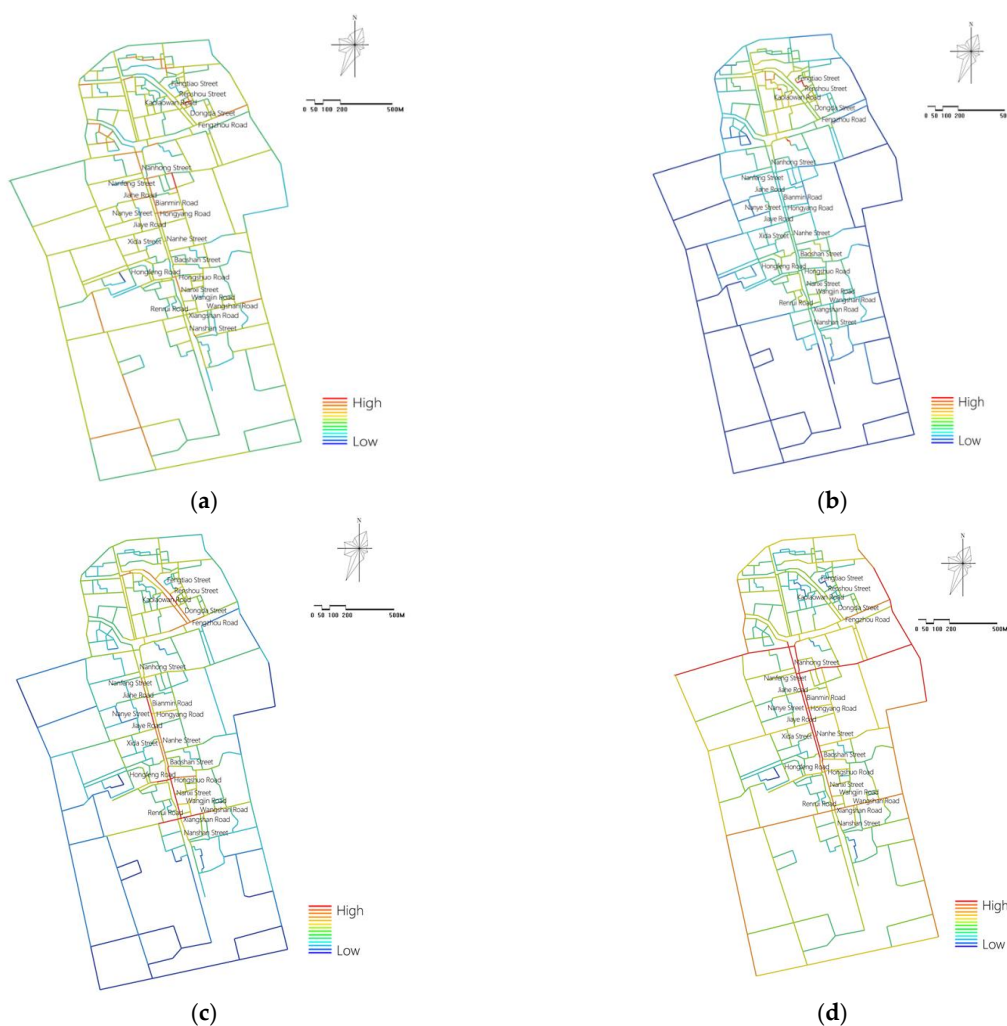
4.3. Data Inference—What May the Data Imply Regarding Perceived Experience?

To better understand the possible relationship between spatial cognition and spatial characteristics, the five indicators employed in this research in Table 2 are correlated with nine spatial cognition indicators in Table 4.

Figure 3a illustrates that the functional streets have significant differences in the connectivity value of the axis, with the average control value being 5.65 in the ancient town area. Xiangshan street, Naxi street, Hongfeng Road and Renshou Street's connectivity value is as high as 8, Nanshan Street and Wangshan Road's connectivity value is as low as 4. Figure 3b shows local integration value, Xiangshan Street is the highest as 78.161, higher than the lowest named Jiahe Road (43.901) ~78%. As shown in Figure 3c, Jiaye Road has the lowest value, 317.762, which is ~58.8% compared to the average value. The global integration value, see Figure 3d, Shenxing street has the lowest global integration value, it means the street has lower coherence and legibility. The street should increase publicness by means of rebuilt public space and tourist center. Renshou street is the main tourist street in Nanxun ancient town area, as we can see that the five values of this street are close to average values.

Table 4. Analysis variables in space syntax model and indicators of spatial cognition.

Analysis Variable in Space Syntax Model	Spatial Characteristic	Indicators of Spatial Cognition
Connectivity value	Spatial permeability	Easy understanding for road-network structure
		Intriguing journey through the town
		Few dead-end roads
Control value	Spatial connectivity	Well interconnected between lane ways and streets
		Few repeated-visit
		High tour efficiency
Mean depth value	Spatial compactness	A clear main tour road
Integration value	Spatial accessibility	A significant gathering centre
	Space publicity	Accurate determined the current location
Intelligibility value	Spatial identifiability	Efficient way finding to the destinations
		Clear and easy identified spatial functional zoning of the block

**Figure 3.** The space syntax model analysis result on Nanxun town: (a) connectivity value, (b) local integration value, (c) mean depth value, and (d) global integration value.

In Figure 3a, there are three streets and one road named Xiangshan Street, Naxi Street, Renshou Street, and Hongfeng Road with the highest connectivity value. The level of accessibility of the streets near the Grand Canal is relatively high, such as Bianmin Road and Xida Street on the west of the Canal, and Hongyang Street on the east of the Canal. Figure 3b shows that Renshou Street has the highest mean depth value in the whole town. It is obvious in Figure 3c that Nanfeng Street has the highest value in local integration, which is 183.368. The higher global integration value is concentrated in the middle of the ancient town area as presented in Figure 3d. Table 3 shows the spatial characteristics of major roads in Nanxun town (Xu et al. 2020). As the color contours in Figure 3d and values in 1, there are four streets with the highest global integration values, namely, Xida Street (183.058), Nanfeng Street (183.368) and Bianmin Road (183.228). Xu et al. [35] suggested that a stronger global integration value makes it easier to accumulate pedestrian flow. Therefore, Xida Street, Nanfeng Street and Bianmin Road are the most public, and convenient spaces for tourists to gather. Local integration value of streets in the ancient town area indicate that Xiangshan Road has the highest value, which is 78.161. It is also the street with the higher global integration value and hence receives the highest public exposure being the main passageway of the block space organization. Xiangshan street is the greatest in connectivity and its control value is much higher than that of other streets.

Figure 4 presents the intelligibility value of Nanxun town. If a spatial group has a high degree of intelligibility, it means that its overall spatial layout is more easily recognized and understood by people [35]. Generally, the range of the intelligence value R^2 can be evaluated according to being either ‘weak’, ‘good’ or ‘strong’ [35]. The intelligibility value of Nanxun ancient town area is calculated as 0.489, the intelligence value R^2 can be 0–0.5, which indicates that the spatial identifiability is weak. The high legibility space will easily minimize the difficulty in finding one’s way. A highly legible scene is simple enough for people to over-see and generate a cognitive map. This term focused on the influences on moving within the space. Therefore, the cognitive degree of the Nanxun’s spatial group could be improved, however by doing so might interfere with the perceived Mystery of the townscape when considering the four factors of Kaplan’s [31]. Preference Matrix. In other words, rather than having an urban morphology where one is able to readily identify their location from any position within the whole town structure, having a more complex street pattern may slow their cognition and thereby enhance their experience of place [10].

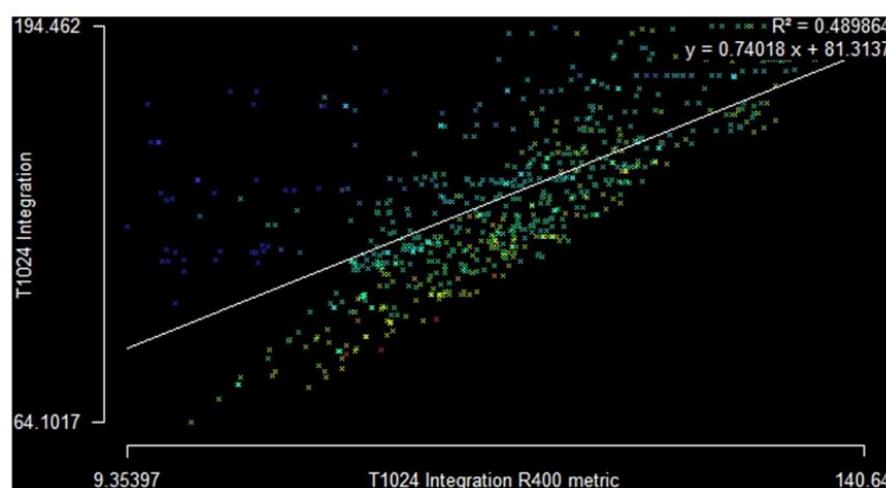


Figure 4. The space syntax model analysis result on Nanxun: Intelligibility value.

4.4. Focused Visibility Analysis of Baoshan Historical Block in Nanxun Ancient Town Area

Nanxun has large volume of people moving through the ancient town area than other historic canal towns, the efficient management pattern of Nanxun is probably a significant reason for more positive rather than negative visitor feedback. Therefore, an analysis of the benefits obtained from the promotion of management efficiency from Nanxun could assist

towns such as Nanyang. Figure 5 displays the serial vision of Baoshan historical block in Nanxun ancient town area.



Figure 5. Serial vision of Baoshan historical block in Nanxun ancient town area.

Compared to other canal towns, Nanxun has more notable landmarks as shown in Figure 5, the stone arch bridge in photo 1, green trees in photo 7, and eaves along with white walls and black tiles in the other photos. The white walls are not well-maintained and part of them are peeling off. Therefore, the serial vision in Nanxun is still lacking certain characteristics. In contrast to the often-dramatic serial version examples of the historic European towns evaluated by Gordon Cullen [2], the successful Chinese ancient town, such as Wuzhen, provides the tourist a quiet and peaceful feeling when moving within the environment, whilst, none of the images from ancient towns includes cultural heritage monuments or historic buildings. They reflect the normal life of ordinary Chinese people in the past hundreds of years. The “standard” serial images include certain landmarks, such as a monument in photo 2, a sculpture in photo 3 and a great temple in photos 4 to 5. The images are significantly different from one to another in that the route the captured slowly unfolds, not all being revealed, but they are continuous showing spatial prominence through the intrigue that is revealed with the slight shift in geometry.

Topological and geometrical analysis of VGA or access graph analysis, metric analysis which uses metric distance, the distance in meters from one space to another. According to the main tourist routes include Baoshan street, Xida street and representative space of the town, the pedestrian flow simulation on VGA model analysis scope including part of the tour path and the space of the square and open space is selected. However, compared with the VGA, the analysis scope of the model is reduced, and the water area on the visible layer is not apparent, so the analysis scope of the model is different.

When viewed from the water space on the south side of the Baoshan historical block to the north side as shown in Figure 6, the street space and bridgehead open space are captured in the first step of sight depth, and the space is transparent and unobstructed. At the second step of sight depth, the main street space and east-west street space connected with the bridgehead open space can be seen, and the northeast space has the largest sight depth. When the line of sight is viewed from the courtyard space on the east side of the study area to the western side, due to the block of the building, the area of the first step of sight depth is the smallest, mainly inside the courtyard space. However, in the second step of sight depth, the main street space connecting the north and the south is completely

visible, but the line of sight is difficult to penetrate further to the west side. When the sight is viewed from the main street space on the northern side of the study area to the southern side, the main street space is in the first sight depth range. However, due to the block of buildings, only part of the open space at the bridgehead can be seen. In the second step of the line-of-sight depth, the global view of the other spaces can essentially be seen, which is the point of view that needs the least line depth to comprehend the global view. When the line of sight is viewed from the main street space in the west of the study area to the east, most of the east-west main street spaces and the west open space can be seen in the first step of line-of-sight depth. In the second step, the north-south main street space is also fully visible, but the east side space visibility is weak.

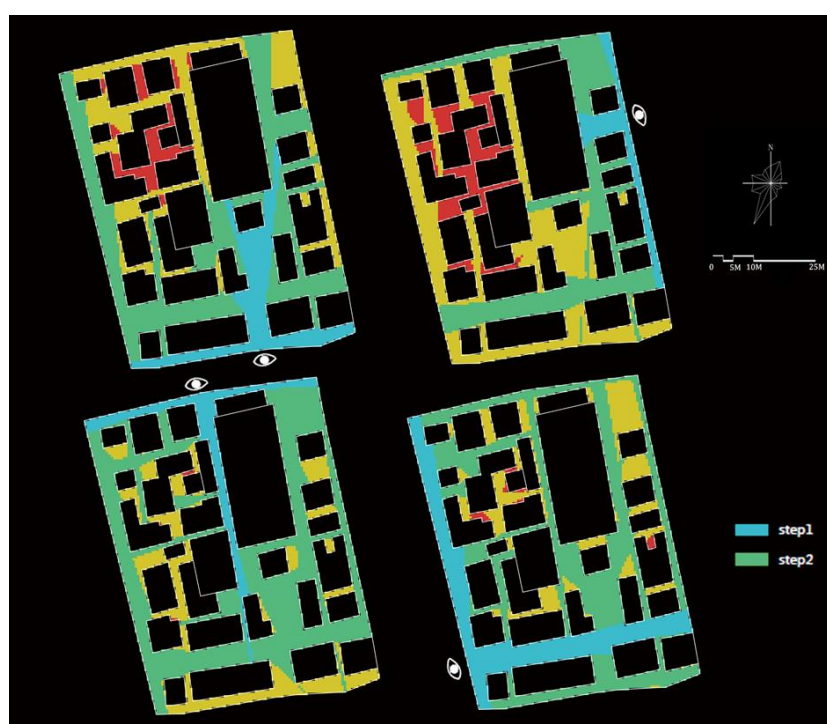


Figure 6. Visibility Graph Analysis of the highlighted block in Figure 5 (The step1 denotes the most likely selected space for a tourist at the location of the eye symbol and step2 denotes the most likely selected space for tourist after step1).

The analysis is from the four directional viewpoint of the Baoshan historical block as shown in Figure 6. When viewed from the water space on the southern side of the Baoshan historical block to the northern side, the street and public space in front of the ancient stage is completely in the first sight depth, and the space is transparent and unobstructed. Through the second sight depth, the space in the east and west connected with the bridgehead open space can be seen and further extended to the interior. On the whole of the Baoshan historical block, the line-of-sight depth of the northwest space is the largest. When the line of sight is viewed from the east space of the Baoshan historical block to the west side, the three sides are blocked by buildings, resulting in the minimum depth of sight range in the first step. However, the main street space connecting north and south in the second line of sight depth is completely visible, but the line of sight is difficult to penetrate further to the eastern side of the block. When the line of sight is viewed from the main street space on the northern side of the Baoshan historical block to the southern side, although the range of the first line of sight depth is not large, but the involved space is wider. In the second step of line-of-sight depth, the people can basically see other spaces of the whole world, and the point of view of the whole space can be seen with the least depth of sight among the four viewpoints. When the line of sight is viewed from the main street

space on the western side of the Baoshan historical block to the east side, the main street space and the street space on the south side can be seen in the first step of sight depth, and penetrate to the western side. In the second step of line-of-sight depth, the bridgehead space and the public space in front of the stage can be seen, but the space visibility in the northeast part of the Baoshan historical block can also be seen. Figure 7 presents the pedestrian flow simulation on the VGA analysis of Baoshan historical block.

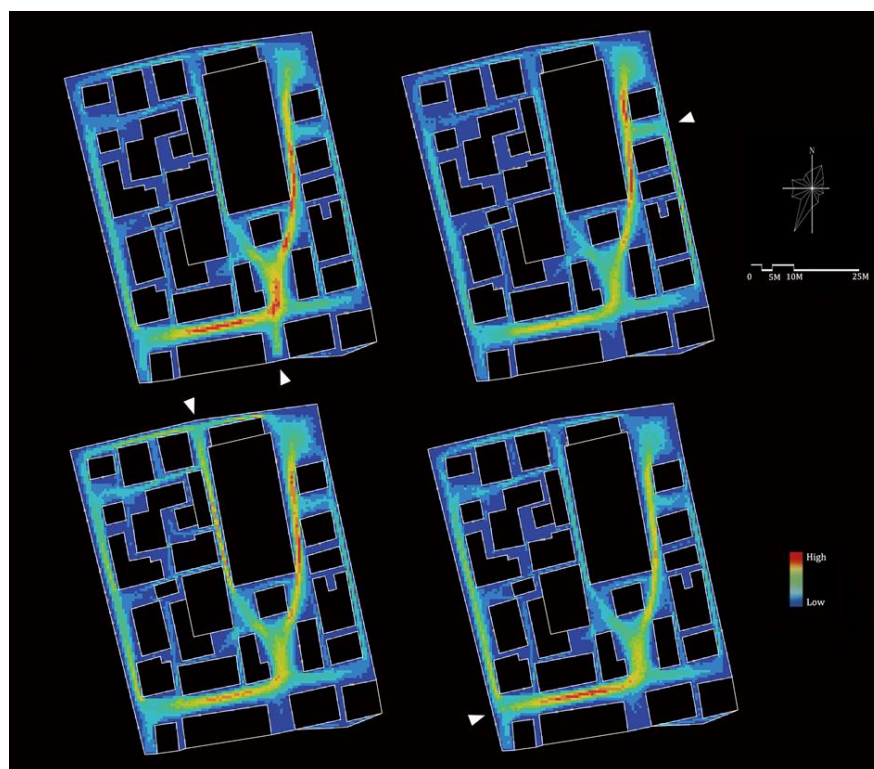


Figure 7. Pedestrian flow simulation on VGA of Baoshan historical block in Figure 5 (The red and the blue denotes the high and low tourist intensity, respectively).

In the simulation of pedestrian flow analysis as shown in Figure 7, when the flow of people is released on the northern side of the historical block, the main space forms an obvious centre in the public space in front of the stage, and it extends to the eastern side and the northern side and gradually decreases. When the flow of people is released in the eastern side of the space, the main space is distributed on the adjacent north-south street, and there is also high flow of people in the open space on the north side. When the flow of people is released in the space on the north side of the space, the main spatial distribution is in the north-south street of the east side. Although the passenger flow of the adjacent north-south street is increased, it is still lower than that of the adjacent street. At the same time, the east-west street space on the south side still attracts higher pedestrian flow. Therefore, the main stream of people is distributed in a mirror-image of ‘L-shaped’ street space. Through comparative analysis, the public space in front of the ancient stage is in the core get-together space centre, and the space reached by high pedestrian flow is always connected with the open large space regularly. Figure 8 presents the integration of the pedestrian flow simulation on VGA of the Baoshan historical block.



Figure 8. Integration of pedestrian flow simulation on VGA of Baoshan historical block.

Through the global pedestrian flow simulation as shown in Figure 8, it can be seen that the human activity track forms a spatial distribution structure of a mirror-image 'L'. At the same time, it intersects with another street space with weak pedestrian flow, which also forms a more obvious secondary public center. Due to the bottom-up organization deduction of eastern building texture in disorder, the arrival of pedestrian flow is weakened. Therefore, the core position of the public space in front of the ancient stage and beside Xida street could be further extended, and the organizational relationship with the bridgehead space could be integrated to further enhance its spatial function and value.

4.5. Suggestions for Nanxun and Future Research

Exploring the relevance experiential qualities of historical streets in townscape aims to provide a reference for policymakers to better understand the experiential qualities of historical streets in townscapes [36,37].

Based on the space syntax analysis results of the streets of ancient Nanxun, combined with the focused visibility analysis on a historic block near the Baoshan Bridge, several suggestions for improving peoples' experiential qualities in historic districts of Nanxun are proposed. In this research, Nanshan Street and Wangshan Road in Nanxun have the lowest connectivity value and control value in the ancient town area, and Jiaye Road has the lowest mean depth value. Considering the road network and town planning, the findings suggest a conservative restoration to solve current negative experiential qualities of Nanxun. For example, if the main tourist street (Baoshan Street) is rebuilt to raise its connectivity, the visiting time will be extended and the complexity and coherence of the space will be increased; two potential gathering centers may also improve integration values of the town so as to prevent periodic overcrowded and way-losing situations.

While Nanxun's overall block structure is relatively clear and regular compared with other historic canal towns such as Wuzhen, where the sense of perceived mystery is evoked on the first impression appears to be reinforced by a low intelligibility value. The opportunities of applying serial vision studies along with VGA at a micro-scale or sub-block level, revealed slight changes in the geometry of streets and lanes which presents tourists with an intriguing experience. Working with these slight shifts of design intervention by further scaffolding opportunities of landscape treatments to improve experiential qualities of historical streets.

5. Conclusions

This paper presents on-going research that attempts to explore the potential of working with space syntax analysis while introducing factors such as complexity, coherence, 'mystery', and legibility from the work of environmental psychologist Stephen Kaplan [31] and the urban designer Gordon Cullen [33]. The study investigated the spatial form and distribution of the ancient area of the Nanxun canal town. The purpose of the research is to

assist in evaluating the spatial and experiential qualities of its historic streets in order to help mitigate the loss of these qualities with increasing development pressures. Reflecting on the computational design analysis for evaluating the relevance of these experiential qualities, further research is needed to explore the application of various environmental psychology factors. The following lists a number of important considerations:

A more detailed study regarding specific physical, social, and economic impacts on spatial cognition, reflecting people's perception of the relevance of the experiential qualities of historical streets, could provide valuable insight to further manage sensitive design outcomes with respect to future development pressures.

Drawing on the methodology developed by Yu, Behbahani, Ostwald and Gu [38], in their paper 'Wayfinding in Traditional Chinese Private Gardens: a Spatial Analysis of the Yuyuan Garden' [38], further research could focus on a space syntax analysis of the waterways in the canal towns in order to study how various locations, such bridges and access points to the water and canal boats, may have added to their spatial and experiential qualities;

To conclude, an analysis of experiential qualities of historical streets based on a questionnaire or interview survey will be conducted to see if a correlation exists between local residents and tourist perceptions, and the interpretations of the results drawn from the combined space syntax, serial vision, and visibility analysis presented in the paper.

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