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Towards Sustainable Heritage Tourism: A Space Syntax-Based Analysis Method to Improve Tourists' Spatial Cognition in Chinese Historic Districts

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Abstract: Historical and cultural blocks in Chinese historic districts are important components of sustainable heritage tourism. In towns along the Grand Canal, historical and cultural blocks are generally integrated with modern commerce, forming a complex space characterized by multi-elements, multi-cultures, and multi-functions. The understanding of tourists' spatial cognition thus becomes extremely important to support heritage conservation and encourage sustainable heritage tourism. This study proposes a space syntax-based methodology to help inform heritage consultants and urban designers in understanding the tourists' spatial cognition of canal town cultural blocks, and thereby assists designers and managers in identifying where cognitive experiences can be improved. The proposed method is applied to Nanyang, which is a canal town currently in decline in Shandong Province, and is contrasted with the ancient town of Wuzhen in Zhejiang Province, China, a highly successful tourist town. By using this proposed method, the relationship between street networks and tourists' spatial cognition has been explored. The results of the analysis were evaluated in order to inform a range of design concepts that could enhance the sustainable heritage tourism experience of these two towns.

Keywords: space syntax; canal town; spatial cognition; sustainable heritage tourism

1. Introduction

Sustainable heritage tourism has been a major concern for many countries who possess rich culture heritages, and its establishment as a discipline requires a systematic analysis of the spatial characteristics of historical districts. At present, research on the spatial characteristics of historical districts in the fields of architecture, landscape architecture, and urban design is largely qualitatively-based on environmental cognition information of tourists being derived by means of interviews, questionnaires, cognitive maps, and factor analysis.

In recent years, the space syntax model has been widely used in the fields of architecture and urban planning [1]. This model is considered to be a vital achievement and method in communicating the juncture between subjective and objective perspectives in the study of urban space [2]. Nevertheless, owing to the complexity of urban space, the differences in cognitive subjects and the limitations of the syntax model in respect of methods and techniques (e.g., subjectivity in the construction of axial diagram models, and difficulties in measuring three-dimensional urban space), there have been some deviations in the quality analysis of spatial syntax modelling. Hence, previous research

using space syntax to analyze Chinese historical districts rarely considered tourists' perceptions of spatial configuration.

This research aims to develop a space syntax-based analysis method that combines environmental psychology and space syntax. The method applies linear mathematical analysis methods in spatial syntax, which is a default built into Depthmap [3] analysis software, to calculate a series of parameters to generate an axis map, and then to select the main variables in the space syntax model by analyzing variables, including the connectivity value, control value, mean depth value, global integration value, local integration value, and intelligibility value. The correlation between the value and spatial information are reported in several recent studies [4–7]. If a space has high connectivity value, it means a large number of spaces connect with this space [4]. Control value could reflect spatial connectivity [5]. 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 [6]. Intelligibility value is used to measure whether the local spatial structure helps to establish an understanding of the entire inter-spatial system, and indicates spatial identifiability [7]. Based on the definitions of main variables and spatial cognition of environmental psychology [8], tourist spatial cognition indicators can be developed.

This proposed method is explored through a case study of Nanyang, in China, in which tourists' spatial cognition is analyzed, in order to develop a range of urban design options to support sustainable heritage tourism. The following paper is divided into five distinct sections. Following the introduction, the second section introduces the methodology that focuses on space syntax. The third section presents the case study that applied contrast analysis theory to correlate the findings of a space syntax analysis of Nanyang. The fourth section elaborates on the limitations and future research, and presents a range of design suggestions to help improve tourists' spatial cognition in the historic districts of Nanyang. Conclusions are drawn in the fifth section.

2. Overview of Space Syntax

Space syntax is a method for describing and analyzing the relationships between spaces of urban areas and buildings [9]. Since Hillier put forward the concept of space syntax in the late 1970s, the model has been widely used as a social logic language to comprehend urban or architectural space [10]. Especially since 2000, the integration of the space syntax model and geographic information systems (GIS) has greatly enhanced its space form analysis and expression competence, making it an important tool for space planning and design. In recent years, the space syntax model has been also used to investigate urban land use, conservation, and renewal of ancient blocks, accessibility of urban public facilities, and distribution of crimes in the city.

As a theory, space syntax differs from classical urban morphology because it focuses on open space systems to pursue a form of spatial representation [10]. Space syntax theorists call sets of simulated relations between spaces a "configuration" or "accessibility" and these terms are used as ways of describing what they understand to be the intrinsic properties of space [11]. Space syntax-based analysis uses three types of distance metrics [12]: topological (fewest turns paths); geometrical (least angle change paths); and metric (shortest physical paths). The space syntax then calculates the street network configuration at different scales according to the size of the research area. The global scale analysis measures the average depth of an axial line or segment to all other axial lines or segments in whole street networks, while the local scale analysis makes calculations in a limited radius [13].

In light of a large number of studies on the comparison and relationship between space syntax model and space image and cognitive map, Turner [14] believed that there was a relationship between isovist graphs and visibility graphs, which can be used in the study of spatial cognition. Shokouhi et al. [15] suggested that the coherent structure composed of the prominent elements of the city, the organic organization of buildings and the continuity between landmark visual inter-domains is the key to the interpretation of the city by comparing the space syntax analysis and image map of different cities. Tao [16] combined the axis map and image map in order to discuss the spatial forms of

villages. Koohsari [17] took the historic block of Taiping Street in Changsha, Hunan Province as an example, comparing the cognitive map with the space syntax model, and found that the space syntax model had a high degree of correlation with the node and road network in the cognitive map. There are also studies that sought to test and revise the research conclusions of the space syntax model by means of experiments upon tourists' behaviours and analysis of their comments.

Li et al. [18] applied space syntax analysis to provide an understanding of tourist space at historic sites on Gulangyu Island in Fujian Province. They explored the relationship between street network integration and the urban fabric as well as tourist preferences. Kubat [19] investigated pedestrian and vehicular activities in Sharjah historic center in the United Arab Emirates (UAE) in order to understand current movement patterns, and analyzed physical structure based on understanding the spatial configuration of the historic center. Data in the research generated a multi-level, electronic database of urban form and function, containing levels of spatial integration in the current street networks and levels of pedestrian and vehicular movement. The analysis results have been comparatively evaluated, leading to an in-depth understanding of the decay of Chinese historic districts. Sheng et al. [20] took the Chaoyang historic block renewal project in Jilin Province as a case study, and applied the space syntax model to traffic volumes and visual integration of the site. All these analyses provided a basis for the full design process from conceptual design to proposal evaluation in order to activate this site by introducing pedestrian vitality.

Multiple spatial characteristics, such as waterways, bridges, streets, laneways, as well as the roadside stalls and performances, benefits the improvement of spatial cognition and experience Spatial characteristics have a direct impact on people's cognition, which is always accompanied by emotional reactions in the process of cognition [2]. Lynch [21] mentioned that different environments were easier to understand and find because different parts are clearer and more memorable for people, additionally, differentiation creates better landmarks and urban space. Montello [22] proposed that urban spatial environments were differentiated by their chaotic and disorienting appearances. Rollo and Barker [23] focused on the responses of 30 postgraduate participants who were asked to evaluate a streetscape experience based on favourable and unfavourable perceptive qualities.

The study presented in this paper intends to promote the research of space syntax. It will provide a visualized and quantitative approach to the field of sustainable heritage tourism via understanding the urban morphological features and tourist preferences.

3. Proposed Method

The proposed space syntax-based analysis method contains two main parts. The first part is the extraction of spatial morphology information on the basis of the space syntax model. The second part is the analysis of tourists' spatial cognition.

3.1. Extraction of Spatial Morphology Information

Depthmap [3], an open source software, is selected to extract the spatial morphology information of block. Having regard to the density of buildings in the ancient Nanyang town area, the axis segmentation method in the space syntax theory is used. In the analysis of variables, the main index items in the space syntax model were selected to analyze the spatial topological relationship of the street axis of the historical block of the canal town. The main index items include a connectivity value, control value, mean depth value, global integration value, local integration value, and intelligibility value [9]. The connectivity value (C_i) refers to the number k of spaces connected to the 'i' space as following equation:

$$C_i = k \tag{1}$$

The higher connectivity value indicates the closer space to the surrounding space, the stronger influence on the surrounding space, and the better space permeability. The control value (C_{1i}) refers to

the reciprocal sum of other spatial connection values connected to the '*i*' spatial node as the following equation:

$$C_{1i} = \sum_{j=1}^{k} \frac{1}{C_i} \tag{2}$$

The larger control value denotes the greater degree of control the '*i*' space over the space which it intersects. The mean depth value (D_i) refers to the shortest topological distance (d_{ij}) of the '*i*' space from all other spaces (j) as the following equation:

$$D_i = \frac{\sum_{j=1}^{n} d_{ij}}{n-1} \tag{3}$$

The lower mean depth indicates the space is more convenient so the lower mean depth value is desired. The global integration value (I_i) refers to the degree of spatial aggregation or dispersion between the '*i*' space and other spaces as the following equation:

$$I_i = \frac{n(log_2((n+2)/3)-1)+1}{(n-1)(D_i-1)} \tag{4}$$

The integration value is the most commonly used and important analysis variable. The higher integration value indicates the higher accessibility and commonality of the space. Besides the global integration value, the local integration value, $I_i(K)$, is used and refers to the relationship between the '*i*' space and other spaces within K steps. Usually K is 3 and this term is named as radius-3 integration.

3.2. Analysis of Tourists' Spatial Cognition

Previous studies [2,8,24] on spatial cognition studied how people recognize and understand the environment, including environmental image, distance judgment, spatial orientation, wayfinding, and place naming. The five analysis variables in space syntax models and the corresponding spatial characteristics and tourist spatial cognition indicators are shown in Table 1.

Table 1. Analysis variables in space syntax model and tourist spatial cognition indicators.

Analysis Variables in Space Syntax Model	Spatial Characteristics	Tourist Spatial Cognition Indicators
Connectivity value	Spatial permeability	Road-network structure is complex. Tourists' journey through the town is intriguing. Few dead-end roads.
Control value	Spatial connectivity	Lane ways and streets are well interconnected. Few repeated-visit happen.
Mean depth value	Spatial compactness	High spatial compactness, high tour efficiency.
Integration value	Spatial accessibility Spatial publicity	There is a clear main tour road. There is a significant gathering center.
Intelligibility value	Spatial identifiability	Tourist can accurately determine the current location. Tourist can efficiently find their way to the destinations. The spatial functional zoning of the block is clear and easy to identify.

The information that people perceive in the canal town is relatively complex. In addition, people's cognition of a space experience is a complex psychological process, involving the characteristics of environmental information, complexity preference, emotional response, social and cultural background, the interaction between people and the environment. Environmental psychologists mentioned that people have different cognitions for different spaces [8]. The information provided by space and environment is the premise of behaviour, and space is the place where behaviour occurs [24]. Spatial cognition is influenced by many kinds of sensory stimuli [25]. When considering spatial cognition, social

and cultural information should be paid special attention. In the environment, different perceptions can also replace each other.

The combination of waterways, bridges, streets, and laneways often within a dense one- and two-storey block structure not only makes the canal towns in China popular for tourists, but also this interest is scaffolded with local food shops along streets, cultural and artistic performances, folk-customs within a cultural background setting, and all these spatial characteristics contribute to make a lasting impression upon tourists. All of these elements contribute to the improvement of spatial cognition and experience.

With respect to the relationship between the space syntax model and subjective analysis methods, this research takes the historic and cultural block of Nanyang ancient town the case study. Research sought to measure its spatial topological relationship under a walking scale by employing the connectivity value, control value, mean depth value, integration value and intelligibility value in the spatial syntax model. In addition, a survey questionnaire has been designed on tourists' spatial cognition in line with the spatial characteristics represented by indexes. The report will discuss the relationship between the two methods from the point of view of both subjective and objective information through data contrast analysis.

4. Case Studies: Nanyang and Wuzhen

4.1. Overview of Nanyang

Nanyang is a canal town located in Weishan County, Jining City, Shandong Province in China. It has an area of 4.5 km^2, spreading over 13 islands, and a population of 30,800. The Nanyang ancient town is located on the main island of Nanyang, covering an area of 1.68 km^2 with 12,000 people [26]. Nanyang used to be a thriving business center during the Ming and Qing Dynasties (1368~1911), and became a ferry port with the construction of a ditch during the reign of Emperor Long Qing of the Ming Dynasty (1368~1644). The Beijing–Hangzhou Grand Canal, the oldest and longest man-made canal in the world, built in 468 BC, cuts through it, and the township served as a water transportation hub between the north and south of China allowing the transportation and exchange of goods such as fish, liquor, rice, bean curd, silk, and kerosene [27].

However, Nanyang has become a town in decline. To date, this ancient town has continued to maintain its historical buildings and natural scenery, being surrounded by small rivers and bridges that cross parts of the Grand Canal [28]. The locals still rely on boats as their main mode of transportation, and their houses retain ancient architectural styles. In 2014, the Beijing–Hangzhou Grand Canal was selected as a World Heritage List place, and Nanyang, as an important part of the Grand Canal, has received much recognition throughout the world as a consequence of this inscription [29].

Recognizing these problems, the local government of Nanyang has invited designs and plans for rebuilding and extending the town. Nevertheless, because parts of the town have been allowed to fall into disrepair, a review of comments on a tourist website reveals a range of opinions that critique the rather tired appearance of this town, as set out in Table 2.

Table 2. Negative comments and source websites (the initial comments were written in Chinese and the authors translated them into English).

Date	Negative Comments	Websites
17 September 2015	The buildings on the island are too crowded and it is boring to visit such an ancient town.	https://bbs.syuan.net/4/s1095657/
20 June 2015	The ancient buildings along the road are special and have a taste. Now, the town is a bit over-developed. Many characteristic houses have been demolished. I didn't see any scenery last time because of walls. The characteristic street can be visited in less than half an hour.	https://bbs.syuan.net/4/s1017001/2/
4 June 2016	Dragon Boat Festival in Nanyang is usually very lively. Such a spectacular scene must not be missed. However, the scene will be very crowded. Do remember to keep your money and belongings, and protect your kids, otherwise you may be overcrowded and injured.	https://m.tuniu.com/tipnews/106197/?p=27183
3 October 2018	The first impression of Nanyang is that this town is still in the initial development stage: the terminal management is not formal, and the tourism facilities cannot satisfy the requirements of tourists. In summary, the tourism development of the ancient town has just begun, and the software and hardware need to be improved. It is pity that there are too many new things and too few old things in the ancient town.	http://www.mafengwo.cn/i/10768070.html
6 June 2019	Back on the island, there are restaurants and shopping streets everywhere. The similar commercial streets are not advisable and attractive.	http://www.mafengwo.cn/i/14721294.html
2 August 2019	It was quite messy on the ancient street, and people are busy with selling.	http://www.mafengwo.cn/i/16289208.html

4.2. Interpreting the Spatial Syntax Analysis of Nanyang

Because the aim of this research is to explore the relationship between the space syntax analysis model of a historic and cultural block and tourists' perception, the road network of Nanyang is segmented according to the principle of the minimum space syntax model, and the total number of axes is 315. The current road network and water channels are illustrated in Figure 1, which is the town planning for 2030. In this map, it is clear to see that the Grand Canal goes across the town and breaks many roads, and multiple squares are located at the ends of the roads.

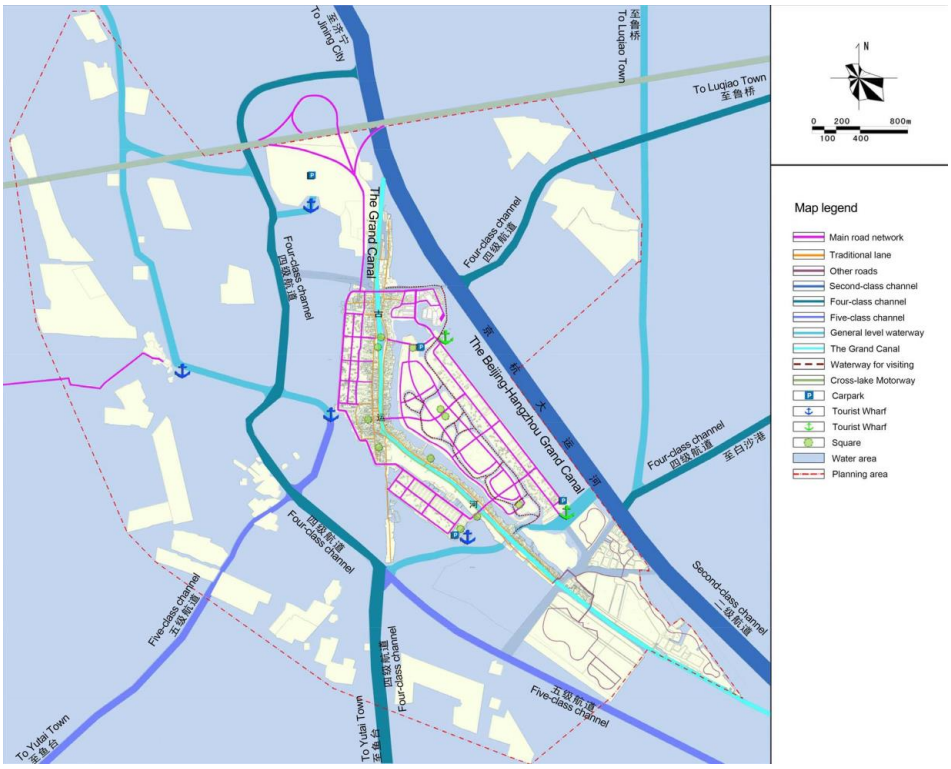


Figure 1. Road-network waterway system plan in Nanyang (Source: Nanyang Government).

Then, a magnified aerial map of the main tourist street near the Grand Canal is shown in Figure 2. Tourist attractions such as residences, palace, temples, etc., are marked and highlighted. In view of the difference between the ancient town area and non-ancient area, the research focuses on the ancient town area and the total number of axes in the ancient town area is 40.

Figure 2. Aerial view map of Nanyang.

In the results of space syntax-based analysis, the colours refer to high and low values; red refers to high values, while blue refers to low values of integration. On the whole, the axis structure of the ancient town area in Nanyang is not relatively simple. The Nanyang street as a clear 'vertical' main tourist street, connects the main tourist attractions such as the Bring-baby Palace and the River-god Temple. Because of the mixed functions of tourism and residence within the block, many living lanes are enclosed to form an independent closed space, or exist in the form of a 'broken road', that results in the weak spatial connectivity of the whole block. The results of space syntax analysis variables for 10 streets and seven hutongs are shown in Table 3, where the average connectivity value for the 17 lanes is only 5. That is, there are on average five axis intersections with each street axis.

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

Road Name	Connectivity Value	Control Value	Local Integration Value	Mean Depth Value	Global Integration Value
Shuangyang Street	6	1.708	105.609	3.887	130.595
Xiangyang Street	5	1.726	90.139	3.961	110.069
Kaiyang Street	5	1.726	92.667	2.931	113.985
Nanyang Street	18	10.031	124.960	3.300	111.841
Jinger Street	4	1.250	92.715	3.681	145.869
Matou Street	4	1.250	73.930	4.743	90.519
Jingzi Street	5	1.726	91.193	3.930	111.232
Shuyuan Street	5	1.726	100.868	3.662	126.501
Zhuangyuan Street	9	3.000	108.751	3.529	129.714
Beiyi Hutong	3	0.814	84.983	4.384	100.951
Beier Hutong	4	1.250	85.537	4.443	100.951
Beisan Hutong	4	1.250	84.198	4.424	100.594
Beisi Hutong	4	1.250	85.931	4.702	102.461
Beiwu Hutong	4	1.076	86.401	4.046	102.487
Beiliu Hutong	4	1.076	89.110	4.054	104.060
Beiqi Hutong	4	1.076	88.094	4.089	103.487
Kaian Street	9	2.430	76.425	4.653	90.414
Average value	5	2.015	85.236	4.505	110.059

The space syntax model analysis result based on four values are presented in Figure 3 where the red and blue denote the high values and low values, respectively. As the colour contour shown in Figure 3a, there is a significant difference in the connectivity of the axis of different functional streets,

and the average control value is 2.01 in the ancient town area. Since the historic and cultural block of Nanyang is a pedestrian street, the local integration value and mean depth value at walking scale were selected to analyze the compactness and accessibility of the ancient town area. On the whole, the space compactness of the historic and cultural block of the ancient town area in Nanyang is not strong. The local integration value of the main tourist streets is 85.236 (see Table 3). Figure 3b depicts the local integration value of streets in the ancient town area and it is obvious that Nanyang Street has the highest value, which is 124.960. This value is ~50% higher than the average value in Table 3. On the contrary, the mean depth value is illustrated in Figure 3c where Kaiyang Street has the lowest value, 2.961, which is ~50% compared to the average value. Considering the results in Figure 3b,c, it is worth noting that Nanyang Street with the highest degree of local integration is the main tourist street intersecting in the middle of the block, and also the streets with the lower mean depth value. However, the level of accessibility of the lanes near the Grand Canal is relatively low, such as Kaian Street on the east of the Canal. This shows that at the walking scale, the block has an obvious central structure. The main tourist street in the middle of the block has the strongest accessibility, convenience, and public exposure and is the main passageway of the block space organization. This obvious central structure strengthens the convergence of people and provides historic sites or attractions in the central region with a clear geographical advantage. Therefore, the central structure of the ancient town area is obvious, and the main tourist street has the potential to offer a strong public interface. The global integration value, see Figure 3d, could test the compactness of all nodes in the whole system.

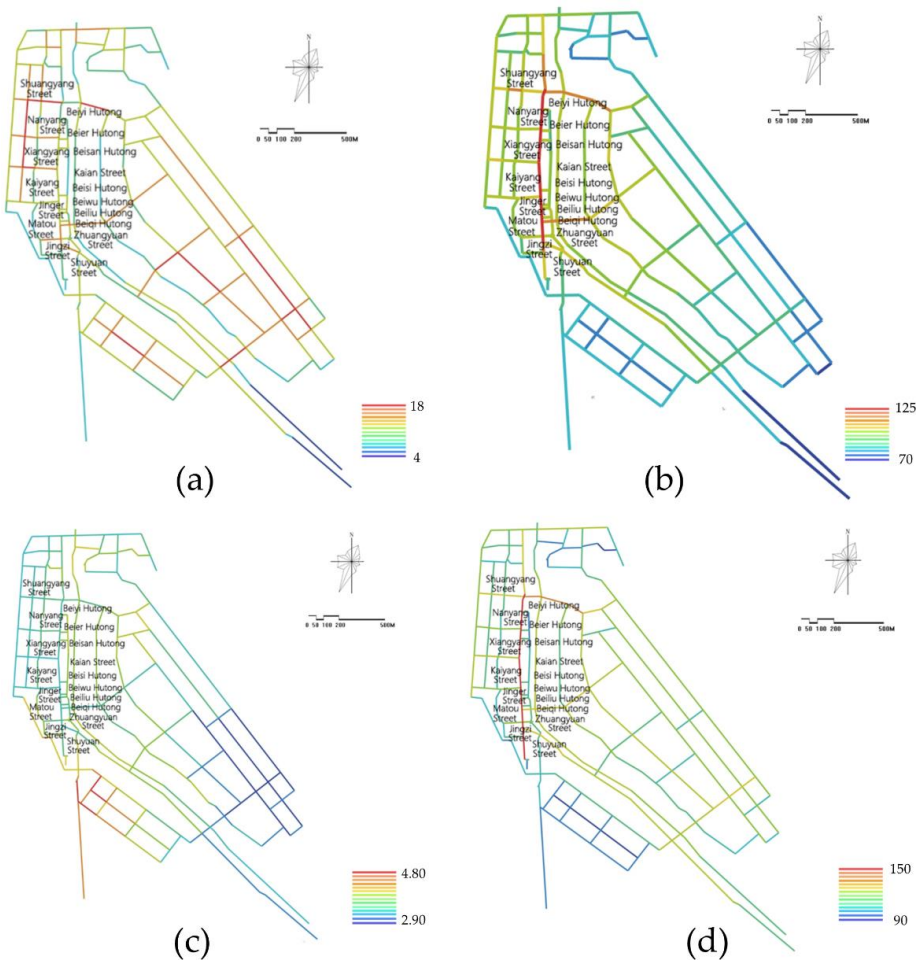


Figure 3. The space syntax model analysis result on Nanyang town: (**a**) connectivity value, (**b**) local integration value, (**c**) mean depth value and (**d**) global integration value.

As the colour contours in Figure 3d and values in Table 3, there are three streets with the highest global integration values, namely, Jinger Street (145.869), Shuangyang Street (130.595), Zhuangyuan Street (129.714). Li and Duan [30] suggested that a stronger global integration value makes it easier to accumulate pedestrian flow. Therefore, Jinger Street, Shuangyang Street, and Zhuangyuan Street are the most public and convenient spaces for tourists to gather.

Spatial intelligibility is used to measure the cognitive degree of a spatial group. If a spatial group has a high degree of intelligibility, this means that its overall spatial layout is more easily recognized and mastered by people [31]. People's cognition of the whole always comes from local information, and the degree of intelligibility reflects the difficulty of judging the whole information according to the local information of spatial groups. The characteristic of comprehensibility means that what one can see from the spatial layout matches or is a useful guide for what one cannot see [9]. For systems lacking intelligibility, there are many connected spaces, that often cannot be well integrated into the whole system. Therefore, according to the visible connections, one can often be misled into understanding the orientation of this space in the whole system [10]. In the space syntax model, intelligence value can measure whether the local space and the whole space are related and unified [9]. Generally, the range of the intelligence value R^2 is 0–0.5, which indicates that the spatial identifiability is weak; R^2 locates at 0.5–0.7 which indicates that the spatial identifiability is good; R^2 locates at 0.7–1.0 which indicates that the space recognizability is strong [32].

In consideration of the high density of historical buildings in ancient canal towns, this research is conducted using the method of segmentation axis and isovist maps based on space syntax [15]. The Depthmap is used to extract the connectivity value of the historical and cultural block of the Nanyang ancient town area, according to the following formula:

$$R^2 = \frac{\sum\left(C_i - \overline{C}\right)\left(I_i - \overline{I}\right)^2}{\sum\left(C_i - \overline{C}\right)^2 \sum\left(I_i - \overline{I}\right)^2} \tag{5}$$

This is introduced to calculate the intelligibility value R^2 of the historical and cultural block of the Nanyang ancient town area, where I_i refers to the integration value, $\overline{C}$ refers to the average of the C_i of all units, and $\overline{I}$ is the average value of the I_i of all units in space. The intelligibility value is calculated as 0.641 as shown in Figure 4. The value indicates that the recognizability of the street axis of the block is good. The intelligence value in Nanyang ancient town reflects that it is not difficult to establish an impression from the local part to the whole ancient town when tourists were walking in the main streets.

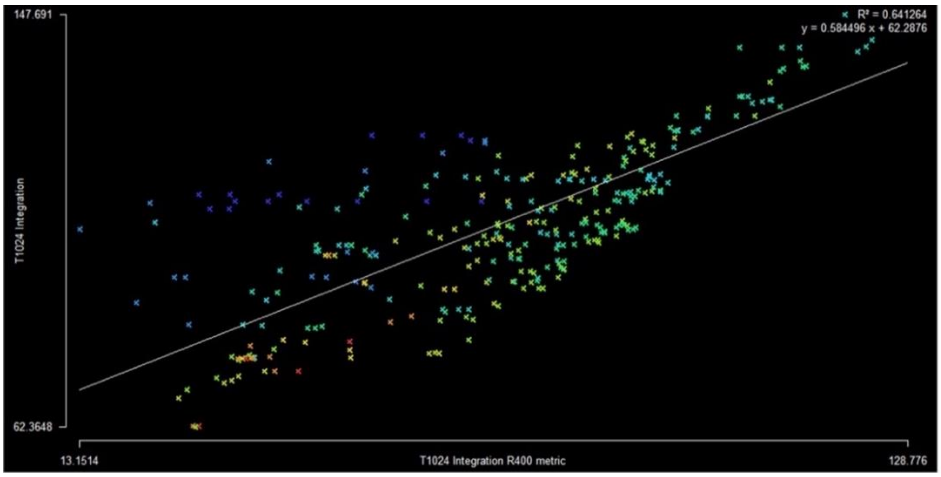


Figure 4. The space syntax model analysis result on Nanyang: intelligibility value.

However, when considering that the functions of tourism, commerce, and residence are haphazardly mixed within the ancient town area, rather than being clearly defined in different sub-precincts, tourists often find themselves walking into semi-private residential areas, which is at first seem part of the public domain. In addition, with the renovation of shops and residential areas in recent years, part of the Hutong and lanes within the block has been interrupted, such as Beiqi Hutong and Beier Hutong. This makes it more difficult for tourists to obtain the overall spatial information of the block efficiently. Therefore, the spatial identifiability of Nanyang ancient town area should be strengthened by upgrading the laneway infrastructure, providing cognitive thresholds between public, semi-public and private areas, and developing a flexible wayfinding strategy for tourists as the town undergoes continued renovation.

In this case study, visibility graph analysis (VGA) is conducted on a block beside Zhuangyuan Bridge. The location of the block for the case study in the ancient town as well as the buildings within the block, as shown in Figure 5. VGA is primarily applied to a building or a semi-urban scale in order to derive how visibility defines relationships of spatial elements and helps to understand the surrounding space [33].

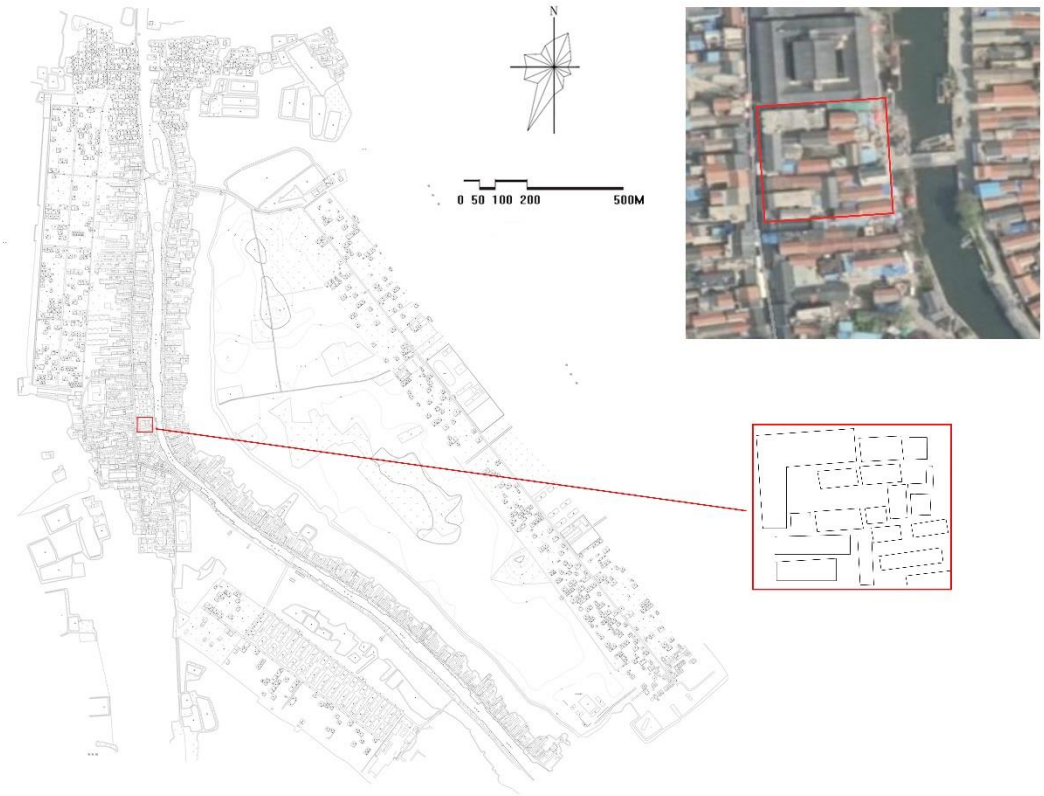


Figure 5. The Current situation map of Nanyang (Source: Nanyang town government).

The VGA results of the selected block based on four view locations were reported in Figure 6 where the white eye symbol denotes the view of one tourist. The red space is the space that the pedestrians need to take more turns on the route through the block to see, and hence takes longer to be revealed and become available for tourists [34]. Based on Kaplan's research [35], the red space has greater depth and enhanced mystery. As the analysis results show in Figure 6, the largest red colour regions were found when the tourist stands at the right east of the block. The yellow, the green and the blue space denote the second least noticed space, the second most noticed space, and the most noticed space, respectively. A little more space is visible for tourist standing at the south. Then, from the north and west perspectives, much more space is available for tourists in terms of visibility.

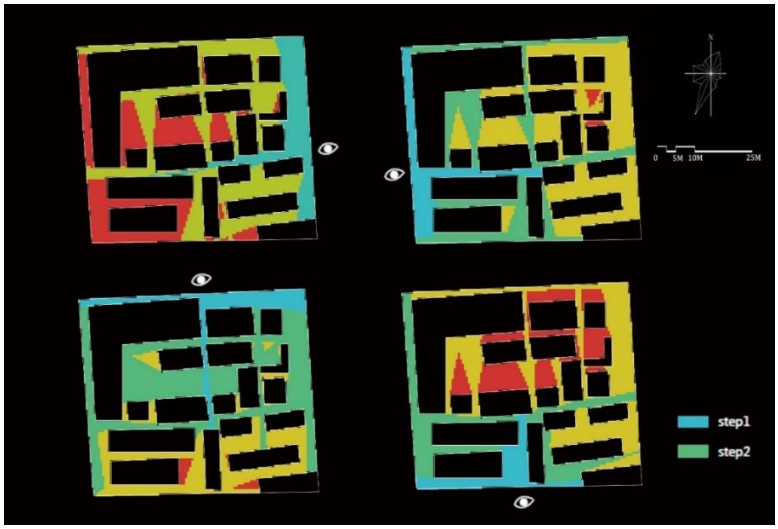


Figure 6. Visibility graph analysis (VGA) of the highlighted block in Figure 5 (step1 denotes the most likely selected space for a tourist at the location of the eye symbol and step2 denotes the most likely selected space for tourists after step1.).

Besides the VGA, the pedestrian flow simulation is conducted and the results based on the four main entrances are shown in Figure 7, where the white triangle symbol denotes the main entrance locations and the directions for pedestrian flow. High pedestrian flow is found in the regions near the entrance as well as the center region of this block. The integrated prediction is shown in Figure 8 and it is clear that, regardless of the perspective, the space in the middle of the block (Songzi Hutong) has the highest pedestrian flow. This may be an important consideration for designers, investors, and policymakers when restoring and enhancing the area for tourists.

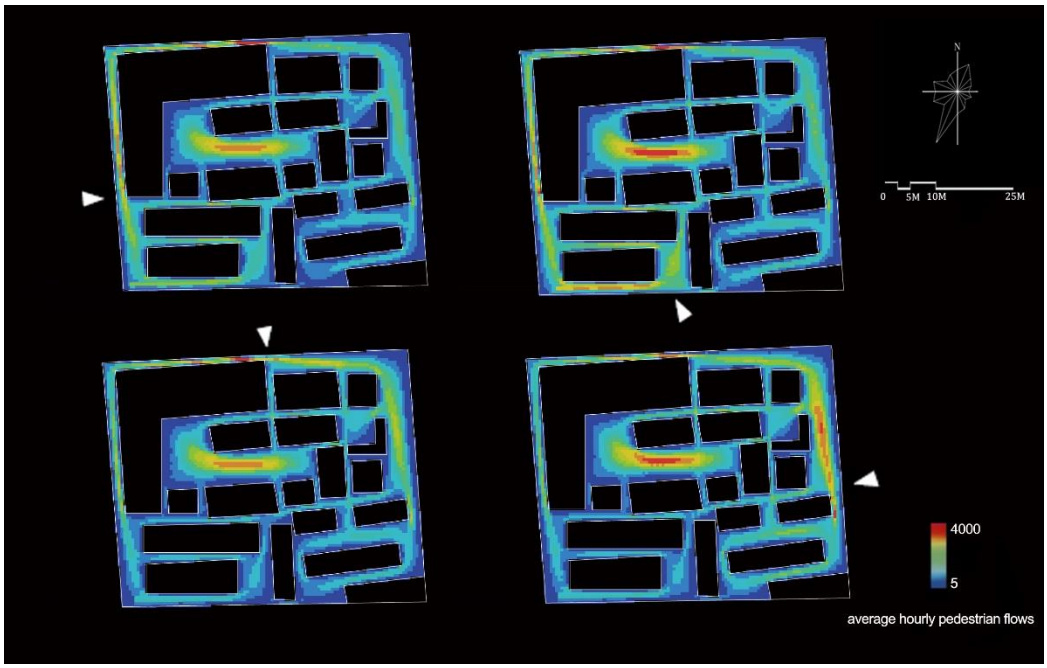


Figure 7. Pedestrian flow simulation on VGA of the highlighted block in Figure 5 (the red and the blue denote high and low tourist intensity, respectively.).

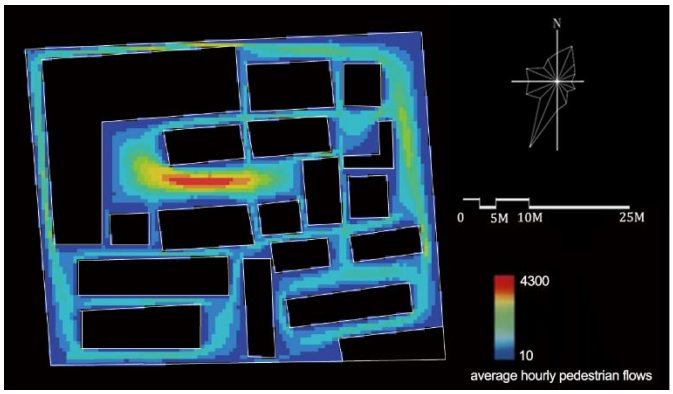


Figure 8. Integration of pedestrian flow simulation on VGA.

4.3. Comparing the Results of Nanyang with Wuzhen

Wuzhen is regarded as the comparative case study in this paper. As with Nanyang, the Grand Canal crosses the town of Wuzhen and has also formed a special cultural relationship based upon water. However, unlike Nanyang, Wuzhen has become a very popular tourist destination along the Grand Canal as the town area map shown in Figure 9 where the highlighted region is selected for comparative study

Figure 9. Wuzhen ancient town area map (Source: http://www.zjditu.cn/, accessed on 12 October 2019).

The space syntax model analysis results based on four values on Wuzhen were illustrated in Figure 10. The space syntax analysis variables of Wuzhen are summarised in Table 4 where the results for the east area and west area are separately listed. As shown in Figure 10a, the highest global integration values were observed in Shifuonan Street and Ziye Road which are located at the boundaries of Wuzhen town. The connectivity values of the streets in Wuzhen are quite different as shown in Figure 10b, however, the high average value in Table 4 indicates a much higher connectivity in Wuzhen than Nanyang. Then, both the highest local integration value and mean depth value were observed in streets in East Scenic Area as shown in Figure 10c,d, respectively. Therefore, this

comparative study investigates the spatial structure of Wuzhen to see if there are any significant differences in the space syntax variables between the two towns (see the comparison between Tables 3 and 4) and, therefore, provides a more informed understanding of the spatial structure, especially relating to route complexity, which may contribute to a favourable canal town experience.

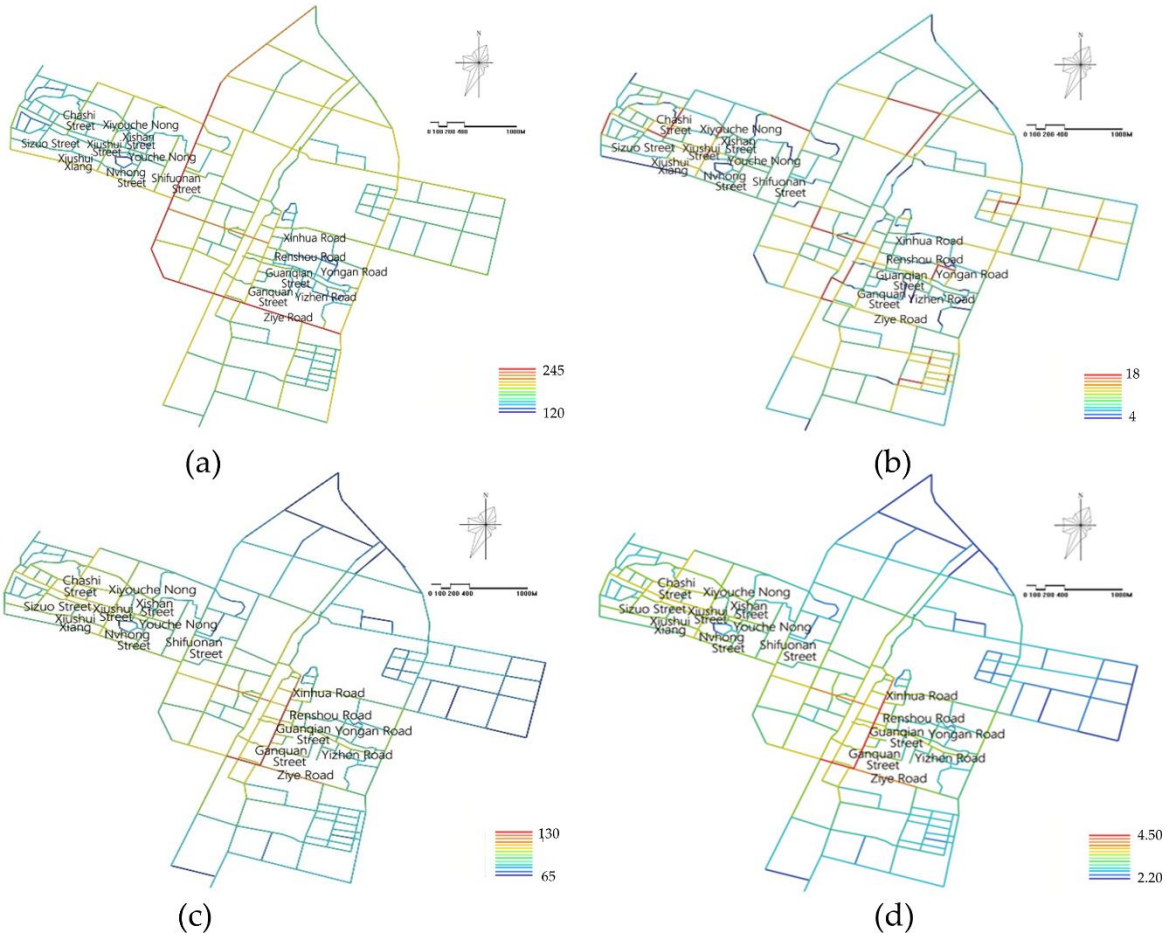


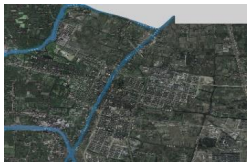
Figure 10. The space syntax model analysis results on Wuzhen town: (**a**) global integration value, (**b**) connectivity value, (**c**) local integration value, and (**d**) mean depth value.

Table 4. Space syntax analysis variables of ancient town area in Wuzhen.

Area	Road Name	Global Integration Value	Connectivity Value	Control Value	Local Integration Value	Mean Depth Value
West Scenic Area	Sizhou Street	134.345	9	2.430	88.988	2.764
	Xiushui Xiang	123.249	4	1.250	69.489	3.556
	Xiushui Street	148.472	7	2.025	89.761	2.962
	Chashi Street	176.199	10	3.452	101.969	2.252
	Xiyouche Nong	123.165	4	1.250	74.044	2.929
	Xishan Street	149.067	15	5.176	94.549	2.430
	Youche Nong	170.513	14	4.408	95.644	2.713
	Nvhong Street	142.149	8	2.500	77.698	3.441
	Shifuonan Street	236.458	11	2.615	75.662	2.301
East Scenic Area	Xinhua Road	207.472	17	5.320	128.387	3.198
	Renshou Road	142.804	6	2.000	127.479	4.009
	Guanqian Street	158.328	12	3.590	93.760	4.402
	Yizhen Road	132.802	5	1.726	67.411	4.413
	Guanquan Road	161.741	3	1.000	85.993	3.943
	Yongan Road	126.591	7	2.025	67.283	4.238
	Ziye Road	240.210	12	3.590	110.947	2.711
	Average value	160.848	9	2.750	90.567	3.266

The similarities and differences of the Nanyang ancient town area and Wuzhen ancient town area are evaluated and summarised in Table 5. On the whole, compared with Wuzhen, the axis structure of the ancient town area in Nanyang is relatively simple. Because of the mixed functions of tour and residence within the block, many living lanes are enclosed to form an independent closed space, or exist in the form of a 'broken road', which results in the weak spatial connectivity of the whole block. Therefore, the average connectivity value is only 5 in Nanyang, that is, there are on average five axis intersections with each street axis. However, the average connectivity value in

Table 5. Similarities and differences of the Nanyang ancient town area and Wuzhen ancient town area.

			Nanyang Ancient Town Area	**Wuzhen Ancient Town Area**
Similarities	Current situation	Location of Grand Canal in the town		
			Grand Canal runs through the ancient town areas	
			Similar scale	
	Space syntax model analysis results	Connectivity value	The streets which have relatively high value are dispersed in the town.	
		Local integration value	The relatively highest value is the main tourist street	
		Global integration value	The streets which have relatively highest value are functionally important.	
		Mean depth value	Relatively low	
Differences	Current situation		One scenic area located on the west side of the Grand Canal.	Two scenic areas located on the east side and west side of the Grand Canal.
			Developing tourist town	Developed tourist town
	Space syntax model analysis results	Connectivity value	Two streets connecting Nanyang Dam have highest value.	Two entrances in West Scenic area have highest value.
		Local integration value	Highest value is main tourist street.	The main street in East Scenic area has highest value.
		Global integration value	Highest value is main tourist street.	A vehicle-way running through the East and West Scenic areas has highest value.
		Mean depth value	Relatively low in ancient town area.	The main entrances in East Scenic area have highest value.
		Intelligibility value	0.641 (strong).	0.356 (weak).

Wuzhen is 9. Additionally, two streets connecting Nanyang Dam have the highest value in Nanyang, and two entrances in West Scenic Area have a relatively high value in Wuzhen. In Nanyang, the highest value is the main tourist street. In Wuzhen, a vehicle-way running through the East and West Scenic areas has the highest value. The intelligibility value of Nanyang ancient town area, which is 0.641 and indicates that the recognizability of the street axis of the block is good.

The intelligence value in Nanyang ancient town reflects that it is easy to establish an impression from the local part to the whole ancient town when tourists are walking in the main streets. On the other hand, in Wuzhen's ancient town area, the intelligence value is 0.356 as the results show in Figure 11. This means that it is not easy to form an overview or cognitive impression for the people who are first-time visitors to the town, which would appear to increase the level of intrigue and enhanced mystery about the town.

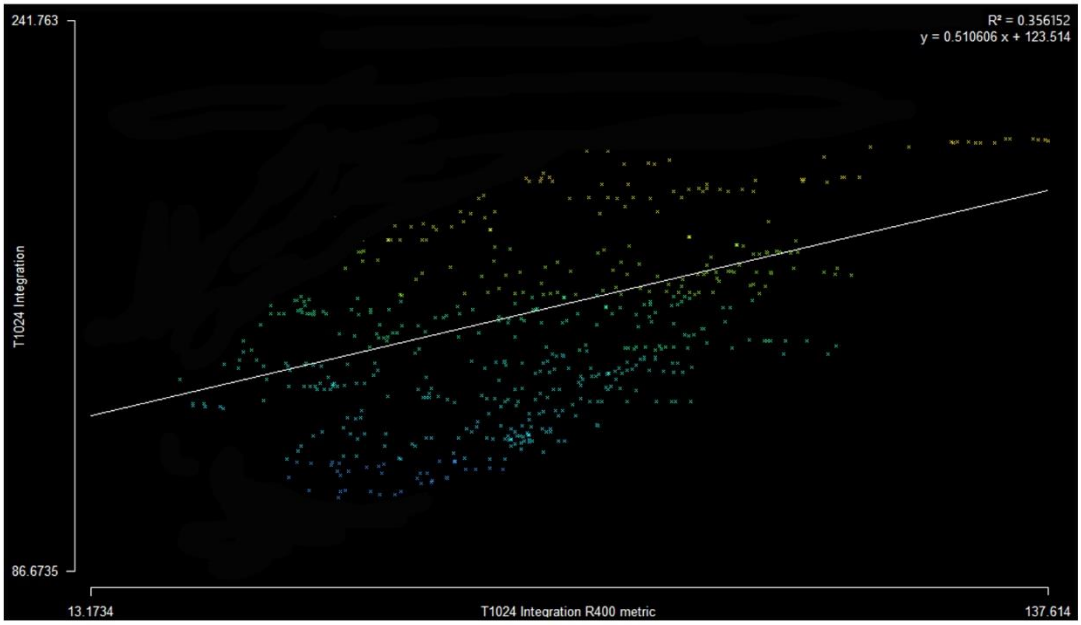


Figure 11. Space syntax model analysis result on Wuzhen: intelligibility value.

4.4. Suggestions for Nanyang and Future Research

Sustainable heritage tourism aims to maximize the quality of tourists' experience and minimize their impacts to protect resources for the next generations, and this is what visitor management intends to achieve [36]. Jones [37] explored sustainable heritage tourism, and demonstrated the need for landscape harmonisation to occur. His research reviewed the historical evolution of sustainable heritage landscape. In addition, Jones and Beza [38] proposed that good sustainability citizenship should depend on heritage tourism's values and cultural perspectives. Therefore, space syntax should be considered as a tool to help improve the quality of tourists' experience of sustainability in heritage tourism.

In this research, Beiyi Hutong in Nanyang has the lowest connectivity value and control value in the ancient town area, Kaiyang Street has the lowest mean depth value, and Matou Street has the lowest local integration value.

Based on the space syntax analysis results, and combined present situation of the streets, several suggestions for improving tourists' spatial cognition in historic districts in Nanyang are proposed in Table 6. Through a consideration of the road network integration of tourist sites and historic districts, the findings suggest a conservative restoration to solve current negative tourist perceptions of Nanyang. For example, if the Beiyi Hutong is rebuilt to raise its connectivity, the visiting time will be extended and the boring feeling of the tourist mentioned above might be diminished; two potential gathering centers in would also improve integration values of the town so as to prevent the overcrowded situations.

Table 6. Suggestions for improving tourists' spatial cognition in historic districts in Nanyang.

Name	Present Situation	Suggestions
Beiyi Hutong	Dead-end road, two key cultural relics are in the Hutong.	Conservatively rebuild and enhance the conserving the historic buildings.
Kaiyang Street	Low spatial compactness.	Strengthen connections between the street and other sites.
Beiwu Hutong	Repeat-visit often happens to tourists in this Hutong.	Introducing new and different functions.
Matou Street	There is no clear main tour destination and gathering center.	Raising the distinctive level.
Kaishan Street	There is no significant gathering center.	A significant gathering center should be built.
Heshen Hutong	Tourists hardly visit this Hutong.	Replacing the service function.
Songzi Hutong	Nearby Zhuangyuan Bridge, this Hutong has the highest pedestrian flow.	Build a gathering center or increase the number of shops.

While Nanyang's overall block structure is clearly more regular than that of Wuzhen, it does not offer the opportunities to reduce intelligibility value, and hence the sense of perceived mystery that Wuzhen evokes on the first impression. The opportunities of applying VGA at a micro-scale or sub-block level, may allow designers to help establish a more intimate sequence of spaces at Nanyang between the Hutong and the Grand Canal, and the western sub-blocks between the Hutong and the lake.

5. Conclusions

This paper presents on-going research that attempts to explore the potential of correlating space syntax analysis with an environmental psychology approach to help facilitate sustainable heritage tourism. The space syntax analysis approach to improve tourists' spatial cognition in historic districts constructs a connection between urban tourism and urban space morphology. The proposed method is applied to the Nanyang ancient canal town, where a part of the streets needs to be rebuilt and conserved. Based on the analysis results, suggestions were provided to help improve tourists' spatial cognition and encourage sustainable heritage tourism in this historic district.

While the spatial experience-applied space syntax method is still being investigated, it would appear that preliminary correlations between spatial variables and the perceived experience of tourists may not only be pertinent to the current issues in Nanyang, but could also be applicable to a large number of historic towns throughout the world. However, limitations still exist in this research. Because space syntax in light of structuralism can accurately describe the spatial characteristics in an axial diagram model, but there are difficulties in measuring three-dimensional urban space, this becomes an important issue to be considered in the application of the space syntax model. There may be some deviations in the spatial analysis. In addition, an analysis of tourists' spatial cognition based on a questionnaire or interview research will be conducted to verify the analysis results of the proposed method.

Future research will develop a questionnaire that will attempt to correlate key questions relating to tourists' experience of the towns with the spatial variables in space syntax. Hence, this study will be carried out from both objective and subjective perspectives: the objective perspective of the research is using space syntactic analysis; the subjective perspective is using ethnographic research methods such as interviews, questionnaires, cognitive maps and indicator analysis, along with other subjective evaluation methods, to extract the indicators of tourist spatial cognition. This study will combine subjective and objective perspectives to explore the tourists' spatial cognition of the Grand Canal towns. It will make original contributions to sustainable heritage tourism.

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