




AKADÉMIAI KIADÓ

Application of normalizing least angle choice in the evolution of Zhanjiang

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ABSTRACT

Based on the theory of space syntax, this research conducts a quantitative study on the four stages of Zhanjiang urban spatial organization system, and draws the urban evolution process. This study found that the development strategy of different periods has a huge impact on the urban development. It determines the structural basis of the original urban space and creates strong development inertia. According to these research results, it can provide an effective theoretical reference for the future spatial expansion of the city.

KEYWORDS

space syntax, normalising least angle choice, spatial organization, integration, choice

1. INTRODUCTION

1.1. Project background

Zhanjiang is located at the southernmost tip of mainland China, at the intersection of the three provinces of Guangdong, Guangxi, and Hainan. It is the main outlet for the provinces of Southwest China. Now, this city has developed from a small fishing village to the sub-central of Guangdong Province, a strong economic province in China, and it is also an important channel connecting mainland China and Hainan Free Trade Port. Cities will obtain new development opportunities, but rapid and disorderly development will have irreparable negative effects on the urban spatial organization. Therefore, studying the evolution of urban spatial organization is of great significance to the future development of cities, and it can be used as a mirror to reflect urban politics, economy, society and culture [1]. After long-term research, a series of theories and methods have been formed to analyze and quantify the urban material space morphology, the most prominent is space syntax [2].

1.2. Space syntax

Street system is an important part of urban morphology, French expert Philippe Panerai regards street system, site and building as the three elements of urban texture [3]. Space syntax mainly studies the network connection relationship between different spaces. Its research paradigm is based on graph theory, and space is abstracted into nodes and paths are regarded as axes to form a dot-line graph representing spatial relationships, and quantitative analysis is carried out by topological algorithms [4]. Space syntax can intuitively express the vitality center corresponding to the urban spatial organization and guide the traditional morphological street system research [5].

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1.3. Normalizing integration and choice

Integration and choice are important indicators that reflect the relationship between urban spatial organizations. Integration can reflect the potential of the line segment elements in the urban spatial system to attract arriving traffic, and express the agglomeration of urban spaces. Choice expresses the potential of the line segment elements in the spatial system to be traversed, and it reflects the discreteness of urban spaces. In order to make direct comparison of urban spatial systems of different scales or different periods, Hillier proposed the calculation method of Normalizing Angle Integration (NAIN) and Normalizing Angle Choice (NACH) in 2012 [6]. NAIN and NACH can more accurately reveal the urban spatial organization, and analyze the evolution law in the process of urban formation and development from a macro perspective,

$$\text{NAIN} = \frac{\text{T1024 Node Count}^{1.2}}{\text{T1024 Total Depth} + 2}, \quad (1)$$

$$\text{NACH} = \frac{\log(\text{T1024 Choice} + 1)}{\log(\text{T1024 Total Depth} + 3)}. \quad (2)$$

Figure 1 shows the difference between normalizing choice and total 1024 choice in Zhanjiang.

2. SPATIAL ORGANIZATION ANALYSIS

In the 1980s, Zhanjiang constructed the core of urban original spatial organization and indelible urban character. This research uses normalizing integration and choice to study the development and changes of local urban space syntax in different periods, and analyze the urban evolution and urban connotation.

2.1. Research sample selection and syntactic translation

Affected by the productivity level and economic structure of different historical periods, different urban spatial organizations will be formed. Therefore, the urban development of Zhanjiang in modern times can be divided into 4 stages: from invaded by France in 1899 to the establishment of new China in 1949, from the establishment of the municipal government in 1950 to the reform and opening policy in

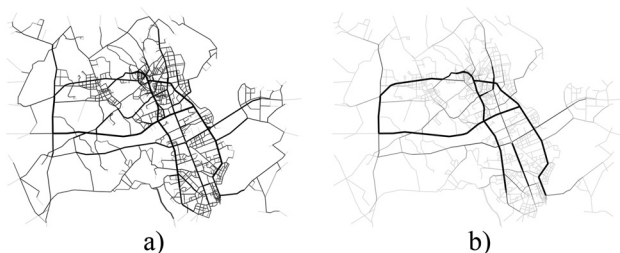


Fig. 1. a) Normalizing choice and b) total 1024 choice
(Source: designed and drawn by Liang Zixin)

1978, from the restoration of government in 1981 to the adjustment of jurisdiction in 2010, and from 2011 to Zhanjiang becoming the sub-central city of Guangdong Province. According to the existing historical maps, the maps of 1899, 1950, 1986 and 2021 are selected as samples, and the maps are transformed into spatial syntax models for quantitative research. In order to avoid the influence of the marginal effect, the research scope should be expanded by 2 km on the basis of the original model as a buffer zone.

2.2. Urban spatial organization in 1899

Analyzing the axis map of 1899 from the DepthMapX software, it can be seen from NAIN and NACH that the high-integrity axis and high-selectivity axis basically coincide (Fig. 2). In 1899, parts of Zhanjiang city were divided into French concessions, and the administrative center was set up in Maxie (C). In 1911, the center moved to Xiying (now Xiashan District, B). This axis connected Chikan (A), Xiying and Maxie, and was the most important transportation hub at that time. In addition, under the influence of the French government's planning policies, urban roads are mainly developed around the eastern bay. Although some roads extend to the west inland, these roads are mainly used as the connection between the village and the city.

2.3. Urban spatial organization in 1950

In 1950 affected by years of war, the streets of Zhanjiang have not developed significantly (Fig. 3). In terms of data,

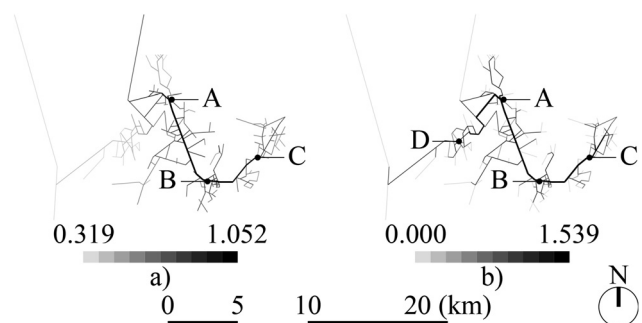


Fig. 2. a) NAIN and b) NACH in 1899
(Source: designed and drawn by Liang Zixin)

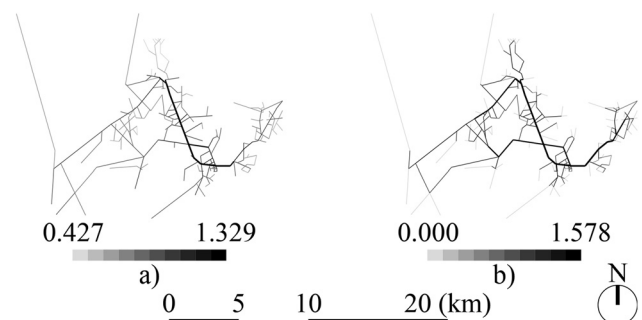


Fig. 3. a) NAIN and b) NACH in 1950
(Source: designed and drawn by Liang Zixin)



total NAIN has increased compared to 1899; in the local integration, the value of the short- and medium-distance range of 500–2,000 m has decreased, while the value of the range of 3,000 m to 10,000 m has increased; the proportion of roads that is better than the average value of NAIN dropped from 49% to 43% (Table 1). Because of the construction of a few long axis with multiple nodes, the depth of many secondary roads is increased. Although the total integration level has increased, the integration level of most roads is declining.

In NACH, the center of gravity of the city’s high-selectivity axis gradually shifts from the east bay to the west inland (Fig. 3). This phenomenon was mainly affected by two aspects: firstly, it was restricted by science and technology at the time, and people lacked attention to the development and utilization of marine resources; secondly, influenced by the international relations at that time, new China adopted conservative development strategies at the beginning of its establishment. Even so, the main transportation axis of the past still plays an important role in the urban spatial organization. In the data, the average value of total choice has increased compared to 1899, and the proportion of roads that are better than the average value of NACH has increased significantly, and roads with high traffic capacity have increased (Table 1). In local choices, the value of roads ranging from 500 to 3,000 m shows a downward trend, while the value of roads ranging from 5,000 m to 10,000 m shows an upward trend. It can be seen that the traffic capacity of pedestrian streets is gradually weakening, while the traffic capacity of car roads is gradually increasing.

2.4. Urban spatial organization in 1986

In 1986, after more than 30 years of development, the foundation for the spatial organization of Zhanjiang has been completed. In 1983, the municipal government moved

to Chikan District (A). In NAIN, it can be seen that the road density in Chikan District has increased significantly, and Xiashan District (B) has also formed a ring road system (Fig. 4). Chikan District and Xiashan District have been constructed as central urban area, and these two areas are connected by three north-south axis. The Shenchuan Avenue in the west has the highest integration, followed by the Haibin Avenue in the east, and the Renmin Avenue in the middle has the lowest integration. Renmin Avenue was the main axis before 80s, but after this time the integration of Renmin Avenue was significantly reduced, and the center of gravity of the integration has shifted. In the data, the total integration has risen, while the local integration has increased except for the 1,000-m scale (Table 1). In addition, the proportion of roads that are better than the average value of NAIN has risen from 43% to 52%, indicating that the number of roads with good accessibility is increasing. The road construction at this stage is mainly to improve short-distance block roads that are convenient for people’s daily activities.

NACH shows the possibility of urban development towards Potou District (E) and Mazhang District (D) (Fig. 4).

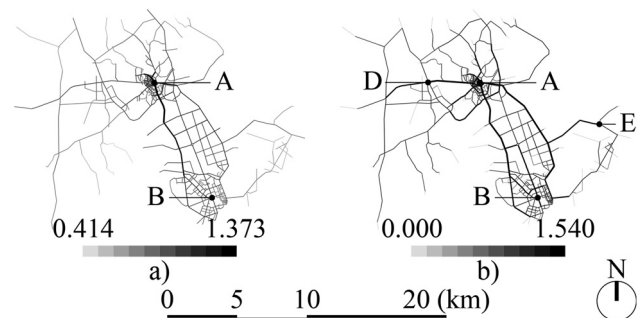
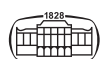


Fig. 4. a) NAIN and b) NACH in 1986 (Source: designed and drawn by Liang Zixin)

Table 1. Spatial organization data of Zhanjiang (Source: by Liang Zixin)

				NAIN	NACH		NAIN	NACH	
Spatial organization data	Total	Average	1899	0.66	0.75	1950	0.83	0.78	
		Sum		329	329		338	338	
		Greater than average		49%	61%		43%	63%	
	Local	R500		1.28	0.17		1.26	0.16	
		R1000		1.4	0.51		1.39	0.48	
		R2000		1.27	0.74		1.26	0.73	
		R3000		1.14	0.8		1.16	0.78	
		R5000		1	0.79		1.05	0.8	
		R10000		0.8	0.77		0.9	0.79	
	Total	Average	1986	0.9	0.94	2021	0.92	0.89	
		Sum		1,111	1,111		2,480	2,480	
		Greater than average		52%	60%		46%	62%	
		Local	R500		1.34	0.54		1.38	0.56
			R1000		1.35	0.76		1.29	0.83
			R2000		1.27	0.91		1.16	0.93
R3000				1.2	0.95		1.09	0.94	
R5000				1.13	0.96		1.02	0.94	
R10000				1.05	0.95		0.95	0.91	



In the data, total choice has risen significantly, and the overall road passing capacity has been improved, but the proportion of roads that are better than the average value of NACH has declined (Table 1). In the local choices, the connectivity of the 500-m-scale road has increased significantly, while the connectivity of the 1,000-m-scale road has an obvious upward trend, and the increase in the other scales is not obvious, which shows that the short-distance road system has been effectively improved. This period was influenced by the reform and opening policy, emphasizing the connection and exchange between China and other countries. In addition, a large number of land reclamation projects changed the original spatial organization of the city, and the development trend of the spatial structure has shifted to coastal areas. On the other hand, a large number of transitional roads have been added between the pedestrian system and the vehicle system, and the correlation between urban streets has gradually increased, but the urban street system has also become more complex. At the same time, the value of intelligibility is 0.32. The intelligibility describes the correlation between the local space and the total space ($R^2 < 0.2$ means low correlation; $0.2 < R^2 < 0.4$ correlation is normal; $0.4 < R^2 < 0.7$ correlation is high; $R^2 > 0.7$ correlation is super high). The higher the intelligibility, it means that people can better understand the structure of the space when they are active in the urban space. It can be seen that the space of this city cannot establish a good connection in people's perception.

2.5. Urban spatial organization in 2021

In 2021, local street network has been improved under the axis framework, and the center of urban spatial structure has not shifted too much. In NAIN, the current development focus is located in the Economic Development District (F) between Chikan District (A) and Xiashan District (B), and as the development of coastal land resources is approaching saturation, the urban has a tendency to expand westward (Fig. 5). In the data, total integration has improved. In the local integration, except for a slight increase in the 500-m scale, the others showed a decline (Table 1). At the same time, the percentage of roads that were better than the average dropped significantly from 52% to 46%. The urban road construction at this stage mainly increased the east-

west multi-node long axis, but the new roads cannot effectively connect the various areas of the city. On the contrary, this situation has increased the accessibility of the original three north-south axis. Therefore, people are more likely to gather on these roads and cause traffic congestion.

NACH can clearly show the influence of the east-west axis and the possibility of developing towards Potou (E) across the bay (Fig. 5). Moreover, with the construction of the Haiwan Bridge, the spatial core of Potou District continues to move northward. In the data, the total choice and connectivity of roads have declined (Table 1). In the local choice, the value at the scale of 500–2,000 m increases, and the value at the scale of 3,000 m to 10,000 m decreases. It can be seen that the functions of the short- and medium-distance road system have been strengthened, and these roads have alleviated the pressure on the long-distance roads.

3. DESIGN METHOD

With the changes in international relations and national development policies, the urban structure of Zhanjiang has undergone many changes. Although the urban space has been further improved in this process, the increase in the depth of urban space has also brought a series of development problems. One is that roads with a high degree of integration and selection overlap too much, which is likely to cause traffic congestion. Second, the level of comprehensibility of urban space is low, and it is impossible to establish effective connections between urban areas. Third, the development of contemporary urban space relies too much on government policies, which is very likely to cause a serious transfer of the city center and destroy the original image and history of the city. This chapter will propose solutions to the future urban planning of Zhanjiang based on these development issues.

3.1. Future urban spatial organization development

Since the old Zhanjiang Airport is located near the urban area, and surrounding buildings are restricted by aviation height restrictions, the speed of the city's westward development is affected. The old airport largely isolated the connection between the western inland area and the eastern coastal area (Fig. 6). In the future development plan of urban spatial organization, as the construction of the new airport in the suburbs is completed; the old airport will be demolished, which will make a lot of space for the city to develop westward. In this case, the local government plans to build a north-south Zhanjiang Avenue in the west to strengthen the city's internal connections. Although the urban area has a tendency to expand westward, the center of urban spatial organization has not shifted westward (Fig. 7). In NAIN, total integration has risen slightly, while the proportion of roads that are better than the average value has risen significantly, and road accessibility has improved. In the local integration, the value of the short- and medium-distance roads at the scale of 500–3,000 m remains unchanged,

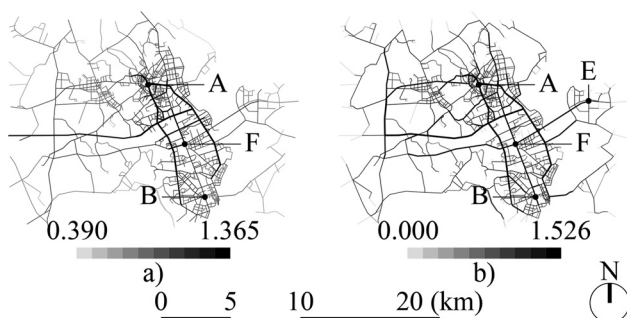


Fig. 5. NAIN and NACH in 2021
(Source: designed and drawn by Liang Zixin)





Fig. 6. Map of Zhanjiang in the Future
(Source: designed and drawn by Liang Zixin)

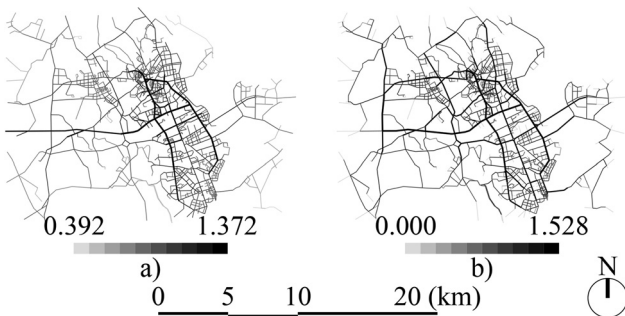


Fig. 7. a) Future NAIN and b) NACH
(Source: designed and drawn by Liang Zixin)

and the long-distance part has a slight increase. In NACH, the total integration and the overall connection of the road are slightly improved. The proportion of roads that are better than the average value of NACH has decreased slightly, but the value is still higher than 50%, indicating that the overall road has good traffic convenience. In the local choice, the value at the scale of 500–5,000 m remains unchanged, while the value of 10,000 m rises slightly. The optimization at this stage improves the accessibility of some roads and relieves traffic pressure in local areas.

3.2. Spatial syntactic analysis of new urban districts

With the large-scale urban construction and old city reconstruction in the west of the city, many large urban masses have been built, which gradually replaced the street spaces with obvious living, historical and cultural atmosphere. In space syntax, if the integration fluctuation range of the original axis exceeds 10% after the intervention of new area, people’s perception of original urban will be destroyed [7]. Comparing the NAIN of the roads in the DepthMapX maps in 1899 and 2021, it can be seen that Renmin Avenue (A) is the core of the original urban space, with an integration of 1.355, and the NAIN value of the city’s external roads was significantly lower than that of the city’s internal roads (Fig. 8). Before the 1980s, the main roads and branch

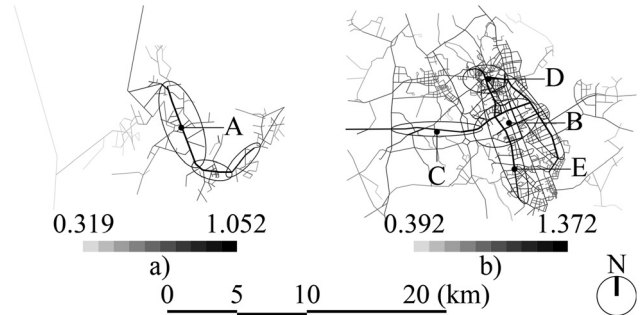


Fig. 8. a) 1899 and b) future NAIN
(Source: designed and drawn by Liang Zixin)

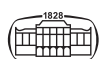
roads in cities were clearly distinguished. Most of the road structures were fishbone-shaped, and there were more dead-end roads, which made the spatial connection less (D, E). However, after the expansion of the traffic structure in the 1980s, the urban spatial form changed from inward to outward. New urban areas are mostly for external traffic and have a strong openness. Although these spaces have become an important platform for the city’s external exchanges, the development also has a huge impact on the sense of cohesion in some areas. Renmin Avenue used to be the urban core of Zhanjiang, but now its integration has dropped to 1.142, a change of 15.7% (B). At this time, people’s original perception of the place has been completely subverted. Next, corresponding improvement measures will be proposed for the spatial organization of the new urban area from a macro perspective based on the above issues.

3.3. Macro development strategy

First of all, in the process of planning and construction of the new district, the development law of the city’s inherent spatial organization should be respected. On this basis, designers’ participation in planning and design should be restrained to ensure that the core of the original urban spatial organization and development inertia will not suffer too much impact, in order to protect the image and history of the city [8].

Secondly, road planning around commercial facilities requires high centrality and convenience, while other urban functional areas, especially life roads, should avoid the same road with high integration and choice. For example, the NAIN of the West City Express Line (C) is 1.288, and the NACH is 1.476. The values of NAIN and NACH are both the highest values in this area (Fig. 8). It can be seen that the road has strong accessibility and connectivity. The urban space around the road is a favorable area for constructing commercial facilities, and the axis should become the core of the future spatial organization of Mazhang District.

Finally, on the basis of establishing the core of regional spatial organization, strengthen the connection between various spaces in the city and improve the intelligibility of the space. In recent years, enclosed residential areas and construction land have emerged as “super-scale” areas, leading to the unconscious extension of the urban axis,



which will be the main reason for weakening the closeness, connection and coordination of urban spatial organization [9]. “Super-scale” areas are prone to form islands in the process of urban development, reducing the overall traffic connection of the city. In addition, the loose road network is not suitable for people’s walking activities in daily life, and it is easy to cause the phenomenon of white nights in the city. Reduce the depth of the space model and improve the quality of the total street network system by improving the end of the road and reducing the dead end.

4. CONCLUSIONS

Based on the theory and method of space syntax, this research conducted a quantitative study on the urban spatial organization of Zhanjiang in four different periods, and obtained the evolution process of urban space. Through research, it is found that the urban structure of Zhanjiang has shifted many times with the changes in international relations and the adjustment of national development policies. It can be seen that the current national policy has a profound impact on the development of Zhanjiang urban spatial organization. Around the 1980s, the core of the urban spatial structure was basically established, which also resulted in a strong spatial development inertia. With the development of coastal areas approaching saturation, cities are gradually developing towards the inland to the west and the opposite side of the bay. For the ensuing urban development problems, corresponding solutions have been proposed from a macro perspective. In general, space syntax not only has a positive influence on the evolution of urban spatial organization, but can also predict the future

development trend of city and provide effective data references for urban planning.

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