The Study on the Evolution of Urban Spatial Structure in Zhuhai City Based on Spatial Syntax

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Abstract: With the deepening of the Guangdong-Hong Kong-Macao Greater Bay Area strategy and the accelerated integration and development of the east and west sides of the Pearl River Estuary, Zhuhai's hub position is becoming more and more prominent. The city of Zhuhai has a dense water network and is divided into two urban areas, the east and the west, under the influence of the Mordor Gate waterway. Based on the theory of spatial syntax, this paper carries out an analytical study on the urban spatial structure of Zhuhai, identifies the distribution characteristics of urban POIs, and provides theoretical support for the urban development of Zhuhai.

Keywords: Spatial syntax; POI data; Transport network; Urban spatial structure

1. Introduction

The regional pattern of Zhuhai has been influenced by the Hong Kong-Zhuhai-Macao Bridge (HZMB), which has transformed it from a transport "terminal" to a transport "hub" on the west bank of the Pearl River Estuary. The bridge connects three places, turning the moat into a road, making Zhuhai the only city on the Mainland connected to Hong Kong and Macao by land.

At present, Zhuhai is seizing major opportunities in the "four zones" of the Guangdong-Hong Kong-Macao Greater Bay Area, the modern International Special Economic Zone, the Hengqin Section of the Guangdong Free Trade Zone, and the Hengqin Guangdong-Macao Deep Cooperation Zone, and promoting the construction of a modern international special economic zone. Therefore, this study will introduce multivariate big data and space syntax analysis technology to analyze the current urban spatial characteristics of Zhuhai and provide an important basis for proposing a reasonable development plan for Zhuhai [1,2].

2. Research background

2.1. Development history of Zhuhai urban pattern

At present, Zhuhai is constantly improving the "twin cities" structure in the east and west, accelerating the adjustment of the urban pattern, strengthening the political, economic, scientific, educational, and cultural functions in the eastern urban area, and strengthening the supporting functions of industrial transportation services in the western urban area, promoting the rapid connectivity of various groups in the city, and accelerating the formation of a new urban look featuring industrial coordination, convenient life, and livable business. To sum up, it is of great practical significance to carry out research on the development of the Zhuhai Twin City structure, dig deep into its mechanism, and predict its specific impact in advance.

2.2. Changes in urban traffic pattern in Zhuhai

From the perspective of urban development, the external corridor represented by the Hong Kong-Zhuhai-Macao Bridge, Huangmaohai Bridge, and the Shenzhen-Zhuhai-Corridor in the bidding process, and the internal main connection line represented by the Zhuhai Bridge, Honghe Bridge, Xianghai Bridge, and Jinhai Bridge will form a comprehensive transportation core network of the Special Economic Zone. In the process of integrated development of the east and west sides of the Pearl River Estuary, Zhuhai will realize more initiatives. It will have a substantial effect on the urban pattern of Zhuhai. Therefore, it is of great significance to study urban spatial networks in combination with urban bridge traffic networks.

3. Research methods

This study will introduce mature "space syntax theory" and GIS multivariate big data analysis method to analyze the evolution process of the urban spatial structure of Zhuhai city through the traffic network [3]. The study of urban form is a classic field of application of space syntax [4,5]. One of the main and essential purposes of space syntax is to understand the natural structure of physical cities, and then explain the structural logic and constructive influence of urban space. The research results of urban form are not limited to the analysis and prediction of urban traffic network characteristics by using space syntax but also involve the correlation of traffic network characteristics with urban density and urban diversity, and the correlation of traffic network with urban life to measure the social representation of urban form [6]. The research will be carried out in an orderly manner from three steps: network model construction, urban traffic axis index calculation, and spatial index analysis [7].

4. Research results

4.1. Structural characteristics of urban traffic network

Influenced by the geographical division of the tributaries of the Pearl River System, the urban space of Zhuhai is divided into two parts, the main urban area in the east and the sub-urban area in the west. The eastern main urban area is not as vast as the western sub-cities in terms of land area and radiation range, but the former is better than the latter in terms of traffic network density and urban positioning. The two urban areas are currently connected by four core cities: Jinhai Bridge, Honghe Bridge, Zhuhai Avenue and Xianghai Bridge. The space syntax software (Depth software) is used to calculate the accessibility index RN of its traffic network, and the traffic road is assigned a color according to its value. The higher the RN value, the closer it is to red [8-10]. Otherwise, the closer it is to yellow (**Figure 1**).
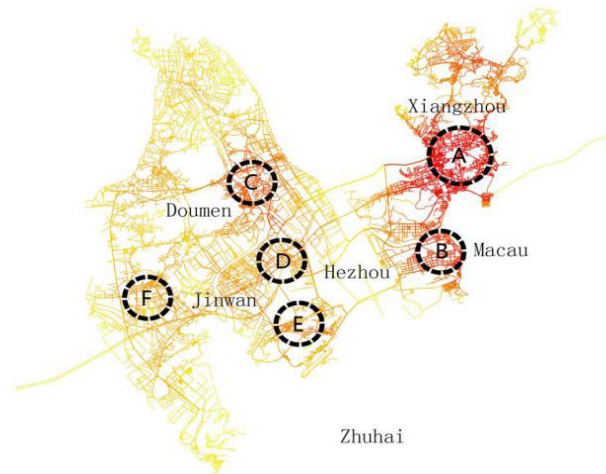
Figure 1. Urban transport accessibility in 2024

According to the urban transportation accessibility analysis chart, the high accessibility area of the eastern main urban area mainly includes two parts: Xiangzhou Old City Area A and Hengqin Port New City Area B. It shows that the convenience of urban traffic in the above two areas is much higher than that in the neighboring urban areas, and the urban traffic flow and people flow easily converge here, and the corresponding urban land value also increases rapidly. However, it is not difficult to find that due to the influence of the coastal line and the administrative boundary of Zhongshan, the radiation range of urban traffic in the two places is severely restricted, and the high-accessibility areas are excessively concentrated, and urban traffic faces great traffic pressure, accompanied by frequent congestion. The core path connecting Yinwan Road and Jialin Mountain Tunnel with Xiangzhou Old City Area A and Hengqin Port New City Area B is blocked by terrain and lacks other traffic to share the traffic flow. Therefore, the development of traffic connections between the two also has great limitations.

The high accessibility traffic in the western urban area can be divided into: Doumen Jingan Baijiao Area C, Jinwan Hongqi Area D, Jinwan Sanzao Area E, and Pingsha New City Area F. The distance of each section is moderate, from south to north, and east to west in sequence. Each section is closely connected by two city-level expressways, Zhuhai Avenue and Huxin Road. Compared with the high integration degree of the eastern main urban area, the traffic accessibility and traffic density of each area in the western urban area are reduced, but the regional radiation range is wider, and there is plenty of reserved space for development. Meanwhile, the traffic links of each area effectively promote the coordinated development of neighboring areas. In addition, the completion of Xianghai Bridge, Honghe Bridge, and Jinhai Bridge in recent years will successively strengthen the traffic links between Doumen Jingan Baijiao Area C, Jinwan Hongqi Area D and Jinwan Sanzao Area E and the eastern main city, bringing more urban vitality and urban function support for the development of Zhuhai Twin cities.

4.2. Analysis of urban POI distribution

In this study, spatial network analysis technology is used to conduct a correlation analysis of urban POI migration changes. The POI data of Zhuhai City in 2023 were visualized, and the specific data included 110,460 points of interest in urban commerce, industry, residence, urban public construction, etc. It is not difficult to find that the POI density of Xiangzhou Old City Area A is much higher than that of other areas, and the urban vitality is the best. The second is Doumen Jing'an Baijiao Area C. The POI density of Hengqin Estuary New

Town Area B does not match the current situation of high accessibility and dense traffic, which reflects that its actual development status and urban vitality are not ideal. Currently, due to the limitation of the urban land administrative boundary, the POI in the eastern part of Zhuhai will gradually move to the western part of the city, and inject urban vitality into the four core areas in the west. Simultaneously, in the process of absorbing urban POI, the west of Zhuhai also promotes the development of the whole city.

5. Conclusion

Based on the theory of space syntax, this paper analyzes and studies the urban spatial structure and traffic network of Zhuhai city and identifies the distribution characteristics of urban POI. It is found that there is a high correlation between urban transportation networks and urban vitality. The vitality of eastern cities is greatly limited and gradually migrates to the west.

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Disclosure statement

The authors declare no conflict of interest.

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