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Research on Spatial Distribution Characteristics of Zhanjiang Industrial Structure Based on POI Data Clustering

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Abstract: Taking 5 counties and 4 districts of Zhanjiang city as the study area, there are 119,900 POI industry classification data introduced to analyze the urban spatial structure and industry spatial structure of Zhanjiang city by standard deviational ellipse, kernel density estimation, DBSCAN and other methods. The analysis results show that the urban elements in Zhanjiang are in a significant clustering form, and the degree of urban elements clustering is equal to the level of urban economic development. The internal structure of Zhanjiang city takes Chikan District and Xiashan District as the center and radiates from inside to outside, with Lianjiang, Suixi and Xuwen as the main node cities. In addition, The primary industry, secondary industry and tertiary industry show the distribution characteristics of "large clustering-small dispersion", with the central region as the main area, forming point and flake industrial clustering areas, and the centripetal force of the secondary and tertiary industries is stronger. The secondary industry is well developed in the central region, while the other main node cities are not well developed, but they still have potential and can be further optimized and upgraded. It can be proved that the spatial distribution characteristics of a city's industrial structure can be mastered through POI data clustering, so as to provide scientific reference and suggestions for urban construction.

Keywords: POI data; clustering algorithm; industry distribution; urban spatial structure

1. Introduction

The spatial layout of industrial structure is of great significance to the development of a city, and reasonable spatial layout is conducive to promote the integration and development of various urban industrial chains, so as to strengthen the overall competitiveness of a city. Therefore, the spatial layout characteristics of urban industrial structure have also become a hot issue, and many scholars have conducted researches on it. For example, Zhang Jie et al. analyzed the spatial evolution dynamics of financial services at different time nodes in Beijing by combining POI big data technology, spatial autocorrelation test model and point density method, providing help for the next development of financial services in Beijing (Zhang & Sun, 2021). Wang Wenxin et al. took the Yangtze River Economic Belt Development Zone as the research object and analyzed its industrial spatial structure change by means of statistical analysis and geospatial analysis (Wang et al., 2021). Liu Yixuan et al. took Lanzhou city as the research object, adopted In fo map community detection algorithm to identify the road network, calculated the location entropy and mixing degree of POI, and divided the community level. On this basis, they studied and analyzed the urban spatial structure and industrial layout of Lanzhou city (Liu et al., 2022). The above researches mostly use POI clustering algorithm to mine and analyze the spatial structure and layout information of different cities. The change of industrial structure affects the upgrading of urban internal structure, which is very important for the development of a city (Hu et al., 2021). On this basis, there are 5 counties and 4 districts of Zhanjiang City selected as the main research area, and POI big data clustering algorithm is utilized to divide the industries in Zhanjiang city. Meanwhile, the average nearest neighbor distance method, kernel density estimation and other methods are used to study the spatial layout characteristics of industrial structure of Zhanjiang city, which provides scientific basis and reference for the optimization and upgrading of urban spatial structure of Zhanjiang city.

2.Data source

Zhanjiang city is located in the southwest of Guangdong Province, China, and it belongs to the prefecture-level city in Guangdong Province. Moreover, Zhanjiang city is mainly composed of Xiashan District, Chikan District, Machang District and Potou District, and Xuwen County, Wuchuan County, Leizhou County, Suixi County and Lianjiang County, which are also the main research areas in this study. Here, POI data mining technology is adopted, and AmAP is utilized to collect the data in July 2022. Then, the collected data are preprocessed. Finally, 119,900 pieces of full-type POI data from

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Zhanjiang city are obtained (Zhang et al., 2021). According to the National Economic Industry Classification and Code (GB/T 4754-2017) (Deng, 2021) and the actual situation of Zhanjiang City, this study reorganized the POI data into 13 types of data. Agriculture, forestry, animal husbandry and fisheries are divided into primary industries; Construction industry, wholesale and retail trade, catering and accommodation industry, finance industry and real estate industry are divided into the secondary industry; Science, education and cultural services, health, transportation and other industries will be divided into the tertiary industry. The specific content of the POI industry division system in Zhanjiang city is shown in Table 1

Table 1. Table Type Styles

Industry type	Serial number	Industry classification	POI data type
Primary industry	11	Agriculture, forestry, animal husbandry, and fishery	Agriculture, forestry, animal husbandry and fishing base
Secondary industry	21	Mining, manufacturing, and construction industry	Factory, company, advertising and decoration
	31	Wholesale and retail	Shopping services, car, motorcycle sales
	32	Catering and accommodation industry	Catering service, accommodation services
	34	Finance industry	Financial insurance services
	35	real estate industry	Commercial residence
Tertiary industry	36	Science, education and cultural services	Science, education and culture services
	37	Health industry	Healthcare services
	38	Sports and entertainment	Sports and leisure services
	39	Transportation industry	Transportation facilities services
	310	Residential services, repair industry	Life Services, car, motorcycle repair, car service
	311	Public administration, social security, and social organizations	Government agencies and social organizations

3. Research methods

3.1 Mean Nearest Neighbor Distance

In this study, the mean nearest neighbor indicator (NNI) can represent the degree of convergence and dispersion of urban elements, so NNI is used to identify the geographical elements with dot distribution. When NNI is less than 1, the point pattern presents a clustering state, and when NNI is greater than 1, the point pattern presents a discrete state. The smaller the NNI value is, the higher the clustering degree is; Otherwise, the higher the dispersion degree is (Tan et al., 2021).

3.2 Kernel Density Estimation

The first law of geography represents that everything is related to other things, and that neighboring things are more closely related to each other. On this basis, kernel density analysis method estimates the distribution of spatial point elements by regular moving samples, and the results can not only reflect the relative clustering degree of POI data points in spatial distribution, but also can distinguish the functional elements of the clustering area, thereby helping to divide urban functions and facilitate the analysis of the spatial structure of urban functions (Lu, 2022).

In order to analyze the spatial layout, regional characteristics and spatial distribution of urban industries in Zhanjiang city, the POI data in the region are estimated with high quality density, and the influence of raster size and location is eliminated. The calculation equation of kernel density is:

$$f(s)=\frac{1}{nr^2}\sum_{i=2}^{1}k\left(\frac{di}{r}\right) \quad (1)$$

Where, k is the selected kernel function, and the kernel function selected in this study is the Gaussian function; r indicates the analysis bandwidth of kernel density, which is 500m.

3.3 Standard Deviational Ellipse

Standard deviation ellipse, a commonly used method in spatial analysis problems, was first proposed by Lefever in 1926. At the beginning, it was used to study the mean center, median center and mode center, and centrality and aggregation can best reflect the spatial structure characteristics of industrial efficiency. Therefore, standard deviation ellipse can be used to summarize the spatial characteristics of geographic elements, namely, central trend, dispersion and direction trend (Chen & Chen, 2022). Based on the standard deviation ellipse method, this paper analyzes the dispersion degree and orientation characteristics of each industrial network in Zhanjiang City,

makes an in-depth exploration of the clustering pattern and spatial structure of different industrial elements, and finally grasps the contribution of the existing industrial spatial layout to the internal spatial structure of Zhanjiang City.

3.4 DBSCAN Clustering Algorithm

DBSCAN clustering algorithm is used to analyze the clustering and structural characteristics of industries in POI data. DBSCAN algorithm is one of the commonly used algorithms in clustering problems, which has advantages in processing spatial data problems. It usually divides the area with high point density into a cluster, and the clustering will continue when the density of the adjacent area exceeds the set threshold. Therefore, the DBSCAN clustering algorithm is selected to calculate the industrial structure and clustering features in the POI data. The DBSCAN clustering algorithm commonly uses *Eps* neighborhood and *Min-points* to describe the clustering degree, and *Eps* neighborhood represents the radius area of a point. *Min-points* indicates the minimum number of points used to form a cluster (Min & Ding, 2020).

In the case of no fixed cluster number, DBSCAN algorithm can still find clusters of arbitrary shape in the noisy spatial database, distinguish various types of samples, and get three types of data points, boundary point, core point and noise point (“Research Group of Shandong Institute of Industry and Information Technology. Study on the Characteristics of Industrial Distribution and Development Countermeasures in Shandong Province -- Based on the Fourth Economic Census,” 2021). Assuming Min-points=3, the obtained classification of the three data points is shown in Fig. 1:

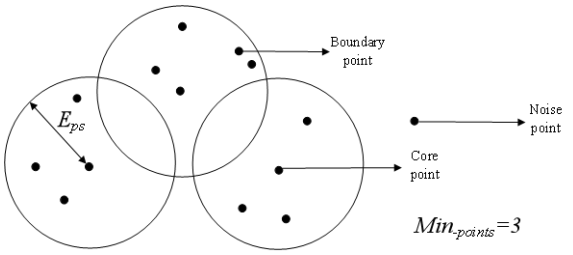


Fig. 1. *DBSCAN algorithm point classification diagram*

According to DBSCAN algorithm, q represents the sample points. When the number of samples in the neighborhood of q is greater than or equal to the number of *Min-points*, q can be called the core point. When the number of samples in the neighborhood of q is less than the number of *Min-points*, q is the boundary point. The other points are noise points. The calculation steps of DBSCAN are as follows:

(1) Select the parameter values of *Eps* neighborhood and *Min-points*;

(2) Select any unprocessed point in the data set and denote it as p;

(3) When p is the core point, the points whose density can be reached are divided into a cluster, and the points whose density cannot be reached are denoted as noise points;

(4) Repeat the above steps until all data points have their own clusters or noise points, then the calculation process will be terminated.

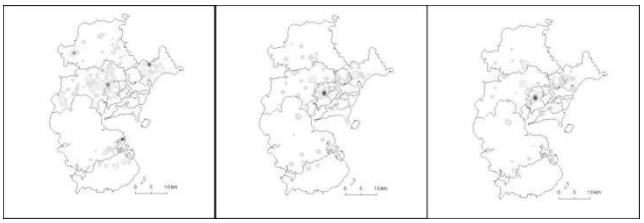
4. Research results and analysis

4.1 Urban Element Clustering results of NNI

The inner spatial structure of Zhanjiang city can be judged by the degree of clustering and dispersion of urban elements. According to the study, the NNI range of 5 counties and 4 districts in Zhanjiang city is 0.167~0.235, and 99% significance test proves that all urban elements in Zhanjiang city show significantly clustered spatial distribution characteristics. When the confidence level is 0.01, the correlation between urban NNI and socioeconomic GDP is strong, which proves that the clustering degree of urban elements is equal to the development level of urban economic.

4.2 Urban Spatial Structure of Kernel Density Estimation

The kernel densities of the primary, secondary and tertiary industries in Zhanjiang are shown in a, b and c in Fig. 2, respectively.



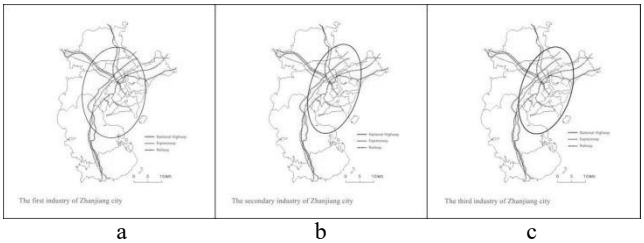
a b c

Fig. 2. *Kernel density distribution of the three industries*

As can be seen from Fig. 2, Chikan District and Xiashan District under its jurisdiction of Zhanjiang City are taken as the center area and radiate from inside to outside, forming an urban spatial structure with Wuchuan as the sub-center and Lianjiang, Suixi and Xuwen as the main nodes.

4.3 Industrial Spatial Distribution of Standard Deviational Ellipse

Figures a, b and c in Fig. 3 show the spatial distribution of primary industry, secondary industry and tertiary industry respectively:



a b c

Fig. 3. *Spatial distribution of the three industries*

As can be seen from Fig. 3, the center point of the the standard deviational ellipse of the three industries in Zhanjiang city almost coincide. The long axis direction of the ellipse is consistent with the direction of

"Xuwen-Chikan" according to the terrain of Leizhou Peninsula. The distribution characteristics of the three industries are all "large clustering-small dispersion". Taking Chikan and Xiashan as the central areas, the point and flake industry cluster areas are formed. By comparing the three industries, it can be seen that the elements of the secondary industry and the tertiary industry tend to be spatiotemporal normal distribution and are more concentrated in the central region. The length difference between the major axis and the minor axis of the industrial standard deviational ellipse is more significant, indicating that the centripetal force of the secondary and tertiary industries is stronger.

4.4 Industrial Spatial Structure Characteristics of DBSCAN Clustering

In order to analyze the spatial characteristics of industries in Zhanjiang city, five industries, including manufacturing industry, wholesale and retail industry, catering and lodging industry, finance industry, and real estate industry, are mainly included in the secondary industry, and the analysis is carried out according to the clustering result chart. At the same time, the parameters of DBSCAN algorithm were set, namely EPS neighborhood =0.20, Min-points =7, and k =5.

Through clustering, the spatial structure characteristics of secondary industry in Zhanjiang city are shown in Fig. 4.

Fig. 4. *Clustering results of five types of industries in the secondary industry*

As can be seen from Fig. 4, the five types of industries are most concentrated in Chikan and Xiashan regions. According to the analysis of the secondary industry, the wholesale and retail industry has the strongest contribution to the overall spatial structure of the city, and its POI points account for the largest proportion among the five industries, with the strongest continuation. This is followed by catering and lodging, sports and entertainment, real estate and finance. Among them, the financial industry and the real estate industry have potential, which have not been explored yet, and can be supported more in the subsequent optimization. The density of sports and entertainment, catering and lodging industry in Lianjiang-Xuwen area is low. It is suggested to optimize the structure and accelerate the overall development.

4.5 Analysis of Urban Spatial Structure and Industrial Layout

The common classification of urban spatial structure includes concentrated cluster type, dispersed combination type, radial type, linear type and so on. The concentrated cluster type mainly includes the circular radial or grid urban road system. The city scale will expand along in different directions, forming the cluster layout pattern, and the distribution characteristics are relatively compact. The dispersed combination types contain 3 or more urban centers of the same size, which are distributed in different regions; Radial structure city is mainly distributed along the railway line and developed according to the traditional railway attachment. Linear structure cities are mainly distributed along the river bank, including multi-center linear structure distribution.

Combined with the analysis of the kernel density of the industries in Zhanjiang City in Fig. 2, the primary industry is mainly distributed in Lianjiang City, Wuchuan City, Chikan District, Xiashan District, Suxi County, and is also partially distributed in the border of Leizhou City and Xuwen County, which is concentrated cluster structure. The secondary industry is centered in Xiashan District and radiates to Chikan District and Wushan City, showing a radial structure. The tertiary industry is distributed in Xiashan District, which is the distribution center. Chikan District, Lianjiang City and Wuchuan City are radially distributed to form the sub-centers of the scattered point-like region. Leizhou City and Xuwen County have a large area, but the proportion of tertiary industry distribution is very small, which proves that the tertiary industry distribution in Zhanjiang City is unbalanced and needs to be adjusted actively, and should be distributed evenly to other districts and counties.

In general, the three industries in Zhanjiang city take Xiashan District and Chikan District as the center and radiate from inside to outside, forming an urban spatial structure with Wuchuan as sub-center and Lianjiang, Suixi and Xuwen as the main nodes. The overall type of urban industrial distribution is dominated by radial structure, and the urban industrial layout needs to be optimized. The three industries are mainly developed in Xiashan District and Chikan District. The distribution of industries is relatively dense, and the surrounding radiation areas are also influenced to some extent. On the one hand, although Mazhang District and Potou District are close to Xiashan District and Chikan District, the distribution ratio of the three industries is very small. Therefore, it is necessary to make good use of geographical advantages, reasonably plan the spatial layout, carry out benign association with the central region, adapt measures to local conditions, and strengthen the construction of characteristic industries. On the other hand, Leizhou City and Xuwen County have a large area, but the three industries are scattered and the space utilization rate is low. Therefore, it is necessary to explore the internal advantages, develop multiple sub-central areas and radiate to the surrounding areas, so as to optimize the layout.

5. Conclusion

In conclusion, the following conclusions can be drawn through the analysis of the POI data in Zhanjiang city:

(1) The urban elements of Zhanjiang city show a significantly clustered spatial structure distribution pattern, and the clustering degree of urban elements is equal to the development level of urban economic;

(2) As for the urban spatial structure of Zhanjiang city, Chikan District and Xiashan District are the centers, and it radiates from inside to outside. With Wuchuan as the secondary center, there are Lianjiang, Xuwen and other main node cities;

(3) By comparing the three industries, the centripetal force of the second and third industries is stronger, and the distribution characteristics of the three industries are "large clustering-small dispersion";

(4) The clustering results of the five types of industries of the secondary industry show that the central regions of Chikan and Xiashan have a high intensity of all industries, but in the other main node cities, except wholesale and retail, the intensity of other industries is scattered.

Therefore, in the work of urban optimization, it is necessary to explore the characteristics of different regions, increase the industry support in other cities, adjust measures to local conditions, establish sub-centers of different industries in each district and county region, so as to drive the development of surrounding regions, achieve balanced development, and comprehensively improve the upgrading effect of urban construction.

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Conflict of Interest

The authors declare that they have no conflicts of interest to this work.

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