Research on industry-spatial relationship of existing industrial zones in Beijiao, Shunde based on comparison of data Point of Interest

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ABSTRACT

Spatial distribution characteristics of existing industrial zones in cities are important to research on their functional upgrading, optimization and transformation. So is the correlation with surrounding functional facilities which providing business supporting and life safeguard. The methods of Kernel Density Estimation, Standard Deviation Ellipse and Spatial Autocorrelation were used in this study, based on comparison of data Point of Interest (POI) of existing industrial zones in Beijiao. The study discussed the changing of characteristics and influence factors of industrial enterprises and surrounding facilities. It made a comparative analysis of the space correlation among the enterprises and facilities, and determined configuration status of facilities. And it provided the optimization strategy which should follow principles of utilization and proper demolition, and a regional centre should be planned. The building density in the area should adjusted in order to restore the ecological environment. A low-carbon and energy-saving urban form could to be constructed by optimizing the facility allocation. Tracking industrial-spatial dynamics by establishing a transformation database.

INTRODUCTION

Township enterprises in Shunde have experienced four important stages: rapid development, enterprise restructuring, low-speed development and industrial transformation since its emergence in 1980s. In recent 10 years, industrial zones in Shunde kept making progress in industrial transformation and "Three old" transformation with the process of new urbanization. But there are still some new problems. How to promote their function improvement, optimization and transformation of the existing industrial zone, which meets current and future demand, is one of the problems to be solved.

Existing domestic studies on Shunde industrial zones focused on the following aspects: First, on the level of economy and industry, the relationship between industrial structure and optimize the economic and spatial strategies of industrial structure were discussed; Second, on the level of land use, the changing characteristics and driving factors of land use, exploring policies and evaluating land spatial performance were studied; Third, on the level of renewal and transformation, the potential evaluation system, transformation planning, policies and strategies were focused on. Fourth, on the level of urban and spatial form, the mechanism of industrial development affecting spatial form of small towns and spatial mode of "industrial development protection zone" was discussed. From the research above, it can be seen that "enterprise rise - urban evolution – "Three old" transformation - industrial protection" is the main venation of development, and "economic model - land use - transformation strategy - spatial optimization" are typical problems. Therefore, the function upgrading, optimization and transformation of existing industrial zones in Shunde is a comprehensive problem about urban development, so it is very necessary to analyse its current spatial layout and characteristics.

With the development of network technology, studies on spatial layout and characteristics of towns using points of interest are increasing rapidly. Some studies focused on the characteristics of urban functional zoning and spatial structure. Some of them studied on living areas, which focus on the spatial distribution of built environments such as living facilities, cultural facilities and leisure functional areas. And some explored the spatial correlation between housing and retail industry by analysing the characteristics of business centres, clusters, and trade mix in business area. To sum up, based on the essential characteristics of POI data, it can be effectively applied to studies of urban spatial structure, which are helpful to explore optimization strategies of urban existing functional areas.

Beijiao is an industrial center of Shunde. By comparing the existing industrial development status and POI data of existing industrial zones in Beijiao, Shunde, this study will analyse the spatial relations between industrial enterprises and related functional facilities according to spatial analysis methods. It will identify the status and problems of industrial zones in Shunde, and put forward optimized transformation strategies.

RESEARCH SCOPE AND DATA

Overview of research scope

Beijiao town total area is about 1300 hectares, where produces household appliances, metal and machinery manufacturing as its pillar industries, is a typical industrial town in Shunde. The study area is located in the south of Beijiao town. Tanzhou watercourse is adjacent to the east of it, and Shunde watercourse is on its south. The east high-speed of the first beltway in Foshan is on its west, and Lintou area and the central district of Beijiao are on its north (Figure 1). The conception "industrial development protection zone" which was proposed by Shunde government in 2017 designated Beijiao as the core area of industrial development protection. It took development as guidance to protect and control the industrial land, providing space reserve for future industrial development. The distribution of industrial enterprises and functional facilities in this area involves the complex function of built environment, which directly affects the construction and development of industrial development protection zone.

Figure 1. Map of research scope (self-drawn)

Data selection and screening

POI data of Beijiao from Baidu Map in December of 2018 and November of 2020 was selected for researching. In order to avoid omissions in data acquisition, the acquisition range was expanded, taking the red line of soil utilization planning as reference. Because the study area is not an identifiable administrative area in Baidu Map, and its boundary is not regular. So the north, south and east sides were bounded by watercourses, and the west side was bounded by east high-speed of the first beltway in Foshan. In addition, the data were screened according to analysis requirements by referring to "Research on classification standards of POI", because of some differences in classification between POI from Baidu Map and research needs. 3302 pieces of effective data were extracted through repetition eliminating, screening, reclassification, deviation correction, spatial matching, sampling review and field from the preliminary 14960 pieces of data (Table 1).

Table 1. POI data classification and quantity

Main class	Subclass	Quantity	
		2018	2020
Industrial enterprise	Production and processing	738	729
Business supporting organization	Finance and commerce	71	71
	Human Resources service	32	28
	Logistics service	49	50
Living security facility	Catering service	359	351
	Retail service	230	233
	Life service	57	63
	Public transportation	58	58
	Accommodation service	28	30
	Housing security	34	34

RESEARCH METHODS

(1) Kernel Density Estimation

Kernel Density Estimation is used to measure the aggregation intensity of elements within a certain range, which is applicable to density estimation of urban facility service impact. It takes a certain element point as a centre, uses kernel function to calculate density value of unit area, and generates density map from superposition of density value, showing distribution of 3D density surface. The closer location is to the centre, the greater obtained density expansion value is. In comparative analysis, the position change of kernel density center will be focused on.

(2) Standard Deviation Ellipse

Standard deviation Ellipse method is used to measure the position and distribution direction of point data in a certain spatial range. This method uses mean centre as the starting point to calculate standard deviation of X-axis and Y-axis coordinates, so as to define the long axis and short axis of the ellipse. The deviation between long and short axes indicates the directivity and discreteness of the analysed object.

(3) Spatial Autocorrelation

Spatial Autocorrelation is used to study the relationship between a certain element and its surrounding elements within a certain space. It calculates autocorrelation degree with statistical methods and describes its spatial distribution characteristics, such as randomness, aggregation or dispersion, including judging whether such relationship has an important impact on the pattern. Global Moran's index (Moran's I) representing spatial autocorrelation was used for analysis in this paper.

ANALYSIS OF RESULTS

Spatial aggregation characteristics

Comparing the POI distribution map between 2018 and 2020, it could be seen that large numbers of industrial enterprises form as several groups. The distribution state of living security was similar to industrial enterprise. The boundaries between them were relatively clear, but mixed in some areas. The distribution state of business supporting institutions was dispersive and homogeneous, and their distribution areas were close to industrial enterprise (Figure 2).

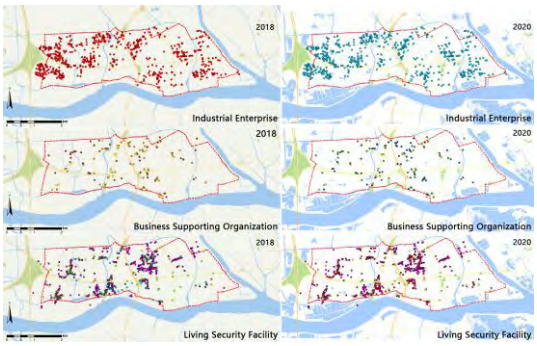

Figure 2. Different coloured dots represent the distribution status of enterprises and functional facilities (self-drawn)

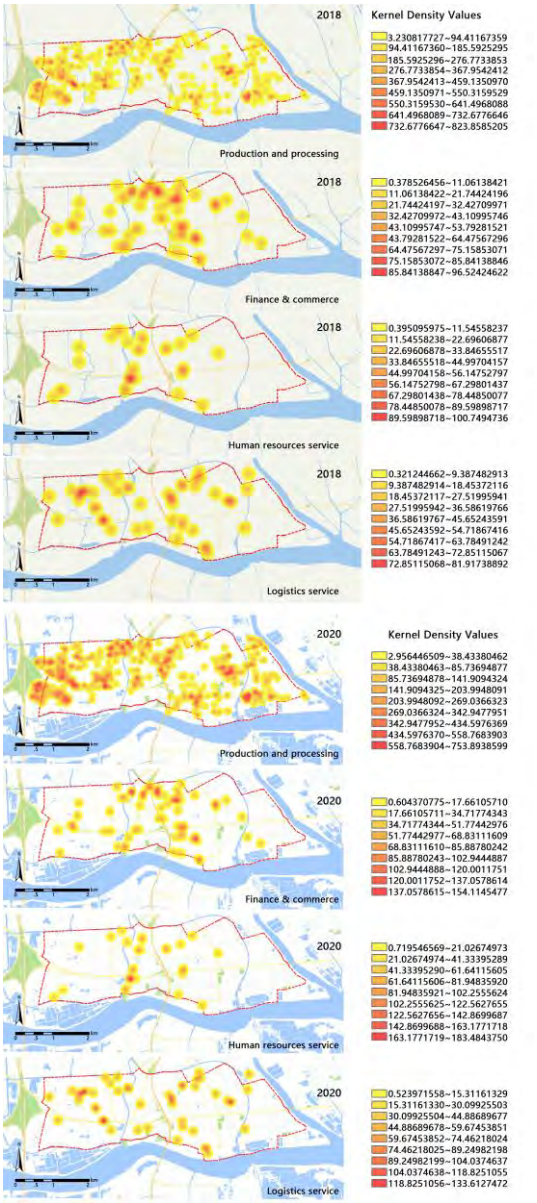

Figure 3. The regions with high kernel density value reflect the aggregation state of industrial enterprises and business supporting organizations (self-drawn)

According to the kernel density map, high-density areas of industrial enterprise were located in four village industrial zones in the west, namely Chachong, Huangchong, San Hongqi and Chen Dajiao, as well as Guangjiao industrial zone in the north, Lingang pioneering park and Shunjiang community industrial zone in the east (Figure 3). The main characteristics of existing industrial zones in the study area, Beijiao, Shunde was distributed group space dominated by industrial enterprises. The concentration density of industrial enterprise and life service was higher in the west. But the environmental quality was not good in areas with high-density of enterprises. The density of catering service and retail service was higher in the east, where business atmosphere was good, in which the density of life service was low, and convenience of life was insufficient. Housing security facilities were mainly concentrated in the south, reflecting the influence of waterfront ecology on living conditions. Human resources service and accommodation service facilities were distributed along main roads, and logistics service and public transportation facilities were equally distributed. Therefore, group space should be inherited as the basic characteristics of existing industrial zones, but the scattered layout was not conducive to the formation and promotion of industrial agglomeration effect. The present situation of high building density and poor environmental quality in the groups interfered with the living environment around them and the improvement of ecological environment in industrial zones. (Figure 4).

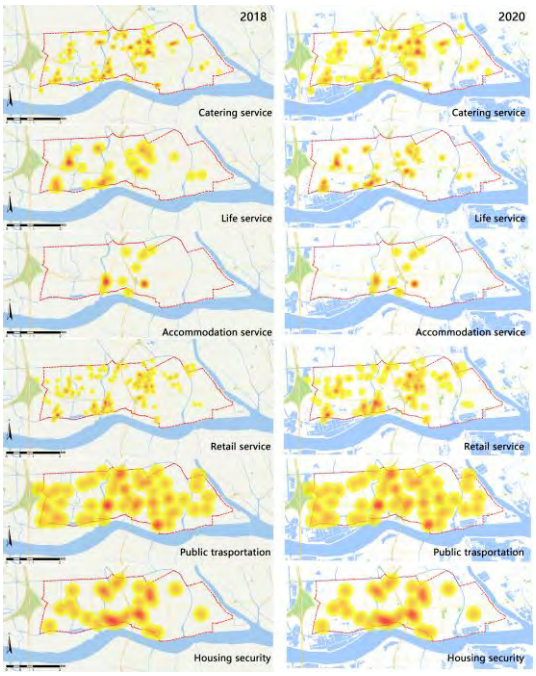

Figure 4. The regions with high kernel density value reflect the aggregation state of living security facilities (self-drawn)

Spatial directional characteristics

According to calculation results (Table 2), the distribution direction of industrial enterprises was close to the east-west direction, which was consistent with the direction of Sanle road and Shunde watercourse. It connected with the Midea industrial park on the west and Taocun industrial park on the

east. By comparing deviation values，it could be seen that the distribution directionality of logistics service, catering service, retail service, life service and public transportation was stronger than that of the others (Figure 5). Among them, public transportation was a result of urban planning and construction, while the other four categories had obvious self-growth characteristics. The distribution directionality of finance & commerce, human resources service, accommodation service and housing security was weaker. Expect housing security affected by urban planning, the other three categories also had self-growth characteristics, and affected by north-south traffic.

Table 2. Standard Deviation Ellipse calculation results

Categories	Deviation		Direction angle	
	2018	2020	2018	2020
Production and processing	2181.36	2180.52	90.12 °	90.04 °
Finance and commerce	837.17	837.12	91.32°	91.32 °
Human resources service	745.99	745.47	83.61 °	82.79 °
Logistics service	1360.50	1360.21	92.84 °	92.53 °
Catering service	124.59	1247.59	79.27 °	80.04 °
Retail service	1356.05	1356.05	78.38 °	78.38 °
Life service	1348.75	1352.41	81.31 °	82.14 °
Public transportation	1605.67	1605.67	88.07 °	88.07 °
Accommodation service	434.60	399.38	66.54 °	63.23 °
Housing security	962.98	962.98	87.59°	87.59 °

According direction angle, it could be seen that the distribution of functional facilities had obvious self-growth characteristics, and most of which have similar distribution directions to enterprises. This was because the relevant functional facilities were gradually attached to enterprises and formed naturally according to requirements of enterprises operation, production and life from the bottom up, in the development process of existing industrial zones. The directional difference reflected that distribution of functional facilities within the area was not only influenced by requirements of enterprises, but also influenced by different factors outside the area. It was reflected most obviously by finance & commerce and logistics service. This feature reflected not only the spatial evolution and basic rules of industrialization in this area, but also the close correlation between current facility distribution and environment outside the area. It could be seen that the dependence of functional facilities on enterprises needed to be maintained in the process of industrial transformation. But the influence and demand of environment outside area on the distribution of functional facilities in the area should be taken into account. (Figure 6)

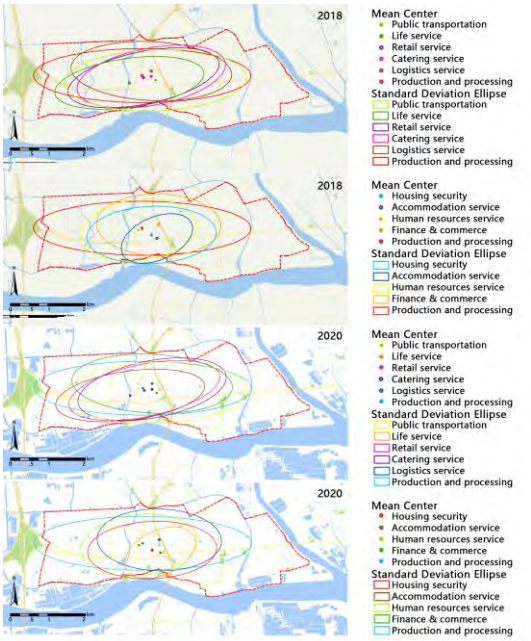

Figure 5. The flatter the ellipse appears, the stronger the distribution directivity of facilities shows (self-drawn)

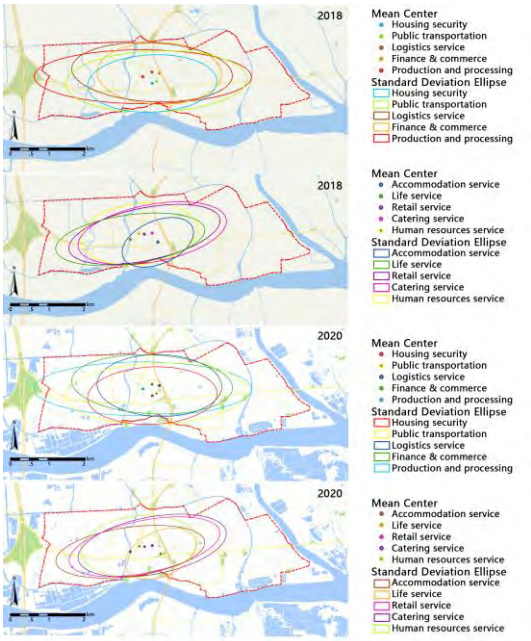

Figure 6. The position of mean centres and direction angle of ellipses reflect that the distribution of facilities is affected by factors from different directions (self-drawn)

Spatial correlation and configuration status of facilities

Based on POI coordinates in two different years, the nearest distance of various functional facilities and industrial enterprises was taken as the spatial weight to carry out autocorrelation analysis, and the calculation results of correlation coefficient were obtained (Table 3). Combined with critical value,

representing multiple of standard deviation, and random probability, z-scores of human resources service, logistics service and life service were less than 1.65, and p-values of which were greater than 0.1. The results showed significant randomness, indicating that the spatial correlation between these three categories and industrial enterprise was not obvious. Z-scores of accommodation service and finance & commerce were greater than 1.65, and p-values of which were less than 0.1. The results showed aggregation and credibility, indicating that these two categories had spatial correlation with industrial enterprise. Z-scores of catering service, retail service, public transportation and housing security were greater than 2.58, and p-values of which were less than 0.01. The results showed significant aggregation and high reliability, indicating that these four categories had significant spatial correlation with enterprises.

Based on the analysis results, it could be found that human resources service and logistics service had weak spatial correlation and insufficient service convenience with enterprises in terms of facility allocation. And the spatial distribution of efficient development with industrial transformation as core was not reflected. In addition, the spatial relationships between finance & commerce, housing security, public transportation and industrial enterprise were mainly affected by urban planning. The self-growth characteristics of service facilities, such as catering, retail and accommodation, formed close relationship with enterprises, which also become one of the reasons for the mixed distribution of facilities and enterprises near the village industrial zones. The results above indicated that there were differences between the actual distribution state of functional facilities and their importance in industrial chain, which led to the fact that their spatial distribution state could not reflect the clear development intention, and the orientation of industry-spatial relationship was not clear. In addition, factors affecting the relationship were diverse and complex. The more comprehensive the information could be obtained, the more conducive it was to optimizing facility allocation and providing guarantee for industrial development needs.

Table 3. Spatial Autocorrelation calculation results

2018			
Related objects	Moran's I	Z-score	P-value
Finance & commerce	0.7525	2.216	0.027
Human resources service	0.6672	1.548	0.122
Logistics service	0.4194	1.575	0.115
Catering service	0.6421	9.994	0.000
Retail service	0.4819	4.903	0.000001
Life service	0.4424	1.441	0.150
Public transportation	0.4822	3.834	0.000126
Accommodation service	0.4123	1.903	0.057
Housing security	0.5688	4.094	0.000042
2020			
Related objects	Moran's I	Z-score	P-value
Finance & commerce	0.7338	2.157	0.044
Human resources service	0.6052	1.322	0.109
Logistics service	0.5012	1.655	0.115
Catering service	0.4934	9.084	0.000
Retail service	0.4819	5.412	0.000001
Life service	0.3901	1.503	0.178
Public transportation	0.4201	3.929	0.00013
Accommodation service	0.4022	2.095	0.063
Housing security	0.5688	3.876	0.000015

CONCLUSIONS AND OPTIMIZATION STRATEGIES

In conclusion, according to POI data of industrial zones in two different times, the spatial relationship and characteristics of industrial enterprises and functional facilities had been analysed as follow: Firstly, the existing industrial zones are characterized by distributed group space; Secondly, the distribution of functional facilities is impact by self-growth and environment outside area; Thirdly, the orientation of industry-spatial relationship needs to be clear.

Therefore, the optimization strategies could be put forward based on the analysis above.

(1) Following principles of utilization and proper demolition and planning to build a regional centre.

In order to inherit and retain the group spatial structure with the core of existing industrial zones, the principle of "More utilization and proper demolition" should be followed for the utilization and upgrading of existing industrial zones. Meanwhile, a regional centre should to be planned to transform the dispersed and uniform distribution of industrial enterprises with demands of industrial transformation and development. It could guide industrial enterprises and functional facilities distribute centripetally, form different levels of business cluster, and provide a foundation for optimizing the configuration of facilities and resources, so as to enhance the agglomeration effect of industry.

(2) Adjusting the building density and restoring ecological environment.

In the study, problems of high building density, mixed functional facilities and poor environmental quality in high kernel density areas are inseparable from the complex ownership of land within the area and the simple pursuit of production space maximization by each owner. Thus , relevant policies based on clarifying and resolving problems of land ownership should be researched and formulated, so as to avoid the disorderly self-growth of functional facilities, and guide the improvement of function and environment. Through policy formulation, the ownership, responsibility and obligation could be clearly defined, and the guarantee for formulating ecological restoration planning of soil, vegetation and water could be provided (Figure 7). In combination with the

establishment of suitable biological retention pool, shallow ditch, storage pool, low-potential green space, complex ecosystem with multi-stage water system and green network as framework, the goal of restoring ecological environment could be achieved.

Figure 7. The Midea Global Innovation Centre is a typical example of restoring nature by adjusting the density of buildings (self-drawn)

(3) Constructing a low-carbon and energy-saving urban form and optimizing the facility allocation.

In order to effectively guarantee the development of enterprises, it is necessary to explore the optimal resource allocation mode and construct the compact spatial form of Beijiao, based on maintaining the existing spatial relationship between facilities and enterprises, combining the development status of functional facilities in several districts including the study area. Meanwhile, the "Composite-TOD" mode should be adopted to guide the improvement of transportation system, strengthen inter-regional industry-spatial relationship, which is helpful to reduce carbon emissions, so as to achieve the goal of constructing a low-carbon and energy-saving urban form.

(4) Tracking industrial-spatial dynamics by establishing a transformation database.

In order to make the orientation of industry-spatial relationship clearer, the distribution characteristics of enterprises and functional facilities should be sorted out synchronously, so as to guide the facilities to be more closely connected with enterprises in space. Meanwhile, due to the diverse influencing factors of industry-spatial relationship, the research cannot be limited to analysing POI data in the current period, otherwise it could not judge whether there was a trend of gradual improvement or decline in configuration of facilities at present. It is necessary to establish a dynamic database of transformation and upgrading of existing industrial zones in Beijiao, Shunde, so as to provide a basis for improvement of planning and planning revision.

ACKNOWLEDGMENTS

We would like to thank the key project of "Green building and building industrialization" in the national key research and development plan of the 13th Five Year Plan, "Function upgrading and transformation technology of existing urban industrial zones" （2018YFC0704900）, for the funding support. We would like to thank the Guangdong Shunjian Planning and Design Institute for providing the urban planning data. And we would like to thank the researchers who participant in the field investigation and classifying POI data.

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