Research on City Center Identification and Optimization Strategy Based on POI Data
——Taking the Four Districts of Qingdao as an Example

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Abstract. With the help of analysis tools such as mean nearest neighbor, standardized ellipse and kernel density of ArcGIS software, this paper uses POI data to deeply identify and analyze the urban polycentric spatial structure of four districts in Qingdao, and draws the following conclusions: the multi-center layout of the four districts in Qingdao presents five major urban centers with “one principal, two assistants and two clusters”, and a polycentric spatial pattern with strong main center and weak sub-center. In the future urban planning and development, it is necessary to establish a hierarchical and orderly multi-center spatial structure system, strengthen the diversity and complexity of urban central functions, and improve the guidance and support role of transportation for each functional center.

1. Introduction
According to the "World Urbanization Outlook" (revised in 2018) released by the United Nations[1], the urbanization rate on a global scale will be further promoted, and it is estimated that 68% of the population will live in cities by 2050[2]. With the rapid increase of urban population, monocentric cities will inevitably cause serious urban problems such as traffic congestion and environmental pollution due to the centripetality of each functional space. In contrast, the advantages of the polycentric structure of the city that is conducive to the efficient operation of the city begin to emerge gradually. Polycentralization of urban spatial structure is an important concept in the field of geographic science and urban planning. Its goal is to decentralize overconcentrated urban social functions, so as to alleviate and eliminate the problems of urban diseases[3]. With the advancement of urbanization in China, the control and guidance of "polycentric" macro urban spatial structure has become the main idea of spatial planning[4].

In recent years, the rise of big data technology provides an effective approach for the study of urban polycentric identification. POI (Point of Interest) data abstracts a geographic entity into a point containing name, latitude and longitude, type, address and other information[5]. Compared with traditional data, POI data has the advantages of large scale, wide coverage, easy access and so on, which is particularly favored by experts in various fields. Many scholars have used POI data to carry out studies on urban structure[6-7], urban boundary[8], urban population change[9-10] and urban functional area identification[11], etc. However, there are few relevant literatures on urban polycentricity using POI data.

Qingdao is located in the southeast of Shandong Peninsula, China, and is in a critical period of transformation to a polycentric spatial structure. In the 2010 urban master plan, Qingdao has proposed...
2. Study area, data and methods

2.1. Overview of the study area
In this paper, the four districts of Qingdao refer to the four districts of Shinan, Shibeib, Licang and Laoshan. Among them, Shinan District is the seat of the municipal Party committee and the municipal government, and it is the political, cultural, financial center of Qingdao and the coastal mountain tourism scenic area. As a commercially developed old city, Shibeib District is vigorously developing innovative industries such as business, science, education, research and development. As a high-tech development zone, Laoshan District is the new blue Silicon Valley growth pole of Qingdao City. Licang district is an important land transportation hub of Qingdao, and it is also one of the logistics, trade and entertainment centers of Qingdao (Figure 1).

2.2. Research data
The POI data used in this paper came from Baidu Map in January 2021. Although each POI has a certain scope of influence, some POIs have very low public awareness\(^{[13]}\) and cannot be directly related to the location of the urban center. Therefore, a total of 17,893 pieces of data from the above four regions were screened for the first time, and each data type was POI data with high public recognition. Then, the data screened for the first time were re-processed, and the data were projected to the WGS1984-UTM-Zone-51N projection coordinate system with the projection and transformation command of ArcGIS software. Finally, the POI data needed in this study were re-divided into eight categories: residential land, administrative land, cultural and educational land, business and office land, medical land, leisure and entertainment land, industrial land and green land, and the final POI database of the four districts in Qingdao was established, as shown in Table 1:(The column of "Middle Class" refers to the Standard for Classification and Planning of Urban Land for Construction Land (GB50137-2011)\(^{[14]}\)). Other spatial data used in this study include the road network data of the main urban area of Qingdao in 2021 and Baidu image data in 2021.
Table 1. POI data reclassification results of Baidu map in four districts of Qingdao

| Class                        | Big class       | Medium class                              | Small class                                                                 |
|------------------------------|-----------------|-------------------------------------------|-----------------------------------------------------------------------------|
| Residential land             |                 |                                          | N: 4523, proportion: 0.253                                                   |
| Administrative land          | (A1)            | Administrative office space               | Governments at all levels, Administrative units, Social organizations       |
| Cultural and educational land| (A2)            | Cultural Facilities Land                  | Museum, Art gallery, Exhibition hall, Cultural palace, Library, Science and technology museum |
| Business office space        | (B2)            | Land for business facilities              | Office buildings, Post offices, Banks                                       |
| Medical use of land          | (A5)            | Medical and health land                   | General hospital, Specialized hospital, Clinic                               |
| Recreation land              | (A4)            | Sports land                               | Sports venues                                                                |
| (B1)                         | Land for commercial service facilities | Star hotel, Express hotel, Apartment hotel, Chinese restaurant, Foreign restaurant, Shopping center, Department store, Supermarket, Market |
| (B3)                         | Recreation land | Cinema, Theatre, Dance hall, Fitness center, Beach |
| Industrial land              |                 |                                           | Factories and mines                                                         |
| Green space                  | (G1)            | Parks, Botanical gardens                  | N: 262, proportion: 0.015                                                   |
| Total                        |                 |                                           | N: 17893, proportion: 1.000                                                 |

2.3. Research method

2.3.1. Mean nearest neighbor analysis of reaction aggregation intensity.
Average nearest neighbor analysis is to calculate the observation distance between each point of interest and its nearest point, and then calculate the average of all the nearest neighbor distances.

If the average nearest neighbor distance of a certain kind of POI data is less than expected, it is proved that this kind of data has the characteristics of clustered distribution in space, otherwise, it presents the characteristics of scattered distribution. In this paper, the mean nearest neighbor tool in ArcGIS was used to carry out the analysis, and the final results included five indexes, namely mean observation distance ($d_i$), expected mean distance ($d_e$), nearest neighbor index ($R$), $z$-score and $P$-value. Among them, the smaller the nearest neighbor index ($R$) is, the higher the degree of aggregation. In addition, $Z$-score and $P$-value can judge whether the null hypothesis is rejected at a certain significance level. The calculation formula is as follows:

$$
R = \frac{d_i}{d_e}$$

$$
E = \frac{0.5\sqrt{N/A}}{d_e}$$

$$
z = \frac{(d_i - d_e) \sqrt{N}}{E / 0.26136}
$$

Where, $A$ is the area of the study area; $N$ is the total number of POIs. When the $|z| > 2.58$ and $P < 0.01$, the null hypothesis is rejected.

2.3.2. The standard deviation ellipse explores the direction of dispersion. Standard deviation ellipse was first proposed by American sociology professor Welty Liefer in 1926. It can directly display the distribution direction of POI data, which is very helpful to reflect the distribution trend of data.

2.3.3. Kernel density analysis to identify urban data clusters. Kernel density analysis is mainly used to analyze the spatial distribution characteristics of spatial point elements and estimate the agglomeration
degree of spatial point elements distribution through a regular moving quadsquare[15]. It conforms to the first law of geography and has been widely used in related studies in the field of urban planning and geography in recent years. In this paper, kernel density analysis tool in ArcGIS is used to carry out this analysis, and its function expression is as follows:

\[ P_i = \frac{1}{\pi r^2} \varphi \sum_{d, s} \left( \frac{d}{r} \right) \]

Where, \( P_i \) is the estimated value of kernel density at \( i \), \( r \) is the calculation radius of kernel density function, \( n \) is the total number of samples, \( d \) is the distance between POI point \( i \) and \( s \), and \( \varphi \) is the weight of distance.

### 2.3.4 AHP analysis to determine the weight

Analytic Hierarchy Process (AHP) is a multi-objective system analysis method combining qualitative analysis and quantitative analysis proposed by American operations researcher Professor T.L. Saaty[16] from the University of Pittsburgh in the 1970s[17]. It can build a rational model of a series of complex problems, which is very beneficial to the decision and implementation of goals. In this paper, Yaahp software is used for AHP analysis, which can automatically carry out consistency test after constructing the judgment matrix, and has been widely used in AHP analysis in recent years. After that, the weight was input through the Weighted Sum Tool in ArcGIS.

### 2.3.5 Natural discontinuity method and standard deviation classification method were used to extract the boundary of central region

Natural discontinuous method refers to the statistical method of resetting the boundary at the interval between groups according to the default grouping situation of data, so as to maximize the difference between groups. After calculating the kernel density of all types of POI data and obtaining the weight, the final data were reclassified into 10 groups using the natural discontinuity method, which could directly and conveniently reflect the central area of each urban element distribution. Relevant studies show that the spatial distribution of POI data conforms to the characteristics of normal distribution[18, 19], so the standard deviation classification method can be used to extract the boundary of the central region. According to the characteristics of normal distribution, the data within the range of 1, 2 and 3 standard deviation curves can respectively contain 68%, 95% and 99% of all the data. Therefore, this method is a method to identify the urban center from a statistical point of view, and the identification result of the urban center is more accurate than the natural discontinuous method.

### 3. Research results and analysis of urban polycentric structure

Firstly, the clustering intensity and direction distribution of various elements were analyzed by means of the mean nearest neighbor and standard deviation ellipse. Then, the density distribution of various urban elements was explored respectively through kernel density and AHP analysis. Finally, the polycentric spatial pattern of the four districts in Qingdao was obtained by combining spatial analysis with density analysis (Figure 2).

| Classification            | Di(m) | Dm(m) | R    | z     | p   |
|---------------------------|-------|-------|------|-------|-----|
| Residence                 | 91    | 218   | 0.4189 | -74.77 | 0   |
| Administrative            | 99    | 281   | 0.3523 | -63.20 | 0   |
| Culture and education     | 101   | 288   | 0.3500 | -63.80 | 0   |
| Business office           | 105   | 349   | 0.3005 | -50.36 | 0   |
| Medical                   | 405   | 797   | 0.5079 | -16.03 | 0   |
| Recreation                | 73    | 192   | 0.3781 | -91.78 | 0   |
| Industry                  | 428   | 887   | 0.4824 | -16.03 | 0   |
| Green                     | 528   | 859   | 0.6146 | -10.86 | 0   |
3.1. Identification and analysis of the central structure of each urban element

It is not difficult to see from Table 1 that there are obvious differences in the number of different types of POI, among which the recreational type is the most, with a total of 33.3%, while the green space is the least, with a total of 1.2%. According to the result of the average nearest neighbor analysis, all of the 4 areas inside city of Qingdao POI data |z| >2.58 and p<0.01, which proves that all of them show significant clustering distribution characteristics in space. The clustering degree of business and office type is the highest, while that of green space type is the lowest, with R of 0.3005 and 0.6146 respectively (Table 2).

Parameters for all kinds of single poi data standard deviations of the standard deviation ellipse analysis (figure 3), the results show that the distribution of all kinds of poi data are in the southwest, northeast spread, including industrial class element migration northward obviously, it reflects the Qingdao city four areas more focused on the north side of licang industry class factors, in addition to the industry class, the elliptical concentric distribution. In terms of ellipse area, the standard deviation ellipse area of business office and residential data is significantly smaller than that of other elements, which proves that their distribution trend is the most concentrated, whereas the distribution trend of industrial and medical elements is relatively scattered.

A large number of studies have shown that in the process of nuclear density analysis, the establishment of radius R is very important in the process of nuclear density analysis [20, 21]. Based on the existing urban research cases [22, 23], the author comprehensively considered the dispersion degree of spatial distribution of various POI data, and selected the optimal radii with 500m, 1000m, 1500m and 2000m as radii respectively (Table 3). It can be seen that when r is 500 meters, the distribution of the central area is too trivial to be identified. When R increases to 1500 meters, the aggregation of Shibei District and Shinan District is converging, and the POI aggregation characteristics of Laoshan District and Licang District are weakened. When R increases to 2000 meters, the above two trends are more obvious, which are not conducive to the identification of the central area. Comparatively speaking, the search radius of 1000 meters can not only identify the local hot spot information of various kinds of data more accurately, but also reflect their distribution characteristics on the whole. Therefore, the calculation radius R of the kernel density function in this paper is finally set as 1000 meters.

According to the classification in Table 1, 1000m was taken as the calculation radius of the kernel density function to conduct kernel density analysis on each type of POI data, and the analytic hierarchy process (AHP) was used to calculate the weight value of each subcategory of factors (Table 4):
Table 3. Nuclear density search radius comparison table

| R=500m | R=1000m | R=1500m | R=2000m |
|--------|---------|---------|---------|
| ![Image 1] | ![Image 2] | ![Image 3] | ![Image 4] |

According to the classification in Table 1, the judgment matrices of all kinds of POI were established respectively, and then the judgment matrices were filled in according to the "1-9 judgment scale method", and the results were later processed by Yaahp software, which mainly included two steps: weight calculation and consistency test, namely, weight calculation of each factor $W_i$, and consistency ratio $C_r$. The weight of each element in all data types is obtained. Then, the weighted sum tool in ArcGIS was used to input the second-level weight, and the results were reclassified into 10 grades (1-10) by the natural discontinuous method (Fig. 4). Finally, the area with the core density $\geq 8$ among the above eight land use types was selected as the central area of the land use type (Fig. 5):

Table 4. Statistical table of weight of each evaluation factor

| Big class               | First class weight | Small class                | Second class weight | Small class weight |
|-------------------------|-------------------|----------------------------|---------------------|--------------------|
| Residence               | 0.2709            | Residence                  | 0.7500              |                     |
|                         |                   | Dormitory                  | 0.2500              |                     |
| Administrative          | 0.0817            | Governments at all levels  | 0.7396              |                     |
|                         |                   | Administrative units       | 0.1666              |                     |
|                         |                   | Social organizations       | 0.0938              |                     |
| Culture and education   | 0.1276            | Museum                     | 0.1277              |                     |
|                         |                   | Art gallery                | 0.1276              |                     |
|                         |                   | Exhibition hall            | 0.0440              |                     |
|                         |                   | Cultural palace            | 0.0465              |                     |
|                         |                   | Library                    | 0.1174              |                     |
|                         |                   | Science and technology museum | 0.0369         |                     |
|                         |                   | Institutions of higher learning | 0.2235     |                     |
|                         |                   | Middle schools             | 0.1192              |                     |
|                         |                   | Primary schools            | 0.0446              |                     |
|                         |                   | Scientific research institutions | 0.0841     |                     |
|                         |                   | Training institutions      | 0.0285              |                     |
| Business office         | 0.1260            | Office buildings           | 0.6483              |                     |
|                         |                   | Post offices               | 0.1220              |                     |
|                         |                   | Banks                      | 0.2297              |                     |
| Green                   | 0.0309            | Parks                      | 0.5000              |                     |
|                         |                   | Botanical gardens          | 0.1667              |                     |
|                         |                   | Leisure square             | 0.3333              |                     |
| Medical                 | 0.0515            | General hospital           | 0.7010              |                     |
|                         |                   | Specialized hospital       | 0.1929              |                     |
|                         |                   | Clinic                     | 0.1061              |                     |
| Recreation              | 0.2817            | Sports venues              | 0.1634              |                     |
|                         |                   | Star hotel                 | 0.1527              |                     |
|                         |                   | Express hotel              | 0.0633              |                     |
|                         |                   | Apartment hotel            | 0.0355              |                     |
|                         |                   | Chinese restaurant         | 0.0259              |                     |
|                         |                   | Foreign restaurant         | 0.0278              |                     |
|                         |                   | Shopping center            | 0.1340              |                     |
|                         |                   | Department store           | 0.0572              |                     |
|                         |                   | Supermarket                | 0.0257              |                     |
|                         |                   | Market                     | 0.0176              |                     |
|                         |                   | Cinema                     | 0.0600              |                     |
|                         |                   | Theatre                    | 0.0211              |                     |
|                         |                   | Dance hall                 | 0.0301              |                     |
|                         |                   | Fitness center             | 0.0619              |                     |
|                         |                   | Beach                      | 0.1238              |                     |
| Industry                | 0.0297            | Factories and mines        | 1.0000              |                     |
According to Figure 5, an integrated analysis is made on the distribution of each center in the four districts of Qingdao: (1) Residential land centers are located in Sifang Street, Taixi Town and Shinan District Government Zone in the North District of Qingdao. In addition, there are small-scale residential land centers in Licang District and Taixi Town. (2) The administrative center is centrally located in the municipal government area of Shinan District. (3) Cultural and educational centers are mainly located around the railway station of Shinan District, the government area of Shibei District and Guangrao Road. There are also small-scale cultural and educational centers around the government area of Laoshan District and Beizhai Street. (4) The business office center is located in the area of Shinan District Government, Laoshan District Government and Shibei District Government. (5) The medical land center is located in the Xiaogang area at the junction of Taidong Town and Shinan Shibei District. (6) The green land center presents a multi-core state. Except for Wusi Square, Badaguan and Trestle in Shinan District, there are green lands of different scales in each of the four districts of the city. (7) Leisure and entertainment centers are mainly located in Zhanqiao, Wusi Square and Licang District. (8) The industrial land is also multi-core. There are multiple industrial centers in Shibei, Licang and Laoshan districts, among which Licang-Xingcheng Road district is the most densely packed.

3.2. Identification and analysis of mixed functional polycenters

The multi-center of mixed function is the embodiment of the multi-center structure of urban cluster, which is more appropriate to the connotation of the multi-center spatial structure within the city [5]. Firstly, the weighted sum tool was used to input the first-level weight index listed in Table 4, and the obtained results were segmented by the natural discontinuous method and the standard deviation classification method respectively. The natural discontinuous method was divided into 10 grades from 1 to 10 (left of Figure 6), and the areas with a value $\geq 8$ were selected as the urban center. The standard deviation classification method was based on the value ranges of 3, 2 and 1 standard deviation curves, respectively, and 0.5%, 2.5% and 16% of the whole kernel density data were extracted as segmentation thresholds (see Fig.6 on the right).

Classification by natural intermittent method of kernel density threshold left (figure 6), in combination with standard deviation ellipses (figure 3), and each land use type distribution center (figure 5), can clearly see that the 4 areas inside city a total of five big city center, Qingdao Hong Kong middle road, respectively central district, Zhongshan road Historical Block, Taidong- Dengzhou road blocks, Licang blocks, Laoshan district government blocks: The central district of Hong Kong Middle Road, with the municipal government as the center, is the city center with the most complete facilities in the city. The historical district of Zhongshan Road, once the origin of Qingdao's urban development and the city center, now has many functions such as culture, education, recreation and so on. Taidong - Dengzhou Road block is a traditional commercial center rising rapidly in the second half of the last century, and has become the center of residential, commercial, medical and other functions. Licang block and Laoshan district government block are two emerging central blocks.

3, 2 and 1 times standard deviation curves were respectively used to extract the central district boundaries (right of Fig. 6). It can be seen that the extracted urban boundaries of different standard deviation curves are significantly different, and the urban central boundary constituted by 3 times
standard deviation curves in the figure is the most obvious. Therefore, this paper takes it as the urban central boundary of four districts in Qingdao. In addition, it can be seen that the top 0.5% and 2.5% of the high-density agglomeration areas are located in the central area of Hong Kong Middle Road, which proves that it is the highest level of the main city center in the four districts of Qingdao. Zhongshan Road Historical District and Taitong-Dengzhou Road District have relatively weak density concentration areas, which are regarded as sub-urban centers. On the other hand, Laoshan District Government Block and Licun Block show the pattern of small-scale cluster city center.

To sum up, the four districts in Qingdao present five urban centers with "one main center, two secondary centers and two groups", and show a polycentric spatial pattern of strong main center and weak secondary center. Combined with the contents of Figure 5 and Figure 6, the main functions of the urban center are summarized (Table 5).

4. Evaluation and analysis of the current situation of the central structure of four districts in Qingdao and its optimization strategy

4.1. The status quo and analyzes
According to the above research, the spatial development strategy of “accelerating the construction of a clustered and ecological Gulf metropolis” proposed by Qingdao in the 2010 urban master plan has been initially realized today, more than ten years later. The four districts already have five central urban areas with "one main, two auxiliary, two clusters", and the functions performed by each central urban area are different. The "group development" has been initially realized, but problems in the spatial structure can still be found:

4.1.1. Multi-center development status of strong main center and weak sub-center. Can be seen from table 5, Qingdao while there are many of the 4 areas inside city center spatial structure model of development, but a large number of city function gathered in the districts of Hong Kong middle road blocks, Zhongshan road Blocks and Shibeit Taidong-Dengzhou road blocks, while the other two central block compared with smaller, mainly to undertake fewer functions.
4.1.2. Imbalance of functional space aggregation. On the whole, the distribution of urban centers in the four districts of Qingdao is not balanced. The four main urban areas are located in the coastal area, while the inland part has only one central area. The other inland areas have not formed multi-centers of comprehensive functions. In terms of the functions undertaken by each center, in the process of the continuous enhancement of the degree of each center in the city, except the central area of Hong Kong Middle Road, there is a certain imbalance of functional space aggregation in other central areas. For example, Taidong-Dengzhou road Block has rich historical and cultural deposits, and Taidong Business District is also one of the most popular business districts in Qingdao, but its surrounding industries are mostly middle and low-end commercial and entertainment facilities serving tourists and local residents, which have certain waste of resources. For another example, the commercial function of Licang Block is outstanding, but the cultural and commercial function is weak, and there are a series of contradictions such as unbalanced development. From the perspective of regional planning and layout, the proportion of business, office and entertainment space in Shinan District is too large, while the proportion of residential land in Shibe District and Licang District is too large, which is easy to cause many urban problems.

4.2. Optimization strategy

4.2.1. Establishment of hierarchical and orderly multi-center spatial structure system. For urban development, what needs to be strictly controlled is neither the construction scale nor static structure, but the order of urban spatial structure\(^5\). At present, the problem of strong main center and weak sub-center in the four districts of the city is actually caused by the relative concentration and lack of decentralization of various functional elements of the city, that is, the strong aggregation of the main center inhibits the development of each sub-center. Therefore, business offices, recreational facilities and residential facilities in the central area of Hong Kong Middle Road should be directed to the central area of Laoshan District Government so as to accelerate the realization of the positioning of Laoshan District Government Block itself. Licang Blocks is given priority to with leisure entertainment industry at present, we should strengthen to guide the business office class elements Licang Blocks together, can the park held at the same time zone as the backing, to speed up the lead to gather the region culture facilities, in order to solve culture education class facilities is too concentrated in the southern coastal area, to Zhongshan road historical Block should be increased a little business office function, make it more functional. In addition, in terms of urban texture, it is necessary to make full use of geographical elements such as mountain and river system to divide urban space organically, so as to further promote the integrity and stability of urban development.

4.2.2. Enhance the diversity and complexity of urban central functions. Functional diversity is the key to ensure a vibrant and healthy and sustainable development of the city\(^5\). Qingdao "one main two two groups" of the 4 areas inside city of multi-center pattern, center the function of the mixed use significantly different at different levels and so on the function allocation between the center should be appropriate in the development of the secondary center of public services such as catering, leisure industry, establish totipotency city centre, to ensure its self balance and the ability to grow\(^5\).

From the development potential of each city center, Laoshan District and Licang District have obvious advantages: Laoshan District has already shared part of Qingdao's business, office, leisure and entertainment functions, and can also undertake the cultural, educational, residential and other functions spread in Shinan District; Licang District will mainly share the residential, business, office, cultural and educational functions of Shinan District and Shibe District in the future. In the future urban development, it is necessary to attach importance to the exchange and penetration of material resources among centers at all levels, especially the interaction between Licang block and Taidong-Dengzhou road block and between Laoshan district government block and the central district of Hong Kong middle road, so as to gradually expand the scale and improve the functions of each sub-urban center.
4.2.3. **Enhance the guidance and support of traffic to each function center.** At present, Qingdao's transportation system is developing very rapidly. The opening of subway lines 2, 3 and 11 has greatly alleviated the pressure of urban overground traffic, and strengthened the traffic connection between the central area of Hong Kong Middle Road, along Hai'er Road and Licang Street in Laoshan District. In order to alleviate urban traffic congestion, it is necessary to further coordinate the relationship between urban traffic construction and land use. In the specific implementation strategy, attention should be paid to improving the accessibility among the centers, so as to strengthen the attributes of some low-level urban centers and make them become new urban sub-centers at the municipal scale. Thus, by changing the mode of traffic travel, the city can be guided to develop along the urban road axis.

5. **Conclusion and Prospect**

At present, although the polycentric spatial structure of the four districts in Qingdao has been formed, it is still in the primary stage of development, and there are some problems, such as the current situation of polycentric development with strong main center and weak secondary center, and the clustering imbalance of functional space. In order to solve these problems, this paper proposes to strengthen the diversity and complexity of the urban center and improve the guidance and support of traffic to each functional center on the basis of reasonable and orderly adjustment and improvement of the multi-center spatial structure system. From single center to multi-center is the only way for urban development. Under the background of big data era, the rapid development of data storage, mining and visualization technology enables us to interpret urban problems in a more rational way. It is believed that with the further development of big data technology in the future, the research on urban issues will be more humanized and refined.

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