

THE IDENTIFICATION OF URBAN VITALITY CENTER AND ITS SPATIAL RELATIONSHIP BASED ON MULTI-SOURCE BIG DATA IN JINAN CITY, CHINA

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1. Introduction

With the acceleration of urbanisation in China, most urban spatial structures have changed from "single center" to "multi center"; urban centers are also gradually showing the characteristics of functional compounding. Scholars' research on urban centers has experienced a transformation from geographical centers to functional places providing trade, finance, administration and other services (Christaller, 1933). Since then, the connotation of urban center is no longer limited to the central location of urban geographical structure, but more from the perspective of the functions undertaken by the center itself. In recent years, with the continuous enrichment of the perspective of urban space research, scholars' research on urban space is no longer limited to the dominant elements such as space and function, and begin to emphasise the non-material space in urban research. Sociological content is added to the connotation of urban center, and it is considered that urban center is not only the functional core of the city, but also a material spatial form that condenses the sense of identity of citizens (Shi, Yang, 2013, p.86). Taking the temporal and spatial characteristics of residents' behavior as an aspect of describing the urban center, it is believed that the urban center should have a certain use intensity (Zhang, Zhang&Zhou, 2017, p.183). For the research on the spatial relationship of urban centers, many scholars took several large cities as examples to analyze the current situation of their urban center system and the influencing factors behind it, and gave the connotation and research framework of the urban center system. However, most of these studies focus on the hierarchical structure or spatial distribution, and use the individual attribute of the center as the research basis for the urban center system (Shi, Yang, 2011, p.29; Zhang, 2012,; Wei, Xiu&Wang, 2014, p.83). In fact, with the continuous development of information technology, the relationship between the centers is often generated through traffic flow, information flow, capital flow, technology flow, there are also obvious element links between urban centers.

The application and development of big data technology provides a better platform for studying the development status and spatial relationship of urban central areas. Many scholars try to visualize different types of big data, and use the address data representing different functions of the city to describe the spatial distribution of urban functions (Wang, Zhen, 2014, p.58; Zhao, Liang&Guo, 2018, p.72). Analyze the flow status of urban residents in urban space according to the track data left by urban residents on the data platform (Liu, Biderman&Ratti, 2012, p.72; Ding, Niu, 2015, p.16, Niu, Ding, 2015, p.100). However, the city is a complex life body. Using a certain kind of data from one aspect alone cannot accurately describe the urban spatial form.

Therefore, based on the existing research of urban center and the dual attributes of urban space material and behavior, this paper combines urban construction space with human space-time behavior, and puts forward the concept of urban vitality center, elect the POI data of AutoNavi which can represent the urban function and the thermal map data of Baidu map which can represent the spatial agglomeration characteristics of urban population as the basic data to identify

the spatial distribution of urban vitality centers, and analyze the spatial relationship of urban vitality centers from two aspects , grade and spatial connection.

2. Research Foundation Of Urban Vitality Center

The concept of urban vitality center appeared in the study of spatial syntax theory in the early stage. At the end of the 20th century, Bill Hillier(1999) pointed out that "Life Center refers to a series of functional clusters that are usually supported by people flow and suitable for the lives of ordinary residents, such as retail, catering and entertainment", it is clear that "urban vitality center" is a dual concept used to determine urban land use and residential activity density(Anon,2017).

By integrating the concepts of urban vitality center and urban vitality, we believe that urban vitality center can be defined as a combination space that is central within a certain region and can provide urban residents with a variety of service functions. At the same time, the center needs to be dynamic, reach a certain use intensity, be able to maintain a stable and sustainable crowd flow. Different from the previous definition of urban center, urban vitality center not only emphasizes the diversity of functions, making it serve different consumer groups, but also takes the population density as an important measure to describe the "vitality" state of urban vitality center, which is different from the "pseudo urban center" with complete functions but unable to attract people.

Therefore, when identifying urban vitality centers, it is necessary to grasp the two directions of human behavior and functional space, select representative index data for comprehensive analysis, and finally realize the accurate identification of urban vitality centers.

3. Data Selection And Processing

The data used in this study are mainly from the data open platform databases of the two websites ,POI data of AutoNavi and thermal map data of Baidu Maps (Fig.1). Among them, the POI data of AutoNavi contains two attributes: function and location, which can describe the functional diversity and spatial correlation of the urban vitality center to a certain extent.



Figure 1. Thermal map interface of Jinan Baidu map

Source: Baidu Maps

The POI data used in this study is from the AutoNav in June 2018. The four sub categories of shopping service, catering service, life service and leisure entertainment in this POI data are extracted for analysis. After correction, spatial matching and de duplication of the data, a total of 49590 valid POI data in the central city of Jinan were obtained (Fig. 2).

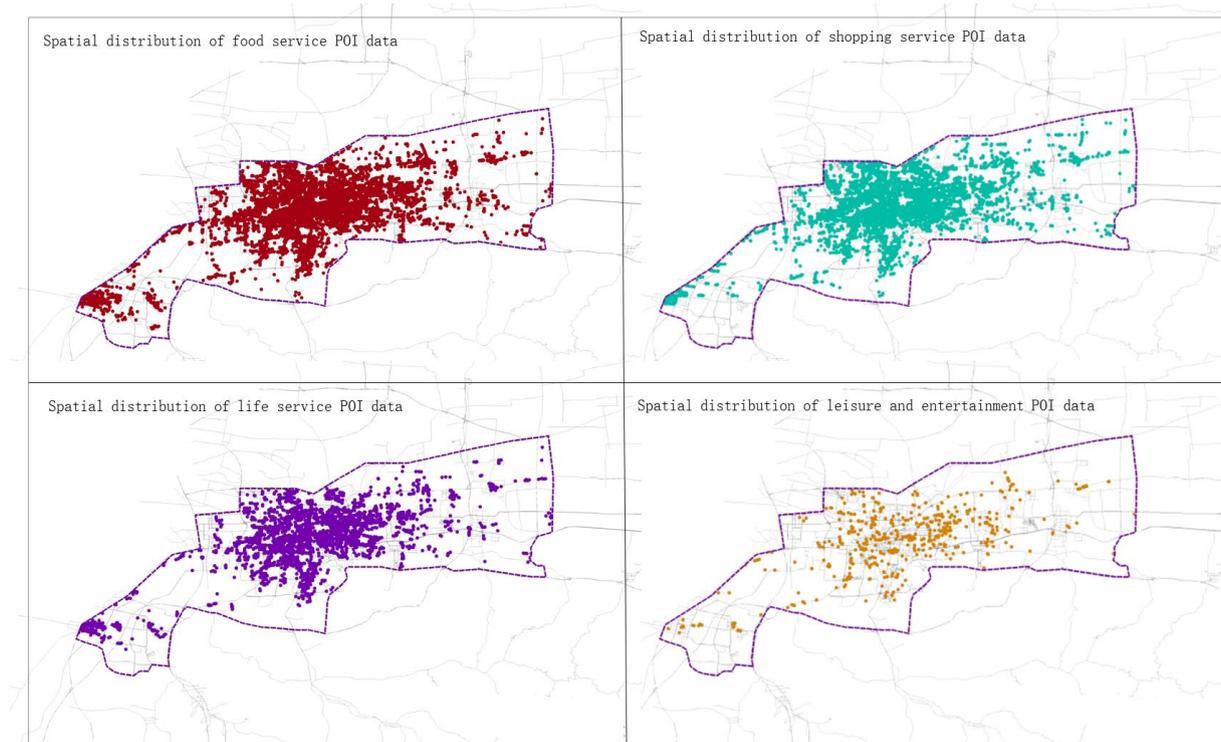


Figure 2. Spatial distribution of POI points of Jinan functional vitality Center

4. Identification Of Jinan Urban Vitality Center

4.1 Identification Of Urban Functional Vitality Centers Based On Poi Data Of Autonavi

We include four steps in identifying the activity center based on the POI data of AutoNavi map: ①Reclassify the POI data based on the conceptual characteristics of the urban activity center and the classification method of AutoNavi map, and obtain the point data types and attributes used in the study.②Use the spatial Global Moran's I tool in ArcGIS and SPSS correlation analysis to verify whether the POI data of various functional types have spatial agglomeration and correlation.③Identify the density center of each functional spatial element distribution within the research scope through ArcGIS kernel density estimation and hotspot analysis tools, and select the high-value area of its density as the candidate functional center. ④The threshold value of nuclear density is determined by using the triple standard deviation method to identify the significant hot spots within the threshold range; using the method of extracting classification isoline to determine the vitality center boundary (Fig. 3).

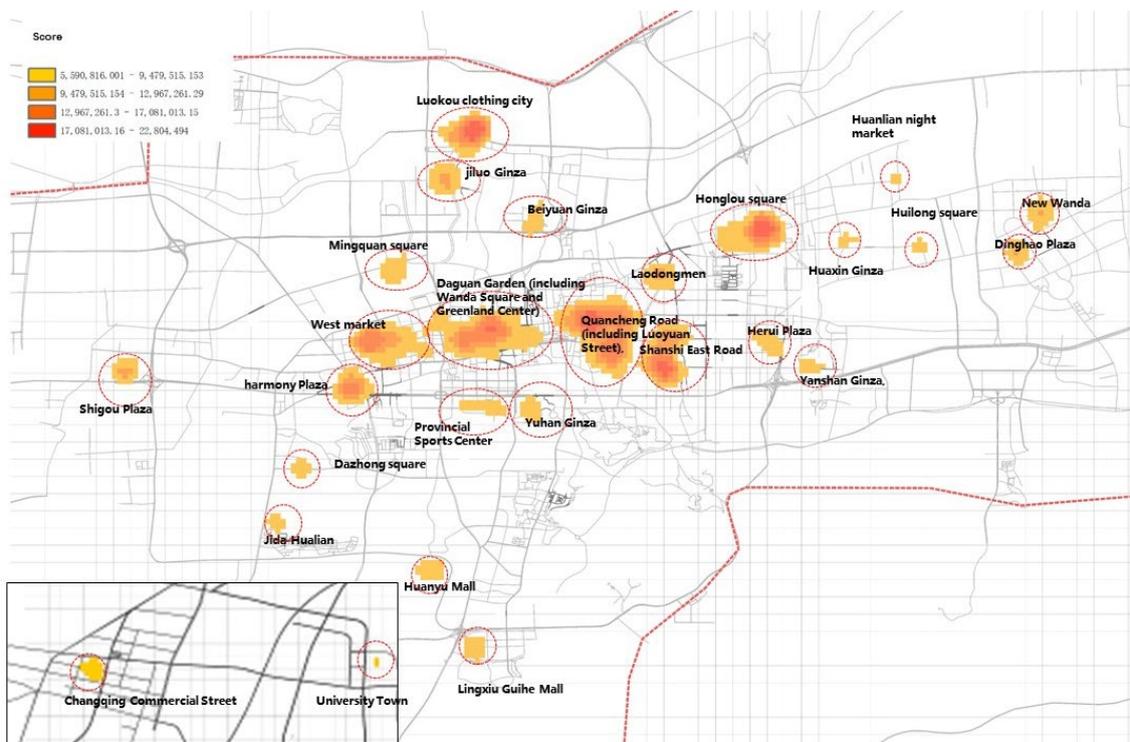


Figure 3. Identification results of Jinan urban function vitality

A total of 27 functional vitality centers in Jinan were identified, belonging to different district (table 1).

Table 1. Identification results of Jinan urban function vitality

	Urban Function Vitality
Lixia District	Herui Plaza, Yanshan Ginza, Laodongmen, Shanshi East Road, Quancheng Road (Including Luoyuan Street), Yuhan Ginza, New Wanda, Dinghao Plaza
Licheng District	Huanlian Night Market, Huilong Square, Huaxin Ginza, Hongjialou
Shizhong District	Daguan Garden (Including Wanda Square And Greenland Center), Provincial Sports Center, Huanyu Mall, Dazhong Square, Jida Hualian, Lingxiu Guihe Mall
Tianqiao District	Luokou Clothing City, Jiluo Ginza, Beiyuan Ginza, Mingquan Square
Huaiyin District	West Market, Harmony Plaza, Shigou Plaza
Chanqing District	University Town, Changqing Commercial Street

4.2 Identification Of Urban Population Vitality Centers Based On Baidu Population Heat Map

We takes the following steps to identify the urban population vitality center based on the thermal map of Baidu map: ① Intercept the thermal map image of Baidu map in different time periods in the central urban area of Jinan Based on the program. ② Use ArcGIS to project and register the geographic coordinates of the collected thermodynamic map images. ③ Use ArcGIS re-classification tool to re classify the thermal map image, and use the thermal degree grade to measure the density reflected by the thermal map. ④ Select the period with better population concentration as the research object, and extract the area with high density value as the population vitality center.

After comparing the heat maps of different time, we find that the daily life of urban people follows certain objective laws, which are generally cyclic changes in weeks. Within a week, there is a difference between the activity status of workday and weekday, which is reflected in the fact that regular activities (commuting) are mainly carried out on workday, and free activities (leisure activities) are more carried out on weekday. Because the definition of urban vitality center in this paper is based on the aggregation of service functions, the weekday is selected as the research time. The data of 13:00 and 14:00 on September 8 were reclassified by using the ArcGIS. The population concentration density was divided into 7 categories by using the natural discontinuity classification method. The 6th and 7th grades were defined as the high heat area of urban population concentration, which was identified as the core area of the urban population vitality center, and then vectorised by ArcGIS, delimit the scope of population vitality Center (Fig. 4).

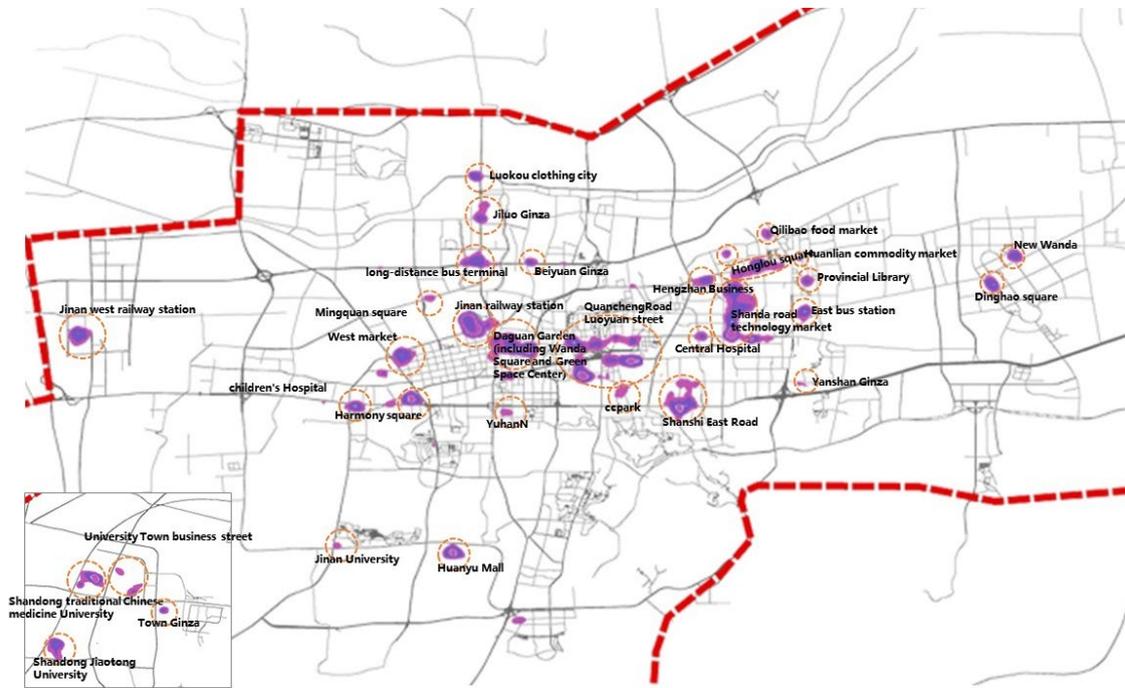


Figure 4. Identification results of Jinan population vitality Center

A total of 33 population vitality centers were identified in the central city of Jinan, belonging to different district (table 2).

Table 2 Identification results of Jinan population vitality center

	Population Vitality Center
Lixia district	Central Hospital, Shanda Road Technology Market, Hengzhan Business, Quancheng Road, Luoyuan Street, Yanshan Ginza, New Wanda, Dinghao Square,
Shizhong Distric	Daguan Garden (Including Wanda Square And Green Space Center), Jinan University, Huanyu Mall
Licheng District	Provincial Library, Huanlian Commodity Market, Qilibao Food Market, Honglou Square
Tianqiao District	Luokou Clothing City, Jiluo Ginza, Belyuan Ginza, Long-Distance Bus Terminal, Jinan Railway Station, Mingquan Square,
Huaiyin District	West Market, Children's Hospital, Harmony Square, Jinan West Railway Station,

Changqing District	University Town Business Street, Shandong Traditional Chinese Medicine University ,Town Ginza, Shandong Jiaotong University
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4.3 Comprehensive Identification Of Jinan Urban Vitality Center

The grid stacking tool in ArcGIS is used to stack the functional vitality center and population vitality center of Jinan without weight, and the results are obtained (Fig. 5).

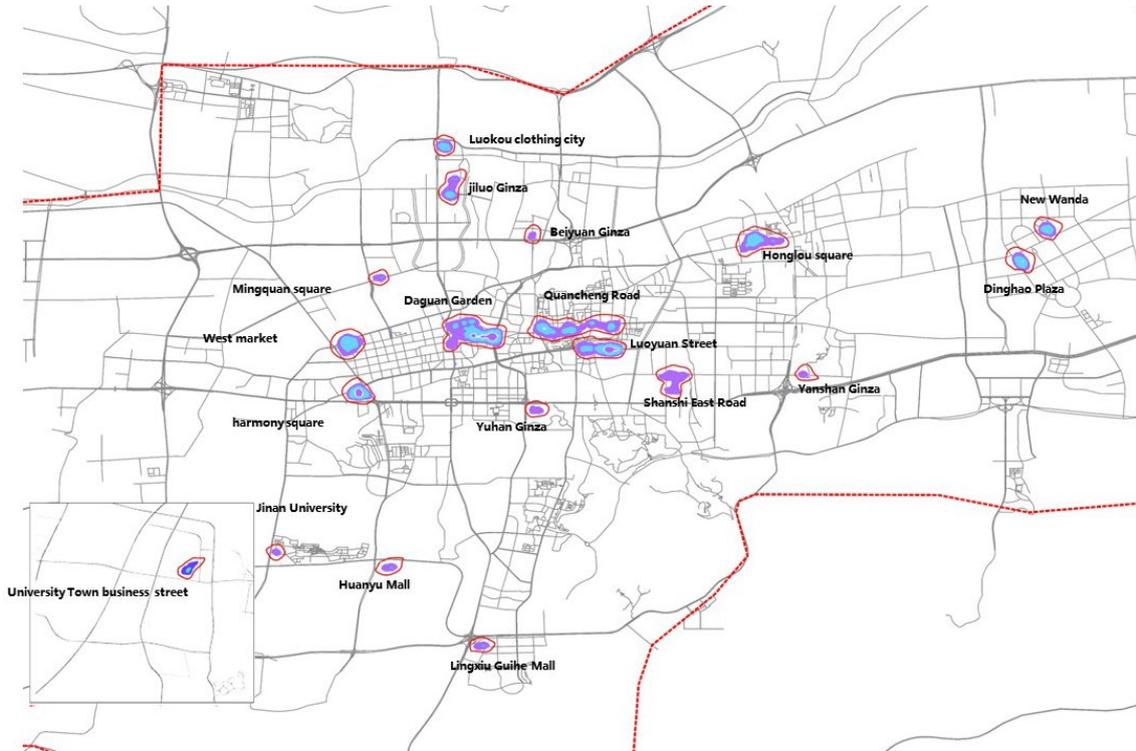


Figure 5. Spatial distribution of Jinan urban vitality Center

After rectifying and correcting the superimposed layers, combined with field investigation and data collection, 19 vitality centers were finally identified, belonging to different district of Jinan (table 3).

Table 3. Identification results of Jinan vitality Center

	Vitality Center
Lixia District	Yanshan Ginza, Shanshi East Road, Quancheng Road, Yuhua Ginza, Luoyuan Street, New Wanda, Dinghao Plaza
Licheng District	Honglou Square
Shizhong District	Daguan Garden, Huanyu Mall, Jinan University, Lingxiu Guihe Mall
Tianqiao District	Luokou Clothing City, Jiluo Ginza, Beiyuan Ginza, Mingquan Square

Huaiyin District	West Market, Harmony Square
Changqing District	University Town Business Street

5. Research On The Spatial Relationship Of Jinan Urban Vitality Center

5.1 Scale Grade Analysis Of Jinan Urban Vitality Center

Area is one of the commonly used indicators to measure the size of urban space. In this paper, it represents the physical space attribute of urban vitality center. The larger the area, the larger the scale of the vitality center, the stronger the spatial agglomeration ability, and vice versa. In the previous, we have defined the scope of urban vitality centers. then the spatial area of each vitality center will be calculated on this basis to compare and analyze the scale differences between vitality centers. The specific calculation steps are as follows: ①Vectorize the scope of 19 urban vitality centers on the ArcGIS.②Use the area field calculator in ArcGIS to calculate the area size of each vitality center, and divided into three grades (table 4).

Table 4. Grade distribution of Jinan urban vitality Center

Level_1 (2)	Quancheng Road, Dagan Garden
Level_2 (4)	Luoyuan Street, Hongjialou, Shanshi East Road, West Market
Level_3 (13)	Jiluo Ginza, Yanshan Ginza, Yuhan Ginza, Jinan University, Dinghao Square, Lingxiu Guihe Mall, University Town Business Street, Mingquan Square, Huanyu Mall, Harmony Square, Beiyuan Ginza, New Wanda, Luokou Clothing City

In terms of the grading results, the number of vitality centers included in the three grades is quite different.

The Level_1 includes Quancheng road and Dagan Garden. It is a municipal commercial center that developed earlier in Jinan. It has superior location conditions, rich service functions and a large space area; at the same time, they are also important destinations for cultural tourism in Jinan. They have a strong ability to attract population agglomeration and a wide range of services. Level_2, Luoyuan street, radiated by Quancheng Road, gathers a certain number of service functions. Hongjialou is the administrative center of Licheng District, with relatively perfect shopping, catering and other industries. Shanshi East Road and west market are two business circles with Jinan characteristics. The former is a shopping paradise for young people, and the latter mainly serves people with low consumption level. The Level_3 vitality centers are mainly divided into two types, one is the traditional area center based on Ginza supermarket, and the other is the large shopping center in the construction of the new city.

5.2 Spatial Hierarchical Analysis Of Urban Vitality Center

Using ArcGIS taking the spatial center of gravity of the vitality center as the center of circle, a multi ring buffer zone with a distance of 5km is established. The research scope is divided into 5 circles, which are spatially connected with 19 vitality centers. Taking the circle center as the intersection point, the circle is divided into four quadrants(Fig.6.)

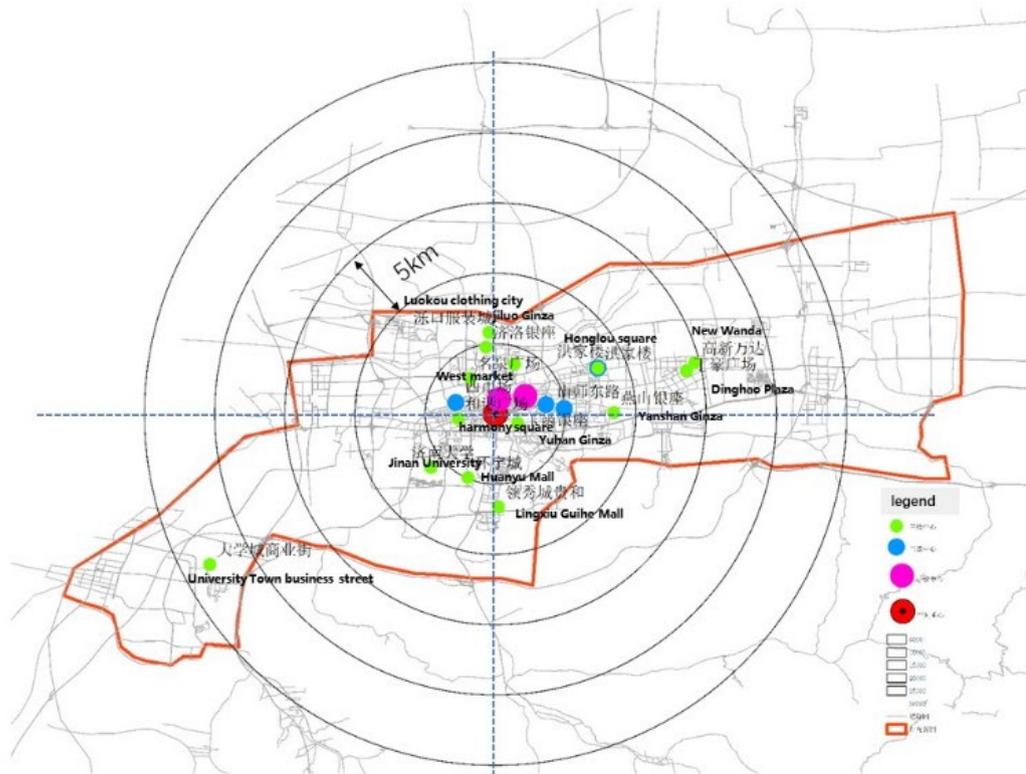


Figure 6. Distribution pattern of urban vitality Center

Results shows that there is a hierarchical ring system with multiple centers in the spatial distribution of Jinan vitality center. In terms of quantity, 0-5km is the largest, including 10 activity centers, accounting for more than half of the total. There are 6 activity centers within 5-10km, and the number of activity centers within 15-20km is zero; in the most marginal circle, there is a vitality center in the commercial street of Changqing University Town. Therefore, it can be concluded that the overall characteristic of the spatial distribution of Jinan urban vitality center is the combination of ring structure mode and core agglomeration mode. Among them, the circle structure mode means that the distribution of urban vitality centers decreases outward along the circle, which is manifested in the reduction of the number and scale of vitality centers. The urban vitality center in the inner circle has obvious scale advantages, showing the characteristics of continuous distribution. The vitality center of the surrounding circle is small. On the other hand, the activity centers of each circle show the characteristics of cluster agglomeration. For example, within the range of 0-5km, 80% of the activity centers are distributed in the north of the center of gravity, and the two activity centers within the range of 10-15km form a cluster. According to this feature, we summarise the spatial layout mode of Jinan urban vitality Center (Fig. 7).

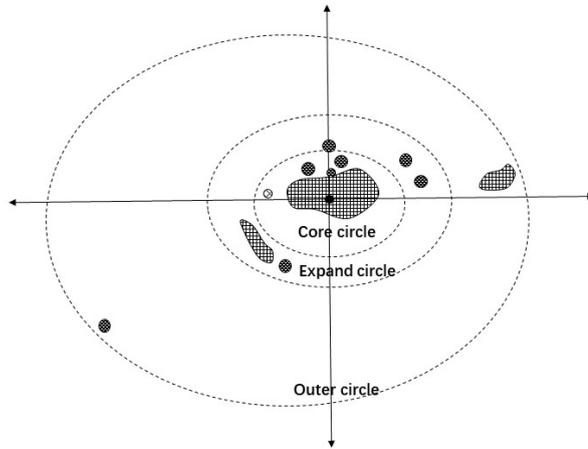


Figure 7 distribution mode of Jinan urban vitality Center

5.3 Spatial Connection Analysis Of Jinan Urban Vitality Center

because urban vitality center is based on the agglomeration of consumer places. Therefore, this paper chooses to study the spatial relationship of the vitality center based on the internal relationship of chain brands. In order to maintain the accuracy and objectivity of the data, the following principles are followed when screening the data of chain enterprises: ① The selected chain enterprises appear at least in two dynamic centers at the same time. ② When screening the enterprises, franchise chain enterprises are not considered, and only direct chain enterprises are retained. ③ The more chain enterprises screened out, the better. Based on the above principles, we selected 33 chain brand enterprises including shopping service, entertainment and leisure, catering service and life service as the basic data of this study (table 5).

Table 5 .Chain Enterprise Selection Results

Catering Services	Dexter, Pizza Hut, Love Gift, 85°C, Zhizhen Dumplings, Zhang Liang Malatang, Yuanliang Porridge, Yuku, Starbucks, Xijiade, Subway, Lao Paifang, KFC, Kelling Cake, Holland
Shopping Service	Amoy, Belle, Swarovski, Jackjones, Jinlilai, Anlifang, Chow Tai Fook, Zhisolang, Slade, Watsons, Jinmuyu, Hailan Home, Chaohongji
Life Service	Gymboree, Child King, Shuang&Yue
Entertainment And Leisure	K-One KTV、 Wanda Cinema

In order to more intuitively reflect the spatial relationship between the vitality centers, we use ArcGIS for visualisation, takes the number of chain enterprises as a hierarchical field, represents the connection strength between the two points, and distinguishes them by color depth and line width. As can be seen from the figure 8, the network pattern between the urban vitality centers of Jinan has initially taken shape. In addition to Luokou clothing city, other vitality centers also participated in the formation of the network. On the whole, the network structure conforms to the characteristics of the Belt and Road city in Jinan, showing the characteristics of long east-west and short north-south.

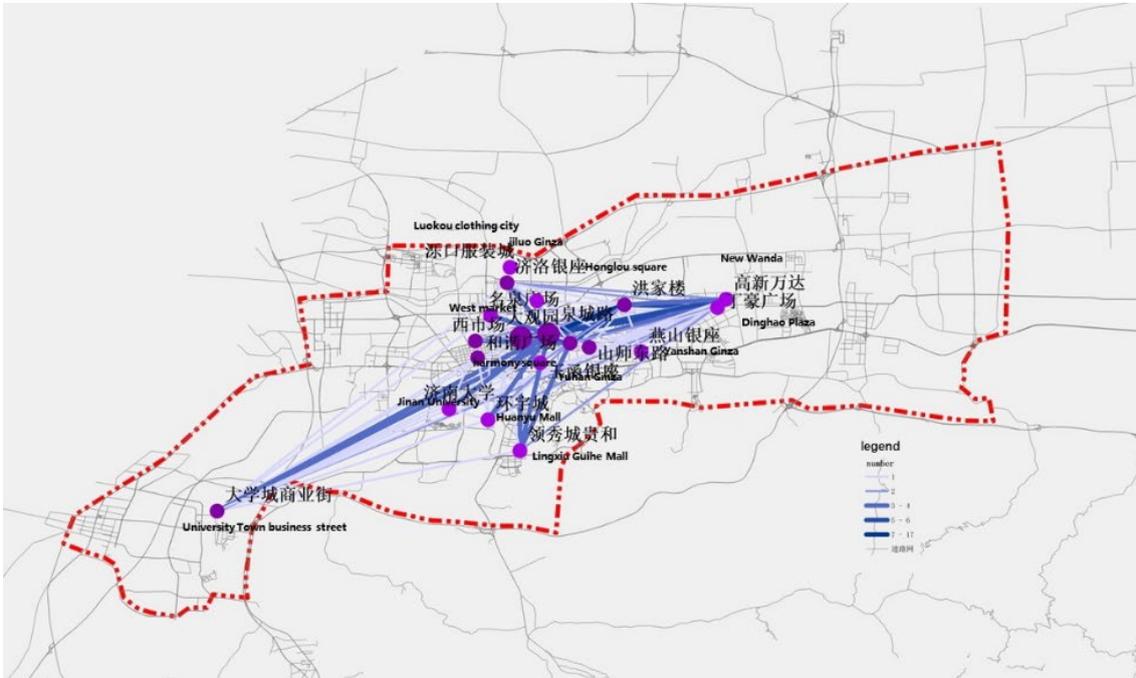


Figure 8. Network structure of Jinan City vitality Center

In order to further explore the relative relationship between nodes in the network structure of vitality center, the paper introduces the degree centrality calculation method in social network analysis to quantify the importance of nodes in the network. UCINET is used to analyze the network of the enterprise contact matrix of Jinan urban vitality center, and calculate the centrality of each node. The relative size of network nodes is used for visualisation. The larger the node, the greater the centrality of the center in the network. Figure 9 is obtained. It can be concluded that in the network structure, there are still obvious differences in the centrality between nodes, and traditional business centers such as Quancheng road and Dagan Garden still have advantages in the centrality, making a great contribution to the formation of the network structure. However, compared with the traditional department stores such as Yuhan Ginza and Yanshan Ginza, the three-level vitality centers such as Dinghao Plaza, New Wanda and the university town business street also show a higher degree of centrality, and the relative relationship with the first and second level vitality centers is gradually weakening.

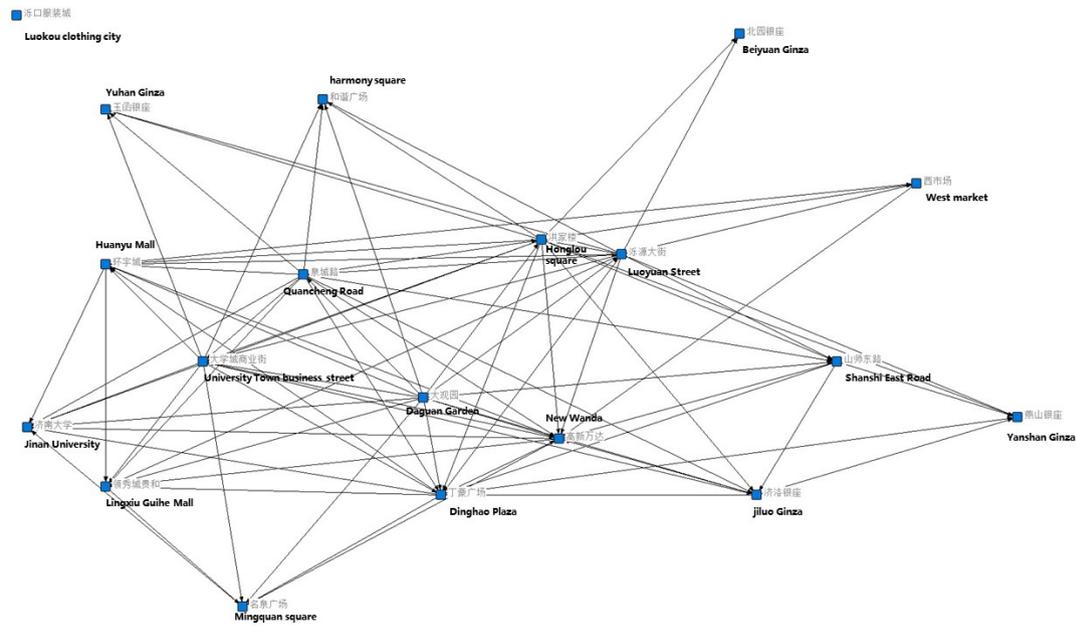


Figure 9. Network structure of Jinan urban vitality Center

We believe that the main reason for this change is the change of business model. As a new generation of business model, Dinghao Plaza and Wanda Plaza have the characteristics of standardisation and branding, and have formed a mature brand enterprise system. In the network system built by enterprise "flow", they have a strong relationship with other dynamic centers. However, the dynamic centers of the older generation, such as west market and East Shanshi Road, lack chain enterprises, so their contribution to the network system is degraded. Similarly, as the benchmark of Jinan's business model development, Quancheng road has many new generation shopping malls, such as Henglong square and Shimao square. Therefore, compared with Grand View Park, there are more chain enterprises, and there is a strong relationship with other dynamic centers. The polarisation phenomenon is significant in the network system.

6. Summary

This paper puts forward the concept of urban vitality center from the perspective of human behavior and material space in view of the current research status of the separation of physical space and social space in urban space research. It also carries out basic research on the connotation and characteristics of the urban vitality center to enrich the research framework of the vitality center. Then, combined with big data processing and analysis technology, Taking Jinan as an example, this paper uses two kinds of big data comprehensive analysis to accurately identify the vitality center of Jinan, and analyzes the multi center network pattern of Jinan from the perspective of hierarchical structure and spatial connection. The main conclusions are as follows: urban vitality center is a dual concept of physical space and behavioral space, and multivariate data combination analysis can more accurately identify urban vitality center. Taking Jinan as the research object, it is concluded that the urban vitality center in Jinan presents a spatial pattern of "grade + network" as a whole, and there are significant differences in the scale of different vitality centers, showing the characteristics of decreasing circles and core agglomeration in space. The network structure of the vitality center has also taken shape, and compared with the scale grade of the vitality center, the hierarchical structure of vitality center has changed under the action of network.

The main deficiency of this paper is lacking of field research data as a supplement. We hope to make up for this deficiency in the next research.

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