Analysis of Neighborhood Vitality in Heping District of Tianjin based on POI big data Analysis

Lizhi Pan[1], Jiaqi Chi[2*]

email address[1]: 18382375619@163.com , email address[2]: 122746267@qq.com[*]

School of Design and Art, Shenyang Jianzhu University, Shenyang, Liaoning, China

Abstract. Exploring and improving the vitality of urban blocks is an important means to promote the healthy development of cities. Taking Heping District of Tianjin as the research object, ArcGIS was used to analyze the spatial vitality of urban blocks, the degree of crowd gathering and the distribution characteristics of POI based on multi-source data such as Baidu heat map and POI data, and the three were matched to carry out correlation analysis. On this basis, the problems affecting the vitality of city blocks are identified, and the ideas and methods for improving the vitality of city blocks are provided.

Keywords: neighborhood vitality; Vitality analysis; POI data; GIS technology

1 Introduction

China's urban renewal has begun to enter a new stage of connotation enhancement and quality priority, and block vitality plays an important role in reshaping the good image of the city, enhancing the power of urban development, stimulating the vitality of the city block, and extending the depth and breadth of the urban context. With the advent of the era of big data, the field of urban renewal has an opportunity to acquire and use data research methods to deeply discover its inherent laws and obtain new knowledge [1]. The study of its development dilemma and causes, rational analysis of the vitality of urban blocks can effectively promote urban renewal and ensure the sustainable development of the city.

2 Research overview and scope

2.1 Research status

In the past studies on the vitality of urban blocks, the domestic and foreign studies mainly focus on qualitative research and theoretical discussion, lack of data support, it is difficult to adapt to the current complex and changeable urban form, and there are certain limitations on the study of urban functional areas and density distribution characteristics. [2] POI big data has been widely used because of its characteristics of fast update, wide coverage, easy access and high precision.[3] POI visual analysis will become a new way to quantitative research on urban spatial quality and improve spatial vitality in the future.

Foreign scholars Alves et al. [4] took Boston metropolitan area as an example to identify the vitality, development and utilization of urban blocks through POI big data; Spanish scholar Thomas Louai [5] collected mobile phone signaling data and POI data to study street vitality in

different cities. Fang Yonghua,[6] a domestic scholar, used POI data to study the law of human activity and spatial distribution from the two dimensions of time and space, and discussed the measurement and influencing factors of urban street vitality. Based on POI data, Yang Zhenshan et al. [7] quantified the day-night difference of functional use intensity and the degree of internal functional mixing in Beijing, and completed the evaluation of urban block vitality and functional mixing degree. Zhang Jingguo[8] took the East coast urban area of Qingdao as an example, studied the spatial layout and crowd gathering of the East coast urban area of Qingdao through POI data, and analyzed the block vitality of the East coast urban area.

All the above studies indicate that POI data has been widely used in the relevant research of urban blocks, and can improve the reliability and accuracy of the results.

2.2 Overview of the research scope

Heping District is the core area of the main city of Tianjin, and it is a block with profound cultural accumulation and a long history. Heping District is located in the middle of Tianjin city, east coastal river; The south is bounded by Xuzhou Road, Machang Road and Jinhe River; West to Weijin Road, South Gate Street; North to South Road, Xing 'an Road, Rongji Street. The administrative area is an irregular quadrilateral, the jurisdiction of Quanye Chang Street, Xiaobalou Street, Xinxing Street, Nanyingmen Street, gymnasium Street, Nanshi Street 6 blocks.

3 Data sources and research methods

3.1 Data source

This research data includes two parts: block spatial vitality data and POI data. The former uses Baidu heat map data[1] and uses python tool to collect Baidu heat map data of Heping District from November 13 (Monday) to November 19 (Sunday) in 2023 through Baidu map API for translation and expression. The latter is derived from the point of interest data within the peace zone, which is divided into 8 categories after screening, including catering, business, leisure and entertainment, tourism and culture, accommodation, companies and enterprises, and culture. A total of 14,318 POI data are obtained for calculation and expression. Finally, based on the statistical tool of band set, the correlation analysis is made between the POI data and the calculation results of historical district vitality, and the relationship between them is discussed.

3.2 Research method

Nuclear density analysis.

This study involves the point element density in the kernel density analysis function, which is used to calculate and analyze the point element density around each basic space unit[9]. The formula is as follows:

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[1] Baidu heat map is to evaluate the vitality of the street's external manifestations. The external representation of the vitality of the block is mainly reflected by the number of people moving in the block and the degree of crowd gathering.

$$f(x) = \frac{1}{nh^d} \sum_{i=1}^{n} k\left(\frac{x - x_i}{h}\right)$$

(1)

In the formula, x_I represents the independent distribution point elements studied, which are randomly selected from the density function f of the population distribution, and $f_{(x)}$ represents the estimated value of the function f at point x. x-x_i represents the distance between the estimated point x and the sample point x_i.

Mixability analysis.

ArcGIS software was used to divide the types of POI and obtain the number of various POI points for statistical calculation[10]. Its calculation formula is as follows:

$$H_m = -\sum_{i=1}^{9} (P_i \times ln\, P_i)$$

(2)

Where, H_m represents the mixing degree level of service facilities in the m block; i is the category of service facilities; P_i is the proportion of the POI of Class i service facilities in the POI of all common service facilities in the block.

4 Analysis of vitality of Heping District in Tianjin

4.1 Quantify the vitality of the peace zone

The kernel density analysis tool of Spatial Analyst in ArcGIS was used to obtain the Baidu thermal maps of working days and rest days (rest days are weekends) in the study area, and the natural breakpoint method was used to classify and assign the thermal maps. The higher the thermal value, the higher the vitality of the block. As can be seen from Figure 1, the vitality of weekday blocks is relatively scattered, because companies and enterprises and science, education and culture are relatively scattered, mainly concentrated in each commercial building. Due to the regional distribution of commercial shopping, leisure and entertainment, and scenic spots, the high-vitality areas of the block are mainly concentrated in the areas of Binjiang Road and Nanjing Road, and also include tourist attractions and leisure places such as the Five Avenues cultural tourism area and Binjiang shopping center.
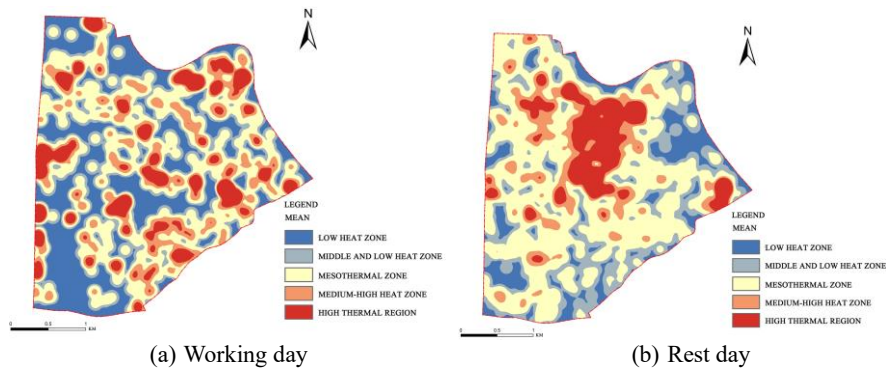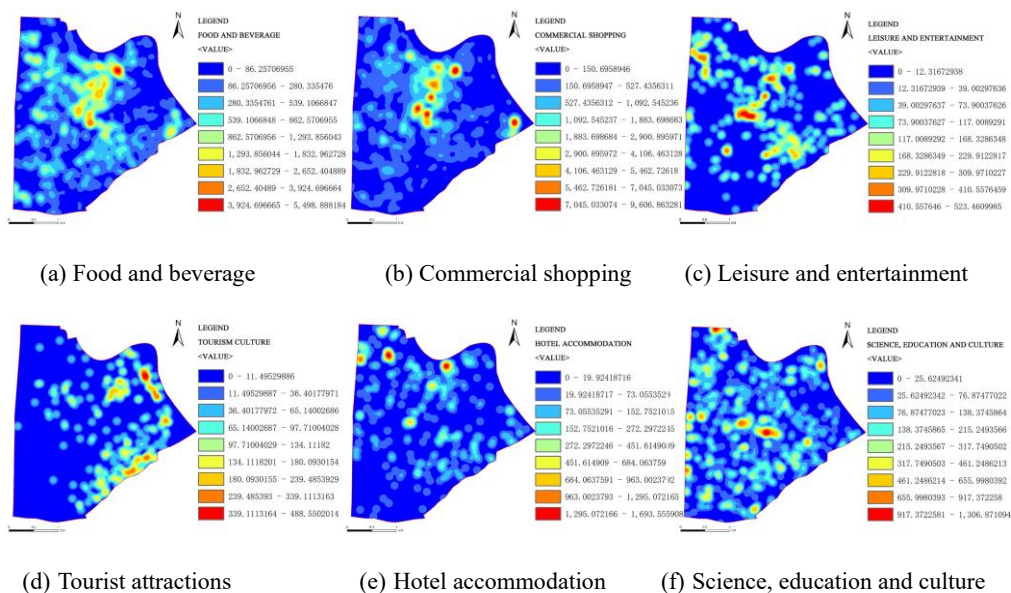

(a) Working day   (b) Rest day

Fig. 1. Heat map of crowd gathering degree in working days and rest days in Heping District.

4.2 POI density analysis in Heping region

Through Arc GIS software platform, kernel density search radius is 100, natural breakpoint method is used to classify, kernel density value decreases from large, base map color changes from red to yellow to blue, POI aggregation changes from strong to weak, and visualization results are obtained in Figure 2.

According to the identification of nuclear density, the food and beverage category shows a multi-core cluster pattern in the central area of the city and scattered in the peripheral areas, mainly concentrated in the vicinity of Harbin Road. Garden Road community, Binxi community and Zhaofeng Road community near Changchun Road, Binjiang Road, Nanjing Road. Commercial shopping mainly gathered around the Garden Road community, Binxi community, Zhaofeng Road community. Leisure and entertainment mainly gather in the vicinity of Zhaofeng Road community, Binjiang Road and Nanjing Road of Xining Road community. The tourist attractions mainly gather in the east side of the region, among which Chifeng Road and Jiefang North Road area, five Avenues cultural tourism area is the highest density area.

The distribution of companies and enterprises is scattered, mainly concentrated in the commercial buildings, and its nuclear density center is located at the interchange of Nanjing Road and Taian Road and Weijin Road and Xinxing Road. Hotel accommodation is mainly located on the north side of Heping District, its nuclear density center is located on the north side of Xing 'an Road and the intersection of Fu 'an Street and Nanshi Street. The distribution of science, education and culture POI is relatively scattered, and the gathering center is at the intersection of Nanjing Road and Yingkou Road. As a whole, the distribution of residential buildings is relatively scattered, and the main gathering areas are west of Heping Road, east of Anshan Road, north of Nanjing Road, east of Yingkou Road and west of Chengdu Road.
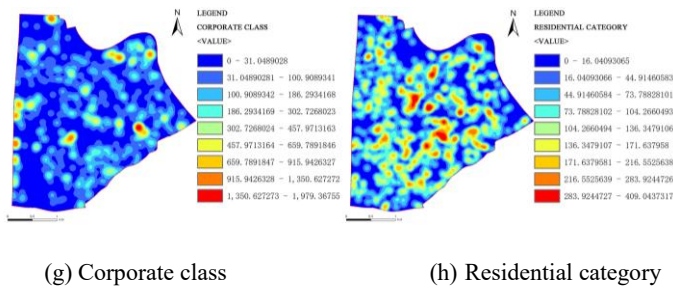

| (a) Food and beverage | (b) Commercial shopping | (c) Leisure and entertainment |

| (d) Tourist attractions | (e) Hotel accommodation | (f) Science, education and culture |

(g) Corporate class   (h) Residential category

Fig. 2. Kernel density analysis diagram of various POI elements.

4.3 POI mixing degree analysis in peace zone

The visualization results of POI mixing degree of historical districts were obtained by ArcGIS. The color ranges from blue to red, indicating the higher mixing degree. As shown in Figure 3, an "L-shaped hot spot" is formed in the middle of the Peace District, which is mainly located in the commercial center of the urban area and distributed in many community commercial centers. Among them, the POI mixing degree is relatively dense in several places, the west side of Heping Road, the intersection of Yingkou Road and Nanjing Road, Shenyang Road, Xuzhou Road and other regional functional formats are large in number and variety. These areas are located in the commercial center, with rich commercial, cultural and public service facilities.
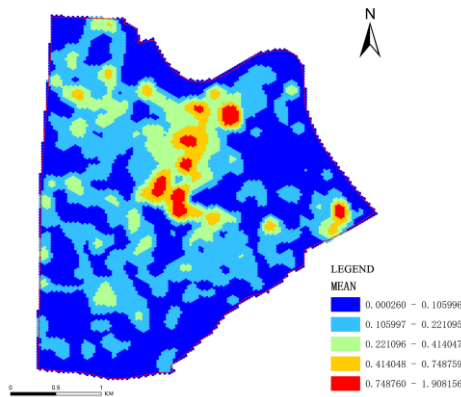

Fig. 3. POI mixing degree analysis diagram of Heping zone.

4.4 Result analysis

On the basis of existing studies, this paper uses band set statistical tools to analyze the correlation between the degree of crowd gathering on rest days and working days, the degree of POI mixing and the correlation analysis of POI kernel density, and analyzes its spatial vitality. The conclusions are as follows:

1)   The correlation between the degree of crowd gathering and the degree of POI mixing on working days was 0.2753, and the correlation between the degree of POI mixing on rest days

was 0.2672. It shows that the intensity of crowd activity in the space is positively correlated with the POI mixing degree of the block, and the influence on working days is more obvious.

2) As can be seen from Table 1, POI of catering, commercial shopping, leisure and entertainment, tourist attractions and housing are all positively correlated with the degree of crowd gathering. Commercial shopping POI has the highest correlation with the degree of crowd gathering. It can be seen that commercial shopping occupies a favorable position, which is basically close to the business district and has convenient transportation, which not only attracts people but also meets the daily consumption needs of residents.

3) From the analysis of the vitality of Heping District in Tianjin, it can be seen that the vitality of the northern region is significantly higher than that of the southern region with Nanjing Road as the boundary. The functional POI is mainly concentrated in several axes and nodes, and the spatial distribution of functional business forms is unbalanced, and the POI mixing degree is not high. On the whole, Heping District is a mature community with relatively mixed functions and rich business forms, but there are still some old blocks with relatively single business forms inside the blocks, which need to be further improved.

Table 1. Correlation analysis of population aggregation degree and various POI nuclei density

sort	Average number of people gathered on weekdays	Average number of people gathering on rest days
Food and beverage POI density	0.02854	0.01306
Commercial shopping POI density	0.23929	0.22695
Corporate POI core density	0.07363	-0.07923
Hotel accommodation POI density	-0.00252	0.05206
POI density of science, education and culture	-0.06181	-0.03871
POI core density of tourist attractions	0.0823	0.1394
POI density in residential category	0.09404	0.07444

5 Conclusions

Through the interpretation of the heat map of the block working day and rest day, this study studies the vitality of the peace zone from the perspective of POI, which provides a more scientific research and optimization possibility. However, because POI data is only the concept of "point", it lacks the description information of the spatial entity volume, and due to the limitations of data acquisition and research area, some old commercial stores do not display the POI data amount and the actual situation of the block may be different. However, the quantitative model and research method of the vitality of the peace district in this study still have certain implications for the promotion of other districts. In the future, we can combine the characteristics of blocks, comprehensively select the factors that affect the vitality of historic blocks, build an urban vitality evaluation system, and seek more scientific strategies to enhance the spatial vitality of blocks.

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