

# Study on the Classification Method of Urban Vitality Spatial Pattern Based on Full-Time Vitality Spectrum: A Case Study of Tianjin, China

*Peng Zeng, Zongyao Sun, Ziwei Gao*

(Prof. Peng Zeng, Tianjin University School of Architecture, No. 92, Weijin Road, Nankai District, Tianjin, urbanplan@tju.edu.cn)

(Ph.D. Zongyao Sun, Tianjin University School of Architecture, No. 92, Weijin Road, Nankai District, Tianjin, sun\_zongyao@tju.edu.cn)

(M.S. Ziwei Gao, Tianjin University School of Architecture, No. 92, Weijin Road, Nankai District, Tianjin, 787782985@qq.com)

## 1 ACKNOWLEDGEMENT

Supported by Graduate Education Innovation Project of Tianjin Education Commission of China (2019YJSB174).

## 2 ABSTRACT

Urban vitality represents the use of urban space. The higher the vitality, the stronger the attraction. How urban space is used in the planning process and how the vitality changes within the space during the day are important evaluation indicators of the quality of urban space. Based on this, this study uses the Internet of Things big data product, the heat map, to change within a day, and draws on the concept of the ground feature spectral curve in remote sensing to propose a full-time urban energy spectral line model. And identify the type of urban space vitality. Taking Tianjin as an example, by classifying and sorting out the temporal-spatial characteristics of urban vitality levels, this paper explores the spatial distribution characteristics of urban vitality in different periods of time, the characteristics of urban vitality changes under day-night contrast, and the spatial distribution of urban vitality types in a full-time perspective feature. Based on the above results, we put forward planning suggestions for Tianjin's vitality promotion and day-night synergy, combined with the business characteristics of key areas, and put forward targeted urban renewal measures and corresponding policy recommendations.

Keywords: Full-time, Vitality spatial pattern, Urban vitality spectrum, Tianjin, China

## 3 INTRODUCTION

Vitality is the vigorous vitality, and refers to the ability of things to survive and develop. Urban sociology believes that urban vitality is composed of economic vitality, social vitality, and cultural vitality. Spatial vitality is merely a spatial representation of above three parts[1]. Urban planning and architecture pin the vitality on physical spaces such as settlements or streets, expressed as the ability of residents' life diversity, species continuity and use intensity. Vitality study is one of the mainstream research directions in the field of urban planning[2]. In 1961, Jane Jacobs analyzed the vitality of street perspectives and proposed it was composed by mixed-use plots, blocks of appropriate scale, mixed-age buildings and high population density. His study is the beginning of research on urban vitality[3]. In 1977, Alexander proposed that urban vitality was affected by the combination of event mode and spatial mode. The connection between cultural activities and public space formed the basis of urban vitality[4]. The above researches represent two perspectives of existing vitality research in planning science: environmental perspective and event perspective. This study uses Baidu's heat map to characterize the intensity of space activities, defined the vitality by the degree of crowd activity, and explores the spatial and temporal characteristics of urban spatial vitality distribution.

In addition, the research methods of urban spatial vitality have gone through three stages[5-7]. In the past, researches were explained from a qualitative and subjective perspective, for example, by constructing a spatial vitality evaluation system and calculating the probability of event occurrence. Later, it has been developed through voluntary geography Information and data to analyze the impact of small-scale spatial vitality, which is shown in space-time geography. With the development of communication technology and the quantitative analysis revolution, big data has provided new technical methods and data to support for the study of spatial vitality. Some scholars constructed a Social Sensing theory that provided a theoretical framework for urban space characterization through Geo-data and GIS technology[8,9]. In China, Internet map supplier such as Baidu and Gaode recorded the latitude and longitude information of service calls on mobile phones to integrate and form heat map products, which own a wide range of practical and scientific value. This study is based on the concept of social sensing, using heat map products and other data to classify urban space under Tianjin case.

## 4 DATA AND STUDY AREA

### 4.1 Data resource

Heatmap is a new kind of big data visualization product, which was launched by Baidu in 2014. This product is based on the geographic location data collected from mobile phone APP. Through a certain spatial expression processing, it is finally presented to users with different grades of clustering. That is, the distribution of the population in the city is described in real time by different color blocks superimposed beyond on-line map. Specifically, it is based on the location information carried by smartphone users when accessing Baidu products (such as search, maps, weather, and music, etc.). Then calculate the crowd density and speed of crowds in each area to reflect the spatial differences in the flow of people with different colors and brightness. The heatmap is displayed on the mobile phone in the form of tiles. According to the scale of the acquisition area, it can be divided into 12-17 levels of spatial resolution. In each level, 7 types of RGB color differences are obtained by inversion. The colors correspond to 7 levels of vitality intensity, respectively, representing extremely low vitality, low vitality, lower vitality, medium vitality, higher vitality, high vitality, and extremely high vitality. This study uses Baidu heatmaps that are updated every half an hour (0-24 o'clock) during the whole day (0-24 o'clock) on November 21, 2019 (Wednesday).

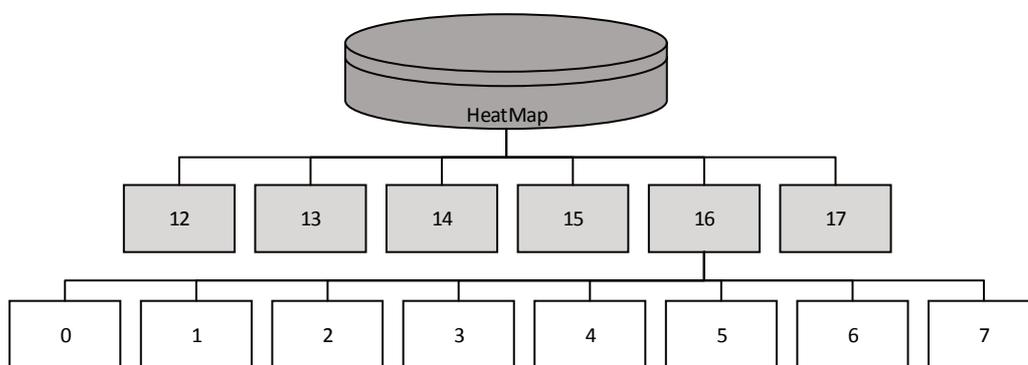


Fig.1 frame of Baidu heatmap product

### 4.2 Study area

Tianjin is one of the four major municipalities in China, with a resident population of 15.956 million and a total area of 1007.91 km<sup>2</sup>. In this study, the area within Tianjin's outer ring road was used as the research area, with a total area of 548.97 square kilometers. The Haihe River as an important tourist natural resource passed through the area. Judging from the light conditions at night, this research area covers Tianjin's main economic and social activity areas, and the study is meaningful of megacities with a population of more than 10 million.

## 5 METHOD

In this study, the 48 pieces of obtained heatmaps is collected into a raster dataset, and the curve is established of each pixel. The curve is called the vitality spectrum. Based on the temporal characteristics of vitality spectrum lines in specific time periods, specific areas, and specific change patterns, the spatiotemporal characteristics of Tianjin's spatial vitality types are summarized. Based on the above results, it is divided into tidal space, quiet space, active space, and transition space.

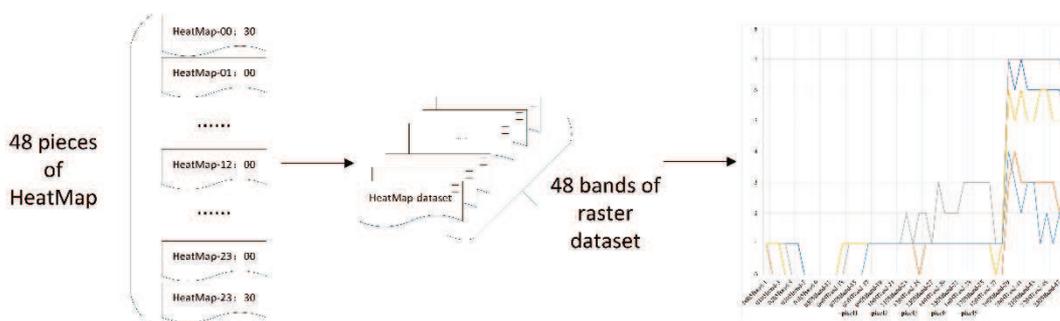


Fig.2 Technical route

## 6 TIANJIN'S VITALITY SPATIAL PATTERN

### 6.1 Level Study

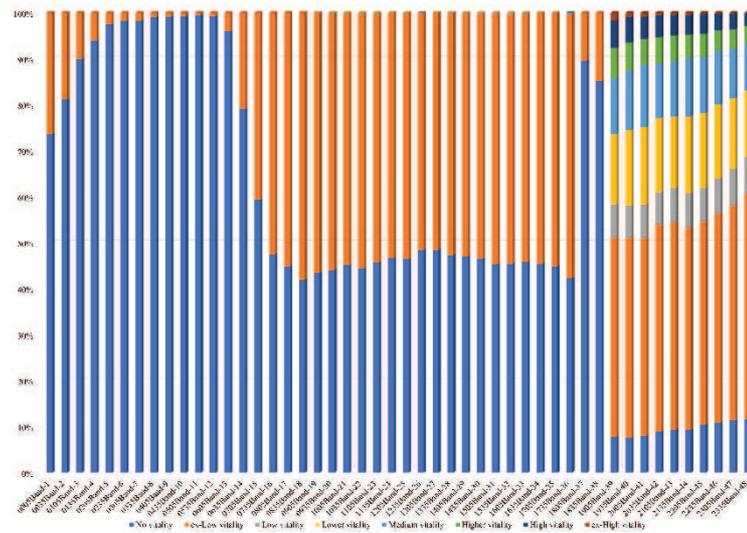


Fig.3 Temporal change of heat level ratio

According to the change of the heat level in a day, the city vitality of Tianjin's 24-hour cycle can be divided into the following phases: 0-5 o'clock means late night period, 6-9 o'clock means morning period, 10-17 o'clock means working period, 18 -23 o'clock means night activity period. At 0-5 hours, there are still some previous-day activities in the city that have not ended. As time progresses, the active public facilities and businesses in the city gradually go out of business, and the city begins to enter the sleep rhythm. At this stage, it shows a decline in urban vitality and heat levels. At 6-9 hours, the city enters the morning busy hour, and the working commute increases, which shows that the level of urban vitality rises and the speed is faster. After 10 o'clock, the morning rush commute phase ends, and the city enters a period of smooth operation. Until 17:00, the city's vitality fluctuates little. After 18:00, the city changed from the working mode to the night active mode. According to the data, the vitality level in the city has changed greatly, from the original 0-1 two-level change to the 0-7 eight-level change. For comparison, the reason for this phenomenon should come from the data itself. Therefore, this study does not explore the difference between day and night, but only performs dimensionless processing at the same time. After analyzing the changes in the area of urban vitality level after 19:00, it can be found that the overall decline of vitality in Tianjin after 19:00, the areas of extremely high activity areas, higher activity areas and high activity areas decreased, and the areas of extremely low activity areas increased. Gradually enter the quiet phase in the middle of the night.

### 6.2 Pixel Study

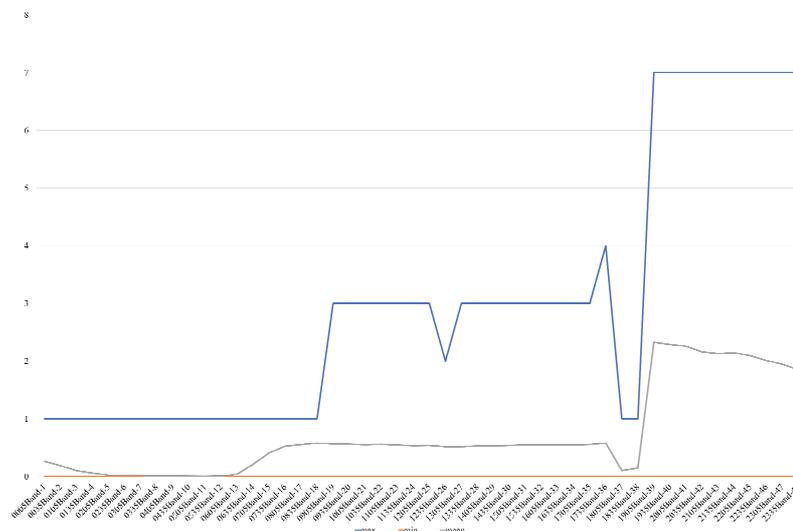


Fig.4 Vitality Spectrum of maximum, minimum and mean heat level

Analyzing the changes in the maximum, minimum, and average values of the heat level in Tianjin in one day, the above rule can also be found. It is worth noting that the maximum value change curve during the daytime working period has an increase lag from the average value. The trend of active areas and overall vitality varies in individual day. By calibrating the above-mentioned areas with special phenomena, we can find that several locations are typical first-class hospitals, retail centers, and financial centers in Tianjin. Compared with the situation before 12 am and daily life experience in Tianjin, Tianjin residents are used to going out for dealing affairs at afternoon, and the space with functional priority has become the first choice for people to gather. The spatial vitality polarization caused by the scale effect is the main driving force of daytime urban operation in Tianjin.

### 6.3 Vitality Spatial Pattern



Fig.5 spatial distribution of heat level at 6 time spots

This study selected six time points: 00:34, 07:04, 10:34, 12:34, 19:34 and 22:34 for comparison. From 0-7 o'clock, the city enters the working commute stage from sleeping, and the vitality of the city increases significantly. The vitality area increases, the area of vitality plaques increases, and the vitality upgrade in the study area is evenly distributed. From 7 am to 10 pm, the city transitions from the morning traffic state to the working state. The level of urban vitality continues to rise. The area of vital plaques in the central area of the city has expanded and formed patches, forming a pattern of daytime urban crowd activity. A small number of roads in the city have obvious vitality, indicating that the road has more traffic at this moment. From 10 am to 12 pm, the urban space vitality changes little, and the overall vitality distribution area slightly diminishes, indicating that Tianjin residents have no obvious travel trend during the lunch break. At 19:00, the city entered the night economic time, and the overall vitality of the city increased significantly. It can be seen that local residents have a certain preference for night trips and activities, and the highly dynamic areas are located in the central area. The circle is a typical representative. The southern of the Haihe River has higher vitality than the northern bank. By 22:00, the night activity entered a declining period, and the vitality of the city declined. Only a few entertainment business districts remained with a certain degree of vitality. The city slowly entered the sleep rhythm.

### 6.4 Space category

Based on the analysis of residents' full-time behaviors and travel characteristics, this study initially considers the space into four categories: quiet space, active space, tidal space and transition space. Quiet space refers to

the area with a small number of users during the whole period, including industrial land, storage land, etc.. Active space is typically represented by business districts and has full-time vibrant urban space. Tidal space is shown significantly dynamic characteristics between daytime and nighttime, such as urban space such as CBD. Transition space refers to the area where the characteristics of vitality change are not clear. In this study, four types of space are distinguished based on the time line of the vitality level: if 80% or less of 48 bands of pixel is lower than average grade ,it is regarded as a quiet pixel; if 80% or more of 48 bands of pixel is higher than average grade, the average value is determined as active pixels; when the vitality level of the pixel shows the opposite situation during the day and night, it is considered a tidal pixel; when the vitality level of the pixel frequently fluctuates near the average value, it is considered to belong to the fourth type of space, the transitional space.

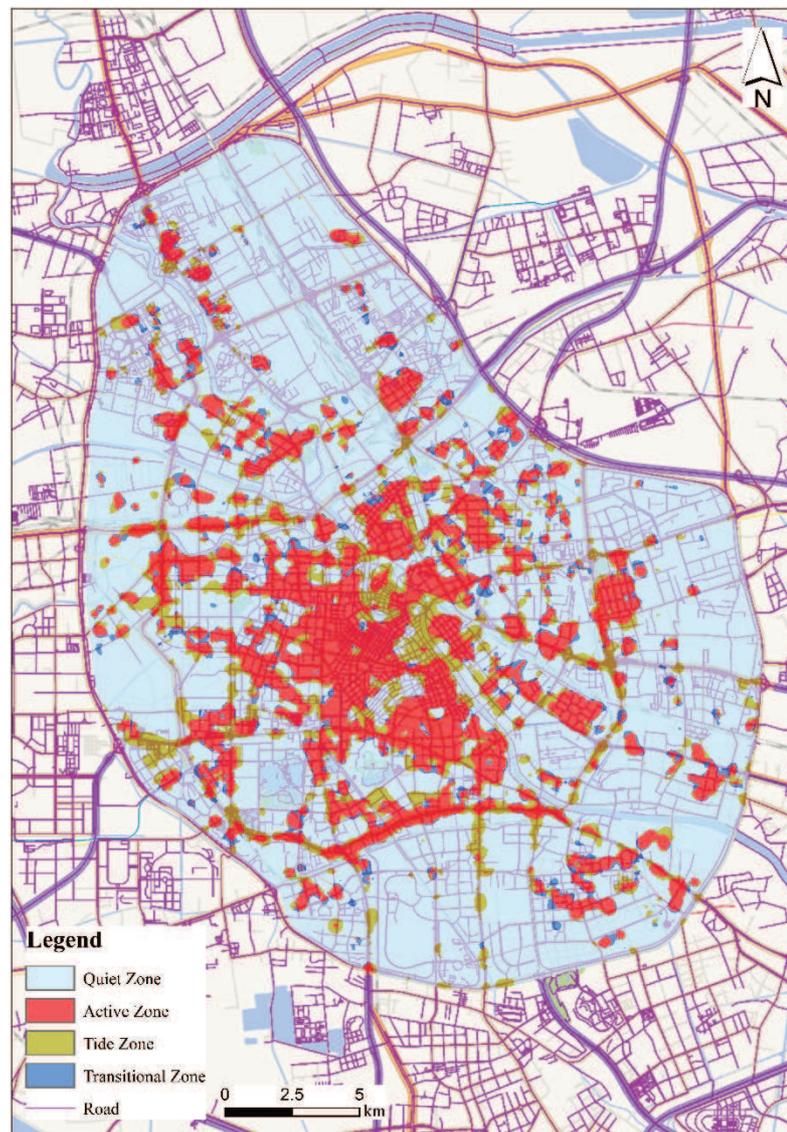


Fig.6 vitality space classification result of Tianjin core area

Through the above classification method, the type recognition of the areas within the outer ring road of Tianjin was performed, and the obtained results are shown in the figure above. Analyzing the spatial pattern characteristics of the vitality types in Tianjin, it is found that Haihe River, as the birthplace of Tianjin, has a strong interference effect on urban vitality. More than 50% of the active space is distributed on the southwest side of it, and its integrity is strong. Patches of vitality distributes independently, the size of patches is basically in line with the scale of the block. In the study of vitality, each block is relatively independent, and the level of activity is not much different. The diffusion effect caused by the vitality of one block isn't significantly stronger than that of other blocks. As a typical tourist area, the Italian style area and Xiaobailou area in the middle of the Haihe River show obvious tidal attributes. It is a dynamic area that promotes urban culture and promotes tourism development during the day, but lacks vitality at night. The blue-green space

and scenic spots in the city are all quiet spaces. For example, the Five Avenues Tourist Area is located in the southwest side of the Haihe River. It is a quiet space in an isolated and active area. The transition space mostly appears in the outer area of the study area, mostly in the northeast direction, and is wrapped around the small-scale active plaques, indicating that these active plaques have initially attracted popularity, but due to their size and function, the attraction point of vitality has a weak driving effect on the surrounding area. Urban planning can be optimized and organized for specific function combinations.

## 7 CONCLUSION

The spatial classification method based on heat map in this study has certain practical significance in the study of spatial vitality pattern. This paper can basically achieve the goal of evaluating the type and spatial pattern of urban densely populated areas through Baidu real-time heat map products. Taking the core area of Tianjin as an example, the 24-hour data on November 21, 2019 were processed. The analysis results are as follows: The full-time urban vitality spatial pattern is that the southwestern region is more active, more widely distributed, and the active areas in the northeast of the Haihe River are scattered. The connection between the vitality areas in the northeast should be strengthened; the number of peripheral vitality plaques is large and the area is small, and there is a need to plan for vitality improvement and transformation to make it a new space active pole.

From a methodological point of view, this method studies the distribution of urban space vitality from a macro perspective through data methods, which can be used as a pre-analysis and analysis of urban vitality enhancement construction. It is also hoped that through this thesis, more scholars will be able to focus on China's urban data construction, and more data sources will be used in urban planning and construction in the future. Of course, there are still many deficiencies in this study, such as: there must be more data verification of urban space vitality on weekdays, how to adjust the underactive areas needs further in-depth analysis, whether the active areas are too active and form negative space. The above issues urgently need further research and discussion.

## 8 REFERENCES

- [1] Cranshaw, J., Schwartz, R., Hong, J.I., Sadeh, N.: The livelihoods project: utilizing social media to understand the dynamics of a city (2012)
- [2] González, M.C., Hidalgo, C.A., Barabási, A.L.: Understanding individual human mobility patterns. *Nature* 453(7196), 779–782 (2008)
- [3] Jacobs J. *The Death and Life of American Cities*[M]. New York: Random House, 1961.
- [4] Alexander C. *A Pattern Language: Towns, Buildings, Construction*[M]. Oxford university press, 1977.
- [5] Katz P. *The New Urbanism: Toward an Architecture of Community*[M]. New York: McGraw-Hill, 1994.
- [6] Montgomery J. Making a City: Urbanity, Vitality and Urban Design[J]. *Journal of Urban Design*, 1998, 3 (1) :93-116.
- [7] Gehl J. *Life Between Buildings: Using Public Space*[M]. Island Press, 2011.
- [8] Rachuri, Kiran K, Efstratiou, Christos, Leontiadis, Ilias, etc. Smartphone sensing offloading for efficiently supporting social sensing applications[J]. *Pervasive & Mobile Computing*, 10(part\_PA):3-21.
- [9] Yu L. Revisiting several basic geographical concepts: A social sensing perspective[J]. *Acta Geographica Sinica*, 2016.