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Spatial Distribution Patterns of Urban Historic Building Groups Combined with Algebraic Geometry and Their Planning and Design Strategies Research

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ABSTRACT

Six historical building clusters in the main city of Changchun, namely People's Street, Xinmin Street, the Palace of the Forged Manchus, the South Square, the First Automobile Manufacturing Plant, and the Kuanchengzi Station of the Middle East Railway, with a total of 2,501 historical building sites, are taken as the research objects. Using ArcGIS software, the morphology and spatial distribution pattern of the historic building clusters in the main city are discussed based on the perspective of spatial layout by invoking spatial measurement methods such as kernel density, standard deviation ellipse, algebraic geometry, and spatial correlation, etc. The results are summarized in the following table. The results show that the spatial distribution of historic buildings in the main city of Changchun is dominated by a “single center (People's Square)” agglomeration, with a maximum kernel density of 0.9950. At the same time, the periphery also appeared to diffuse re-agglomeration, hierarchically showing a “two-axis” diffusion pattern. Among them, the main axis resides in the center of the city and extends infinitely from north to south. The secondary axis is the administrative office and center of the pseudo-Manchukuo State, which is the pseudo-Manchu Imperial Palace and Xinmin Street respectively. Finally, from the perspective of planning and design, it tries to put forward the strategy of protection and utilization, including environment, function, and culture, etc., to provide methods and bases for the holistic protection and utilization of Changchun's historical buildings.

Keywords: historical building complex, ArcGIS, algebraic geometry, spatial distribution, planning design

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1. Introduction

Residential buildings and traditional streets and alleys preserved in the city under historical changes often show the historical value with their unique appearance, and also reflect the lineage of urban development. However, with the acceleration of urbanization, the spatial distribution and planning design of historical building groups have become an important part of urban planning. Historical building groups are closely related to the organization of urban space, which is not only a simple stack of buildings, but also should reflect the multiple relationships of society, culture and environment. Among them, the principle of architectural design is based on the considerations of functional needs, pedestrian flow lines, convenience of use and customs, etc., in order to divide the different functional areas and make the building space more rational and efficient [1-2]. First of all, the architectural design should pay attention to the diversity, flexibility and auditory perception of the spatial structure [3-4]. For example, it is possible to combine residential and commercial facilities, which not only meets the living needs of residents, but also creates a vibrant commercial space. Secondly, the architectural design should also consider the humanization of space, sustainable development and environmental conditions [5-7]. For example, parks and recreational facilities should be set up in residential areas to provide residents with places for leisure and recreation, as well as environmentally friendly building consumables. In addition, the architectural design also needs to be coordinated with urban planning to meet the spatial aesthetics of the building group [8-9]. For example, public transportation hubs can be set up in the buildings to facilitate the travel of residents and tourists. Finally, the architectural design should also focus on innovation, cultural heritage and protection [10-11]. For example, the integration of modern design concepts in the historical building groups, to create a new space with a unique flavor. Only when these aspects are fully considered can we create a more livable urban environment and improve people's quality of life. The architectural design is one of the important applications of algebraic geometry, which involves the spatial planning, shape and size planning, and façade design of buildings [12-15]. Therefore, the application of algebraic geometry to urban architectural design is an important means to realize the spatial distribution and planning design of urban historical building groups.

Abstracting geographical entities into points of interest is a common method to study the distribution characteristics of various things within the city. This study attempts to take is the spatial distribution of historical buildings as an entry point to analyze the essential characteristics of the spatial structure of the historical building clusters in the main city of Changchun, which is conducive to embodying the state of historical building clusters in terms of agglomeration and diffusion. Through the spatial autocorrelation, kernel density, algebraic geometry and other methods in ArcGIS software, the spatial aggregation of the geographical distribution pattern of 2,501 buildings is studied, and its spatial distribution pattern is analyzed to restore the urban development space and the social spatial structure of the historical architectural planning, so as to construct the planning and design strategy of Changchun City.

2. Study area, data sources and methodology

2.1. *Study area*

2.1.1. Geographical location. This study takes the main urban area delineated in the Changchun City Master Plan (2010-2020) as the study area, with a total area of 1351.25km^2. The main urban area encompasses the built-up area of Changchun, suburban areas and some peripheral township groups, which can comprehensively reflect the spatial distribution characteristics of the urban historical building groups in the core area of the city, and the study area is shown in Figure 1.

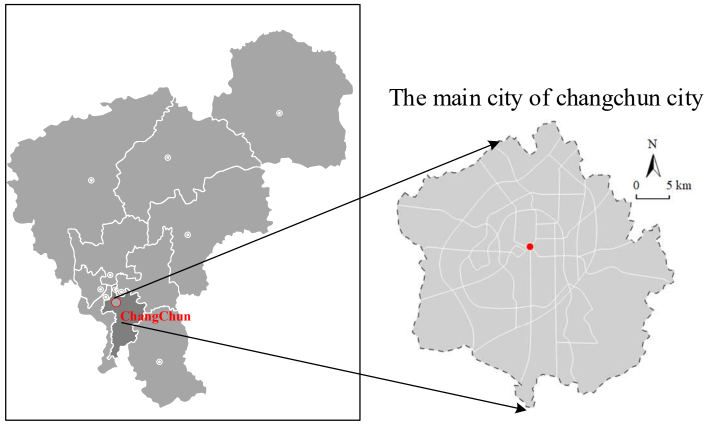


Fig. 1. Study area

2.1.2. Changchun Historic Complex. Existing historical buildings in Changchun are mainly located in Kuangcheng District, Chaoyang District, and the Automobile Industry and Economic Development Zone. Historical building types in different administrative areas have their own different characteristics due to their historical reasons. According to their different spatial distribution characteristics and the distribution characteristics of historical building areas, we can summarize the corresponding logical correlation for the implementation of the overall conservation strategy and planning strategy. Taking Kuancheng District as an example, it is mainly characterized by the historical architectural remains constructed during the pseudo-Manchurian and Tsarist Russia periods. The main building types are residential buildings, commercial buildings, religious buildings, administrative office buildings, hotel buildings, cultural and educational buildings. The second is the Automobile Industry Development Zone, where the main historical building types are industrial heritage buildings, mainly dominated by FAW plants. Again, the Chaoyang District is dominated by industrial heritage buildings, residential buildings, and commercial buildings. The building types are relatively homogeneous, and the historical buildings were basically constructed after 1930.

The spatial layout structure of the historical and cultural complex is summarized as “one axis, five sections”.

1) An axis, along the People's Street for a historical style sequence axis.

2) Five sections, from north to south will be divided into five sections of People's Street, including Changchun Railway Station to Shengli Park, Shengli Park to Jiefang Road, Jiefang Road to Freedom Road, Freedom Road to Satellite Road, Satellite Road to the municipal government.

The historical building complex of the section from Changchun Railway Station to Shengli Park concentrates on the low, small and eclectic style buildings before 1940, with the colors of grey, light yellow, rice-white and brown as the main colors of the façade. The historical architectural complex of the section from Shengli Park to Jiefang Da Road concentrates on the combination of western modern urban planning ideas and Chinese traditional planning ideas, with courtyards mainly in the former courtyard style and the overall space is open and atmospheric. The historical architectural cluster on the section from Jiefang Dajie to Freedom Dajie focuses on the combination of historical and modern architecture, with a high and low skyline and a large architectural volume. The architectural style of the historic preservation buildings is dominated by Oriental and eclectic styles, and the buildings are more colorful. The historical building style from Freedom Avenue to Satellite Road is mainly eclectic, interspersed with excellent contemporary buildings, and the colors of the buildings are mainly deep red and earthy yellow. The historical buildings from Satellite Road to the City Hall are mainly large in size, with an undulating skyline, and the architectural styles of eclecticism and Japanese temple-style buildings. In addition, this section has a relatively high concentration of excellent modern buildings with high building heights.

2.1.3. Research Value of Historic Buildings in Changchun. Changchun is a typical city in China with baroque artistic temperament, with a grand and imposing radioactive axis, a more complete square system, roads and public buildings form a unique atmosphere Changchun is a model city with a grand and imposing radioactive axis city. The road network in the main city reflects the typical baroque characteristics and continues in today's urban pattern. The three important axes of Changchun, Renmin Avenue, Xinmin Avenue and Dama Avenue, are the spatial witnesses of Changchun's century-long history of urban development. Among the three axes, Renmin Avenue and Xinmin Avenue are the most prominent parts of Changchun's historical architectural and cultural characteristics, as they link up Changchun's century-long urban construction history.

At the same time, the establishment of the pseudo-Manchukuo state brought about a larger scale of urban planning and construction led by the colonizers. In 1932, the Xinjing Construction Plan was formulated, and the city of Xinjing was constructed from 1932 to 1934, which was the first unified urban planning in Changchun, and was rapidly implemented on a large scale. In this planning, political factors played a direct role in the construction of Changchun, and the prominent urban functions of regional economic center and transportation hub gave way to the political center of the pseudo-Manchurian rule. Historical architectural heritage conveys historical facts, and preserved historical imprints, conveying a large amount of historical information is an extremely valuable resource.

In conclusion, the study of the spatial distribution pattern of Changchun's historical buildings and the planning of this paper have certain cultural and historical value.

2.2. Data sources

The adopted data sources of spatial outlets are mainly based on electronic maps such as Baidu and Tencent, and at the same time, relevant information is collected and referenced to update the data uniformly until 2024, and the land use data is mainly derived from the current status map of Changchun City's master plan land use (1:100,000). After comparative study, a total of 2501 outlets data of Renmin Avenue historical building cluster (A1), Xinmin Avenue historical building cluster (A2), the pseudo-Manchu Imperial Palace historical building cluster (A3), the South Square historical building cluster (A4), the First Automobile Manufacturing Factory historical building cluster (A5), and Middle East Railway Kuanchengzi Station historical building cluster (A6) are selected as the study area, as shown in Table 1. The 2501 outlets of these six historic building clusters can basically reflect the main characteristics of the basic spatial distribution of historic buildings in the main city of Changchun. Combined with Google maps, the latitude and longitude of the points were determined, imported into ArcGIS software, and the authenticity and accuracy of each outlet data were judged and corrected.

Table 1. Historical buildings network data and source description

Architectural complex	Dot data	Main contents
A1	485	The historical architecture remains in this area mainly include the buildings in the Manchu period and the Manchu period, which is an area with outstanding urban architecture characteristics in Changchun.
A2	733	The planning design, landscape construction and architectural design of this area take into account the traditional Chinese urban planning concept and also absorb the modern western planning concept.
A3	512	The Royal Palace of the puppet Manchu is the most well-preserved architectural complex among the existing palace architectural sites in China.
A4	204	It is the core area of the annexed area of Manchu Railway during the Japanese occupation period, and the current historical buildings are very intact
A5	371	This area is the beginning and witness of China's industrial development, and also the beginning of Changchun's urban transformation into an industrial economy. It is also one of the largest industrial gathering areas and supporting residential areas built after liberation.
A6	196	This area reflects the transformation of Changchun from military rule to transportation hub functional city during its initial establishment.

2.3. Research methodology

2.3.1. Kernel density analysis. Kernel density analysis is a visualization method used to explore the pattern of data distribution, which calculates the probability density function of a data distribution by estimating its kernel density and plots it in a graph to explore the distribution of hotspots in a spatial region and the characteristics of changes [16].

Kernel density estimation is a nonparametric statistical mathematical method, the basic idea is to estimate the probability density function of the data distribution by placing a kernel function at each data point in the data sample, this process can be regarded as an approximation of the probability density function, and its principle is shown in Fig. 2. Specifically, the sample points are treated as a set of independent and identically distributed random variables, and the unknown probability density function is estimated by selecting a kernel function and a bandwidth parameter, and weighting and summing the contributions in a certain area (a circular area with a bandwidth radius) around each sample point. Data points closer to the center are given higher weights and vice versa, and the estimated density for each point is the weighted average density of all data points in the region.

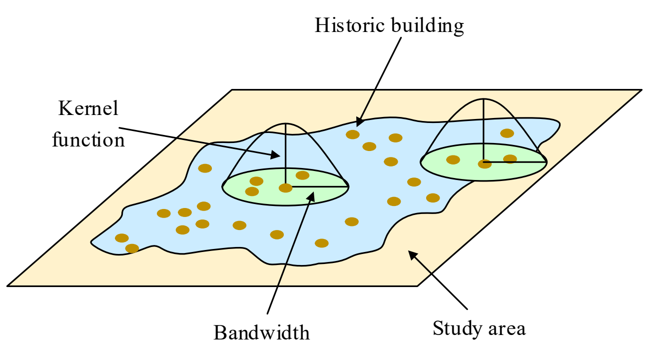


Fig. 2. Schematic diagram of kernel density estimation principle

Let x_n be an independent sample drawn from some unknown probability density function $\hat{f}(x)$, and h be a positive number called the bandwidth (or window width). The basic formula for the kernel density estimation method is as follows:

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

where $\hat{f}(x)$ denotes the density estimate at x, n denotes the number of data points in the dataset, bandwidth h controls the range of influence of the kernel function in the estimation process, and $K(x)$ is the kernel function.

The role of the kernel function in kernel density analysis is to smooth the data distribution, eliminate noise and outliers in the data, and obtain a more continuous and natural distribution profile.

The kernel function usually has the following two properties:

1) non-negativity, the kernel function is always greater than or equal to zero in the domain of definition, i.e.:

$$K(-x)=K(x) \tag{2}$$

2) Normalized, the integral (or summation) of the kernel function is equal to 1 over the entire domain of definition, i.e:

$$\int_{-\infty}^{\infty}K(x)dx=1 \tag{3}$$

At present, the main commonly used kernel functions are Gaussian kernel function, Yeppanichnikov kernel function kernel function, rectangular kernel function and so on.

(1) Gaussian kernel function. Gaussian kernel function, also known as normal kernel function, is one of the most commonly used kernel functions in kernel density estimation. Gaussian kernel function has smoothness and symmetry, and its basic mathematical form is:

$$K(x)=\frac{1}{\sqrt{2\pi}}e^{\frac{-x^2}{2}} \tag{4}$$

The Gaussian kernel function takes its largest value at the center point and decreases with distance, producing a smooth distribution curve.

(2) Yipanechennikov kernel function. The Yipanechennikov kernel function has the excellent property of minimizing the mean square error and bias. Its basic mathematical form is:

$$K(x)=\begin{cases}\frac{3}{4}\left(1-x^2\right) & |x|\le 1\\ 0 & |x|>1\end{cases} \tag{5}$$

The Yipanechennikov kernel function is more widely used in kernel density estimation. One of its important features is that it has smaller bias and variance compared to other kernel functions, and thus can produce more accurate estimates under certain conditions.

(3) Rectangular kernel function. The rectangular kernel function is also known as the box kernel function, and its basic mathematical form is:

$$K(x)=\begin{cases}\frac{1}{2b} & |x|\le b\\ 0 & |x|>b\end{cases} \tag{6}$$

Considering that the number of samples in this study is 2501, and the Gaussian kernel function has the advantages of smoothness, continuity, good mathematical properties as well as approximation to the real distribution in kernel density estimation. Therefore, in this paper, a modified quadratic kernel function that approximates the Gaussian kernel function is chosen as the kernel function for calculating the kernel density estimation of the spatial distribution of historical buildings in the main urban area of Changchun.

Its expression is as follows:

$$K_0(h) = \frac{3}{\pi}\left(\left(1-h^2\right)\right)^2 \tag{7}$$

2.3.2. Algebraic geometric analysis. Boundaries, centers of gravity, networks, and textures are dependent on the urban material space, but because they cannot be directly perceived by human beings themselves, they need to undergo a series of complex calculations, and then be quantified or geometrically abstracted, and converted into readable index data and geometrical forms [17]. In this paper, we analyze 2501 historical building sites in Changchun main city through algebraic geometric analysis, and excavate the geometric features of boundary, center of gravity, network, and texture of the historical buildings in the area, as well as the characteristics of spatial distribution differentiation.

1) Boundary shape. On the basis of identifying the boundary line of Changchun's main urban area, the 2,501 historical building points are analyzed using shape index, aiming to summarize the common features of Changchun's historical building groups through quantitative calculations.

Specifically, the complexity of a shape is measured by calculating the degree of deviation of the shape from a circle, or a square, of the same area. The larger the shape index, the higher the complexity of the boundary line and the more complex the form. Conversely, the smaller the shape index, the closer to 1, the closer the shape of the boundary line of the Changchun Historic Complex is to European geometry.

The formula for the shape index with a square as the reference is:

$$P_S = \frac{0.25L}{\sqrt{A}} \tag{8}$$

where P_s represents the shape index of a square as a reference, L is the total perimeter of the boundary of the study area, A is the total area of the study area, and the closer the value of shape index P_s is to 1, the closer the boundary line of the area is to a square.

The shape index formula with a circle as the reference is:

$$P_c = \frac{L}{2\sqrt{\pi A}} \tag{9}$$

where P_c represents the shape index of the circle as a reference, L is the total perimeter of the study area boundary, A is the total area of the study area d and the closer the value of the shape index P_c is to 1, the closer the boundary line of the area boundary is to a circle.

2) Center of gravity pattern. The spatial development of the city is unbalanced, and its material spatial form is also uneven. The spatial construction and neighborhood division of Changchun's historical architectural complexes are non-homogeneous, and their spatial centers of gravity are different based on different objects of investigation. Since this paper is based on the spatial form of material entities of urban buildings, two categories of geometric center of gravity and construction center of gravity are selected.

Specifically, the geometric center of gravity measures the center of gravity of the geometric shape of the contiguous built-up area, whose coordinate point falls at the average value of the x and y coordinates of all vertices of the boundary shape of the study area. Based on the ArcGIS software platform operation and export, the coordinate point formula is:

$$X_G = \frac{1}{n}\sum_{i=1}^{n} X_i, Y_G = \frac{1}{n}\sum_{i=1}^{n} Y_i \tag{10}$$

where X_G represents the x -coordinate value of the geometric center of gravity, Y_G represents the y -coordinate value of the geometric center of gravity, n represents the number of vertices at the boundary of the study area, X_i represents the x -coordinate value at the ith vertex position, and Y_i represents the y -coordinate value at the ith vertex position.

Among them, the construction center of gravity measures the center of gravity of urban spatial intensity, i.e., the weighted average center of spatial intensity, whose coordinate point falls at the point constructed by the average x and y values of the center of mass points of the total area of historical buildings. Based on the ArcGIS software platform operation and export, the coordinate point formula is:

$$X_F = \frac{\sum_{j=1}^{n} A_j X_j}{\sum_{j=1}^{n} A_j}, Y_F = \frac{\sum_{j=1}^{n} A_j Y_j}{\sum_{j=1}^{n} A_j} \tag{11}$$

where X_F represents the x coordinate value of the center of gravity of the construction, Y_F represents the y coordinate value of the center of gravity of the construction, n represents the number of points of all historic building elements in the area, X_j represents the x coordinate of the point of the j th historic building element, Y_j represents the y coordinate value of the point of the j th historic building element, and A_j represents the total building area of the j th historic building element.

3) Network form. In addition to the boundary and the center of gravity, the urban form also needs the support of the network skeleton, especially the transportation network represented by the road, which is an important carrier for the urban social and economic activities as well as the passenger and cargo transportation, and as the basis of the material facilities for the transmission of the urban passenger, logistics and information flow, it influences the spatial distribution pattern of the urban buildings.

The center of Changchun main city (People's Square) is used as the center to construct an isometric concentric circle with 1km incremental radius. Specific steps:

First, the geometric center of the triangle of gravity of Changchun main urban area is calculated based on the ArcGIS platform as the center of the concentric circle circle, and the spatial coverage of the analytical model is based on the main urban area of Changchun.

Secondly, a number of concentric circles with a fixed distance of 1km as an incremental radius are constructed with the center to cover the road network and neighborhood spatial elements in Changchun.

Then, the road network density, road network connectivity, average neighborhood size, neighborhood area ratio and other indicators within concentric circles of different radii are calculated.

Finally, scatter plots of each indicator are drawn on the three-dimensional coordinate axes with distance as the horizontal coordinate, and the radius fractal dimension1 of each indicator is calculated, so as to determine the change trend of these indicators with distance.

Where the radius fractal dimension is calculated as:

$$M\left(r\right)=krD \tag{12}$$

Taking logarithms on both sides of the above equation yields Eq:

$$\ln M\left(r\right)=\ln k+D\ln r \tag{13}$$

where D is the number of radius subdimensions, r is the radius of the circumference, $M\left(r\right)$ represents the measure of the corresponding road or neighborhood element within the circumference, and k is a constant in the presence of $M\left(r\right)\propto rD$.

4) Texture form. Texture is literally the organization texture of things, from the level of urban material space form texture refers to the organization texture of the surface of urban material space, urban texture reflects the organization form and type characteristics of urban material space. In order to reflect the internal spatial organization order of the texture of the historical architectural complex in the main city of Changchun, the architectural texture and its external spatial texture are selected as the objects of measurement and analysis, and based on the lattice fractal dimension model as the method of measurement, respectively, the architectural texture of the city is transformed into quantitative indexes that can be quantitatively described, so as to reveal the characteristics of the change of the hierarchical order of the texture form and planar pattern of the historical architectural complex of this region.

The formula for calculating the grid fractal dimension number of architectural texture and building external space texture is:

$$N\left(\frac{L}{2^{n}}\right)=2-D*N\left(\frac{L}{2^{n+1}}\right) \tag{14}$$

where D is the number of grid dimension, L represents the grid edge length covering the research object, the grid edge length L bisecting the grid cells to get the grid cell for the $L/2$ subdivided grid, subdivided into the n th step, the grid cell edge length is $L/2^{n}$, n represents the number of times the grid is divided into equal parts. At this point, the number of statistical non-empty grid or the number of blank grids will be $N\left(L/2^{n}\right)$, N and grid cell length into double logarithmic coordinates on the graph, these points are distributed along a straight line, the slope of the straight line that is the number of grid dimensions of the research object.

2.3.3. Standard Deviation Ellipse Analysis. The standard deviation ellipse (SDE) is an important method in statistical methods to study the characteristics of the spatial distribution of elements [18], which can accurately reveal the central, discrete and directional trends of the spatial distribution of geographic elements, and a range of standard deviation ellipse can include the quality centers of input elements that account for about 68% of the total number of elements when the elements have a normal distribution.

2.3.4. Spatial correlation. The reality of spatial statistical analysis is based on the fact that each unit of spatial existence is not independent of each other, and each unit is related to and influences each other.Moran's index is a commonly used index in spatial data analysis, and in this chapter, Moran's index is used to measure whether there is an overall and local spatial correlation between the historical architectural clusters of Changchun's main urban area.

Spatial autocorrelation studies whether the spatial aggregation effect exists or not, and its value is between [-1,1], Moran'I is greater than 0 for the existence of spatial positive correlation, and less than 0 indicates the existence of spatial negative correlation, and the closer the absolute value is to 0, the closer the relationship is [19]. The Moran's index model in this paper is:

$$I = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij} (x_i - \bar{x})}{s^2 \cdot \sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij}}$$
$$s^2 = \frac{1}{n} \cdot \sum_{i=1}^{n} (x_i - \bar{x})^2 \tag{15}$$

where, I is the Moran index, n represents the total number of historical buildings in the regional space, and 2501 is selected in this study. w_{ij} is the spatial weight matrix of historical buildings, and the spatial weight matrix mainly has neighbor matrix and distance matrix, and the distance matrix includes economic distance matrix and inverse distance matrix, which is mainly constructed based on the geographical distance between the districts of the study area.

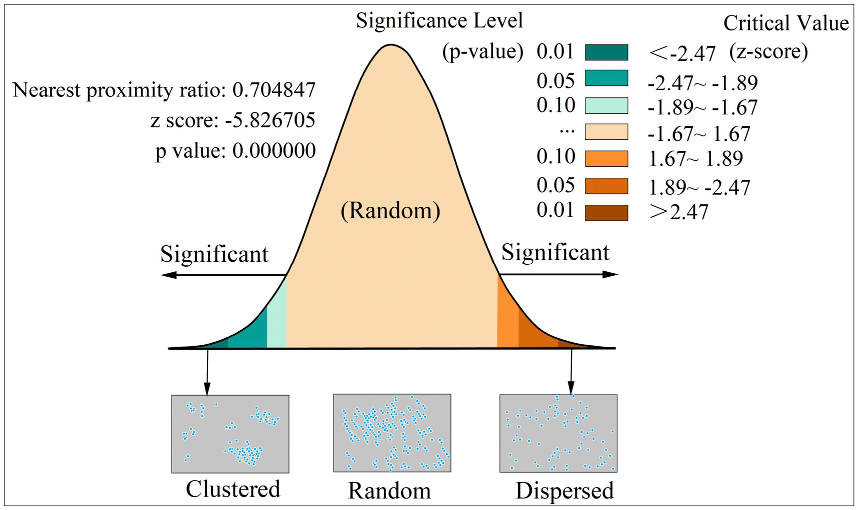
3. Analysis of the spatial distribution of historic building groups in Changchun

3.1. Spatial distribution of historic buildings based on ArcGIS analysis

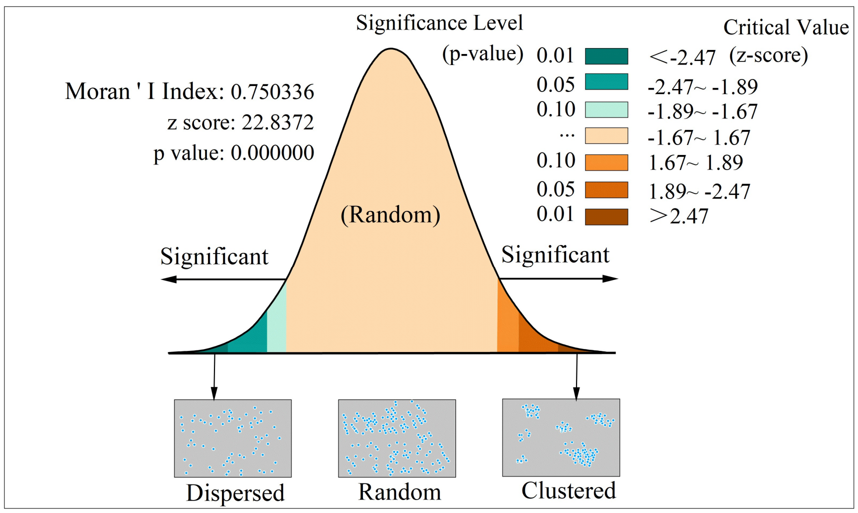
Using ArcGIS software analysis, combined with spatial autocorrelation, kernel density, algebraic geometry and other methods, the geographic distribution pattern of 2,501 buildings of the historical building cluster in the main city of Changchun is studied in terms of spatial aggregation, analyzing its spatial distribution pattern, and restoring the space of urban development and the social-space structure of the historical architectural planning, so as to construct the planning and design strategy of Changchun City.

3.1.1. Spatial autocorrelation analysis. The nearest-neighbor analysis and autocorrelation analysis (Moran's index) methods in geospatial analysis were used to analyze the spatial clustering status of the historical architectural clusters in the main urban area of Changchun. Average nearest neighbor analysis refers to judging the spatial distribution pattern based on the ratio obtained by dividing the average distance between the average center of each building and the average center of its nearest site by the expected average distance. If the nearest-neighbor index is less than 1, it means that the average distance between the average centers of historical building clusters in each period is less than the average distance in the hypothetical random distribution, and the spatial distribution pattern shown is the clustering distribution. The lower the nearest neighbor index, the more obvious the degree of clustering distribution. Spatial autocorrelation analysis is used to determine whether there is autocorrelation in space, i.e., to determine whether spatial entities within a certain range are correlated with each other, and the value of Moran's index is distributed in [-1,1], and if it is distributed in [0,1] it indicates that there is a positive correlation between each entity building.

The nearest neighbor analysis curves and autocorrelation analysis curves of 2501 building points in the historical building cluster in Changchun main city are shown in Figure 3. The nearest neighbor ratio is 0.704847 (Fig. 3a) and the Moran index is 0.750336 (Fig. 3b), indicating that the spatial analysis of the historical building cluster in the main city of Changchun has an autocorrelation clustering distribution pattern.



(a) Nearest neighbor analysis curve



(b) Autocorrelation analysis curve

Fig. 3. Spatial autocorrelation analysis of historic buildings in Changchun main urban area

3.1.2. Standard deviation elliptic analysis. Using the directional distribution (standard deviation ellipse) method in ArcGIS software to analyze the historical buildings in the main city of Changchun, the larger the difference between the long axis and the short axis of the ellipse, the more obvious the trend of distribution of the existing historical buildings in the region along a certain direction, that is, the more obvious the axis of distribution is. On the contrary, if the output ellipse is closer to a circle, it means that the distribution of historical buildings in each direction is more even and there is no obvious distribution direction.

The spatial standard deviation ellipse of the distribution of historical buildings in the main urban area of Changchun is shown in Fig. 4, which shows that the difference between the length of the long axis and the short axis is obvious, the long axis is in the north-east direction, and the buildings are mainly distributed along Renmin Avenue and Xinmin Avenue, and the distribution is concentrated.

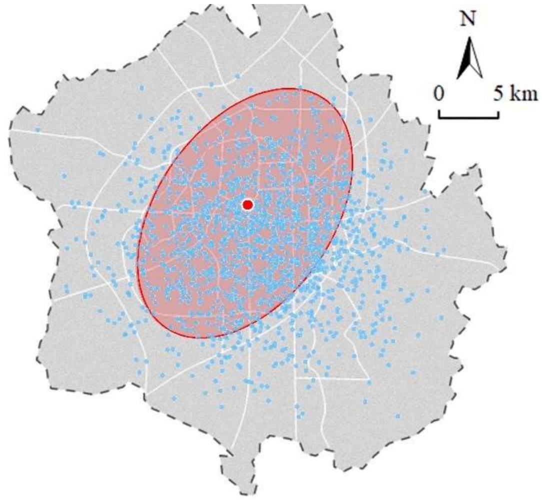


Fig. 4. Ellipse analysis of spatial standard deviation of historical buildings

3.1.3. Kernel density analysis. By calculating the density of elements in the surrounding neighborhood, we find out the distribution law of spatial element point concentration. With ArcGIS software, using the kernel density analysis tool in the Spacial Analyst module, according to the spatial distribution characteristics of the historical building groups in Changchun main urban area, the distribution density of the existing historical buildings in Changchun main urban area was analyzed to obtain the distribution density as shown in Figure 5. Among them, the darker color indicates the higher distribution density of historical buildings in that place. By analyzing the kernel density, it can be seen that the existing historical buildings in this area are clustered along People's Park, with a maximum kernel density of 0.9950, and are distributed more along People's Street to the north and south. Among them, the northern part of People's Street is the most clustered, which is mostly commercial and financial or entertainment land, and the administrative land around People's Square is also denser. The existing historical buildings on both sides of Xinmin Street are also more clustered, and most of them are the administrative buildings of the pseudo-Manchu period.

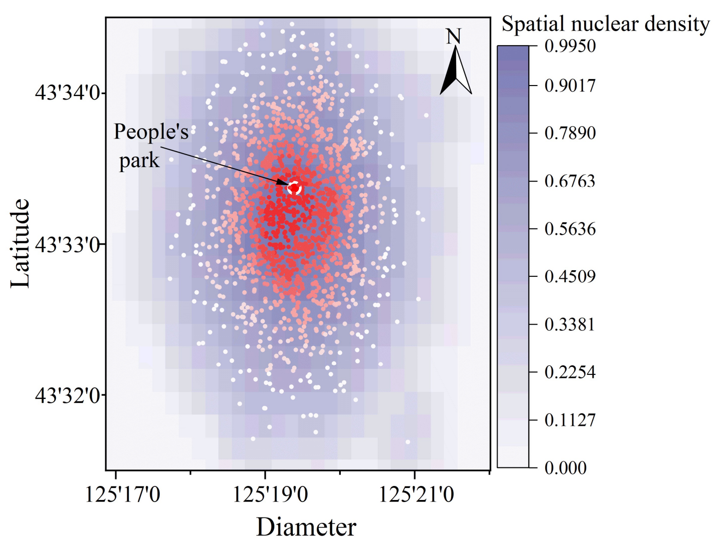


Fig. 5. Nuclear density distribution of historic buildings in Changchun main urban area

3.1.4. Spatial Distribution Patterns on the Twin Axes. Changchun main city after the pseudo-Manchukuo capital construction planning, in the city construction style, the use of baroque ring-type plaza, radioactive main street and grid shape combined with the urban spatial form, in the urban structure of the formation of dual-axis, “main and secondary dual-axis” of the urban framework structure. The main axis, the main heart for the Japanese military and political ruling bodies, respectively, the layout of the district line and the ruling center, that is, the people's street and the people's square, imposing. Sub-axis for the Manchukuo administrative offices and the center, respectively, for the pseudo-Manchurian Imperial Palace (now Geological Palace) and the first automobile manufacturing. The main axis resides in the center of the city, sitting in the north to the south of the infinite extension, the sub-center of the surface of the “heavenly square”, the axis of the north-south depth, but in fact the region north and south were cut off by the Imperial Gardens and South Lake, resides in the local area.

1) Main Axis. The main axis, the architectural group of 2, respectively, the People's Street historical architectural group (A1) and Xinmin Street historical architectural group (A2). Historical protection of 734 buildings, the number of historical buildings distributed, the Japanese Kwantung Army Command and other occupying and architectural volume of magnificent, architectural forms, architectural protection is intact. North from Changchun Railway Station, to the People's Street to the south extends for the city's main axis, the formation of the railway station transportation center as a starting point, station south of the Manchurian Railway Dependencies industrial and commercial centers, the People's Square colonial rule centers, the South Ridge culture, education, science and health colonial ideological transmission centers, T-shaped main axis linear layout characteristics.

Urban architectural space based on the Manchurian Railway Annex, focusing on the construction of the People's Street as the main axis of the southern extension of the area and the secondary axis on both sides of Xinmin Street area. Large buildings in addition to continue to build economic groups, municipal utilities, military and political institutions, cultural and educational units and religious rituals, etc., the distribution of the total number of numerous, different sizes and styles of the pseudo-Manchurian period of the rapid development of the architectural complex. In particular, the architectural style, steppe architecture, modern architecture, and traditional architecture, changed to "Manchurian" architecture, which fully demonstrated the change of colonial political intentions of the Japanese colonizers from "leaving Asia and joining Europe" to "royal Taoism", and made the urban architectural thinking fully implement the transformation of Western-style architecture and local architecture to "Pan-Asianism".

2) Secondary Axis. Sub-axis, the architectural complex of 2 places, respectively, the pseudo-Manchu Imperial Palace historical complex (A3) and the first automobile manufacturing plant historical complex (A5). Historically protected buildings 331, although the number is not large, but the pseudo-manchu period, “eight departments” concentrated distribution, is the “Xingya-style” architecture of the typical works, is the pseudo-manchu puppet rule of the implementation of the area and the main official residence distribution place, is located on both sides of the Xinmin Street and the Cultural Square It is located on both sides of Xinmin Street and Culture Square and carries the functions of Japanese colonial rule. At the same time, it is also the collective architectural style of the First Automobile Manufacturing Plant of New China. The existing historical buildings are of grand scale and distinctive features, mostly composed of main buildings, annexes and closed courtyards. The basic form of the architectural style emphasizes symmetrical composition, highlights the visual effect of the roof, pays attention to the proportionality of the windows, and imitates or draws on the common methods of the “Manchurian style”. Postmodernism” is expressed from the “cultural lineage”, and adopts the overall imitation or partial transplantation of various architectural forms or spatial patterns.

3.2. Analysis of the correlation between spatial vitality and functionality

The protection of historical buildings cannot only rely on protection measures, but should also be widely concerned by people from all walks of life, and active protection means and development and utilization strategies should be adopted to develop and utilize Changchun's historical buildings in depth, while this section analyzes the spatial vitality of the region's historical buildings and the correlation analysis with the functional sectors, which can provide references to planning and designing of the historical buildings.

The degree of influence of functional modes on the spatial vitality of the six historic building clusters can be derived from the correlation analysis of the kernel density of functional modes with the population heat index. The extreme values, mean values and standard deviations of the nuclear density of working days, rest days and various functional modes in each neighborhood were counted by ArcGIS software. The thermal index and the parameters of the kernel density of functional sectors for the six historic building clusters in the main city of Changchun are shown in Table 2, and it can be seen that the thermal value of the six historic building clusters on weekdays is 1.8981 (on a scale of 1-5), and that the value of the thermal value on rest days is 2.0137. In terms of the kernel density of the functional sectors, the mean value of the People's Square Historic Building Cluster (A1) is the largest of 38,224,840.33, which also indirectly indicates that the main city of Changchun is a cluster of the People's Square Historic Building Cluster. The main urban area is a spatial layout pattern with People's Square as the gathering center and spreading out in all directions. The People's Street Historical Complex is the political, commercial, entertainment and cultural center of Changchun.

Table 2. Thermal index of historical buildings and operational core density parameters

	Minimum value	Maximum value	Mean value	Standard deviation
Working day heat value	1	5	1.8981	0.5021
Rest day heat value	1	2	2.0137	0.4409
A1	0	146725283	3822484.33	11752332.26
A2	0	28859406	890405.40	2848665.67
A3	0	19880550	561105.19	1893347.16
A4	0	7890521	323058.77	872806.97
A5	0	7010084	50423.08	394552.44
A6	0	17344250	289005.88	1317337.56

The correlation between the historical building complex and the degree of crowd gathering was analyzed by correlation, and the results are shown in Table 3. The analysis found that the density of functional business is positively correlated with the degree of crowd gathering ($P \geq 0.05$).

Table 3. Correlation between thermal index and kernel density

	Working day heat value		Rest day heat value	
	Mean value	Standard deviation	Mean value	Standard deviation
A1	0.5033**	0.6785**	0.6842**	0.5819**
A2	0.4348**	0.2254*	0.6342**	0.5213**
A3	0.4205**	0.2731*	0.4812**	0.4431**
A4	0.2619*	0.3675**	0.7915**	0.5663**
A5	0.2364*	0.2889*	0.6343**	0.4942**
A6	0.2758*	0.3806**	0.4334**	0.3983**

In terms of functional business composition, the commercial space in the historic building cluster lacks its unique functional positioning. Among them, there are more commercial complexes in the People's Street Historical Complex (A1), which affects the vitality of the stores in the pedestrian street. The functional modes of the Xinmin Street Historical Complex (A2) are relatively single and backward, with poor adaptability to changes in the consumption structure of the crowd. The overall commercial vitality of the Fake Manchu Imperial Palace Historical Complex (A3) is low, with only one large shopping mall with high vitality, and the overall commercial atmosphere of the neighborhood is weak, which needs to be optimized and improved through the adjustment of the functional modes to the existing problems of the functional modes of each neighborhood.

4. Planning and design strategies for historic building complexes

4.1. Environmental planning strategies

In addition to its own historical, artistic and scientific value, each historical building also derives its spatial environmental value and memory value by integrating with its surrounding environment such as plants and trees, streets and lanes, as well as the characteristics of its geographical location and other related factors. Therefore, the protection and utilization of Changchun's historical buildings should not only stay in the maintenance and use of the historical buildings themselves, but also take into account the effective management of the environmental space for the survival of the historical buildings, and create an environmental space for the historical buildings that inspires the public to love them. This will strengthen the memory and protection consciousness of historical buildings. Therefore, the strategy of environmental protection of historical buildings should be the following aspects of work.

1) Preparation of protection plan. Changchun has a large number of historical buildings, involving a wide range. Moreover, the property rights belonging to them are complicated, and it is difficult and impractical to protect and utilize them in the same way and at the same time. So the protection of Changchun historical buildings is first of all to do a good job of investigation, master these Russian buildings ontology and environmental conditions, and identification and record. Do a good job of preliminary investigation and preparation work, so as to develop a specific conservation planning program accordingly.

2) Delineate the scope of protection of historic buildings. Historical buildings and their environment is a kind of symbiotic relationship, purely protect the historical building body without regard to the environment in which it is good or bad, will also threaten the future survival and development of historical buildings. The government and relevant departments have formulated corresponding protection and repair strategies, which mainly include cleaning up the environment of historical buildings, restoring the original appearance of their protective restoration, as well as improving the quality of people's livelihood infrastructure renovation, which is of great significance to the protection and development of Changchun's historical buildings.

3) Improvement of the environment around historical buildings. It is found that Changchun's historical buildings are surrounded by residents' affiliated facilities and in a messy environment, which is extremely unfavorable to their protection. Therefore, it is of great significance for the conservation and utilization of Changchun's historical buildings to improve the surrounding environment and maintain their original appearance.

4.2. Functional planning strategies

The best way to protect historical buildings is to fully explore their own functional use and various favorable factors, so that they still have the possibility of use value and economic utilization value while avoiding the secondary destruction of the main structure and materials of historical buildings, and to maintain the originality while carrying out conditional restoration. It is precisely because of the functional use value of historical buildings that people will be prompted to carry out effective protective restoration, thus extending the service life of historical buildings. Therefore, according to the specific situation of Changchun historical buildings, the following strategies are summarized for their targeted functional protection and utilization.

1) Extend the original function utilization. According to statistics, “the protection and reuse of historical buildings and new buildings, compared with 80% reduction in carbon emissions”. It can be seen that the continuation of the use of historical buildings and protective restoration is of great significance to society in terms of saving resources and reducing capacity consumption.

2) Functional replacement utilization. With the change of the social era and the transformation of people's life style, the original function and use of some historical buildings are no longer used by people, so their protection and utilization will inevitably face brand-new requirements, which prompts the transformation of the function and use of historical buildings to adapt to the needs of the modern society. The Changchun Kuan Chengzi Railway Station Club is one of the typical successful cases of functional replacement and utilization of Russian-style historical buildings.

4.3. Cultural planning strategies

Changchun historical buildings have witnessed the vicissitudes of Northeast China over the past hundred years and truly recorded the historical process of construction, operation and development, and are important historical and cultural resources and scarce human landscape resources in the modern history of Northeast China. In order to protect these historical and cultural heritages, it is more important to strengthen the protection and utilization of Changchun historical buildings from the cultural perspective.

1) Excavate and give cultural significance to historical buildings. Changchun historical buildings themselves have distinctive architectural characteristics, showing a strong Tsarist colonial culture, Japanese colonial culture and so on. However, the colonial culture often has a forced and rigid means, the performance of the building often make it produce the feeling of witnessing history. This “traces of history” give new meaning to the historical buildings, so that it has been greatly appreciated.

2) Strengthening cultural publicity and advocating citizen participation. The protection of historical buildings, in the final analysis, is inseparable from the protection of people, so to improve the people's awareness of the protection of historical buildings. Let the public know Changchun historical buildings, understand its historical background and value, expand the protection of group enthusiasm and participation, is the protection and utilization of Changchun historical buildings is an effective way and means.

5. Conclusion

Taking the main city of Changchun as an example, the following main conclusions are drawn from the spatial distribution of historic buildings in the area to understand the urban spatial structure:

First, in terms of spatial core density distribution, the spatial distribution of historic buildings in Changchun's main city reflects the urban spatial structure where agglomeration and diffusion coexist, with a strong “monocentric” character. At the same time, the periphery has also appeared diffusion of re-agglomeration, along the main road “axial” diffusion.

Secondly, the results of geospatial analysis show that the historical buildings in the main urban area of Changchun City have the significant characteristics of cluster-type spatial distribution and distribution along the main and secondary axes of Renmin Avenue and Xinmin Avenue. The area of the pseudo-Manchurian palace, including the pseudo-Manchurian palace, the Wang pseudo-embassy in Manchuria and the Tsarist Russian embassy, is dominated by Western-style buildings, which do not have the traditional symmetrical layout. These buildings, on the one hand, show the high level of construction in the pseudo-Manchurian period, which is a good material for studying the history, theory and technology of Changchun urban planning and construction.

Thirdly, through the analysis of spatial vitality and functionality, the planning and design strategies are proposed, including the overall protection of the environment, the graded protection of functional utilization, and the cultural publicity to raise the awareness of protection, which provide a practical basis for the sustainable development of Changchun's historical architectural heritage.

Due to the limited personal ability and research scope, there are inevitable omissions in the research process, so the relevant content of the paper needs to be further strengthened by subsequent research work. But at the same time, we should also note that the planning and design of historical buildings is a dynamic evolution of the process, to be closely linked with the development needs of the times. Therefore, the research results of this paper is to throw a brick to attract jade, to provide reference for the subsequent related research work, so as to make Changchun historical architectural heritage to play the maximum advantage of performance, to create more value.

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