



Design Strategies for the Integration of Historic District Preservation and Modern Architecture in the Process of Urban Renewal

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SUMMARY: *As an independent geographic unit, a historic district is a cultural card of a city. However, in the process of urban renewal, the regionalized architectural features of historic districts are gradually lost, so it is urgent to re-examine the features of architectural features of historic districts and explore the design strategies for the integration of historic district preservation and modern architecture. The article firstly presents a reconstruction method of historical and cultural neighborhoods based on airborne LIDAR point cloud data. Then, it explores the method of extracting, converting and expressing the 3D digital information of the historic district, and integrates the modern architectural elements. Finally, the spatial syntax and color quantification methods are applied to analyze the landscape features and architectural colors of four historic districts in Jiangsu Province. Through the three-dimensional reconstruction experiment of an ancient building, the absolute value of the error of its architectural reconstruction accuracy result is within the range of 0-3cm, which verifies the validity of the historical neighborhood reconstruction method based on airborne LIDAR point cloud data. Through the numerical analysis of the spatial syntax of the four historic districts in Jiangsu Province, it is found that the average global integration degree and departmental integration degree of Historic District B is the highest, and its global integration degree is 1.9051. That is to say, Historic District B has a larger urban area, a rich road network, and the highest degree of recognition of historic districts. The method of this paper can provide some reference ideas for the integration design of historic district protection and modern architecture.*

KEYWORDS: *point cloud data; airborne LIDAR; spatial syntax; color quantization*

1 Introduction

As the material embodiment of the city's historical and cultural heritage, historical and cultural neighborhoods carry the memories of the local people and are the crystallization of local people's wisdom, and face the dual challenges of protection and development in the wave of urban renewal [1, 2]. In the face of rapid urbanization, many historical and cultural neighborhoods in China are facing the challenge of survival. It is distressing to see that some local governments, in developing a modernized urban landscape, view historical preservation and urban progress as mutually exclusive processes, resulting in serious damage to many historic and cultural districts or their internal architectural heritage and traditional structures. Historic districts are not only crucial for maintaining cultural heritage, but also become prominent symbols for showing urban development and unique cultural charms [3, 4].

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Numerous problems have gradually emerged in the traditional methods of renovating historical and cultural neighborhoods. Nowadays, cities are facing increasing spatial pressure, and more attention has begun to focus on old urban areas in order to find a more economically efficient and implementable renewal model, with the aim of optimizing spatial resource allocation to the maximum extent possible, and thoroughly exploring the potential value of old neighborhoods, so as to make them become a source of power for urban development once again [5-7]. The formation of historic districts is closely related to the development of the city, and their unique spatial layout and architectural composition reflect the local humanistic history and geographic characteristics, and are the result of long-term evolution [8, 9]. Detailed analysis of the unique historical and cultural development of the historic district, spatial structure characteristics and architectural composition of the form, and apply the results of the analysis in the subsequent planning and construction of the neighborhood, to create a unique historical and cultural connotation of the city is of great significance [10-12]. This not only helps to ensure the continuity of the urban cultural lineage and avoid the loss of urban individuality, but also promotes the inheritance of neighborhood culture and sustainable economic development.

In recent years, urban development has been rapidly changing, and when people have not yet established the concept of conservation, the modern buildings implanted in the big demolition and construction type of urban renewal have gradually eroded the characteristic style of the neighborhood [13]. The barbaric growth of modern buildings has disturbed the spatial and temporal dominated architectural iteration of historic districts, the texture of the neighborhoods has been destroyed, the main status of historic buildings has been buried, and the coordination between the old and the new buildings has been lost, so that the vitality of historic districts will be gradually annihilated in the tidal wave of urban construction [14-16]. Fortunately, China attaches great importance to the protection of historic and cultural districts and historic buildings, and has made it clear that all localities should fully understand the importance and urgency of protecting historic and cultural districts and historic buildings, intensify the protection efforts, and resolutely stop all kinds of behaviors that destroy historic and cultural districts and historic buildings [17-19]. How to protect the historical buildings from being “eroded” and how to continue the characteristics of the neighborhood when implanting modern buildings in the historic district has become the focus of scholars when studying the renewal and revitalization of historic districts [20, 21]. The protection of cultural heritage of historical buildings does not mean the sealing of the museum-style glass box, it is the product of urban development, both historical and practical [22, 23]. Therefore, it is necessary to introduce the idea of “harmony and difference” into the issue of implanting new buildings in the renewal of historic districts.

The article firstly proposes a historical and cultural neighborhood reconstruction method based on airborne LIDAR point cloud data. The airborne LIDAR point cloud data is preprocessed, and the laser footpoints are segmented using the area growth algorithm to complete the acquisition of point cloud data of the building, and the Alpha Shape algorithm is used to extract the feature information of the building, obtain the contour lines, and realize the three-dimensional reconstruction of the historical and cultural neighborhood through the method of plane fitting. Subsequently, taking an ancient building as the research object, we realized the construction of the real 3D model of the building. Then we explore the process of extracting, converting and expressing the utilization of three-dimensional digital information of historical buildings, and fully integrate modern architectural elements. Finally, the spatial syntax method is applied to study the spatial characteristics of the historic districts in Jiangsu Province, and the color quantification method is applied to quantify and statistically analyze the color attributes of Suzhou buildings.

2 Historic neighborhood reconstruction methods based on point cloud data

2.1 Methodology for the redevelopment of historical and cultural neighborhoods

2.1.1 Airborne LIDAR data preprocessing

Using airborne LIDAR to acquire point cloud data of historical and cultural neighborhoods, the raw point cloud data obtained contains a large amount of noise, which needs to be removed to facilitate subsequent building edge extraction. Therefore, it is necessary to process the original data of historical and cultural neighborhoods acquired by airborne LIDAR at first. The data preprocessing process is as follows: the noise of the data is categorized into high-altitude isolated points, localized points and hollow points, the high-altitude isolated points are removed by the plane fitting mentioned in the subsequent processing, and the hollow points are assigned values by interpolation. Then, the pre-processed airborne LIDAR data are further processed.

2.1.2 Airborne LIDAR point cloud data acquisition

The region growing algorithm is used to segment the laser footpoints of the buildings in the historical and cultural neighborhoods, and the region growing algorithm can be used to segment the more complex building images in the historical and cultural neighborhoods. The process of region growing algorithm is shown in Figure 1.

Create a set of regions $Q = \{A_1, A_2, \dots, A_N\}$ for the neighboring ground object corner points. Arbitrarily select a non-ground footpoint as the initial seed point to start creating the region. Recursively connect the non-ground footpoints in the eight neighborhoods of the seed point to form a region until there are no more points that can be connected and the region creation is finished. The process is repeated until each non-ground footpoint is partitioned into a region A_i . Then, each region A_i is divided into 2 parts I_i and B_i . Where I_i denotes the interior footpoints of the region and B_i denotes the edge footpoints of the region. If at least one of the eight neighbors of a footpoint is a ground point, this laser footpoint is defined as an edge point, and vice versa. If the number of footpoints inside a small region A_i is zero, A_i is removed from the set Q . After that, the following loop is performed for each small region in the set region.

1) Given an interior point $d_k(x_0, y_0, z_0)$, set up a right-angled coordinate system with this interior point as the origin, and use d_k and its 8 neighboring points to obtain a fitting plane by the least squares method. Assume that the equation of the plane is shown in equation (1):

$$p = ax + by + c \quad (1)$$

where (a, b, c) is obtained by solving for the minima σ_k of the sum of squares of the deviations σ , and the minima are solved as shown in equation (2):

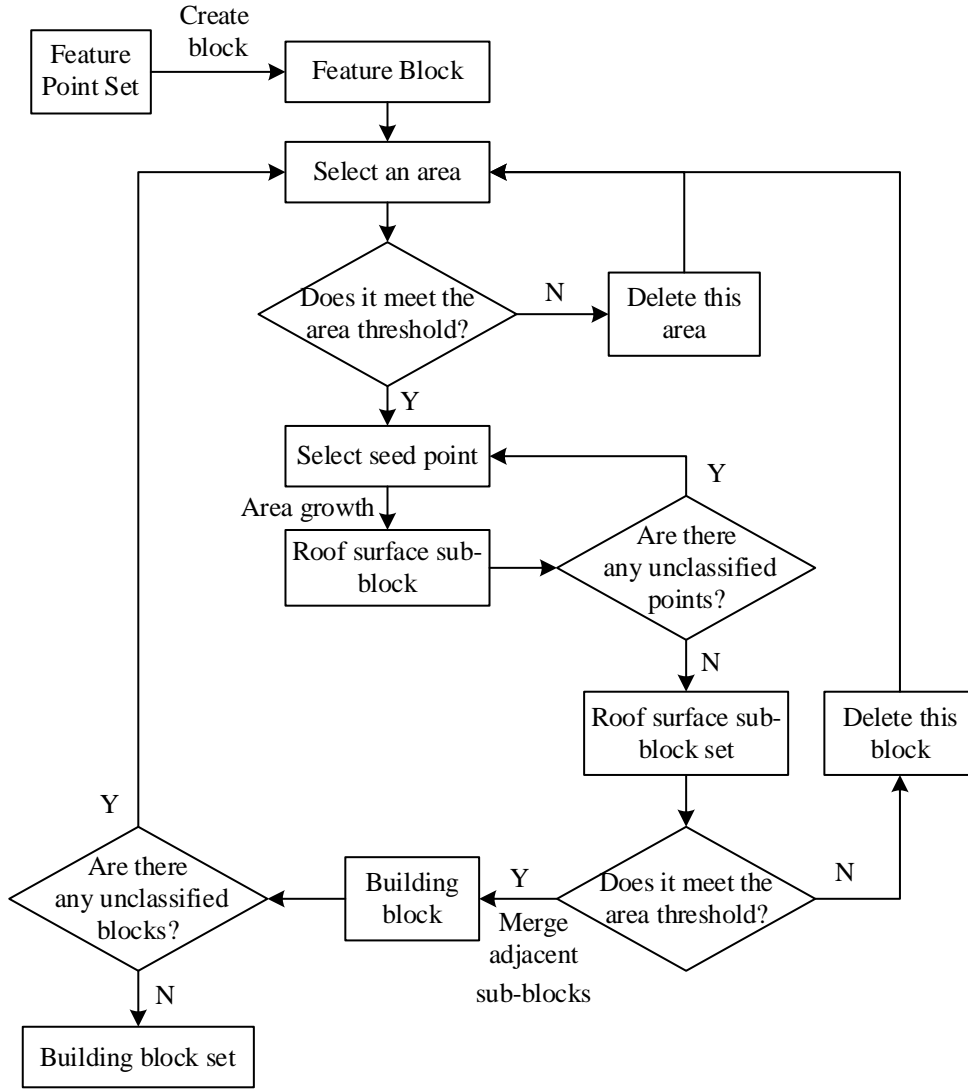


Figure 1: Region growing algorithm procedure

$$\sigma_k = \min \sum_{d_k=1}^K d_k (z_k - h_k)^2 \quad (2)$$

where: K denotes the set formed by d_k and its neighboring points. h_k denotes the elevation measurement of laser point d_k . z_k denotes the elevation measurement of the fitting plane. The set $\theta_i = \{\sigma_{1i}, \sigma_{2i}, \dots, \sigma_{Ni}\}$ consisting of the minimum value of all the internal laser footpoints in the small area A_i can be obtained by the above equation.

2) If $\theta_i \neq \emptyset$, set $D_j \neq \emptyset$ and the initial value of j is 1.

3) The point with the smallest value is selected as the seed point to carry out the region growing task, and the point is added to the set D_j .

4) Neighboring seed points are detected using a plane fitting method to determine whether they are a set or not, and mark the neighboring locations. The laser foot points belonging to the same class are constructed into a plane by the least squares method. If the height difference of the neighboring points from this plane is lower than a critical value, the neighboring points are

added to the set D_j until there are no laser footprints that can be added to the union D_j , and this process ends.

5) Remove the set D_j from the set A_i , and at the same time, remove σ from θ and return to step 2).

6) Loop the above steps until $A_i = \emptyset$.

By the above looping process, the set D of small regions D_j is obtained, $D = \{D_1, D_2, \dots, D_j, \dots, D_M\}$, and $D_j = \{d_{1j}, d_{2j}, \dots, d_{Nj}\}$, where d_{kj} is the k th laser footprint in cell block j . If D_j is not completely contained in other regions, D_j is removed from D . Afterwards, the connected regions in D are merged to obtain a new set D_M . Adjacent roof surfaces of historic buildings with different heights are merged into one large block, and D_{Mj} is removed from D_M if D_{Mj} is smaller than a predefined minimum building area threshold, and finally, all remaining blocks in D_M are building blocks in the historic-cultural neighborhood.

2.1.3 Regularization of building contours in historical and cultural districts

Firstly, Alpha Shape algorithm is used to extract the contour lines of the buildings, then simplify them and finally regularize their geometry. The specific steps for extracting the contour of buildings in historical and cultural neighborhoods using Alpha Shape algorithm are as follows.

Suppose the shape of the building is a polygon which is the contour of a finite set of points X , and a circle of radius β is rolled along the edge of the polygon, and if β is small enough, the trace of the roll of this circle is the boundary of X , and every point is a boundary. If β is large enough, it is a convex envelope of the contour line X .

Adjust the smoothness of the contour line by controlling β . Take 2 points V_1, V_2 inside X and draw a circle with β as the radius, if no other points fall in the circle except V_1, V_2 , then V_1, V_2 is determined to be the boundary point, and the line between V_1, V_2 is the boundary line segment.

The coordinates of V_1, V_2 are known to be $(x_1, y_1), (x_2, y_2)$, respectively, and the coordinates of the center of the circle V_3 are obtained. Because the contour line extracted by the previous algorithm is very rough, it is further simplified using the pipe algorithm to make the contour line regularized.

Specific processing: the use of the diameter of ω tube simulation of the outer edge of the contour line of the building in the historical and cultural district, if all the points on the contour line of the building are in the tube, the distance between these points changes is less than ω , then discard the middle of these points, the contour line is considered to be unchanged. On the contrary, if the distance change of these points is greater than ω , beyond the diameter of the tube, the inflection points of the building contour line are retained, and the regularization of the contour line is achieved through the rectangular outer circle. For polygonal contour lines, the classification forced orthogonal method is used to regularize them, and the polygonal regularization process is shown in Figure 2.

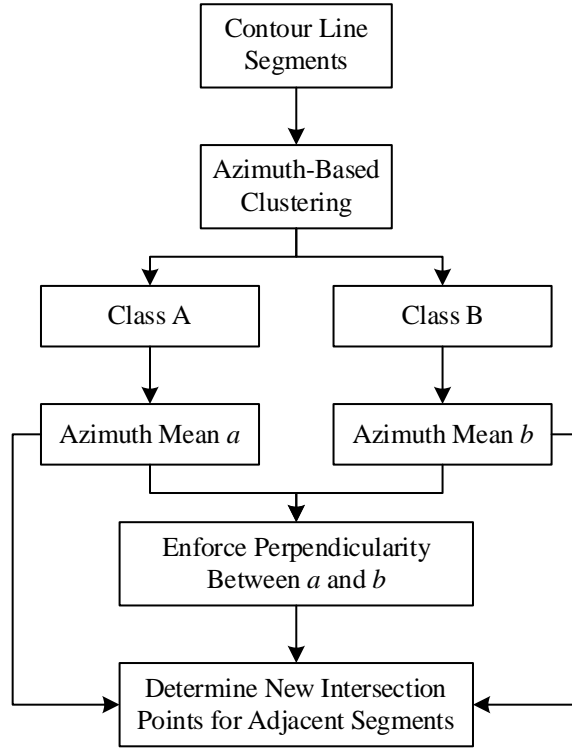


Figure 2: Polygon regularization processing flow

The data regularization process improves the facet meta-properties of the point cloud data and facilitates the subsequent 3D reconstruction of the historic neighborhood.

2.1.4 Three-dimensional reconstruction of historical and cultural neighborhoods

After extracting the feature information of the historical and cultural neighborhoods from the airborne LIDAR data, the building outlines of the historical and cultural neighborhoods are obtained, and the 3D reconstruction of the historical and cultural neighborhoods is carried out. The plane equation $p = ax + by + c$ is processed by the least squares method, and the point-to-plane distance is calculated as shown in equation (3):

$$L = \frac{|ax + by + c - z|}{\sqrt{a^2 + b^2 + 1}} \quad (3)$$

Eq. (3) is further processed with Taylor's formula, and the fitting plane of the herringbone roof plane is obtained through iterative calculation.

For roof buildings of other shapes, the coordinate system is established by taking any point on the roof surface as the origin, and taking the main direction and vertical direction of the building as the horizontal and vertical coordinate axes, respectively, to reconstruct the roof buildings of other shapes by linear fitting. The coordinates of the laser footprints of the roof of the building in the established coordinate system $o - x'y'z'$ are obtained from equation (4):

$$\begin{bmatrix} x' \\ y' \\ z' \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos \varphi & -\sin \varphi \\ 0 & \sin \varphi & \cos \varphi \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix} \quad (4)$$

where φ represents the clockwise rotation angle at which the coordinate system can coincide with the newly constructed coordinate system. The buildings with other shapes, such as four-slope roofs, are reconstructed by linear fitting. In summary, the 3D reconstruction of the building is completed by plane fitting and straight line fitting.

So far, the design of the historical and cultural neighborhood reconstruction method based on airborne LIDAR point cloud data is completed.

2.2 Building 3D reconstruction experiment and result analysis

This experiment adopts the historical and cultural neighborhood reconstruction method based on airborne LIDAR point cloud data proposed in this paper for the reconstruction of a historical and cultural neighborhood. FAROFocus terrestrial 3D laser scanner is used in the field work of this experiment to obtain the scanned point cloud data of the buildings in the survey area, and the 3D point cloud data is obtained after data processing in the supporting software FARO SCENE, and the 3D reality model is constructed in ContextCapture Center after that. ContextCapture Center to realize the construction of three-dimensional model.

2.2.1 Field data collection efforts

(1) Field survey

In order to better refine the three-dimensional reconstruction of the building, we need to go to the field to conduct a site survey, grasp the overall situation of the survey area, and scan the difficult areas in advance of the design. Understand the overall structure of the building and the details of the characteristics, according to the performance of the scanner, roughly define the scanner station vantage point.

(2) Develop scanning program

In this paper, the experimental object of the building door structure is more complex, the main building has more columns, more corners of the corridor, the eaves and corridors inside and outside the eaves of the texture is more delicate, the corridor through the bucket structure caused by the blockage, in order to ensure that the through the vision and refinement of the modeling, it was decided to set up a number of stations in the corridors inside the corridor corners and corridors outside the corridors, about 4-5 meters to set up a station. In addition, because of the high flow of people at the south gate, it is not easy to set up stations at the entrances and exits for the safety of the instruments, so stations are set up at 10-meter intervals in the distant open area to ensure that the overall scanning operation has sufficient overlap and completeness.

Splicing method. The scanning data from multiple stations need to be spliced into a whole, and the splicing methods can be divided into two categories: target-based splicing and targetless splicing, target-based splicing is to utilize the same target sphere in different stations for alignment, and targetless splicing is to utilize overlapping areas between different stations for splicing. In this paper, the experimental selection of non-standard target splicing requires that the scanning operation of each station has a certain overlap area, the overlap rate is not less than 30%, and the overlap should be increased in difficult areas of scanning.

Control measurement. The spatial coordinates of the scanning data are measured based on the scanning coordinate system, which belongs to the relative coordinate system, so after splicing, there is only the relative position relationship between multiple stations. In order to obtain absolute coordinates, a certain amount of black and white checkerboard paper should be set up for use in the internal processing of coordinate conversion, and the checkerboard paper should be evenly arranged inside the survey area, and the total station should be used to carry out point measurement.

2.2.2 Results and Analysis

In this experiment, the total station is used to obtain the measured coordinates of the check points, measure the coordinates of the corresponding points on the 3D model, calculate the difference between the two ΔX_i , ΔY_i and ΔZ_i , and calculate the median errors in the direction of X , Y and in the plane and elevation, respectively, by using the formula. The accuracy statistics of 3D reconstruction of buildings based on airborne LIDAR are shown in Table 1. The accuracy statistics of the 3D model of the building based on the airborne LIDAR point cloud data for the reconstruction method of the historical and cultural neighborhood are as follows: the median error in the X-direction is $\pm 2.8\text{cm}$, the median error in the Y-direction is $\pm 2.60\text{cm}$, and the median error in the plane is $\pm 0.7\text{cm}$, and the absolute value of the error is within the range of 0-3cm. In summary, from the evaluation of the positional accuracy of the 3D model, the reconstruction method has high accuracy, which is due to the fact that the 3D laser scanning itself is characterized by high accuracy and directly realizes the measurement of the points on the surface of the object. At the same time, the measurement area is small, and the splicing of the scanned point cloud from multiple stations is basically no problem.

Table 1: Statistics on the accuracy of 3D building reconstruction

Dot	The measured coordinates of the total station are /m			The measured coordinates of the total station are /m			Difference /m		
	X	Y	Z	X'	Y'	Z'	ΔX	ΔY	ΔZ
1	512385.657	3786803.945	49.483	512385.676	3786803.971	49.482	-1.89	-2.6	0.1
2	512380.614	3786813.149	49.494	512380.603	3786813.126	49.487	1.1	2.3	0.7
3	512381.976	3786823.43	47.563	512381.962	3786823.423	47.566	1.4	0.7	-0.3
4	512356.643	3786836.295	47.553	512356.631	3786836.315	47.552	1.2	-2	0.1
5	512353.091	3786832.779	49.499	512353.083	3786832.785	49.504	0.8	-0.6	-0.5
6	512338.333	3786828.467	49.517	512338.305	3786828.472	49.521	2.8	-0.5	-0.4
7	512391.372	3786800.966	50.923	512391.382	3786800.97	50.926	-1	-0.4	-0.3
8	512381.093	3786821.761	50.934	512381.099	3786821.768	50.938	-0.6	-0.7	-0.4
9	512359.206	3786830.055	48.395	512359.195	3786830.051	48.397	1.1	0.4	-0.2

3 Proposed design strategies and related technical studies

3.1 Design Strategies for the Integration of Historic District Preservation and Modern Architecture

The application and expression of 3D digitalization of historic districts is a continuous process. China's traditional concept of conservation and restoration of historic districts is relatively passive to the adoption of new technologies, and it is an important issue for the conservation of historic districts to take "authenticity" and "no change of the original status" as the premise, and reasonably and passively use new technologies to form an organic and complementary unique conservation and restoration technology strategy. It is an important issue for the protection of historic districts. Using the intuition and authenticity of the 3D digital model, the new mapping technology can be efficiently applied in the process of preventive conservation of historic buildings by maintaining, monitoring and risk assessment of the architectural body and environment of the neighborhood.

In the case of 3D digitization of the historic district, after obtaining the complete 3D data, the spatial features of the buildings in the historic district are extracted and analyzed based on the 3D point cloud, and the planar, elevation and vertical features of the buildings in the historic

district are obtained. The vectorized editing processed point cloud data, combined with GIS software for spatial analysis of the historic district, the use of spatial syntax and other means to calculate the spatial pattern of the streets and lanes of the relevant indicators, so as to carry out ecological environment and other evaluations of the historic district. At the same time, we can extract, convert and express the fine 3D digital information of the historical buildings, draw CAD drawings, create BIM models of the historical buildings, extract the relevant components, establish corresponding family libraries, and build 3D digital information models of the historical buildings for archiving. At the same time, it can carry out digital rendering, virtual restoration of historical buildings, as well as the use of 3D printing and other technologies for the virtual and real display of historical buildings. We maximize the extraction and conversion of 3D digital information of historical buildings by various means, and integrate all the information obtained in the BIM digital archive, so as to provide corresponding support for the research, analysis, protection, restoration, archiving, display and continuation of historical buildings.

According to the collection and fusion of high-precision three-dimensional point cloud data of the historical neighborhood, the plan, elevation, section and other graphics of the building can be accurately and quickly drawn. Using the slicing method to obtain the corresponding flat, elevation and section point cloud slices, after denoising the point cloud, CAD is used to fit the contour direction of the slices and deepen the drawing of details and dimensions, so as to realize the drawing and expression of the two-dimensional drawings of the historical buildings and the archiving work. Based on BIM technology, parametric modeling of buildings in historic districts, recording data such as component dimensions, materials, and craft practices, and organizing and storing information in combination with the 3D model, the daily operation and repair and protection of architectural heritage can be realized in an intuitive and efficient way. Using the fusion point cloud model of the historic district obtained by the air-ground integrated 3D scanning and reconstruction technology, the 3D data are stored in the database and imported into the BIM software Revit, and the BIM model of the historic district is established with reference to the point cloud data, as well as the corresponding component management models of the roofs, walls, doors, windows, railings, and other components.

The value of architectural cultural heritage is not only its historical value and scientific value, but also its display value. Using the obtained three-dimensional digital model, 3D printing and other technologies can be carried out to three-dimensional three-dimensional restoration of the historic district display. Using 3D printing technology, the three-dimensional digitization of the historic district according to the 1:50 scale to make a removable micro-model, fast, efficient and accurate restoration of the original appearance of the historic district, for the integration of historic districts and modern architecture to provide a strong technical support.

3.2 Overview of space syntax

The space syntax is based on two recognized ideas that attempt to reflect the objectivity of space and our intuitive involvement in it. The first idea is that we should see space not as a context for human activity, but as a context for objects, and that it should be seen not as a basis for human activity, but as a context for traversing objects. The second idea, known as “spatial configuration”, suggests that human space is related not only to the characteristics of individual spaces, but also to the interrelationships between the many spaces that make up the spatial layout of a building or city.

Here a new theory of architecture and urbanization is proposed. The key point of this theory is the notion of spatial morphology: for any system, each of these factors determines the other factors associated with it, and this factor is the spatial syntax. This theory and methodology shows how to favorably analyze the spatial pattern inside and outside of a building, so as to

understand how human behavior affects the formation of material space and how material space shapes human mobility, thus realizing the interaction between human and space. In it, the understanding of space is compared with the simple design of space and is developed and integrated within it.

In a function-centered discursive environment, the understanding of a specific space and the function it performs is not determined by the space itself, but by the relationship between this space and other spaces.

Spatial syntax is a research procedure that examines the relationship between human society and space from the perspective of a general theory of the various structural forms of population space: buildings, settlements, cities and landscapes. Spatial syntax is also defined as a theory based on graph theory, which is used by architects and urban designers to examine how the spatial layout of buildings and cities affects human activities and social development, as well as the economic and environmental consequences of their interaction. Its techniques provide an accurate and quantitative description of how built space is organized in the environment.

3.3 Quantitative factors for spatial configuration analysis

3.3.1 Connectivity (ON)

In a spatial system, the number of articulations of a spatial node with other neighboring nodes is the connectivity value of that spatial node. The connectivity of a node can be defined as the number of other nodes directly connected to it. Connectivity, path length and clustering coefficient are three key metrics for topological analysis of a given space. Pedestrian movement speed in outdoor space can be predicted from other syntactic results of spatial syntactic analysis. The formula is expressed as:

$$C_i = k \quad (5)$$

3.3.2 Control values

The control value indicates the degree of control that a certain space node has over the space nodes connected to it, assuming that the weight of each node in the space system is 1, the weight assigned to a node a from the neighboring node b is $[1/(\text{the connection value of } b)]$, then the sum of the reciprocal of the connection values of the nodes directly connected to a is the weight assigned to a from each of the neighboring nodes, this indicates the degree of mutual control between the nodes and is therefore called the control value of the a node. The formula is expressed as:

$$Ctrl_i = \sum_{j=1}^k \frac{1}{C_j} \quad (6)$$

3.3.3 Depth values

In a spatial system, the distance between two neighboring spatial nodes is specified to be one step, then the shortest distance traveled from one spatial node to another spatial node is the spatial depth between these two spatial nodes. The average value of the shortest distance traveled from a node to all other nodes in a spatial system is called the average depth value of that node d , with a minimum value of 1 and a maximum value of s , and the formula can be expressed as $[MD = (E \text{ depth} * \text{number of nodes at that depth}) / (\text{total number of nodes} - 1)]$.

$$D_i = \sum_{d=1}^s d \times N_d \quad (7)$$

$$MD = \frac{\sum_{d=1}^s d \times N_d}{m-1} \quad (8)$$

3.3.4 Degree of integration

The “integration” of a space is a function of the average number of lines and the required change in direction from that space to all other spaces in the spatial system. All lines in a spatial layout have a certain value of depth between them and other lines. The formula is $RA = 2(MD-1)/(n-2)2$. [where n is the total number of nodes].

The overall integration degree indicates the ease with which a node is connected to all nodes within the entire system. Whereas, the local integration degree indicates the ease of connection between a node and the nodes within a few steps of its neighborhood. Its formula is expressed as:

$$Rn = \frac{1}{RRA_i} = \frac{m \left[\log_2 \left(\frac{m+2}{3} - 1 \right) + 1 \right]}{(m-1)|MD-1|} \quad (9)$$

3.3.5 Comprehensibility

Intelligibility is a measure of how easy it is for a pedestrian to recognize the overall spatial structure of a system in a spatial system by identifying local spatial features. Therefore, the higher the value of connectivity in the spatial system, the higher the integration, and the stronger the positive correlation between the two, the higher the degree of intelligibility. In other words, the higher the degree of spatial recognition. The formula for this is:

$$R^2 = \frac{\left[\sum (c_i - \bar{c})(I_i - \bar{I}) \right]^2}{\sum (c_i - \bar{c})^2 \sum (I_i - \bar{I})^2} \quad (10)$$

3.4 Color Quantification and Methodology

Mensel color longitudinal cut diagram shown in Figure 3. In the expression of color to see, Mensel color system is fully scientific, color has its own specific hue and saturation, so we can use these characteristics to color matching, Mensel color system gives it is how to coordinate the color of the three main points, first of all, will be uniformly stirred, mixed to get the medium brightness gray, that is to say, if a variety of colors mixed and matched to get the brightness of 5 gray, they are harmonic colors. They are harmonic colors. In addition, if there is no color, the brightness level difference should be maintained at 3 or more, for example, brightness 1 needs to be matched with brightness 4 or more, and brightness 2 needs to be matched with brightness 5 or more, in which case it is blended. The second is the composition of equal intervals. That is, each color block does not overlap each other. That is, in the color three-dimensional, can be a horizontal direction of reconciliation, such as 3 in the purity of the interval of 2 levels (Figure a). Can also be a vertical direction, such as 3 colors in the brightness of the interval 2 levels (Figure b).

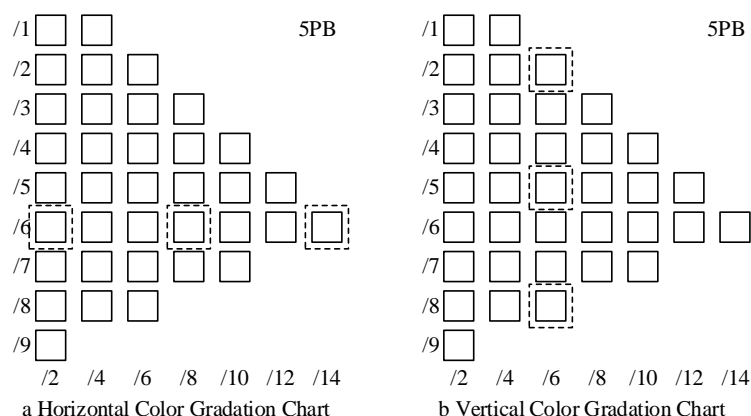


Figure 3: Munsell color longitudinal cut illustration

Regardless of the direction and order, you can harmonize the colors by maintaining equal color intervals. Third, the inverse relationship between color and area. Color and area are inversely proportional to each other, and so is the mathematical expression. If an object is divided into several areas, the brightness of each area is the same, then in different locations, the greater the brightness of the place, the area occupied by the less, and vice versa. Color and area is inversely proportional to the integrated proportionality will find that the focus is the brightness and purity of the larger the color, the greater the stimulus, the more the area must be controlled. For example, color a is 5PB4/6, color b is 5PB8/6, then according to the following formula (11), a area of 25, b area of 48, so the b area of high purity brightness, stimulation is stronger, the need to control management.

$$\frac{a \text{ Brightness} \cdot a \text{ Saturation}}{b \text{ Brightness} \cdot b \text{ Saturation}} = \frac{a \text{ Area}}{b \text{ Area}} \quad (11)$$

In this quantification in Adobe Photoshop for image processing techniques, the use of Excel to edit the chromatographic data, imported into Origin and Matlab, read the picture data and converted to LAB color values, the general layout of the building is divided into XXY cells, select the most representative color card values of the color within the unit, and perform statistical quantities. Calculate the Munsell color value of each pixel: in the Munsell color system, the value of the hue range of R, YR, Y, GY, G, BG, B, PB, P, RP, color purity, that is, the saturation of the color, the value of the range of 0 to 100. in the Munsell color system, the value of the purity of the color is also from 0 to 100 that the larger the value of the color saturation the higher the value of the color luminance range of 0 to 10, value of the range of 0 to 10, value of the value of the color brightness. The value of color brightness ranges from 0 to 10, and the larger the value, the brighter the color. The color value of each pixel in the Munsell color system is estimated by calculating the sum of the squares of the a and b values of each pixel and the color brightness L. The color values are converted to the Munsell color system and then converted to the Munsell color system. Convert color values to hue values in the Munsell color system: The code calculates the hue angle in the range -180 to 180 degrees, while in the Munsell color system, the hue ranges from 0 to 100, and can be used to calculate the hue value of a color by mapping the hue angle h to this range. The code takes the absolute value of the hue angle and divides it by 2, and rounds it to the nearest whole number. The scatter plot is drawn using the scatter function, where the x-axis represents the hue (R, YR, Y, GY, G, BG, B, PB, P, RP), and the y-axis represents the color purity or color brightness. A sample of 50 random pixels is set for each image. By this method, the building color distribution and composition data can be more clearly organized. The recorded sample data are described and quantitatively analyzed in

terms of hue, lightness, and purity by the Munsell color system.

4 Application of design strategies for the integration of historic district preservation and modern architecture

4.1 Research on the Characteristics of Historic Neighborhoods in Jiangsu Province Based on Spatial Syntax

This section takes four historic districts in Jiangsu Province as the research objects, which are noted as A Historic District, B Historic District, C Historic District and D Historic District. The spatial syntax method is applied to study their landscape characteristics, thus favoring their traditional landscape protection and sustainable development.

4.1.1 Study on the Morphological Pattern of Historic Neighborhoods in Jiangsu Province

(1) Landscape pattern

The water system often influences the origin and development of a city, especially in Jiangsu Province, so most of the cities in Jiangsu Province are situated along rivers or at the junction of several rivers. Historic District A is a semi-open pattern, Historic District B and Historic District C are an encircling pattern, Historic District A is surrounded by rivers in the north and the east, and Historic District B is surrounded by mountain ranges in the north and the east. Surrounded by mountains, the Historic District B, in particular, is surrounded by a microclimate that provides an environment rich in resources for agriculture and urban development. On the other hand, Historic District D is only surrounded by mountains in the south, and the space in Historic District D is relatively open.

(2) Urban pattern

In ancient times, the city pattern of “squareness” was already set in the “camping system” in the Western Zhou Dynasty, and the construction pattern of ancient Chinese cities mostly followed this system. In the Ming and Qing Dynasties, Historic District A expanded from its original rectangular pattern, while Historic District B expanded to the east and south from its original square pattern to form a complete citadel system, and Historic District B's Prefectural City was centered on Zhenyuanlou, with four intersecting streets corresponding to the four gates, and the architectural layout of Historic District B's Prefectural City was more loosely organized, with a moderate amount of residential buildings and large areas of public space and green areas. C. The historic district has a building outside the east gate, forming a “convex” shape. C. The historic district is centered on the Drum Tower, with two streets intersecting horizontally and vertically, and four avenues corresponding to the four directions. D. The historic district has the Drum Tower at the center of the city, and two avenues running through the Drum Tower.

4.1.2 Research on urban patterns based on spatial syntax

Based on the basic principle of spatial syntax, this paper compares the urban street patterns of four major cities in Jiangsu Province in the Ming and Qing Dynasties horizontally, which can show the spatial characteristics of the four cities more clearly. Specifically, three measurement variables are used: integration degree, selectivity, and comprehensibility. By analyzing the degree of selectivity and integration of the cities in Jiangsu Province, the potential of traversing traffic and arriving traffic between city streets in Jiangsu Province is explored. Then the comprehensibility of urban space in Jiangsu Province is determined by analyzing the global integration degree and local integration degree ($R=3$).

The numerical analysis of spatial syntax is shown in Table 2. The main features of the urban pattern of Jiangsu Province in the Ming and Qing dynasties are:

(1) Among the four historic districts, B historic district has the largest city area, D historic district has the smallest area, and there is a tendency for the city area to become smaller from east to west. The spatial syntax analysis shows that Historic District D has the highest average value of selectivity, and the smaller area makes the streets have strong traversal. The average global integration and departmental integration of Historic District B are the highest, and the global integration of Historic District B is 1.9051. The larger urban area and rich road network of Historic District B make the streets of Historic District B have the highest potential for reachable traffic, and the Historic District recognition The highest degree of recognition is found in Historic District B.

Table 2: Spatial syntactic numerical analysis

	Global integration	Local conformity	Understandability	Degree of selectivity
A	1.5833	1.7919	0.9258	0.0833
B	1.9051	1.91	0.9934	0.1317
C	1.5504	1.6672	0.921	0.1683
D	0.9759	1.0857	0.9187	0.2199

(2) The value of correlation coefficient R^2 of the scatterplot obtained by comparing the global integration degree and local integration degree. The comprehensibility is shown in Fig. 4, and Figs. a~d represent the comprehensibility of historical neighborhoods A~D, respectively. From the figure, it can be seen that the R^2 values of the four historic districts are all greater than 0.8, which are at a high level of correlation, indicating that the intelligibility of the historic districts is high, among which the highest value is found in the city of historic district B, indicating that historic district B has the best fit, and it is easiest to perceive the whole of the historic district B.

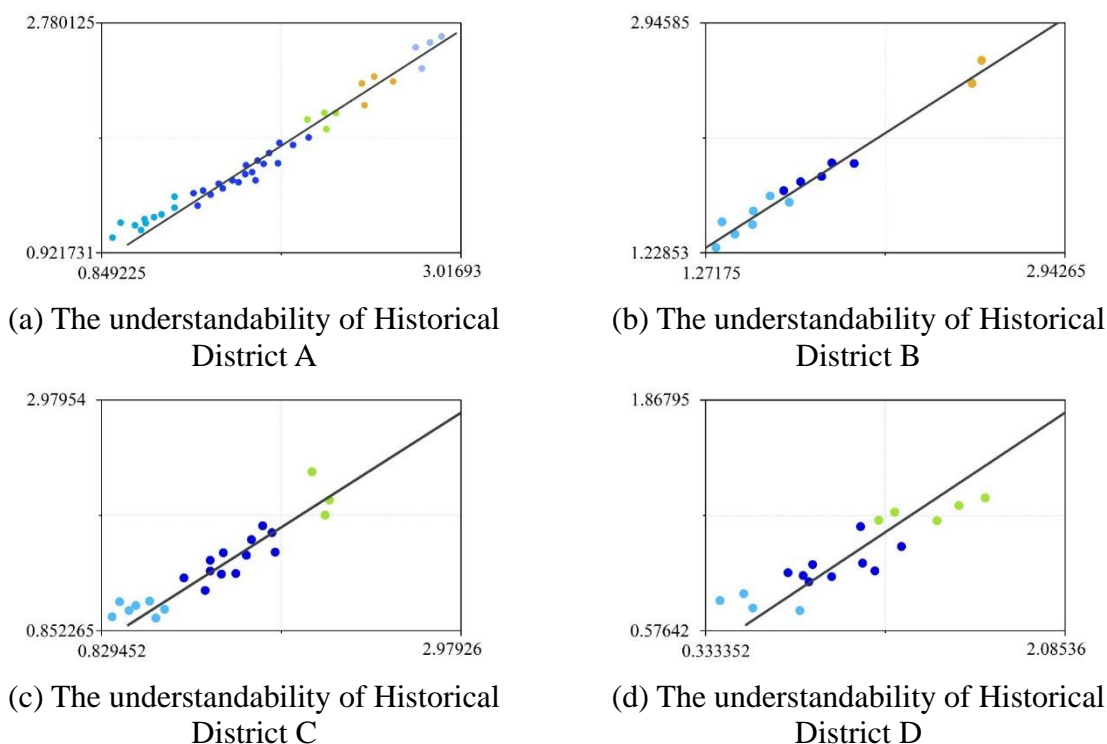


Figure 4: Understandability

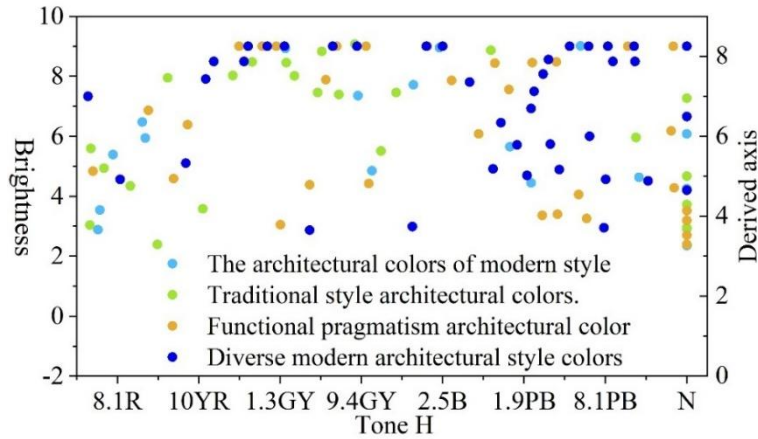
(3) The shapes of the four historic districts are all expanded from the original regular pattern to form a combined pattern. The streets in the four historic districts are highly selected and integrated, with major religious buildings and city high point landmarks nearby, which are important nodes in the landscape of the historic districts.

(4) The analysis of the spatial syntax shows that the streets with high degree of urban choice and integration in Historic District A are located in the north, and that the streets in the northern part of the Historic District have higher potential for traversal and popularity, and the surrounding area is covered with major typical landmarks and religious buildings. The highly integrated and selective streets of Historic District B are to the southwest, where the main towers, religious buildings, and administrative buildings of Historic District B were erected. The spatial system analysis of the Historic District C reveals that the streets with high integration and selection are to the east, and that this segment has good through-traffic. After analyzing the spatial system of Historic District D, the street with high degree of integration and selection is in the northeast, the street connects the inner city and the outer city streets of the city, which makes it have better accessibility, and there are also a large number of religious buildings, administrative buildings, and cultural and educational buildings in the surrounding area, and this section of the street has better penetrability.

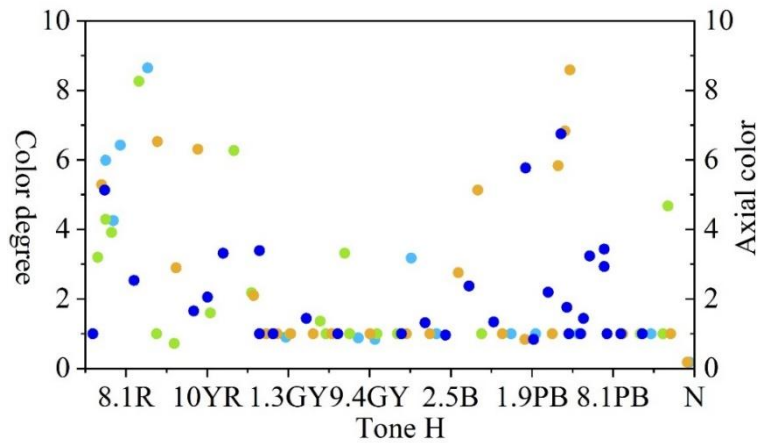
4.2 Quantitative Statistical Study on Color Attributes of Suzhou Buildings

In this section, a total of 276 samples are selected from the Suzhou color database of the building samples in the old city of Suzhou (consistent with those in the distribution of architectural styles), of which 60 cases are traditional style buildings, 30 cases are modern buildings, 90 cases are functional pragmatism buildings, and 100 cases are multifunctional modern style buildings. The color samples were selected on the basis of stratified sampling in equal proportions, so as to include as comprehensively as possible the architectural cases under the subcategories of each style. A color database was established for the building color samples, including three parts: building color illustration, building color in Chinese architectural color card, and color HVC value information. In this paper, a database is established for different styles of architectural classifications, architectural cases and color samples, with the color sample color card number as the main key.

The traditional architectural color, modern architectural color, functional pragmatism architectural color, and diversified modern architectural color are represented by four kinds of legends in the axes, and the HVC value axes are established by using SPSS software to analyze the color database obtained after the collection of color samples, and obtain the Munsell chromaticity diagram of the color samples. The color sample Munsell chromaticity diagram of Suzhou buildings is shown in Figure 5. Firstly, the data intervals of the architectural colors are read separately, and secondly, the aggregation trend and the discrete direction of the three values of hue, lightness and chroma are summarized in the characteristics. The way of research is to compare the color values of the aggregated intervals or outliers with the data in the color database, to restore the comprehensive information of the color samples, to describe and summarize them. In order to facilitate the description, the hue ring is represented by the horizontal axis, the starting point is 5R, the end point is also 5R, the hue values are arranged counterclockwise, and the hues located in the counterclockwise direction of the color ring between [5GY, 5P] are the cool tones, and the rest of them are the warm tones, and [N] is the neutral color. Brightness is divided into 11 levels, the interval [0,3] for low brightness, [3,7] for medium brightness, [7,11] for high brightness. The more common 16 levels of color as a scale, with the interval [0,5], [5,10], [10,16] is divided into low, medium and high three grades.



(a) Brightness



(b) Color degree

Figure 5: Munsell chromaticity diagram of architectural color sample

5 Conclusion

The article proposes a reconstruction method of historical neighborhoods based on airborne LIDAR point cloud data, explores the method of extracting transforming and expressing 3D digital information of historical neighborhoods, and explores the strategy of integrating modern architectural elements. The experimental conclusions drawn from the article are:

(1) In the statistical experiment on the accuracy of 3D reconstruction of buildings based on airborne LIDAR, the absolute value of the error of this article's method in the X-direction, the Y-direction and the plane is within the range of 0-3cm, which proves that the reconstruction method proposed in this article has a high accuracy.

(2) Using the spatial sentence method to analyze the comprehensibility of four historic districts in Jiangsu Province, it is found that the R2 values of the four historic districts are all greater than 0.8, which are at a high level of correlation, among which the value of the B historic district city is the highest, which indicates that the B historic district has the best fitting degree.

Urban architectural bodies are complex, and each part that constitutes them has different values. The architectural style of historic districts has unique characteristics, forming an overall style unique to the old city. Historic districts are the business cards of a city to show to the outside world, it is the memory of history, and the unique architectural form of historic districts

witnesses the origin and change of the city, and has valuable historical value. Therefore, the inheritance of the architectural style of the historic district should be adapted to the local conditions as well as the time, and at the same time, it should also pay attention to the architectural style, spatial structure, architectural color and skyline of the historic district, so as to realize the protection of the historic district and the good integration of modern architecture.

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