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Analysis of the Impact of Urban Renewal Plans on the Appearance of Historic Buildings in Industrial Heritage Sites

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Abstract This study takes the industrial architectural heritage of Study Area A as its research object and systematically analyzes the impact of urban renewal plans on the appearance of historic buildings. Combining field research and questionnaire surveys, it explores respondents' evaluations of the value of industrial heritage and their willingness to renovate it. SketchUp is used to record information about industrial heritage, and JX-4 is used to create a digital elevation model (DEM) of the study area. A three-dimensional point cloud model of the study area is constructed, and its effectiveness is examined through accuracy evaluation. Using multiple linear regression, the study investigates the varying degrees of contribution and differences among the various elements of urban renewal plans to the vitality index of the study area. The explanatory power of macro-level influencing factors on the heat index of Study Area A shows significant differences ($R^2 = 0.814$). The standardized regression coefficients for commercial facility density ($\beta = 0.554$, $p = 0.002$) and transportation facilities ($\beta = 0.401$, $p = 0.001$) are the highest. Although the effects of land use mix ($\beta = 0.247$, $p = 0.012$) and Simpson's index ($\beta = 0.312$, $p = 0.001$) were relatively weaker, they were still statistically significant, indicating that functional complexity and ecological diversity have a synergistic effect on the revitalization of historical building facades.

Index Terms urban renewal plan, industrial heritage, DEM, point cloud model, multiple linear regression

I. Introduction

Urban renewal is an important part of modern urban development, which is not only related to the improvement of infrastructure and urban functions, but also involves the protection and inheritance of historical and cultural heritage [1]. In urban renewal projects, some initiatives focus solely on superficial repairs to historical buildings, neglecting their underlying cultural, historical value, and unique architectural structure [2], [3]. Such superficial restoration methods only maintain the “old” appearance of historical buildings but fail to authentically recreate their original appearance and cultural character [4], [5]. Additionally, the internal spatial structure, functional layout, and material craftsmanship of historical buildings are often overlooked, leading to the gradual loss of their cultural significance and historical memory, and preventing effective protection of their historical appearance [6]-[8]. Furthermore, some urban renewal projects lack systematic planning and management for the protection of historical building landscapes [9]. This fragmented approach to protection often focuses solely on individual buildings, neglecting the overall integrity of the regional historical landscape [10]. Since urban renewal and transformation are an indispensable part of urban development, it is essential to conduct in-depth research and meticulous planning to ensure the smooth progression of such initiatives [11-12]. Therefore, based on the historical context of the city and buildings, the locations for retention and reconstruction should be determined, and existing resources should be utilized reasonably or demolition and reconstruction should be carried out [13]. Only after fully understanding the characteristics of the buildings can feasible renovation plans be formulated, and construction strictly adhering to planning requirements can be carried out, thereby achieving the goals of urban renewal and transformation while preserving historical character [14]-[16].

The renovation of historical buildings and the protection of their appearance are crucial components of urban renewal activities. The effectiveness of such renovations and the extent to which the original appearance is preserved directly impact the quality of urban development. As such, scholars have conducted research on strategies for conducting historical building renovations and protecting their appearance. Literature [17] emphasizes the importance of protecting historical commercial streets in urban centers, noting that most traditional commercial streets lose their historical identity during urban renewal processes, which is detrimental to local economic and cultural development. Several governance strategies are needed to protect the rich historical value of commercial districts. Literature [18] demonstrates that regional social networks and local characteristics are disrupted by large-scale demolition during urban renewal. Through empirical surveys, it analyzes the impact of social factors on the renewal of historic building areas, aiming to provide urban planners and decision-makers with multiple policy recommendations for heritage protection. Literature [19] constructs an identification framework applicable to urban building renewal based on three dimensions: renewal needs, development potential, and protection constraints. This framework provides high reference value for urban planners in assessing building renewal in historic districts. Literature [20] designs a decision-support tool to promote urban regeneration and heritage protection, known as the Urban Transformation Matrix. This tool comprehensively considers the historical and cultural value of buildings and their post-renovation functions to effectively optimize urban building renewal projects. Literature [21] constructs a spatial decision support system, URBIUS, which supports urban renewal projects that adapt to the unique needs of existing buildings, businesses, and residents, thereby promoting sustainable urban renewal. Literature [22] emphasizes that the protection of historical artifacts must be combined with their practical value, and thus proposes an innovative economic evaluation model to ensure that urban historical building renewal maximizes economic benefits while maintaining the historical value of the buildings.

This paper first uses a questionnaire survey to quantify the value system of industrial heritage and the public's willingness to renovate it. Using SketchUp software, a dynamic management model for three-dimensional visualization of industrial heritage is established. Combining three-dimensional visualization modeling technology with digital elevation models, high-precision industrial heritage models are constructed to support landscape analysis. Precision evaluations are conducted on point cloud models and segmentation effects to assess the effectiveness of three-dimensional model construction. Through multiple regression analysis, the mechanisms by which macro-level factors such as commercial layout and transportation accessibility influence building vitality are revealed.

II. Research and analysis of historical architectural features in the study area

Industrial heritage, as an important carrier of urban historical memory, plays a crucial role in urban sustainable development. This study focuses on the steel industrial architectural heritage in Research Area A, employing a multi-dimensional analysis to explore the impact of urban renewal on the historical architectural landscape.

II. A. Research subjects

This study focuses on industrial relics related to the steel production process during the industrial construction period in Study Area A, with the railway lines serving as the main connection between the main industrial buildings and ancillary structures of the industrial and mining facilities, as well as the surrounding environment. Specifically, the study covers industrial buildings related to iron ore mines, ore dressing plants, sintering workshops, blast furnace workshops, steel making workshops, rolling mills, coking workshops, non-core raw material mines, and non-core supporting infrastructure such as railways, coal, power, water supply, roads, and forestry. The content will encompass historical research, current status analysis, conservation planning, building renovation, and conservation management.

The steel industrial architectural heritage in Research Area A is based on resident and tourist questionnaires and expert evaluation questionnaires, combined with on-site surveys of the steel industrial architectural heritage in Research Area A, providing scientific and feasible basis for the research. Based on the evaluation results, this study adheres to the principles of authenticity, integrity, and feasibility to establish a comprehensive value evaluation archive table and evaluation scores.

(1) Resident and tourist questionnaire design for the steel industrial architectural heritage in Research Area A: First, the basic information of residents and tourists in Research Area A was statistically analyzed. Second, the value evaluation of the steel industrial architectural heritage in Research Area A was investigated from the residents' perspective. Finally, based on the current issues faced by the steel industrial architectural heritage in Research Area A, the residents' willingness for renovation was explored.

(2) Questionnaire Distribution: Online and offline survey questionnaires were distributed for analysis and summary. A total of 206 valid questionnaires were collected. Analysis of the survey population shows that more women than men participated in the survey, with men accounting for 41.75% and women accounting for 58.25%. The educational attainment of the survey population was relatively evenly distributed, with 22.33% having an education level below junior high school, 24.76% having a high school or vocational school education, 18.45% having an associate degree, 20.39% having a bachelor's degree, and 14.07% having a master's degree.

II. B. Questionnaire Analysis

II. B. 1) Value Evaluation

The results of the industrial heritage value assessment for Research Area A are shown in Figure 1. Respondents generally believe that industrial architectural heritage possesses a diverse value system. Within this value system, historical value ranks first at 91.26%, followed by cultural value at 90.72% and technological value at 86.89%.

Economic value, social value, and artistic value follow thereafter. Most people believe that industrial architectural heritage has significant development potential. Among the approaches to managing industrial architectural heritage, creative parks and urban parks were the most commonly chosen options, accounting for 66.99% and 54.37%, respectively, indicating the highest level of public acceptance for such renewal models.

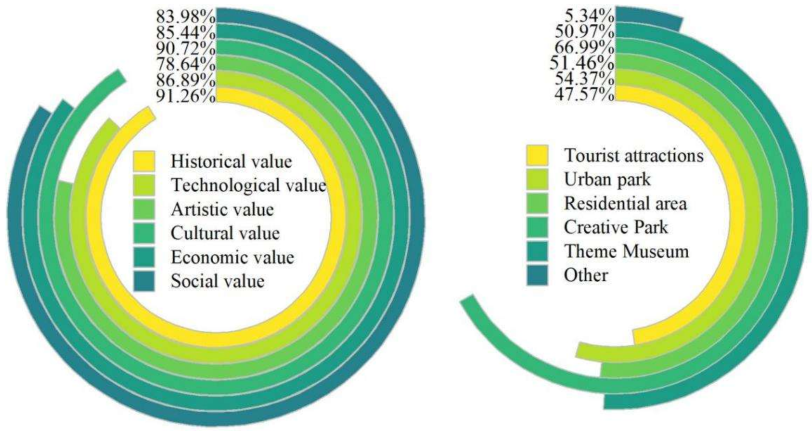

Figure 1: Evaluation of Industrial Heritage Value

The results of the analysis of the significance of reusing industrial architectural heritage in Research Area A are shown in Figure 2. Over 90% of respondents believed that heritage symbolizes history for the city. Interest in industrial architectural heritage was highest for multicultural themes, followed by leisure and sightseeing, cultural education, interactive experiences, and creative industries. This indicates that there is strong demand for retirement, sightseeing, and leisure activities. Therefore, when protecting and reusing heritage, these factors should be taken into consideration to provide models that truly meet people's needs.

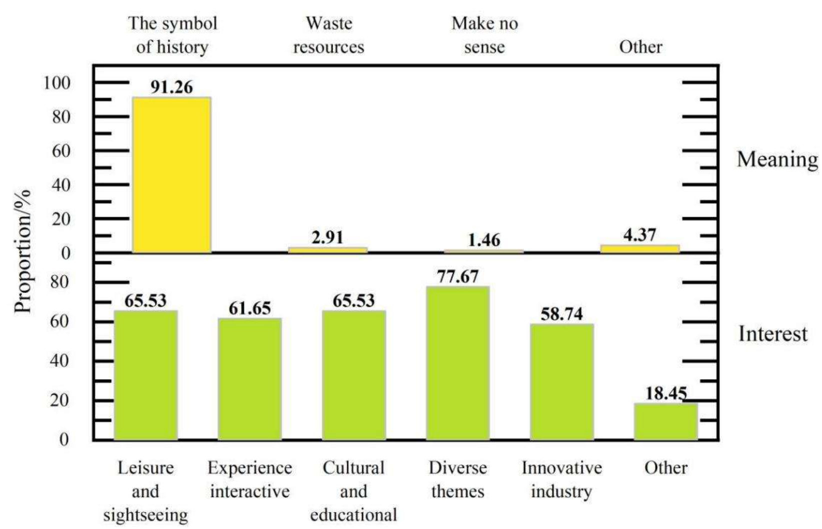

Figure 2: Analysis of the Significance of Reusing Industrial Building Heritage

II. B. 2) Willingness to renovate

Respondents' evaluations of the architectural style, traffic flow, landscape system, infrastructure, and business functions of Study Area A are shown in Figure 3. The figure clearly shows that people's overall evaluations of Study Area A are poor. The percentage of respondents who chose “dissatisfied” exceeded 40% in all categories.

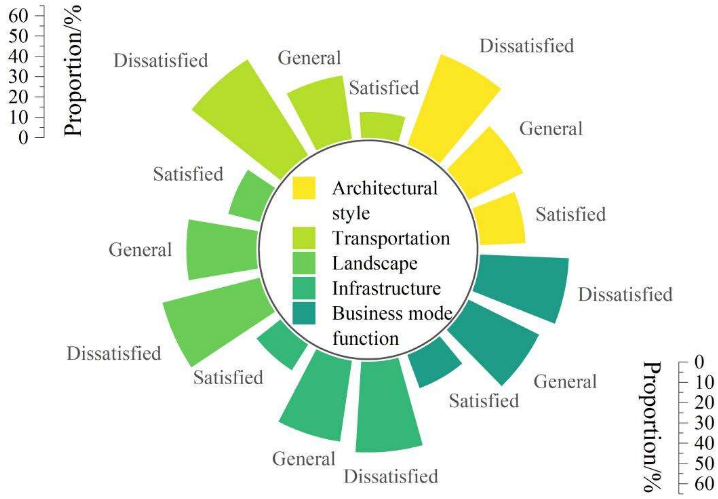

Figure 3: Evaluation of various aspects of study area A

The respondents' willingness to renovate Study Area A is shown in Figure 4. 77.18% of respondents expressed support, while the proportion of opposition was low, indicating that the public has high expectations for environmental improvements in Study Area A.

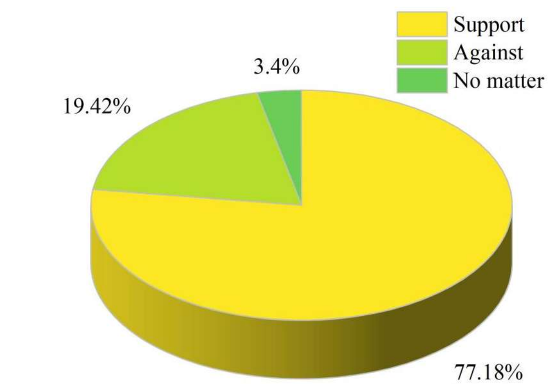

Figure 4: Willingness of respondents to transform study area A

III. Analysis of the impact of urban renewal plans on the appearance of historic buildings in industrial heritage sites

III. A. Establishing a three-dimensional visualization model based on su software

Establish a dynamic management model for a 3D visualization of industrial heritage using SketchUp, leveraging the Google Earth platform, which already provides high-resolution topographic maps as a reference base map for the entire site. Using Google Earth's search engine, locate the area where the 3D visualization model needs to be created. After locating the area, return to SketchUp software to capture the satellite terrain imagery of the target area into SketchUp and set the corresponding geographic coordinate points. Before modeling, the satellite images from Google Earth can be pre-processed using methods such as enhancement and color correction. For the height of buildings, data from relevant historical archives and literature can be used for height determination. Additionally, surveying instruments such as total stations can be employed to measure and apply the height data of the entire building. For the surface texture of the constructed 3D visualization building model, built-in materials within the software can be used for filling, or texturing methods can be applied. Real-world building surface textures can be captured through two-dimensional imaging and ultimately textured onto the surface of the constructed 3D visualization model, thereby achieving an authentic representation of the building's texture. However, due to the building's size and the angle of photography, the generated two-dimensional images may have some perspective differences. Therefore, when applying textures to the building's surface, it may be challenging, and other methods must be employed to first repair the two-dimensional images to ensure they align with the building facades in the three-dimensional visualization model. Based on the construction process from the industrial heritage site to the building complex to the details of individual buildings, the three-dimensional visualization model construction records are divided into three levels. The first level is the overall framework model of the entire industrial heritage site, which remains stable for a certain period of time; the second level is the building complex; and the third level is the individual buildings and their details. The three levels differ in terms of information volume and hierarchy. The first level involves a broader scope of three-dimensional visualization model construction, with recorded information primarily focusing on the functional zoning of the entire factory area, the distribution of building locations, the overall environment, and the three-dimensional visualization records of activity organization and production workflow worker memories present within the first level. The second level involves three-dimensional visualization of building complexes and individual buildings, focusing on depicting the structure, volume, dimensions, and texture of buildings, as well as the three-dimensional visualization of activity organization and production workflow memories of workers within the second level. While the scope of the second level is not as extensive as the first level, it provides a more detailed description of individual buildings compared to the first level. The third level involves the three-dimensional visualization of the functional layout, structural elements, and operational processes within the buildings, as well as the three-dimensional visualization of the organizational structure and production workflow of the workers within the third level. The third level is more detailed than the second level and requires a more meticulous three-dimensional visualization construction method. The first level provides an overall recording framework, the second level covers the conditions and information of building complexes and individual buildings, and the third level focuses on the spatial division of the building's interior. Compared to the first level, the third level is more practical and operational due to its smaller scale, making it more practical and operational. For most non-professional recorders, the third level is easier to document. Among the three levels of three-dimensional visualization records, the third level is characterized by its strong practicality, a more diverse group of participants, higher levels of engagement and openness, and more comprehensive and detailed content compared to the second and first levels, with a greater emphasis on the construction of details. Recorders of different backgrounds can upload their 3D visualization models created using SketchUp to the Google Earth platform, spontaneously documenting changes in heritage sites and the interaction process with each recorder. When recorders upload their three-dimensional visualization models from the same period to the Google Earth platform, others can download and share them. Through this platform, dynamic three-dimensional visualization models of the entire industrial heritage site can be recorded. Changes in parts of the industrial heritage that have undergone alterations at different periods can be promptly recorded and updated, thereby enriching and perfecting the three-dimensional visualization records from different periods.

III. B. Acquisition of terrain data

III. B. 1) DEM Data Acquisition

Generally speaking, the surface morphological attributes of terrain include terrain attribute characteristics and spatial location characteristics, while a digital terrain model is the digital representation of these attribute characteristics. A digital elevation model (DEM) is a digital terrain model whose attribute characteristic is elevation. Traditional spatial data are two-dimensional geographic information data, and a digital elevation model serves as the third-dimensional coordinate of spatial data, providing a crucial supplement to two-dimensional geographic information data. There are various methods for representing DEMs, among which the regular surface network cell representation is the most commonly used. Other methods include triangular networks and contour lines for digital representation.

There are multiple methods for obtaining DEM data, with two being the most commonly used. One involves processing aerial and satellite remote sensing images to extract DEM data, while the other involves scanning existing topographic maps and then digitizing them to generate a DEM. This study adopts the second method, directly interpolating DEM from topographic maps. This method is further divided into three approaches: contour line discretization, direct contour line interpolation, and DEM generation via TIN value interpolation.

(1) Contour line discretization method: This method treats contour lines as discrete data points and uses the moving average method to perform internal interpolation on each discrete data point, thereby obtaining the elevation values of each point. This method has the advantages of simple calculations and low computational time, but it has a significant drawback. When calculating the elevation value of each point, it is necessary to search for the elevation values of known points within a small radius around that point, and then perform a weighted average calculation to obtain the value of that point. If the elevation values of the known points searched are the same, the elevation obtained through weighted averaging will also be the same, leading to identical elevation values in the narrow regions adjacent to each contour line, resulting in a “step-like” terrain.

(2) Direct contour line interpolation method: This method involves searching for the intersection points between the planned axis and the contour lines, then interpolating these intersection points to obtain the elevation values of each point. This method effectively avoids the “step-like” terrain issues caused by the contour line discretization

method. The time required is proportional to the number of grid points and data points, and the calculation is simple. The eight-point weighted average method is a typical example of direct contour line interpolation, where the elevation value of the target point is obtained by calculating the weighted average of the eight known points.

(3) Interpolating a DEM from TIN values: This method uses contour lines to establish TIN values, and the elevation value of any point within the study area A is obtained by solving the TIN values. The general steps are as follows: first, determine which triangle the desired point is located in and determine the coordinates of the three vertices of that triangle. Then, interpolate the elevation value of the desired point based on the vertex coordinates. Through multiple calculations, the DEM values of the study area are obtained. Therefore, how to quickly determine the triangle in which the desired point is located is the main factor affecting the efficiency of this method.

If $P(x,y)$ lies within triangle $\Delta P_1P_2P_3$, then the elevation value Z of point P can be obtained by interpolation using the coordinates of the three vertices of the triangle $(x_1,y_1,z_1),(x_2,y_2,z_2),(x_3,y_3,z_3)$ of the triangle. The equation of the plane determined by the three points P_1,P_2,P_3 is given by the following formula:

$$\begin{vmatrix} x & y & z \\ x_1 & y_1 & z_1 \\ x_2 & y_2 & z_2 \\ x_3 & y_3 & z_3 \end{vmatrix} = 0 \tag{1}$$

Modify the above equation and set:

$$A = -\{y_1(z_2 - z_1) + y_2(z_3 - z_1) + y_3(z_1 - z_2)\} / D \tag{2}$$

$$B = -\{x_1(z_2 - z_1) + y_2(z_3 - z_1) + y_3(z_1 - z_2)\} / D \tag{3}$$

$$C = -\{x_1(y_2 z_2 - z_3) - x_2(y_1 z_3 - y_3 z_1) + x_3(y_1 z_1 - y_2 z_1)\} / D \tag{4}$$

$$D = -\{y_1(y_2 - y_3) + x_2(y_3 - y_1) + x_3(y_1 - y_2)\} / D \tag{5}$$

Then there is the plane interpolation formula: $Z = AX + BY + C$.

III. B. 2) DEM Creation

Obtaining DEM in JX-4 requires two processes, namely orientation modeling and vector mapping. The workflow is shown in Figure 5.

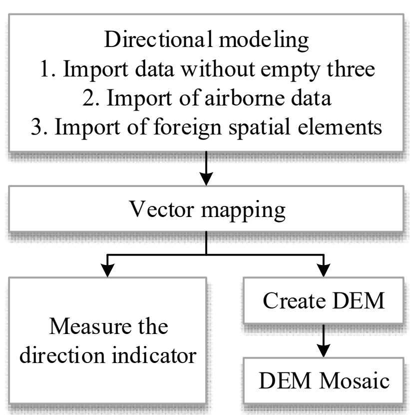

Figure 5: The workflow of creating DEM by JX-4

Since control point data from the experimental area was obtained, oriented modeling was performed using data imported without aerial triangulation, rather than using aerial triangulation data or external orientation elements for oriented modeling. The workflow for oriented modeling using data imported without aerial triangulation is shown in Figure 6.

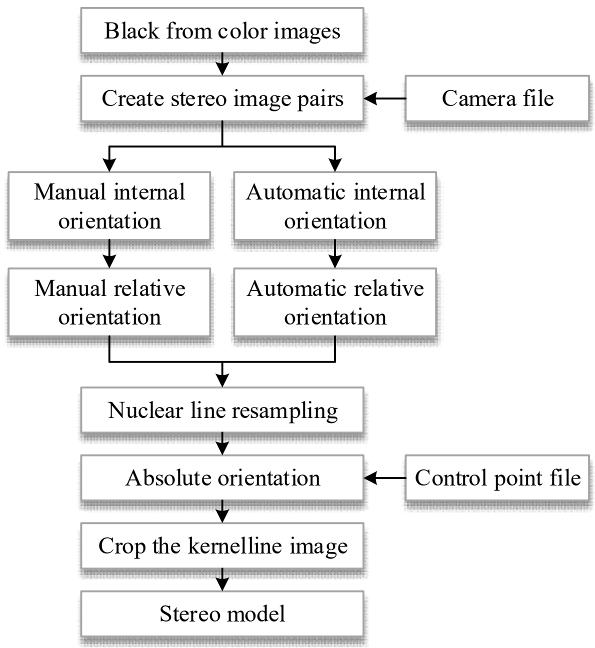

Figure 6: Workflow of Directional modeling for imported data without space three

(1) Internal orientation

Internal orientation is achieved by entering the image principal distance and measuring the image frame markers and performing the corresponding calculations. The purpose is to restore the internal orientation elements of the image, determine the relationship between other image plane coordinate systems and the image plane coordinate system with the image principal point as the origin, and identify any possible image distortion.

$$\begin{cases} x = (m_0 + m_1 I + m_2 J) \cdot \Delta \\ y = (n_0 + n_1 I + n_2 J) \cdot \Delta \end{cases} \tag{6}$$

where Δ is the sampling interval. Therefore, the essence of internal orientation is to determine the parameters m_0, m_1, m_2 and n_0, n_1, n_2 in the above equation. JX-4 can automatically recognize various types of image frame markers and can also perform manual internal orientation, with results that meet the required accuracy. Manual internal orientation was used in this experiment.

(2) Relative orientation

The process of solving the relative orientation elements of a stereo image pair is called relative orientation. Its purpose is to restore the relative orientation of the two images that make up the stereo image pair and establish a geometric stereo model of the object being photographed. When the relative orientation elements of the image pair are restored, the corresponding projection rays will intersect within their respective core planes, i.e., the corresponding projection rays and the baseline should be coplanar, satisfying the basic form of the coplanarity equation: the cross product of the baseline vector B and the left and right projection vectors R_1, R_2 is zero, i.e.:

$$B \cdot (R_1 \times R_2) = 0 \tag{7}$$

Its coordinate expression is as follows:

$$\begin{vmatrix} B_x & B_y & B_z \\ X_1 & Y_1 & Z_1 \\ X_2 & Y_2 & Z_2 \end{vmatrix} = 0 \tag{8}$$

Among them:

$$\begin{bmatrix} X_1 \\ Y_1 \\ Z_1 \end{bmatrix} = \begin{bmatrix} a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \\ c_1 & c_2 & c_3 \end{bmatrix} \begin{bmatrix} x_1 \\ y_1 \\ -f \end{bmatrix} = R \begin{bmatrix} x_1 \\ y_1 \\ -f \end{bmatrix} \tag{9}$$

$$\begin{bmatrix} X_2 \\ Y_2 \\ Z_2 \end{bmatrix} = \begin{bmatrix} a_1^{'} & a_2^{'} & a_3^{'} \\ b_1^{'} & b_2^{'} & b_3^{'} \\ c_1^{'} & c_2^{'} & c_3^{'} \end{bmatrix} \begin{bmatrix} x_2 \\ y_2 \\ -f \end{bmatrix} = R' \begin{bmatrix} x_2 \\ y_2 \\ -f \end{bmatrix} \tag{10}$$

In the equation: x_1, y_1, f are the image space coordinates of the image point on the left image; x_2, y_2, f are the spatial coordinates of the image point on the right image; R' is the rotation matrix.

(3) Absolute orientation

The task of determining the orientation and scale factor of the stereo model in the specified object-side spatial coordinate system, i.e., solving for the absolute orientation elements, is the absolute orientation of the stereo image pair to the geometric model. Essentially, this is a problem of spatial similarity transformation between two coordinate systems, expressed by the following equation:

$$\begin{bmatrix} X_T \\ Y_T \\ Z_T \end{bmatrix} = \lambda \cdot \begin{bmatrix} a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \\ c_1 & c_2 & c_3 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix} + \begin{bmatrix} X_0 \\ Y_0 \\ Z_0 \end{bmatrix} \tag{11}$$

In the equation: X_T, Y_T, Z_T are the coordinates of the ground point in the ground coordinate system; X, Y, Z are the coordinates of the corresponding model points in the model coordinate system; X_0, Y_0, Z_0 are the model translation values; λ is the model scaling factor. After absolute orientation, the area for vector mapping can be set in the resulting stereo image pair, and vector mapping can be performed.

III. C. Construction of three-dimensional models

III. C. 1) Point cloud model accuracy evaluation

According to the relevant standards for low-altitude photography and modeling, the results of information collection and processing in this paper are primarily evaluated based on three criteria: the geometric accuracy of representative segments of architectural facades, the number of model triangular meshes, and the number of regular or irregular architectural components.

Regular or irregular architectural components form the foundation of the building structure. The geometric accuracy of these components directly impacts model quality and the accuracy of facade information extraction. Among these, the parametric dimensions of geometric segments are a prominent characteristic of architectural components. Therefore, representative segments within the building are selected as the evaluation targets for precision. The dimensions of these segments in the model are compared with their corresponding dimensions in the actual scene to analyze model precision. A total of 12 comparison line segments were selected. The corresponding dimension parameters were measured using the distance measurement function in 3D modeling software and a handheld distance measuring instrument in the actual scene. The differences between the two were analyzed and compared. The results of the building component model accuracy test are shown in Table 1. It can be seen that the errors of different components are all within 0.1, with an average accuracy of 98.64%.

Table 1: Accuracy Test Results of Building Component models

Measuring point	Actual size/m	Model size/m	Error	Accuracy
Window width	1.78	1.79	0.01	99.44
Window height	2.53	2.50	0.03	98.81
Door width	1.96	2.01	0.05	97.45
Door height	4.01	3.96	0.05	98.75
Building height	9.05	9.03	0.02	99.78
Base width	2.46	2.41	0.05	97.97
Component spacing	1.73	1.76	0.03	98.27

The number of triangular mesh faces is also one of the criteria for determining the accuracy of a 3D real-world model. The comparison results between the multi-view data model and the single-view data model in terms of the number of mesh faces are shown in Figure 7. The model reconstruction results in this paper also have an advantage in terms of the number of triangular faces compared to those obtained from drone-based reconstruction alone, particularly in complex areas such as windows and staircases. When the model level is set to LOD21, the number of triangular mesh faces is 215% higher than that of the single data model.

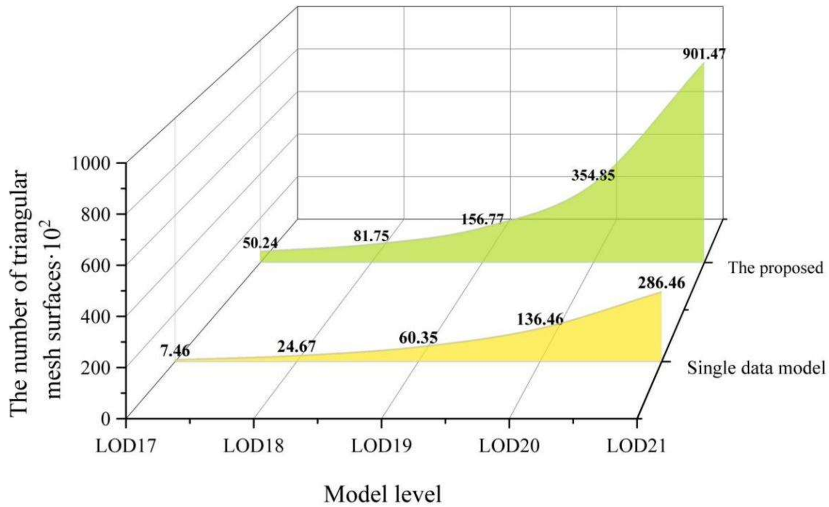

Figure 7: Comparison results of the number of grid surfaces

III. C. 2) Point cloud segmentation accuracy evaluation

Common metrics used to evaluate the accuracy of point cloud semantic segmentation include accuracy, precision, recall, F1 score, and support for testing. Accuracy refers to the percentage of correctly identified objects that meet the requirements out of the total number of identified objects. Recall refers to the percentage of correctly identified objects that meet the requirements out of the total number of objects in the test set. The F1 score is a statistical measure used to evaluate the accuracy of binary classification models. The intersection-to-union ratio is the ratio of the intersection of two sets to the union of the two sets. The accuracy evaluation results for each element of the segmentation are shown in Table 2. The average accuracy rate exceeds 70%, indicating a high level of accuracy in identifying the geometric features of architectural styles, which can improve modeling efficiency.

Table 2: Accuracy evaluation results of each element for segmentation

	Rrec.	Rec.	F1-Score	IoU
Wall	0.805	0.794	0.799	0.799
Door	0.784	0.801	0.792	0.791
Window	0.779	0.794	0.786	0.786
Roof	0.817	0.811	0.814	0.812
Chimney	0.763	0.758	0.760	0.763
Steps/platform base	0.738	0.743	0.740	0.754

III. D. Impact of regression analysis

To assess the impact of urban renewal plans on the architectural character of historical buildings within industrial heritage sites, this study employs multiple linear regression analysis. The dependent variable is the average heat map value for each type of study area A, while the independent variables are the corresponding numerical values of six macro-level influencing factors. The aim is to determine the varying degrees of contribution each influencing factor makes to the vitality value. The results of the regression analysis are shown in Table 3. The explanatory power of each macro-level influencing factor on the thermal activity value of Study Area A exhibits significant differences ($R^2 = 0.814$). The standardized regression coefficients for commercial facility density ($\beta = 0.554$, $p = 0.002$) and transportation facilities ($\beta = 0.401$, $p = 0.001$) are the highest, indicating that these factors contribute most significantly to enhancing the vitality of industrial heritage. Although the effects of land use mix ($\beta = 0.247$, $p = 0.012$) and Simpson's index ($\beta = 0.312$, $p = 0.001$) are relatively weaker, they are still statistically significant, reflecting the synergistic effects of functional complexity and ecological diversity on the revitalization of historical building facades. These quantitative results provide empirical evidence for the protection and reuse of industrial heritage in urban renewal. In future planning, priority should be given to optimizing commercial layout and transportation accessibility, while also emphasizing functional mixed-use configurations to enhance the sustainable vitality of historical building facades.

Table 3: Regression Analysis Results

Variable	Non-standardized coefficient		Standardized coefficient	t	Sig.	Collinear statistics		R^2
	B	SE	β			Tol	VIF	
Constant	.0.215	.104		-2.067	.042*			.814
Transportation facilities	.412	.087	.401	4.736	.001**	.632	1.582	
Commercial facility density	.587	.095	.554	2.031	.002**	.584	1.713	
Simpson's Ratio	.326	.072	.312	3.968	.001**	.703	1.472	
Land use mixing degree	0.253	.064	.247	3.953	0.012*	.685	1.455	

IV. Conclusion

This study systematically assessed the impact of urban renewal on the historical appearance of industrial heritage buildings by integrating public perception, technical modeling, and quantitative analysis.

The survey results showed that respondents generally believed that industrial architectural heritage has a diverse value system. Among the value system, historical value ranked first with 91.26%, followed by cultural value and technological value with 90.72% and 86.89%, respectively. Economic value, social value, and artistic value ranked lower. Most people believe that industrial architectural heritage has significant development potential. Among the approaches to handling industrial architectural heritage, creative parks and urban parks were the most commonly chosen, accounting for 66.99% and 54.37%, respectively. Overall evaluations of various aspects of Study Area A were generally poor, with over 40% of respondents selecting "unsatisfied." Regarding renovation intentions for Study Area A, 77.18% of respondents expressed support.

There are significant differences in the explanatory power of various macro-level influencing factors on the heat map values of Study Area A ($R^2 = 0.814$). The standardized regression coefficients for commercial facility density ($\beta = 0.554$, $p = 0.002$) and transportation facilities ($\beta = 0.401$, $p = 0.001$) are the highest. Land use mix (β=0.247, p=0.012) and Simpson's index (β=0.312, p=0.001) had relatively weaker but still statistically significant effects, indicating that functional complexity and ecological diversity have a synergistic effect on the revitalization of historical building facades.

References

[1] Wang, X., Shi, R., & Zhou, Y. (2020). Dynamics of urban sprawl and sustainable development in China. Socio-Economic Planning Sciences, 70, 100736.

[2] Jayantha, W. M., & Yung, E. H. K. (2018). Effect of revitalisation of historic buildings on retail shop values in urban renewal: An empirical analysis. Sustainability, 10(5), 1418.

[3] Boussaa, D. (2017). Urban regeneration and the search for identity in historic cities. Sustainability, 10(1), 48.

[4] Nesticò, A., & Sica, F. (2017). The sustainability of urban renewal projects: A model for economic multi-criteria analysis. Journal of Property Investment & Finance, 35(4), 397-409.

[5] Alkinani, A. S. (2019, May). Urban renewal of the historic centre of Rusafa. In IOP Conference Series: Materials Science and Engineering (Vol. 518, No. 2, p. 022075). IOP Publishing.

[6] Pendlebury, J., & Porfyriou, H. (2017). Heritage, urban regeneration and place-making. Journal of Urban Design, 22(4), 429-432.

[7] Awad, J., & Jung, C. (2022). Extracting the planning elements for sustainable urban regeneration in Dubai with AHP (analytic hierarchy process). Sustainable Cities and Society, 76, 103496.

[8] Roberti, F., Oberegger, U. F., Lucchi, E., & Troi, A. (2017). Energy retrofit and conservation of a historic building using multi-objective optimization and an analytic hierarchy process. Energy and Buildings, 138, 1-10.

[9] Ding, Z., Liu, S., Liao, L., & Zhang, L. (2019). A digital construction framework integrating building information modeling and reverse engineering technologies for renovation projects. Automation in construction, 102, 45-58.

[10] Janssen, J., Luiten, E., Renes, H., & Stegmeijer, E. (2017). Heritage as sector, factor and vector: conceptualizing the shifting relationship between heritage management and spatial planning. European Planning Studies, 25(9), 1654-1672.

[11] Foster, G. (2020). Circular economy strategies for adaptive reuse of cultural heritage buildings to reduce environmental impacts. Resources, Conservation and Recycling, 152, 104507.

[12] Korkmaz, C., & Balaban, O. (2020). Sustainability of urban regeneration in Turkey: Assessing the performance of the North Ankara Urban Regeneration Project. Habitat International, 95, 102081.

[13] Guzmán, P. C., Roders, A. P., & Colenbrander, B. J. F. (2017). Measuring links between cultural heritage management and sustainable urban development: An overview of global monitoring tools. Cities, 60, 192-201.

[14] Feng, Z., Ge, M., Meng, Q., & Chen, Y. (2025, April). Research on old building renovation strategies by using green building technologies. In 2024 6th International Conference on Civil Architecture and Urban Engineering (ICCAUE 2024) (pp. 81-87). Atlantis Press.

[15] Klaus, V. H., & Kiehl, K. (2021). A conceptual framework for urban ecological restoration and rehabilitation. Basic and Applied Ecology, 52, 82-94.

[16] Cabeza, L. F., De Gracia, A., & Pisello, A. L. (2018). Integration of renewable technologies in historical and heritage buildings: A review. Energy and buildings, 177, 96-111.

[17] Mehanna, W. A. E. H., & Mehanna, W. A. E. H. (2019). Urban renewal for traditional commercial streets at the historical centers of cities. Alexandria Engineering Journal, 58(4), 1127-1143.
[18] Yung, E. H. K., Zhang, Q., & Chan, E. H. (2017). Underlying social factors for evaluating heritage conservation in urban renewal districts. Habitat International, 66, 135-148.
[19] Wang, M., & Yang, J. (2022). Sustainable Renewal of Historical Urban Areas: A Demand–Potential–Constraint Model for Identifying the Renewal Type of Residential Buildings. Buildings, 12(8), 1210.
[20] Knippschild, R., & Zöllter, C. (2021). Urban regeneration between cultural heritage preservation and revitalization: Experiences with a decision support tool in eastern Germany. Land, 10(6), 547.
[21] Pérez, M. G. R., Laprise, M., & Rey, E. (2018). Fostering sustainable urban renewal at the neighborhood scale with a spatial decision support system. Sustainable Cities and Society, 38, 440-451.
[22] Ribera, F., Nesticò, A., Cucco, P., & Maselli, G. (2020). A multicriteria approach to identify the Highest and Best Use for historical buildings. Journal of cultural heritage, 41, 166-177.