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Retraction

Retracted: Model of the Integration of the Building Interior with the Natural Environment Based on Nanomaterials and I.M. Pei's Design Concept

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] Y. Gu, Y. Wang, and J. Li, "Model of the Integration of the Building Interior with the Natural Environment Based on Nanomaterials and I.M. Pei's Design Concept," *Journal of Nanomaterials*, vol. 2022, Article ID 6373574, 8 pages, 2022.

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Research Article

Model of the Integration of the Building Interior with the Natural Environment Based on Nanomaterials and I.M. Pei's Design Concept

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The current pair of fusion models for fusing the information of building interior and natural environment treats the two separately due to a large amount of computation, which leads to low efficiency and poor results of fusion. Regarding the above-discussed problems, the study constructs a fusion model of building interior and the natural environment under I.M. Pei's design idea. Following an examination of how the interior of the building and the natural environment relate to one another by I.M. Pei's design concept, information about the natural environment and the interior of the building is obtained through the use of remote sensing technology and 3D modeling technology. To finish the development of the model, the neural network model is used after the training of the parameters, and then, feature-level and information-level fusion of the obtained data is carried out. The validation data of the model showed that the fusion efficiency of the constructed model was improved by about 58.9%, and the fusion effect was significantly improved.

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1. Introduction

People spend more than 80% of their time in the interior of buildings, and the interior environment that people perceive through their five senses affects their health, comfort, and work efficiency, making the interior design part of the building design more important for the design and users of the building. With the continuous enrichment of architectural design concepts and the increase of people's demand for building use, the interior design of buildings has been prompted to shift from a purely spatial function to a more multidimensional direction [1]. The internal space of the building is an important medium of communication between people and the building, a carrier that encompasses the main use function of the building and reflects the main inner temperament of the building. Compared to the external space, the internal space is more directly concerned with the needs of human use and psychological needs in the space. Maltseva et al. studied the integration of architecture and nature in mountainous environments and proposed the main means of coordination between architecture and landscape composition, visual perception, and aesthetic definition [2]. Mirmoradi started from the concept of fractal architecture using logical reasoning to analyze the relationship between architecture and nature in order to achieve a well-designed building [3]. Hoffmann et al. jointly used aerial and street view images to map building features through deep learning techniques, used modern remote sensing techniques to acquire building images, and coped with heterogeneous image modality problems with the help of data fusion strategies to achieve the study of building exterior and natural environment of the study of the relationship [4]. In Reference [5], information about the internal structure of the building was acquired using sensors and the information fusion process was carried out with the help of finite layer acceleration measurements and Bayesian filter estimation. The credibility of the fused information was greatly enhanced with the help of modern equipment like sensors. Ahana and Ronita investigated how to incorporate natural breeze in the design of the ventilation system inside the building with the aim of saving energy consumption in the building and practically fused the natural environment with the interior design of the building [6]. Reference [7] used the plain Bayesian theory to fuse the information, which is computationally complex and biased, and is not suitable for independent processing of fusion of building interiors with the natural environment.

Modern people are more interested in the design of building interiors that can be effectively integrated with the natural environment, and this development trend is very much in line with I.M. Pei's architectural design philosophy. I.M. Pei's architectural works have a wide range and many types, and he insists on considering art and history as the essence of architecture, and with the help of his superb architectural visual imagination, he makes architecture a cultural carrier and artistic pursuit with the subtle stacking of geometric shapes, the integration and extension of spatial layout, and the visual leap of light and shadow [8]. Believing that space is more important than symbols, I.M. Pei has incorporated cultural roots such as the Eastern concepts of time and space into his aesthetic thinking and creative practice, and pays more attention to the introduction of natural elements in his design works, linking internal and external spaces, introducing light, and making nature blend into architecture. He also attaches great importance to the concept of integrating the whole picture, creating a space around his architectural works for stopping and viewing, and creating an external space that incorporates a deep expression of personalization and personification [9]. In I.M. Pei's architectural design works, the atrium bears a large proportion of the internal structural design of the building, and with his calm, prudent, and elegant design characteristics, he cleverly integrates the wisdom and poetry of traditional Eastern architectural design into the creation of the artistic space inside the building, improving the visual quality of the building in addition to cherishing tradition and daring to innovate, distinctly and artistically reflecting the new aesthetics generated by the intersection of the two traditions of East and West. The building is characterized by a different artistic spirit. According to the above discussion of I.M. Pei's design concept and the current situation of building interior design, in order to improve the harmony between building interior design and natural environment, this paper will study the construction of a model for the integration of building interior and natural environment under I.M. Pei's design concept, in order to provide mathematical tools for designing building interior.

2. Model of Integration of Building Interior and Natural Environment under I.M. Pei's Design Concept

2.1. Analysis of the Relationship between the Interior of Buildings and the Natural Environment under I.M. Pei's Design Concept. The overall design of the building needs to consider the relationship between the building structure, function, and the building exterior and the environment, but inside the building, the natural environment outside the building will directly affect the senses of the building interior users when viewed through different angles towards the outside of the building. At the same time, building users inside the building observe both the building interior design and the natural environment, and the humidity, temperature, and light in the natural environment will affect the human experience of the building interior design. The interior design of a building is always based on the sensory experience of people. The interior design of a building should follow the needs of people and consider the interaction between building users, building, and nature as a whole in the same system. Figure 1 shows the interaction between the natural environment, the built environment, and the building user, and the relationship between the building interior and the natural environment needs to be analyzed before the integration of the building interior with the natural environment can be processed [10].

Therefore, based on the interaction between architecture, nature, and users, it is important to analyze the relationship between the building interior and the natural environment to determine the appropriate target values for creating the indoor environment. The main natural elements present inside the building are natural light, air, and water bodies, all of which affect the experience of building users inside the building. Among them, natural light has an important role in influencing the construction of all three basic elements of the building. At the same time, people's mood perception in architecture is obtained through the form, color, texture, light, and shadow expressed in architecture, and all this is because of natural light. At the same time, natural light not only satisfies the normal work of human beings in their daily life but also stimulates people's pleasure in the space. I.M. Pei's famous saying "Design with light" means the way in which the interior of a building is lit directly determines the amount of natural light available inside the building and the amount of atmosphere it can create. Natural ventilation is the main part of the exchange between the interior and exterior of a building, and the air exchange brought about by natural ventilation not only influences the design of the interior of the building but also the design of the exterior form and structure [11–13]. At the same time, different types of natural ventilation combine with the internal space form, texture, and color to create a certain cultural meaning and a certain spatial context. The functions of water bodies are divided into three aspects: aesthetic role, climate regulation, and contextual compensation. The water bodies in the internal spaces of buildings are usually shaped on a human scale, mainly to enhance human emotions and set up the atmosphere of the internal space. Other things such as plants placed inside the building can greatly enrich the facade form; natural materials can increase people's real perception of nature in the space and so on.

There is first of all a transfer of energy and matter between the building interior and the natural environment. For the building, its envelope is mostly multilayer porous media, and its interior is filled with air, pollutants, and water in different phases; i.e., it is a combination of multiphase substances coexisting. The transfer of energy and matter between the building interior and the natural environment is accompanied by diffusion, migration, and mutual transformation of each phase and sometimes physical and

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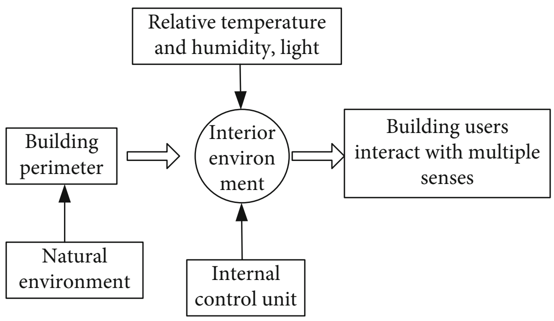

Figure 1: Schematic diagram of the interactions of architectural design elements.

chemical changes, which is a nonlinear process with a complex mechanism and can be regarded as a thermodynamic vector change. Therefore, the following equation is used in this paper for the relevant description [14].

$$I_i = L_{i1}X_1 + L_{i2}X_2 + \cdots + L_{ij}X_j. \tag{1}$$

In the formula, L is the transfer coefficient of energy and material transfer between building interior and natural environment, I is the energy flow of energy and material transfer within the building and the natural environment, and X is the driving force for energy and material transfer between the interior of the building and the natural environment. In the actual interior design of the building, this driving force can be temperature, air flow, sunshine radiation, etc. After analyzing the relationship between the interior of the building and the natural environment, the information of the interior of the building and the natural environment will be obtained with the help of modern information technology.

2.2. Access to Information on Building Interiors and the Natural Environment

2.2.1. Building Interior 3D Spatial Data Acquisition. In this paper, a 3D laser scanner will be used to acquire data related to the internal structure of the building and remote sensing technology will be used to acquire information related to the natural environment outside the building. According to the current design standards for building interiors, this study uses a 3D laser scanner with parameters that conform to those shown in Table 1 to capture spatial information about building interiors [15].

After using a 3D laser scanner with parameters that meet the requirements in Table 1 to collect the spatial information inside the building, a 3D spatial model of the building is established. In the process of 3D point cloud data acquisition, usually, the fixed target object changes the position of the laser scanner, and it can be considered that the scanned object does not move, but only the position of the scanner changes; that is, the 3D spatial right-angle coordinate system of the point cloud is rotated and displaced transformed. Therefore, spatial 3D point cloud alignment is required; that is, the source point cloud is transformed to the target point cloud under the same coordinate system.

The process of point cloud stitching is to find the rotation translation matrix between the two point clouds transformed from the source to the target point cloud, which can be expressed as the following equation [16].

$$A_1 = A_2 * \alpha + \beta. \tag{2}$$

In the formula, A_1 and A_2 are the corresponding points of source point cloud and target point cloud, α is the rotation matrix of the transformation coordinate system of source point cloud and target point cloud, and β is the translation matrix of the transformation coordinate system of source point cloud and target point cloud. After denoising the data after point cloud splicing, point cloud segmentation surface screening is carried out to avoid the point cloud data volume being very large due to high-precision description and to reduce the computing speed of computer data processing during model reconstruction. For the two oversegmented planes, whether they belong to the same original plane can be judged according to the following criteria:

(1) Calculate the angle of the normal vector between the face pieces, which is less than a certain threshold value

(2) Calculate the distance between the origins to each face slice, and the absolute value of the difference between the two distances is less than a certain threshold value

When both conditions (1) and (2) are satisfied, it can be determined that the two planes are oversegmented in the same plane and the two face slices are fitted. The fitting of the two planes is performed according to the following equation [17].

$$\begin{cases} a_1x + b_1y + c_1z = \varepsilon, \\ a_2x + b_2y + c_2z = \gamma. \end{cases} \tag{3}$$

According to the normal vectors (a_1, b_1, c_1) and (a_2, b_2, c_2) of the two point cloud planes in the above formula, the included angle value of the normal vectors of the two planes is calculated, and the relationship between the two planes and the threshold value is judged. If the angle between the normal vectors of two cloud surfaces and the absolute value of the distance difference are both less than the threshold value, the two planes can be determined to belong to the same plane, and then, the two planes can be fitted into a new plane according to the point cloud data of the two surfaces.

2.2.2. Access to Information on the Natural Environment. Using remote sensing technology to obtain information about the natural environment around the building, the boundary between the building and the natural environment is firstly segmented from the remote sensing image. Edge features are one of the most basic underlying features in target detection. By observing the characteristics of buildings in remote sensing images, it is found that compared with the

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Table 1: 3D laser scanner parameter items and the range of values.

Serial number	Parameter items	Parameter value range
1	Maximum measurement range, target reflectance 90%	550~800 m
2	Maximum measurement range, target reflectance 10%	200~400 m
3	Minimum measurement distance	1.5~2.0 m
4	Repetitive measurement accuracy	±5, ±8 m
5	Laser emission frequency	300,000/s
6	Vertical line scan, maximum scan angle	$100^\circ \pm 40^\circ$
7	Vertical line scan, minimum scan angle	0.0025°
8	Horizontal plane scanning, maximum scanning angle range	$360\sim540^\circ$
9	Horizontal plane scanning, minimum scanning angle range	$0.0024\sim0.0029^\circ$

background, buildings generally have complete and obvious edges, which are uniformly distributed in four quadrants with the center as the origin. Therefore, in this paper, the algorithm is solved for edge density and edge distribution to jointly characterize the edges of buildings and thus obtain information about the natural environment. The Prewitt operator and Sobel operator template is used to detect building edges in high-resolution remote sensing images. The calculated edges are subjected to nonmaximum suppression; i.e., the gradient magnitude of the current edge point is compared with the gradient magnitude on both sides of its gradient direction, and if the gradient value at that location is larger than the gradient values on both sides of its gradient direction, the gradient value is retained; otherwise, it is set to 0. Thus, the edge point with the largest local gradient is retained, the other gradient edges are suppressed, and the location with the sharpest gradient change is retained as the final edge result. The edge density and edge distribution are calculated according to the following equations [18].

$$\rho_e = \frac{N_e}{N_w}, \tag{4}$$

$$\rho_s = \frac{\min(N)}{\mathrm{mean}(N_i)}. \tag{5}$$

In the above formula, N_e represents the number of edge points included in the calculation of edge density in the sliding window, N_w is the total number of pixels in the sliding window, and the edge density ρ_e is obtained by comparing the two. A two-dimensional Cartesian coordinate axis is established with the center of the sliding window as the center of the circle, and the sliding window is divided into four quadrants, as shown in Figure 2. Among them, N_i represents the number of edge points contained in quadrant i. The minimum number of edge points contained in the four quadrants $\min(N)$ was divided by the $\mathrm{mean}(N_i)$ number of edge points contained in each quadrant to obtain the edge distribution ρ_s, which was used to measure the uniformity of the distribution of edge points in the four quadrants [19–21].

Rectangular structure buildings have mostly more rules or polygon structure; thus, it has the obvious main direction and shows the main direction of orthogonality, which has two perpendicular directions to the main direction. Therefore, in this paper, the gradient direction is divided into 12 intervals m with 15° as one direction and N_m edge points contained in each direction interval which are counted, as shown in Figure 3.

If the sliding window contains a vertical orthogonal structure, it should have dense edges in two specific mutually perpendicular directions, and that specific direction is the target principal direction. By calculating the sum of the number of edge points of the two mutually perpendicular direction levels and taking the two perpendicular direction levels with the maximum value as the main direction of the window, the following equation is shown.

$$\max(N_m + N_{m+6}), \quad m \le 7. \tag{6}$$

The orthogonal exponent of the region is calculated by grading the two directions perpendicular to each other. After determining the boundary between the building exterior and the natural environment, the difference of brightness in remote sensing image is used to divide the natural environment area. In remote sensing images, most of the buildings are surrounded by natural environment and some shadows of buildings, so there are contrasts in brightness. Therefore, the square template with the same size of the sliding window is used to set the gray value of the circular region with the template center as the center, 3/4 of the template side length as the radius as 0, and the rest of the region as 255, forming a template with light in the middle and dark around. The template completely covers the sliding window, and the matching measure T'between the window and the template is calculated according to the following formula, so as to reflect the similarity between the sliding window and the template and to measure the brightness contrast between the center and the surrounding window.

$$T'(i, j) = \frac{\sum\sum w(q, p) T(q,p)}{\sum\sum w(q, p)^2}. \tag{7}$$

In the formula, w is the width of the sliding window and T is the designed square template. The larger the matching measure is, the more similar the window and template are. Therefore, the stronger the brightness contrast between the

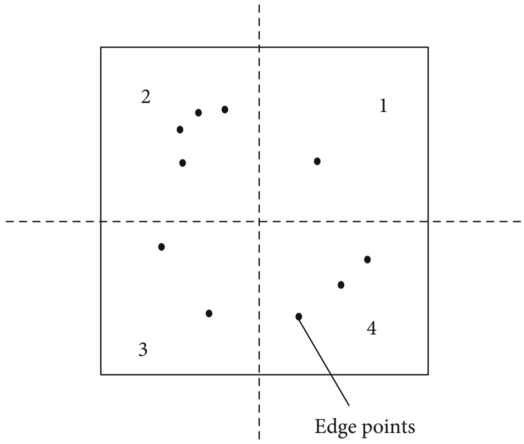

Figure 2: Distribution diagram of building edge in 2D left quadrant of remote sensing image.

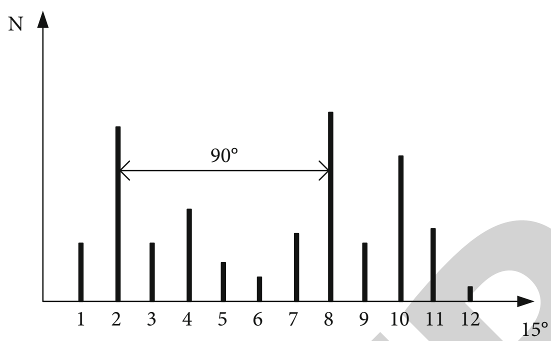

Figure 3: Histogram of edge point distribution.

center of the sliding window and its surroundings is, the greater the possibility that the sliding window contains buildings. According to the above content, different elements in the natural environment are divided to obtain the information of the external natural environment of the building.

2.3. Realization of Model Construction for Integration of Building Interior with Natural Environment. In this paper, we use neural networks to process the building interior and natural environment information obtained in the above paper to realize the building interior and natural environment fusion model construction. The data description language of the IFC data standard is EXPRESS language, which adopts an object-oriented approach to organize the data into hierarchically related classes. Select type and entity to specify the IFC standard model, as shown in Table 2 [22, 23].

The spatial structure elements of a building body are IfcProject, IfcSite (site), IfcBuilding, and IfcBuildingStorey (building floor), as shown in Table 3.

After building a point cloud model of the building interior using IFC, the surrounding natural environment data is imported and the natural environment information of the building interior is obtained based on the conclusion of the analysis of the relationship between the building interior and the natural environment in I.M. Pei's design concept. The above information is processed using neural networks to complete the fusion model construction.

The output function of the artificial neural network model is as follows.

$$\text{out} = f\left(\sum r_i l_i - \theta\right). \tag{8}$$

In the formula, r_i is the neuron input of the neural network, $l_i$is the connection parameter of each neuron in the neural network model, θ is the set threshold for the integration of the interior of the building with the natural environment, f is the activation function of the neural network model, and ReLU function is selected in this paper. Building internal information and natural environment information are input from different input units of neural network, and the data information level fusion is realized under the action of function. Taking the features of building interior and natural environment information as the input, the feature-level fusion results can be obtained. At this point, the construction of the integration model of the interior and natural environment under the design concept of Ieoh Ming Pei was completed.

3. Instance Validation and Analysis

As an outstanding architect in the history of architecture, with a macro historical perspective, I.M. Pei's remarkable architectural creations are an important inflection point in the overall development framework of modernist architecture and the historical process of modernization and transformation of Chinese architecture. By analyzing and interpreting his architectural cases in depth from a microscopic perspective, sorting out his creative history and the flow of his methods, and summarizing the modernist architectural aesthetic ideas with Chinese implications embedded in the forms of his works, we can better explore the way he transformed his ideas into forms, the interaction between his personal creations and the styles of his time, and help later generations inherit and interpret the modernist architectural ideas.

In the above section, a model for the integration of building interior and natural environment under I.M. Pei's design concept is constructed from the perspective of mathematical research in the context of analyzing I.M. Pei's architectural design concept. In this section, the fusion model is applied to an actual architectural design project, and the feasibility of the model as well as the performance indicators of the model are analyzed in depth.

3.1. Validation Scheme Design. Presurvey data of an architectural design project and information about the overall design architecture parameters of the building are selected as background data for model validation, and the fusion model constructed in this paper, the plain Bayesian-based fusion model, is used to simultaneously use the above background data for building interior design. The performance of the model is evaluated by comparing the redundancy ratio of

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Table 2: Types of information defined by the IFC model.

Serial number	Defined type	Description of building interior construction information
1	Enumeration	Define textual information to express the properties of the model ontology, which must be one of the four language rules.
2	Select type	Instead of simply representing a type, it can define itself as an information type if it satisfies the defined type or entity language definition.
3	Entity	Describing the information on the various attributes of building components and the inheritance relationships between building components is one of the most important types of information.

Table 3: Elements of the spatial structure of the point cloud data inside the building.

Serial number	Key constituent	Instructions
1	IfcProject	Classes expressing all information about construction work
2	IfcSite	Information on all buildings
3	IfcBuilding	Classes describing building accessory information, excluding building geometry information
4	IfcBuildingStorey	A class describing information about the floor itself, including detailed geometric profiles of building components such as windows, doors, and walls, spatial relative position information, and correlation between the components

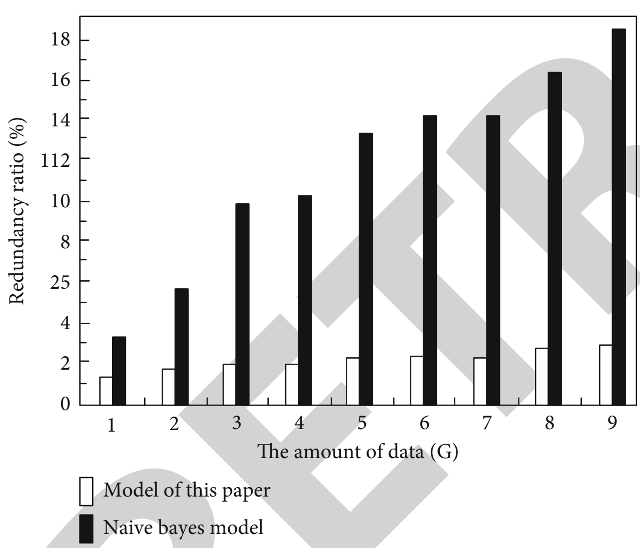

Figure 4: Comparison of convergence redundancy ratio.

the two models after fusion, the processing time of the model, and the computational resource share of the model when applied.

3.2. Validation Results and Discussion

3.2.1. Model Validation Results. Figure 4 shows the variation of data redundancy ratio when the two fusion models are fused.

Table 4 shows the comparison of the processing time of the fusion model and the percentage of resources used for processing.

3.2.2. Discussion and Conclusion. Analysis of the curves in Figure 4 shows that the redundancy ratios of the data fused by the models in this paper are all lower than 7.8%, while the redundancy ratios of the data fused by the plain Bayesian model appear to be greater than 20%. As can be seen from the data analysis in Table 4, the processing times of the models in this paper are all shorter than the fusion times of the plain Bayesian model, and on average, the fusion efficiency of this paper is improved by about 58.9%. As the amount of fused data increases, the time cost of the plain Bayesian model keeps increasing, which is caused by the large computational volume of the plain Bayesian. Also, the large computational volume not only causes high time cost but also causes the proportion of resources occupied by the model to keep increasing.

Table 4: Comparison of model processing time and resource share.

Data volume (G)	This paper models		Plain Bayesian model	
	Time (s)	Share of resources (%)	Time (s)	Share of resources (%)
1	2.1	2.7	2.7	3.8
2	2.2	3.1	3.5	5.7
5	2.9	5.2	6.8	8.3
10	3.5	6.9	9.2	12.5
20	4.4	7.8	14.6	20.4

Based on the above analysis and summary of the data information obtained from the validation, it can be judged that the processing efficiency of the fusion model of building interior and natural environment under I.M. Pei's design concept constructed in this paper is greatly improved, the redundancy ratio of information after the processing of the fusion model is greatly reduced, and the evaluation obtained by applying the fused data information of this model for building interior design is better. It shows that the fusion

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model of building content and natural environment constructed in this paper has improved performance compared with the traditional fusion model and can be used in the actual architectural design work to assist architects in better architectural design.

4. Conclusion

I.M. Pei's philosophy of integrating architecture with nature has dominated his life's work. The emphasis on the relationship between architecture and the environment has given Pei a sensitive insight into site selection, and he has always been able to discover the connotations unique to the culture of a region and express them in the language of architecture. Although the original environment of a building has a greater restrictive effect on the construction of a new building, it is also because of the specific geographical environment that a special architectural art is built, and it is the environment that creates I.M. Pei's artistic architecture. In view of the characteristics of the integration of environment and architectural design in I.M. Pei's design concept, this paper constructs a model of the integration of building interior and natural environment under I.M. Pei's design concept and visualizes I.M. Pei's design language through mathematical form, so that later, architectural designers can understand more accurately how to effectively integrate building interior design with natural environment in architectural design work, so as to improve the beauty of architectural landscape and the harmony with the natural environment. The validity of the constructed model was tested through example verification, and the verification data showed that the constructed model has a good integration effect, which is a good representation of I.M. Pei's design concept from the mathematical perspective. In future research, other factors affecting the integration of the building interior design and the natural environment in the architectural design work will be explored in depth in order to improve the general usability of the constructed integration model. An attempt will also be made to study the integration model of the overall design of the building and the natural environment so as to enhance the harmony of the overall building interior and exterior and the natural environment.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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