Construction and Optimization of CAD Teaching System for Interior Decoration Design Major

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Abstract. With the rapid progress economy and technology, the interior decoration design industry is also developing rapidly, and its modernization level is gradually improving, which makes the competition in this industry gradually intensified, and traditional hand-drawn drawings or floor plan design can no longer satisfy users. For this reason, the industry continues to have a large number of high-level interior decoration design talents in the industry. In order to better achieve the effect of interior decoration design teaching, the current interior decoration design education work gradually takes the training of high-tech talents as the main goal of teaching, and its core connotation is to carry out practical training teaching. In the teaching of interior decoration design, the computer-aided design using the more efficient effect panoramic display technology can fully display the effect of the interior design space to the user, so that the user can understand the interior decoration design effect more clearly. Based on this background, this paper applies neural style transfer algorithm and computer-aided design to interior decoration design, which can not only assist designers to quickly select various indoor furniture accessories, but also provide users with immersive selection through virtual reality rendering. Experience, to meet the diverse service needs of users.

Keywords: Interior Decoration Design; Cad; Teaching System.
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1 INTRODUCTION

People spend more than 90% of their time indoors. Whether it is the structure of the space or the color, texture and furnishings of interior decoration, they all profoundly affect people's mood and behavior indoors. A good interior design, especially comfortable and satisfactory interior decoration, is particularly important in people's modern life. And assisting users to efficiently select a satisfactory interior decoration scheme before decoration has become one of the keys in practical work [1]. However, the current display methods for interior decoration schemes have the

disadvantages of being time-consuming, single-function, and requiring a large amount of indoor space information [2]. The importance of interior design to human beings is self-evident. Whether it is living space or working space, whether it is interior decoration or interior decoration [3]. The effective display of interior decoration scheme is conducive to the effective development of subsequent interior decoration work, and a good indoor environment is also conducive to improving the quality of human life and work [4]. However, these four methods cannot display different interior decoration schemes in different spaces at the same time, and provide an immersive experience without specific information such as house structure [5]. The use of computer-aided design technology to achieve interior decoration design has become the current development trend Table 1.

Software company	*Core modeling software*		
Autodesk	Revit Architecture	Revit Structure	Revit MEP
Nemetschek Graphisoft	ArchiCAD	ALLPLAN	Vector works
Gery Technology	Digital Project	CATIA	
Tdkla	Tekla Structures	Tekla Structures Designer	Tekla Tedds

Table 1: Typical CAD core modeling software.

2 STATE OF THE ART

2.1 Design Status

In the process of interior decoration design, Kalantari and Neo [6] completes the drawing of design drawings in combination with the basic nature of the building and the specific standards of environmental design. With the continuous improvement of national living standards and consumption levels, the standards and quality requirements for interior decoration are also improving. With the diversified development trend of intensive, intelligent and serialized interior design, the theory of Larsen et al. [7] plays an important role in modern interior construction. With the flexible use of interior design style and the diversification of elements, interior design itself presents a diversified development trend, but also presents some characteristics of the new era. Maghsoodi et al. [8] discusses its use value by studying the function analysis of different interior designs on users. Man and Damasio [9] utilizes and converts the structural value through the analysis of housing design. Minda [10] found that two-dimensional data are prone to information loss or distortion in different majors and stages of the project. Namazovna [11] uses CAD and other design software for design and 3D software such as 3D Max and rhino for production. However, in the actual construction application, there are differences between two-dimensional construction drawings and three-dimensional solid engineering projects, which can not achieve work efficiency. Further improvements will have a direct impact on 3D space design and interface visualization. The multi-professional coordination is relatively poor. As shown in Figure 1, in a construction project, there are many participants. In the process of realizing multi-party collaborative work, because the drawing information is very prone to defects or information distortion, this will directly affect the design of the construction project [12]. In the process of comprehensive application, the construction standards of different disciplines will cause conflicts. For example, when designing a ceiling-mounted air conditioner, there will be conflicts in the reserved space of the indoor ceiling and the routing and elevation of the electrical and mechanical professional pipelines in the ceiling. The traditional conflict detection is to find conflicts from drawings, but human operation is very prone to defects or misjudgments, which delays the efficiency and accuracy of indoor collaborative design.

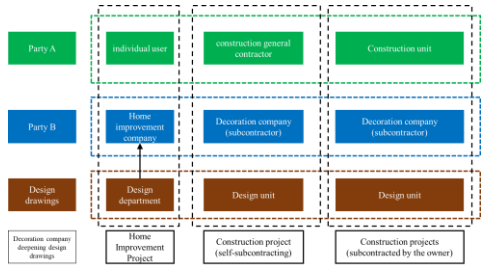

Figure 1: Participants in interior decoration design.

In the actual design process, it is easy to stack decorations, blindly pursue novelty, but ignore the overall coordination and unity. Therefore, we need to pay attention to the visual effect of interior decoration design and the importance of green buildings to improve the comfort of interior space [13]. Due to some designers' lack of innovation consciousness, they do not pay attention to the health of life, and are not cautious in the selection of materials and processes, which has affected the diversified development of interior design [14].

2.2 The Current Status of CAD Teaching of Interior Decoration Design

Although industry university research cooperation has attracted the attention of the central government and the government has gradually participated, it is still at a low level compared with the international community. This shows that the government's response to industry university research cooperation is still not sensitive enough, often in a passive position. There is too little money for teaching and research of design CAD. In fact, any mode of cooperation involves the distribution of interests and intellectual property rights. Therefore, it is still necessary to strengthen the market interaction operation mechanism of universities, scientific research institutions and enterprises relying on enterprises [15].

2.3 Application of Computer-Aided Design Technology in Interior Decoration

3D models of interior decoration components are drawn on the basis of architectural models. Using computer-aided design technology can realize the three-dimensional model drawing of interior walls, floors, ceilings, partitions, etc. The specific step process is shown in Figure 2.

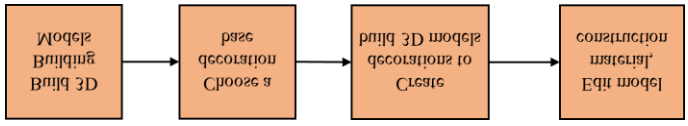

Figure 2: Drawing steps of 3D model of decorative components.

Collision checking. In the decoration construction site, the conflict and collision between the decoration components and various pipes and equipment is a thorny problem that is often encountered. In the traditional way of using two-dimensional state design, the design and construction of buildings, structures, equipment, decoration, etc. are carried out separately, and each set of drawings is produced. In this discrete way of working, conflicts and collisions between components are frequent and unavoidable problems. Under the computer-aided design technology, each component is created with a 3D solid model. Just select the model category to be tested, and use the "Collision Check" command in the "Collaboration" menu to check and scan the 3D model according to the selection. to identify overlapping or conflicting elements and generate a conflict report that informs you of the number of conflicts caused by overlapping elements that could lead

to errors during construction. After receiving these alerts, errors can be corrected. In order to achieve the effect of simulation. We use the rendering commands in the computer-aided design software to render the three-dimensional space to achieve photo-realistic images, as shown in Figure 3.

Figure 3: Final rendering of interior decoration design.

3 METHODOLOGY

According to the shortcomings of existing methods, the characteristics of existing technologies and algorithms, and the interior decoration design scheme based on neural network style transfer and computer-aided augmented reality, realizing the free conversion of interior decoration styles can greatly improve the current process optimization of interior decoration design teaching. The overall process is shown in Figure 4.

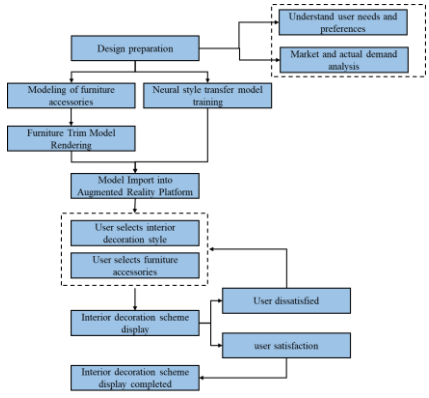

Figure 4: Optimization process of interior decoration design scheme.

3.1 Neural Network Style Transfer Algorithm

A large number of images to be processed and images of a specific style are constrained by the loss function to obtain the corresponding parameters and the relative optimal loss function value under the corresponding training data set and iteration times, and then the neural style transfer model is obtained. The input image to be processed is processed and a stylized image of a specific style is output. The neural network style transfer algorithm can quickly transform the user's interior decoration style.

3.2 Principle of Neural Network Migration Algorithm

It is time to replace batch normalization in the previous algorithm with instance normalization. This paper uses the above two methods, which can make the neural network architecture of the neural

style transfer algorithm perform better, the quality of the output image is better, and the image resolution is higher.

Symbol	*Meaning*
$\vec{p}$ 、 $\vec{a}$ 、 $\vec{x}$	Image to Convert, Style Image, Stylized Image
j	The jth layer of the loss network
ϕ	loss network
C_j 、 H_j 、 W_j	The jth layer of the loss network， Feature map de Number of channels, height and width
$\phi_j(\vec{x})$	Loss network ϕ when processing image $\vec{x}$, activation function value of layer j
$\phi_j(\vec{x})_{h,w,c}$	The feature of each point on the $H_j \times W_j$ grid of the jth layer of the loss network in the C_j dimension
$G_j^{\phi}(\vec{x})_{c,c'}$	The gram matrix between the image channels of the jth layer of the loss network (can be regarded as the eccentric covariance matrix between the two feature maps)
$L_{total}(\vec{p},\vec{a},\vec{x})$、 L_{total}	Total loss function value
$L_{conten}(\vec{p},\vec{x})$、 $L_{content}$、 $L_{feat}^{\phi,j}(\vec{x},\vec{p})$	Content loss function value
$L_{styfe}(\vec{a},\vec{x})$、 L_{styfe}、 $L_{styfe}^{\phi,j}(\vec{x},\vec{a})$	style loss function value
α、 β	The weight of the content loss function value, the weight of the style loss function value
T	number of images per batch
x_i	The output value of the activation function of each layer of the neural network
μ	average value
σ^2	variance

Table 2: Symbol description table.

The following describes the neural network migration algorithm, and the symbol description is shown in Table 2. During the training of neural style transfer algorithm, specific style images and images to be processed, or training images, need to be input. The first calculates the loss value of the style image and the stylized image, as well as the loss value of the to-be-processed. The weighted average of the loss values is used to obtain the loss function value. In each training parameter process, under the conditions of certain training data and iterations, the one with the smallest loss value is the best, so as to determine the optimal neural style under specific conditions. Migration model. The smaller the similarity between the stylized image and the image to be processed, the greater the similarity to the styled image.

$$L_{total}(\vec{p},\vec{a},\vec{x}) = \alpha L_{content}(\vec{p},\vec{x}) + \beta L_{style}(\vec{a},\vec{x}) \tag{1}$$

Calculated with perceptual loss for real-time conversion and high pixel value conversion. The loss function formulas used in this paper are as follows:

$$L_{content}(\vec{p},\vec{x}) = l_{feat}^{\phi,j}(\vec{p},\vec{x}) = \frac{1}{C_j H_j W_j}\left\|\phi_j(\vec{x}) - \phi_j(\vec{p})\right\|_2^2 \tag{2}$$

$$L_{style}(\vec{a},\vec{x}) = l_{style}^{\phi,j}(\vec{a},\vec{x}) = \left\|G_j^{\phi}(\vec{x}) - G_j^{\phi}(\vec{a})\right\|_F^2 \tag{3}$$

Hj and Wj are the height and width of the jth layer. After entering the convolutional network, the number of channels will change and can be greater than 3; φ is the activation function value of the jth layer of the loss network φ when processing the input image. When stacking layers, φ is the feature image of:

$$G_j^{\phi}(\vec{x})_{c,c'} = \frac{1}{C_j H_j W_j}\sum_{h=1}^{H_j}\sum_{w=1}^{W_j}\phi_j(\vec{x})_{h,w,c}\phi_j(\vec{x})_{h,w,c'} \tag{4}$$

Both batch normalization and instance normalization are normalization methods. Normalization refers to a data nonlinear processing method that maps data to a specific area in the calculation process of the convolutional neural network. At the same time, batch normalization can also reduce the need for regularization methods. usage of. Suppose that for each activation function x, there is a pair of parameters γ, β such that:

$$y^{(k)} = \gamma^{(k)} x_i^{(k)} + \beta^{(k)} \tag{5}$$

The expression for batch normalization is as follows:

$$\mu_B \leftarrow \frac{1}{m}\sum_{i=1}^{m} x_i \tag{6}$$

$$\sigma_B^2 \leftarrow \frac{1}{m}\sum_{i=1}^{m}(x_i - \mu_B)^2 \tag{7}$$

$$x_i \leftarrow \frac{x_i - \mu_B}{\sqrt{\sigma_B^2 + \varepsilon}} \tag{8}$$

$$y_i \leftarrow \gamma x_i + \beta \equiv BN_{\gamma,\beta}(x_i) \tag{9}$$

$$y_{tiwh} = \frac{x_{iwh} - \mu_i}{\sqrt{\sigma_i^2 + \varepsilon}} \tag{10}$$

$$u_i = \frac{1}{HWT}\sum_{t=1}^{T}\sum_{w=1}^{W}\sum_{w=1}^{H} x_{tiwh} \tag{11}$$

$$\sigma_i^2 = \frac{1}{HWT}\sum_{t=1}^{T}\sum_{w=1}^{W}\sum_{w=1}^{H}(x_{tiwh} - h\mu_i)^2 \tag{12}$$

Instance normalization only calculates the average and variance of each image itself, which is more in line with the purpose of style transfer, and the model trained with instance normalization is naturally better under the same conditions.

$$y_{tijk} = \frac{x_{ijk} - \mu_i}{\sqrt{\sigma_i^2 + \varepsilon}} \tag{13}$$

$$u_{it} = \frac{1}{HW}\sum_{w=1}^{W}\sum_{w=1}^{H} x_{tiwh} \tag{14}$$

$$\sigma_{it}^2 = \frac{1}{HW}\sum_{w=1}^{W}\sum_{w=1}^{H}(x_{tihw} - h\mu_{ti})^2 \tag{15}$$

3.3 Decoration Design Style Conversion Network

The style transfer network consists of three parts. The first part consists of three convolutional layers, and down-sampling is achieved by setting the stride (1, 2, 2 respectively); the second part consists of 5 residual blocks; the third part consists of 3 convolutional layers, by setting the stride (respectively 1/2, 1/2, 1) to achieve up-sampling and complete deconvolution; as shown in Table 3. Down-sampling reduces the image size to fit the training needs of the residual network, and up-sampling enlarges the image. In the conversion network, the image is restored to the input size by up-sampling, which facilitates the output of stylized images on high-resolution devices without affecting the visual quality of the image.

Floor	*activation layer size*
input layer	$3\times256\times256$
Convolutional layer, number of convolution kernels=32, kernel size=9×9, stride=1	$32\times256\times256$
Convolutional layer, number of convolution kernels=64, kernel size=3×3, stride=2	$64\times128\times128$
Convolutional layer, number of convolution kernels=128, kernel size=3×3, stride=2	$128\times64\times64$
Residual block, number of convolution kernels = 128	$128\times64\times64$
Residual block, number of convolution kernels = 128	$128\times64\times64$
Residual block, number of convolution kernels = 128	$128\times64\times64$
Residual block, number of convolution kernels = 128	$128\times64\times64$
Residual block, number of convolution kernels = 128	$128\times64\times64$
Convolutional layer, number of convolution kernels=64, kernel size=3×3, stride=$\frac{1}{2}$	$64\times128\times128$
Convolutional layer, number of convolution kernels=32, kernel size=3×3, stride=$\frac{1}{2}$	$32\times256\times256$
Convolutional layer, number of convolution kernels=32, kernel size=9×9, stride=1	$3\times256\times256$

Table 3: Information on the network architecture of decorative design style conversion.

4 RESULT ANALYSIS AND DISCUSSION

4.1 Determination of Neural Network Parameters

The result of interior decoration style conversion depends heavily on the α and β parameters in the neural style transfer model, which are the key parameters to determine the display effect. However, researchers have not reached a consensus on how to determine the specific values of α and β, so this paper conducts experiments through experiments. Select parameters. According to the characteristics of the algorithm, this paper will select the best parameters in the variable set to meet the experimental and application scenarios. The number of training images is 6000, the first

generation training (epoch) value is 2, and the batch data (batch) value is 4. Therefore, the training model is iterated for a total of 3000 times. Figure 5 shows the model output corresponding to different α/β parameters.

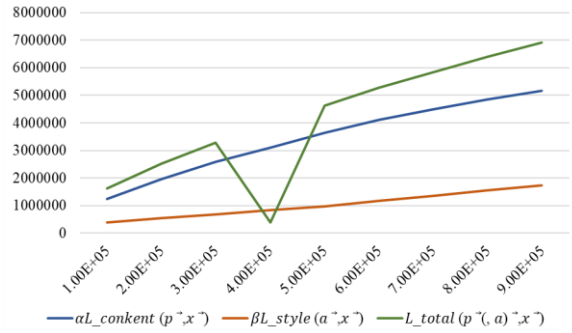

Figure 5: Loss function value of neural style transfer model with different parameters (change to line graph).

According to the experimental results, it can be found that when the value of α/β is 4e−5, the experimental results are the most satisfactory. On the one hand, the output image retains the content information of the image to be converted to the greatest extent, and on the other hand, it also minimizes the error. The style of the style image is transferred to the output image. Nonetheless, the loss function of the model is not the smallest when the value of α/β is 4e−5. At present, the neural network is still a black box, and how to select the best value of α/β is still unknown. In this experiment, the observation and comparison method is the best solution that this paper can take.

4.2 Comparison and Analysis of Experimental Results

For the transformed images, two evaluation criteria are designed. First, the stylization effect of interior decoration images is evaluated. Then, an evaluation is made for salient regions where whether the stylized image can be consistent with the content image. Ask users to rate the stylized results of each algorithm, and the final average is divided into the algorithm's final score for that question. Figure 6 is a histogram of the user survey results. It can be seen that the stylized images generated by the algorithm in this chapter can not only perform style conversion but also maintain the salient regions consistent with the content images, with excellent visual effects.

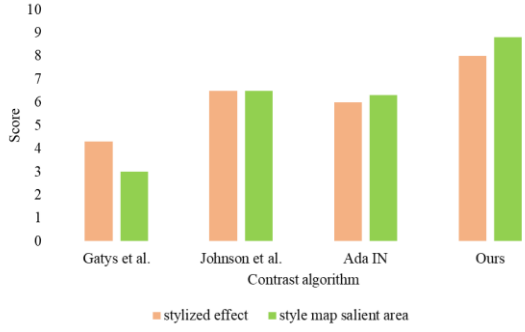

Figure 6: Histogram of designer user survey results.

Since the interior decoration design is influenced by the user's stylistic tendency, a questionnaire survey is used to evaluate the stylization effect. Evaluation of stylization effects. The first link requires the selection and pairing of the generated stylized images with several given style images. A total of 20 questionnaires were used, and each algorithm in each questionnaire generated 4 stylized images, and each stylized image gave Get 3 style images, one of which is the style of the stylized image, let the user choose which style the stylized image comes from, calculate the correct matching rate of each algorithm and take the average value. In the second step, use the same style Different algorithms for content images and style images generate stylized images, allowing users to select the algorithm with the best visual effect, and then make statistics to calculate the percentage of each algorithm selected as the user's preference score for the algorithm Figure 7 and Figure 8.

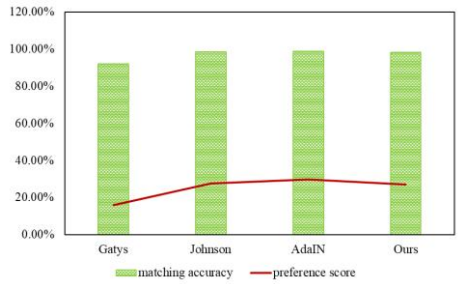

Figure 7: The stylized decoration scheme generated by the model is investigated in the visual perception (change the bar chart and the line combination chart).

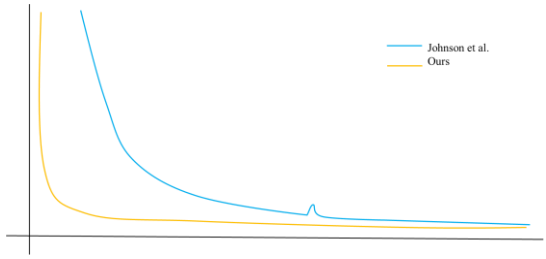

Figure 8: Loss decline rate of different algorithms.

The convergence speed than the algorithm of Johnson et al. As shown in Figure 9, training on the same dataset uses evaluation scores to measure the quality and diversity of style transfer images. The better the image quality of style transfer and the faster the convergence speed.

Table 4 shows the performance comparison results of several interior decoration design schemes, and evaluates the specific implementation process of this method and the four existing interior decoration scheme display methods. Function, time-consuming to change the plan, applicable population and cost of changing the plan" are compared, which fully proves the great advantage of the new interior decoration plan display method proposed in this paper compared with the existing method. It provides a new perspective and direction for the development of existing indoor display methods, and is more expected to replace existing methods and has great future development potential.

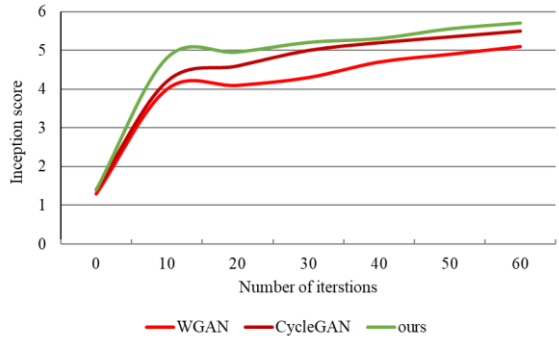

Figure 9: Comparison of convergence rates of different algorithms.

Display method of interior decoration scheme	*Immersive experience*	*Instant display of interior decoration solutions*	
		interior decoration style conversion	*Pick upholstery*
Hand-painted drawings interior decoration scheme display method			
Traditional interior decoration scheme display method			
Display method of interior decoration scheme based on virtual reality	√		
Display method of interior decoration scheme based on augmented reality	√		√
Display method of interior decoration scheme based on neural style transfer and augmented reality	√	√	√

Table 4: Comparison of various interior decoration design schemes.

5 CONCLUSION

With the continuous improvement of residents' living standards and the continuous pursuit of a better life, the aesthetic standards continue to improve. Residents' requirements for interior decoration and decoration continue to increase. Interior design includes not only interior space design, interior furniture, decoration items, but also interior decoration style design. Due to people's increasing aesthetic demands, interior decoration has attracted more and more attention from users, and the requirements for interior decoration have become more diverse and higher. As to satisfy people’s needs. Comfortable requirements for living and working environment. In view of the fact that the existing interior decoration scheme display methods cannot meet the short-term consumption at the same time, the functions are comprehensive (both interior styles can be converted and interior furniture can be selected), there is no need to obtain interior space information in advance, and an immersive experience can be provided to enhance the communication efficiency between users and designers. This paper proposes an interior decoration scheme display method based on neural style transfer and augmented reality. The neural style

transfer algorithm is used to realize the unified transformation of interior decoration styles for indoor colors, textures, etc., and computer-aided design is used to assist users to quickly select various indoor furniture accessories. The results show that the interior decoration design method proposed in this paper has great advantages over existing methods, and provides a new perspective and direction for the development of existing interior display methods.

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