Computer Aided Technology and Its Application in the Teaching of Interior Design

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Abstract. With the improvement of the current economic level, the requirements for residential space in this paper are becoming more and more refined. Home layout needs to consider not only personal aesthetic preferences, but also culture. With the popularization of interior design professional information technology and computer-aided art design disciplines, the application scope is becoming more and more extensive. The emergence of computers has greatly helped the development of home design. This has effectively transformed the aesthetic planning and design. The application of computer-aided software has changed the traditional design and construction process of the interior design industry and improved the design efficiency, but the display on the design software interface cannot take into account the requirements of instant response and rendering effect. Because the teaching scene needs to realize the rapid display of the design effect as soon as possible, so that the teacher can better explain the teaching, so the rendering system has become an important part of the interior design function. This paper mainly analyzes some problems designs and implements a set of efficient indoor scene rendering system based on computer cluster, automatically generates rendering scene, adaptively adjusts lighting, and automatically sets rendering parameters. The research of this paper provides a certain reference value for the development of indoor aesthetics.

Keywords: Interior Design; Computer-Aided Technology; Teaching.
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1 INTRODUCTION

Indoor space is a place with strong privacy. People spend more than 90% of their time indoors. Whether it is the structure of the space or the color, texture and furniture of the interior decoration, they all profoundly affect people's mood and behavior indoors [1]. A good interior design, especially comfortable and satisfactory interior decoration, is particularly important in

people's modern life. In the interior design, it is necessary to meet the basic needs of basic users, and at the same time, it must be able to fully demonstrate the user's personality and pursuit [2].

After meeting the most basic survival needs, most of them expect their living places to not only meet the traditional needs such as food and accommodation, but also Beautiful, comfortable, functional, personalized design and other requirements [3]. The traditional interior design market industry involves complex subjects, and there is a problem of information asymmetry and opacity. The relevant design knowledge that consumers understand is far less than that of traditional interior design industry service providers [4]. Customers at the end of the interest chain do not understand these rebate behaviors, and it is easy to spend high prices to buy inferior quality Material [5]. The model and scene data are constructed in the computer and displayed on the screen through a series of pixel transformations, so the rendering operation can be regarded as a 2D image processing behavior based on a certain 3D scene [6]. In the teaching of interior design, the limited teaching time needs to realize the display of design effects as soon as possible, so that teachers can better explain the teaching. 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 [7]. The interior design scene is complex and changeable, and the rendering process automation faces many challenges. Under this background, it is extremely necessary to design a complete rendering system.

2 STATE OF THE ART

2.1 Computer-Aided Design Software and Its Application Status

Computer aided design software refers to a data system that uses the graphic function of the computer, and Zhang et al. [8] use the corresponding technology and other technologies to carry out the corresponding graphic design, so as to help the designer complete the design work. This kind of data system is usually based on an interactive computer system with graphic functions, which is mainly composed of graphic display terminals, graphic input boards, and computer hosts.

The most basic function is to present the content of the design work in an intuitive way. In order to clearly show the key points of design work, Kösa and Karakuş [9] designed the most special functions of computer-aided design software to show the basic ideas and innovative designs of designers. Computer-aided design software is particularly important for carefully designing plans, changing plans, adjusting designs, innovating designs, and improving work efficiency.

Computer aided software has been widely used in interior design. In fact, Nayak et al. [10] have long used computer-aided software for design, which is really used in interior design work. By the end of the 20th century, computer-aided design has become the main form of design and the main tool. People use computer-aided design to design, and then effectively promote the progress and development of the design industry. From the current application situation, computer-aided design software is widely used in all walks of life. In the process of design and art, Oh and Zurlo [11] mainly uses it for video editing. There is special video editing software. Pictures and animations are rendered by special 3D model software.

2.2 Application Analysis of Home Aesthetic Design

Computer aided design software is a good teaching tool for interior design majors. It helps mobilize students' enthusiasm for learning. Sun et al. [12] research has stimulated students' creative thinking, thereby improving the quality of professional teaching. Traditional interior design spends most of its energy and time on manual drawing, which limits the development of students' creative thinking and cannot provide students with a variety of spatial styles, so that students' contact surface is very narrow and some good ideas are limited. Van et al. [13] used computer-aided design software to display some contents that cannot be drawn manually through Auto CAD,

3ds Max and other software. Display colorful works representing students' personalities, and give full play to students' creative talents and innovative consciousness.

2.3 Main Functions of Interior Design Computer-Aided Design Software

The relevant design content is presented in a three-dimensional way, so that the relevant personnel can see the various content and organizational structure in the design scheme, so as to present the final interior design effect three-dimensionally and achieve a more ideal design effect. Computer-aided software for interior design mainly completes the following main functions: Drawing function. The specific application analysis can use the auxiliary software for drawing processing. Apply modeling capabilities. In addition to drawing operations using computer-aided design software, modeling operations can also be utilized. Apply the rendering function. V Ray is a very popular rendering software in the current industry, and it is also a widely used software in the current industry, providing high-quality rendering effects for 3D modeling software. Table 1 presents some typical rendering elements of the software. For interior design work, images and rendering are very important. Relevant designers should accurately grasp the key points of rendering, and carry out reasonable rendering and design according to the actual needs of users. It is necessary to improve the rendering effect to achieve a more ideal design effect. actual needs of users.

Render elements	*Describe*	*Dimension*
VRayTotalLighting	Reflection of all light model surfaces in the scene Refraction of model surfaces	3
VRayReflection	Specular highlights on the model surface	3
VRayRefraction	The normal of the model	3
VRaySpecular	Sampling rate	3
VRayNormals	Type is set to point, the coordinates of the pixel in the camera coordinate system	3
VRaySampleRate	RGB value output by the renderer	1
VRaySamplerInfo	Camera aperture size	2
RGB	Camera Field The focal length of the camera	3
lens aperture radius	describe	1
field of view	Reflection of all light model surfaces in the scene Refraction of model surfaces	1
lens focusing distance	Specular highlights on the model surface	1

Table 1: Typical rendering elements of V-Ray software.

3 METHODOLOGY

3.1 Theoretical Basis of Rendering

The Bidirectional Reflectance Distribution Function (BRDF) is a method for calculating the brightness of the light in the scene that is reflected from the surface of the material to the viewpoint. When the light radiates from the light source to the surface of the object, reflection will occur. The BRDF parameter refers to the reflection ratio of the light in the direction of the incident to the incident light. The incident direction of the light is w_i, P is a point on the observed object, and the incident light irradiance is L_i. The brightness of the outgoing light in the direction is L0. Then the differential irradiance at point P is:

$$dE(P,w_i) = L_i(P,w_i)\cos\theta_i dw_i \tag{1}$$

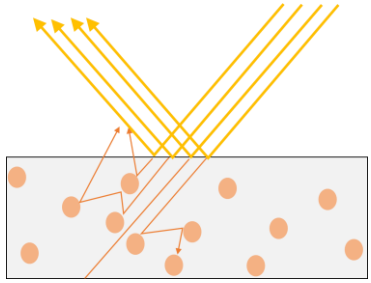

Figure 1: Reflection and refraction diagram of light.

As shown in Figure 1, the less smooth the surface of the object, the larger the area of specular reflection, on the contrary, the smaller the range of specular reflection, the higher the light intensity, and the smoother it will be. This is why, as seen in reality, the mirror reflection of the glass on the building is stronger and the reflection of the wooden floor is not harsh. BRDF describes the ratio of the differential radiance in the outgoing direction w0 to the incident differential radiance dL0, so the definition formula is:

$$f_r(P,w_0,w_i) = \frac{dL_0(P,w_0)}{dE(P,w_i)} = \frac{dL_0(P,w_0)}{L_i(P,w_i)\cos\theta_i dw_i} \tag{2}$$

BRDF has the properties of reciprocity and energy conservation. Reciprocity means that for the pair of outgoing and incident directions (wi, w0)

$$f_r(P,w_i,w_o) = f_r(P,w_o,w_i) \tag{3}$$

The specific form of the rendering equation is as follows:

$$L_0(x,w_0) = L_e(x,w_0) + \int_\Omega f_r(P,w_i,w_o)L_i(x,w_i)(n \bullet w_i)dw_i \tag{4}$$

3.2 Monte Carlo algorithm

Monte Carlo integration uses randomness to obtain integration, which is an unbiased estimation of integration, and the convergence rate of integration is not directly related to the integrand. To facilitate the understanding of Monte Carlo integration, taking one-dimensional integration as an example, suppose the following integration is required:

$$I = \int_a^b g(x)dx \tag{5}$$

Suppose; xi is a random variable with uniform distribution in the interval [a, b], then the Monte Carlo estimator is

$$G_N = \frac{b-a}{N}\sum_{i=1}^{N} g(x_i) \tag{6}$$

Find the expectation of the Monte Carlo estimator, we know that the Monte Carlo estimator is an unbiased estimator of the integral. In the above example, the random variable x is required to obey a uniform distribution, but the actual random variable is generally not uniformly distributed. In order to make the estimator more widely applicable, the Monte Carlo estimator is changed into the following form:

$$G_N = \frac{1}{N}\sum_{i=1}^{N} \frac{g(x_i)}{p(x_i)} \tag{7}$$

The condition that p(x) of the above formula needs to be satisfied is to satisfy for any sampling point

$$p(x_i) \neq 0 \tag{8}$$

Similarly, it is easy to prove that for any distribution it can be concluded that the Monte Carlo integration is an unbiased estimate of the value of the integral. This conclusion is extended to the multidimensional case. Consider a three-calculus:

$$I = \int_{a_0}^{a_1}\int_{b_0}^{b_b}\int_{c_0}^{a} g(x,y,z)dxdydz \tag{9}$$

If the sample points are uniformly sampled in the bounding box of the composition. Then the probability density function p(x) is as follows, which is a constant:

$$p(x) = \frac{1}{(a_1-a_0)(b_1-b_0)(c_1-c_0)} \tag{10}$$

Then the estimator of the integral is:

$$G_N = \frac{(a_1-a_0)(b_1-b_0)(c_1-c_0)}{N}\sum_{i=1}^{N} g(X_i) \tag{11}$$

Noise reduction technology is an important rendering acceleration technology in the rendering field. Reduce the sampling rate and improve the rendering speed. The low sampling rate makes the rendering results noisier. The noise of the rendering results is eliminated through the noise reduction algorithm to obtain high-quality rendering results. The noise reduction algorithm is divided into two categories according to the model used, one is the traditional method based on regression, and the other is the deep learning method based on neural network and so on. The core idea of the noise reduction algorithm is to consider the relationship between each pixel and nearby pixels in the rendering result, and use an appropriate filter to filter the original image. The noise reduction problem can be abstracted as the solution of the influence factor of the surrounding pixel values to the target pixel:

$$\hat{c}_p = \frac{1}{c_p}\sum_{q\in N_p} c_p w(p,q) \tag{12}$$

The above formula is called the kernel function, and the goal of the noise reduction problem is to find the above kernel function. In recent years, there are mainly two mature researches in the field of denoising algorithms based on deep learning. One is the kernel prediction convolutional neural network (KPCN). The model is divided into three parts, namely the input feature generation part, the neural network part, and the image reconstruction part. Because the neural network has a

fixed input and output mode, the original input must be processed accordingly before it can be used as the input of the network. The neural network part is the process of fully connecting or convolving the input model to obtain the filter kernel. Image reconstruction is the process of regenerating an image using a filter kernel combined with the original input image. The algorithm is described in Table 2:

Stepl (model input feature selection) : Select appropriate auxiliary features, set parameters related to propagandizing device, and get rendering channel diagrams. Analyze these propagandizing channel diagrams to get auxiliary features, and add propagandizing result diagrams to get complete feature input
Step2 (Neural network model construction) : Design the neural network model, input the model constructed in the first step, and obtain the filtering kernel of each pixel
Step3 (output image reconstruction) : Use the filter generated in the second step to filter the original image, and use kernel_splating method to generate results

Table 2: Deep learning rendering noise reduction algorithm based on kernel-splating.

3.3 Evaluation Indicators of Denoised Images

The quality of the noise-reduced image requires objective evaluation indicators. Two commonly used indicators for evaluating the noise-reduction effect.

Given a clean image I and a noisy image K of size mxn, the mean squared error is defined as:

$$RMSE = \sqrt{\frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}\left[I(i,j)-K(i,j)\right]^2} \tag{13}$$

By introducing perceptual phenomena related to perceptual changes such as brightness and contrast, the model can take into account the structural information of the image in human perception. These structural informations mainly refer to the internal dependencies between pixels, especially the dependencies between adjacent pixels. The calculation formula of SSIM is as follows:

$$SSIM(x,y) = \frac{(2\mu_x\mu_y + c_1)(2\sigma_{xy} + c_2)}{(\mu_x^2 + \mu_y^2 + c_1)(\sigma_x^2 + \sigma_y^2 + c_2)} \tag{14}$$

Structural difference degree (DSSIM) is a deformation of SSIM for convenience as the error of neural network training:

$$DSSIM(x,y) = \frac{1 - SSIM(x,y)}{2} \tag{15}$$

4 RESULT ANALYSIS AND DISCUSSION

4.1 Experimental Design

Select five representative scenes: living room, bedroom, kitchen, bathroom, balcony, basically covering several scenes and lighting conditions most commonly encountered in the system. The living room is relatively open, and the lighting conditions are simple and direct. The bedroom is smaller than the living room and the lighting is dim. The kitchen space is narrow, there are many objects in the scene, and the lighting conditions are more complicated. There are many mirrors

and glass in the bathroom, and the reflection of tiles is strong. The balcony space is relatively small, but due to the presence of sunlight, it will have a strong single light. Take the above five scenes as the test set, the rendering size is 1920x1080, which is the same as the training set, set the sampling rate and renderElement, and obtain the test set. Among the commonly used computer-aided design software at present, Vray software is a software with relatively good performance. Most of the domestic use of VRay is the plug-in version in 3dsmax or Maya, etc.

4.2 Comparison and Analysis of Static Rendering Experiment Results

After using the interior design efficient rendering system designed in this paper to render the entire designer's complete house plan, the rendering results of the experimental case are shown in Table 3.

Use case name	*Use case number*	*Apply colours to a drawing is*	*Number of render servers*	*Time of render servers*
European style living room	1	Render success	3	300s
Chinese style bedroom	2	Render success	3	300s
Chinese style alliance wash room	3	Render success	3	300s
European study	4	Render success	3	300s
Modern balcony	5	Render success	3	300s

Table 3: Rendering module test case results.

In order to further verify the effectiveness of the algorithm, for the above scenarios, the algorithm results were compared with the ATT algorithm and the Reinhard global algorithm. It can be seen from Figure 2 that compared with the other two algorithms, this algorithm retains more detailed information, especially in brighter areas, such as windows and tops, this algorithm can better display the details of the top grid and windows.

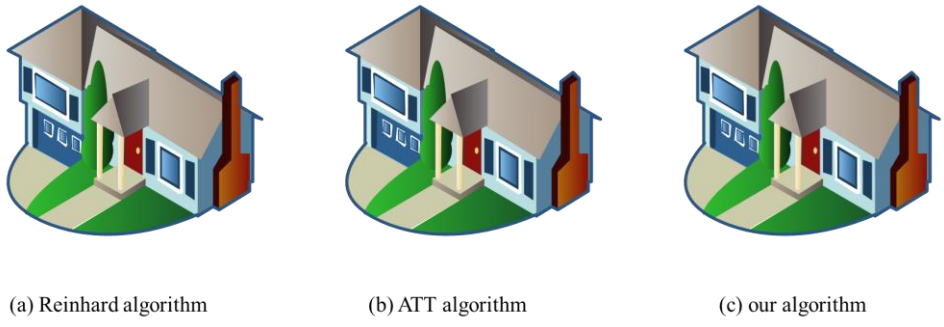

Figure 2: Comparison of indoor rendering results of different algorithms.

Figure 3 shows the rendering efficiency of the three algorithms in different scenarios. The results show that in most scenarios, this algorithm has good results, only slightly inferior to the ATT algorithm in two scenarios, but the actual effect is not much different, which shows that the tone mapping algorithm proposed in this paper is effective in most scenarios.

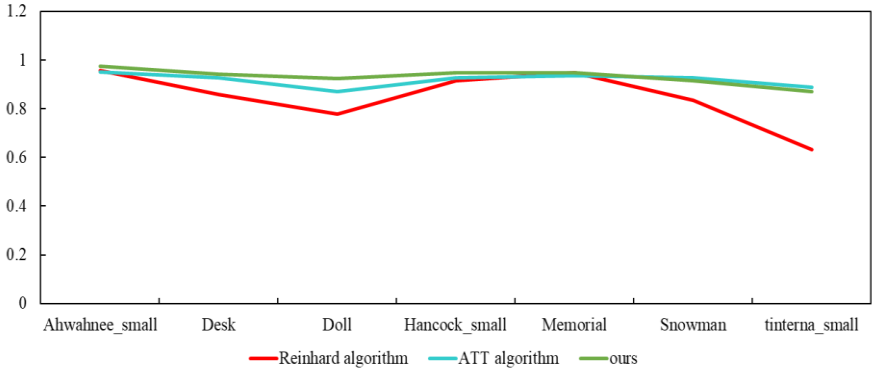

Figure 3: Comparison of the effects of each algorithm in different scenarios (change to a line chart).

Using multiple identical rendering files and the same rendering host configuration, a total of 8 sets of Json file data and related scene files and image files are simulated. The detailed test result information is shown in the Figure 4 and Figure 5 below. It can be seen that when the model data is small, the difference in rendering time is not large, but when the number of models and lights increase more, the rendering time of VRay cloud rendering is roughly the VRay plug-in version. The rendering time is about 0.6 times, and as the number of models and lights increases, the rendering efficiency will increase, but it will be lower than about 0.3 times the rendering time of the VRay plug-in version. It is in line with the performance test expectations of this system.

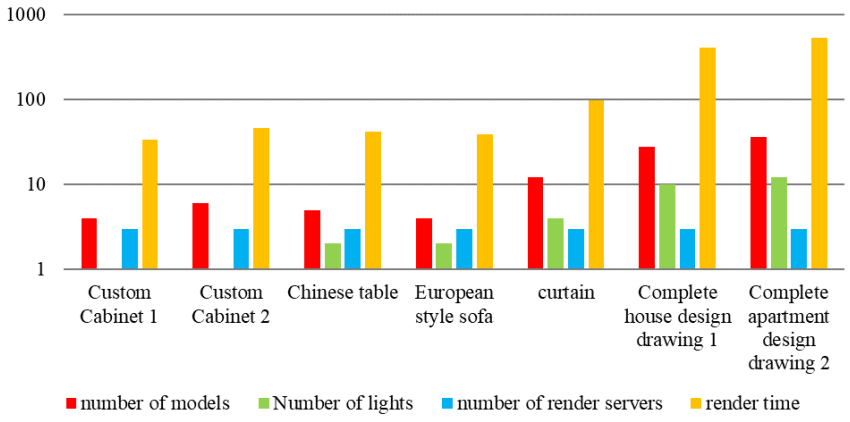

Figure 4: Rendering performance test result table of VRay rendering engine plug-in version (change rendering time to histogram).

It can be seen from this that the convergence of the model can be accelerated to a certain extent by adopting this multi-path residual channel structure and adding instance regularization.

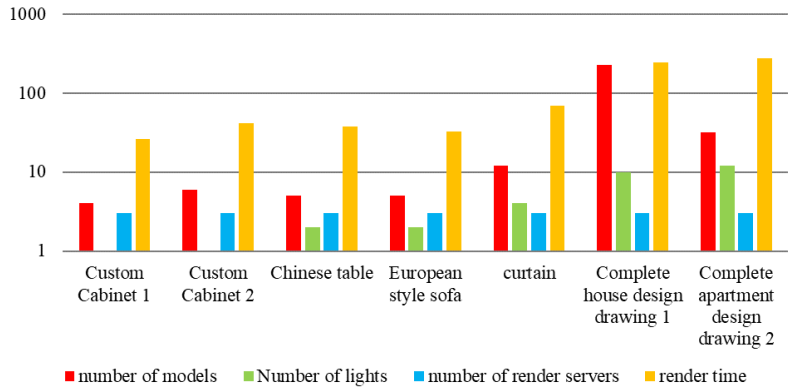

Figure 5: Rendering performance test result table of VRay cloud rendering (change rendering time to histogram).

4.3 Comparison and Analysis of Static Rendering Experimental Results

Since the interior design does not realize the rendering display of a single image, in the process of display, the rendering of the entire apartment needs to be completed. In order to examine the rendering effect in real-time use, it is necessary to measure and compare the rendering effect in the entire interior design. Using the frame rate of the video can effectively measure the rendering effect of the algorithm. Now suppose there is such a large-scale indoor scene, there are 7 rooms in the scene, and each room contains 1-2 unequal light sources, as shown in Figure 6.

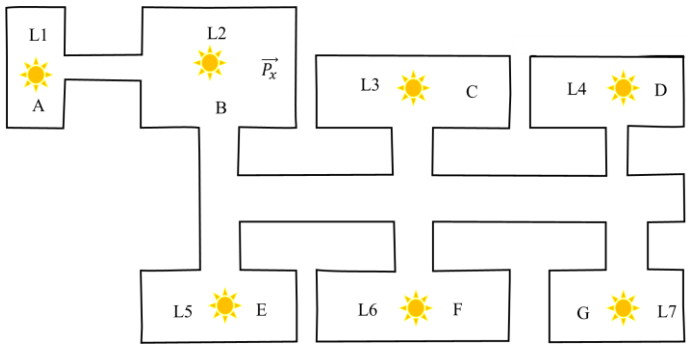

Figure 6: The scene where the interior design needs to be completed for the experiment.

Light sources are added to each node in turn, and the number of light sources is changed from 1 to 11. The adaptive octree algorithm of Wang Zheng et al. and the potentially visible light source set algorithm proposed in this chapter are used respectively. The frame rate of ray tracing rendering varies with the number of light sources. The changes are shown in Figure 7.

As can be seen from the figure, the calculation frame rate of Wang Zheng et al.'s algorithm continues to increase with the number of light sources, and the rendering frame rate continues to decrease, because the frame rate and time consumption are inversely proportional.

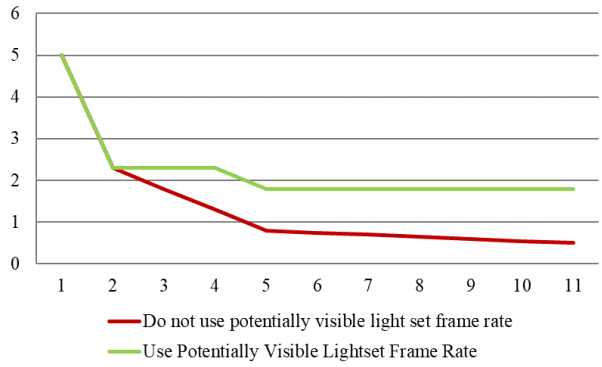

Figure 7: Graph of the change of frame rate with the increase of the number of light sources.

In the case of only 2 light sources, it can be seen that the frame rate of the two algorithms is almost the same; but when the number of light sources reaches 5, the frame rate using the potential visible light source set reaches 1.654, while the original method changes for 0.972, the improved algorithm increases the frame rate by about 70.16%; when the number of light sources reaches 11, the difference is more obvious, and the improved method increases the frame rate by nearly 263.30%.The variance values of the first 20 frames in the experimental results are shown in Figure 8.

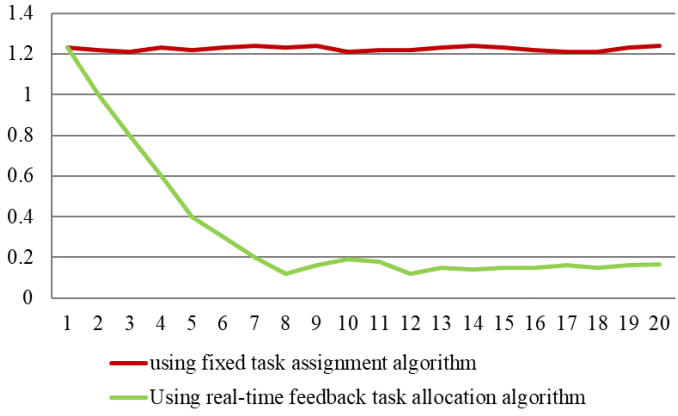

Figure 8: Variance graph when using the allocation algorithm.

As can be seen in the figure, when the fixed task allocation algorithm is used, the first 20 frames almost maintain a high variance value, which shows that the processing power of each computer is different or the task splitting complexity of the allocated tasks is different. When the real-time feedback task allocation algorithm is used, the initial variance value is also relatively high. This is because when the system is initialized, the tasks are evenly distributed, but with the with the feedback from the client, the server constantly modifies the latest task shards of each client according to the task allocation algorithm, and the frame rate of each client will continue to tend to be the same, resulting in a lower and lower variance value. It can also be seen that the final variance value fluctuates around a fixed variance value, but remains at a low level overall.

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. Rendering is involved in the fields of film and video, home decoration, game special effects, and visual design, but each field is a combination of different rendering features and technologies. In the interior design industry, a high-quality, realistic rendering of interior design can make it easier for designers to express their designs and allow customers to express their needs more intuitively, so there are many different types of rendering software products.

Based on the need to realize the rapid display of the design effect in the teaching scene as soon as possible, in order for the teacher to better explain the teaching, the high-efficiency rendering system has become an important part of the interior design function. This paper mainly analyzes some problems related, designs and implements a set of efficient indoor scene rendering system based on computer cluster, automatically generates rendering scene, adaptively adjusts lighting, and automatically sets rendering parameters. It has greatly improved the presentation efficiency of interior design, and played a certain role in promoting the teaching of industry design and interior design.

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