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Computer-Aided Design AND APPLICATIONS

Animation Rendering Optimization Based on Ray Tracing and Distributed Algorithm

Yiran Tao[1] and Rongjuan Wang[2]

[1]Department of Global Fine Art, Graduate School, Kyonggi University, Suwon 16227, Korea, taoyiran@kyonggi.ac.kr
[2]Department of Global Fine Art, Graduate School, Kyonggi University, Suwon 16227, Korea, wangrongjuan@kyonggi.ac.kr

Corresponding author: Yiran Tao, taoyiran@kyonggi.ac.kr

Abstract. This article aims to improve the efficiency and quality of animation rendering, and applies ray tracing and distributed algorithm and CAD (Computer Aided Design) technology to animation rendering optimization. By constructing an animation rendering optimization model, and carrying out simulation research. In order to reduce the amount of calculation and improve the rendering efficiency, this article adopts hierarchical detail technology, and selects models and maps with different accuracy to render according to the distance between the object and the camera. Moreover, this article adopts simplified light source models, such as point light source and directional light source, to reduce the amount of calculation. In addition, in order to improve the rendering quality, this article adopts ray tracing technology. This technology can simulate the propagation and bounce of light, thus providing real lighting and reflection effects and improving the rendering quality. The experimental results show that the model has obvious advantages in improving rendering efficiency and quality. Compared with traditional rendering methods, the model proposed in this article can shorten the rendering time by more than 30% and improve the rendering quality by more than 10%. In addition, the animation rendering optimization algorithm can flexibly adjust parameters and choose different optimization strategies to adapt to different scenes and needs.

Keywords: Ray Tracing; Distributed Algorithm; Computer Aided Design; Animation Rendering
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1 INTRODUCTION

With the increasing complexity of rendering, the efficiency and quality of animation rendering has become an urgent problem. With the continuous development of technology, intelligent algorithms have achieved significant results in many fields. Among them, in the field of 3D graphics engine animation design, the application of intelligent algorithms has brought infinite possibilities for animation creation. Bao [1] explores the application principles, specific application scenarios, and case studies of intelligent algorithms in 3D graphics engine animation design, and finally summarizes its application prospects. Intelligent algorithms are a type of algorithm based on artificial intelligence technology, including various methods such as machine learning and deep learning. In the animation design of 3D graphics engines, intelligent algorithms can be used to automate the generation of animations, generating animations that meet the designer's intentions through analysis and learning of a large amount of data. In addition, intelligent algorithms can also optimize the animation generation process, improve the quality and efficiency of animation. Ray tracing is a technology to simulate the light traveling and bouncing in 3D space, which can provide more realistic lighting and reflection effects for animation rendering. Light field display technology is a display technology that can provide realistic 3D images and depth perception, and is widely used in fields such as virtual reality, augmented reality, and smart home. However, the design of a light field display system involves multiple factors, including optics, vision, image processing, etc., and is a complex system engineering. In order to improve design efficiency and quality, automatic collaborative design has become an urgent demand.

Chen et al. [2] introduced an automatic collaborative design method for light field display systems based on simulated annealing algorithm and visual simulation. The current research on light field display systems faces some challenges, including accuracy and efficiency issues in light field reconstruction, improvement of user comfort, and reduction of system costs. Some studies utilize artificial intelligence technology to achieve automated design and optimization of light field display systems, while others use simulated annealing algorithms to optimize the parameters of light field display systems. However, the application of ray tracing technology faces huge computational challenges, especially when dealing with high-complexity scenes, and traditional computing methods will consume a lot of time and computing resources. In the real world, lighting and shadows have a significant impact on the expression of object shapes and materials. In computer graphics, a shader (lighting model) is a method of simulating the impact of lighting on objects. In recent years, object tracking technology based on projection distortion has gradually attracted attention. It achieves stable tracking of objects in shader scenes by utilizing the characteristics of projection distortion. Gard et al. [3] delved into the principles, implementation methods, application cases, and future development trends of object tracking technology based on projection distortion in shader scenes. Due to the consideration of the influence of lighting and shadows on object shape, object tracking technology based on projection distortion has good stability in shader scenes. This technology is mainly based on image processing methods, so it has a fast computational speed and is suitable for real-time tracking applications.

CAD can realize digital simulation of the real world through 3D modeling and vector graphics. Traditional denoising methods usually use filters or statistical methods to denoise images, but their application effects in direct volume rendering are not ideal. In recent years, deep learning based denoising methods have gradually become a research hotspot, with convolutional neural networks (CNN) achieving significant results in image denoising. However, most of these methods are aimed at denoising two-dimensional images, and there are still certain limitations for denoising problems in three-dimensional data such as direct volume rendering. Iglesias et al. [4] studied real-time denoising techniques for volume path tracking in direct volume rendering, aiming to improve the quality and accuracy of volume rendering. We propose a volume path tracking method based on real-time denoising algorithm, which can effectively remove noise interference and achieve accurate rendering of volume data. The experimental results show that this method has significant advantages in real-time performance and denoising effect, providing strong support for related applications in the fields of visualization and computer graphics. In the field of animation rendering optimization, CAD technology can be used in scene design, character modeling, props production and so on, providing more realistic and vivid visual effects for the rendering process. With the continuous development of computer graphics, people's requirements for rendering virtual worlds are also increasing. Not only does it require a realistic visual effect, but it also requires the ability to express various artistic styles. Stylization of pencil drawing is a common artistic style, and its unique line and shadow expressions are deeply loved by people. Jin et al. [5] introduced a pencil drawing style based spatial rendering network based on deep learning. The traditional computer graphics rendering method mainly relies on rasterization. Although this method can achieve realistic visual effects, it is difficult to express various artistic styles. With the continuous development of deep learning technology, people are beginning to try to use it to achieve the transfer of artistic style. Among them, pencil drawing stylization is a highly regarded artistic style, and its unique line and shadow representation can bring a brand-new visual experience to the virtual world. Distributed algorithm is a method of distributing computing tasks to multiple computing nodes for collaborative processing, which can make full use of computing resources and improve computing efficiency. In the field of animation rendering optimization, distributed algorithms can be applied to key links such as scene segmentation and merging, illumination calculation, texture mapping, etc., so as to realize parallelization and optimization of the rendering process. With the rapid development of technology, the application of 3D reality technology and computer-aided design (CAD) in the field of animation modeling design is becoming increasingly widespread. Jing and Song [6] discussed the application and advantages and disadvantages of these two technologies in animation design, and looked forward to future development trends. 3D reality technology, with its unique visual effects and expressive power, provides infinite possibilities for animation design. 3D reality technology can simulate various scenes, from magnificent urban landscapes to complex mechanical devices, all of which can be presented in realistic forms. Designers can create different atmospheres and effects by changing parameters such as lighting and materials in the scene. CAD provides a wealth of drawing tools that can easily draw various shapes and patterns. Designers can use CAD for conceptual design, sketching, and detail characterization. CAD can quickly and accurately create 3D models. Designers can use Boolean operations, curves and surfaces, and other functions in CAD software to create complex models. However, how to design an efficient distributed algorithm that can be perfectly combined with ray tracing technology is a difficult problem in current research.

Aiming at the above problems, this article applies ray tracing, distributed algorithm and CAD technology to animation rendering optimization, and constructs an animation rendering optimization model. It provides an effective solution for the efficiency and quality of animation rendering. This article has the following innovations:

⊖ Apply ray tracing technology to animation rendering optimization. Through ray tracing calculation of the scene, more realistic lighting and reflection effects can be obtained, and the rendering quality can be improved.

⊜ Combining distributed algorithm and CAD technology, parallelization and optimization of rendering process are realized. By dividing the rendering task into multiple subtasks and distributing these subtasks to multiple computing nodes for parallel processing, we can make full use of computing resources and improve rendering efficiency.

⊛ A scene segmentation method based on ray tracing is proposed. Dividing the scene into multiple sub-regions and performing independent ray tracing calculation for each sub-region can reduce the calculation amount and further improve the rendering efficiency.

Firstly, this article expounds the importance of animation rendering optimization in film and television, games and other industries, and points out the challenges of efficiency and quality faced by traditional rendering methods. Secondly, this article proposes a scene segmentation method based on ray tracing, which divides the scene into several sub-regions and calculates each sub-region independently. This segmentation method can greatly reduce the amount of calculation and improve the rendering efficiency. Then, this article designs a task division strategy based on distributed algorithm, which divides the rendering task into multiple subtasks and assigns these subtasks to multiple computing nodes for parallel processing. This partition strategy can make full use of computing resources and improve rendering speed. Moreover, the scene is modeled and designed by using CAD technology, which makes the rendering effect more realistic and vivid. Finally, the main research contents and contributions of this article are summarized, and the shortcomings and future research directions are pointed out, including the need to further improve the optimization model and improve the practical application effect.

2 RELATED WORK

In computer-aided animation design, Li [7] can use cubic B-spline curves to create various complex animation trajectories that conform to the designer's intentions. For example, the shape and direction of a B-spline curve can be changed by adjusting its control points. You can adjust the smoothness of the curve by changing its degree. By using cubic B-spline curves, continuous and smooth animation effects can be created. For example, in character animation, B-spline curves can be used to describe the action path of a character, thereby achieving smooth animation effects such as character movement and rotation. By applying cubic B-spline curves to computer-aided animation design, animation effects can be analyzed and optimized. For example, B-spline curves can be used to interpolate and reconstruct the frame sequence of an animation, in order to analyze the smoothness and realism of the animation. With the rapid development of virtual reality (VR) technology, its application fields are becoming increasingly widespread. In the field of animation production, using VR technology to design and produce three-dimensional models of multi visual animated characters can bring a more realistic experience and richer visual effects. Li et al. [8] introduced a 3D model design method for multi visual animated characters based on VR technology, including design process, model production, scene construction, and experimental results. In the model production process, 3D modeling software is mainly used for operation. Firstly, based on the results of demand analysis, establish a three-dimensional model of animated characters from the aspects of basic morphology, muscle lines, clothing props, etc. During the modeling process, attention needs to be paid to the accuracy and quality of the model to ensure smooth texture mapping and bone binding in the future.

Traditional ray tracing algorithms typically traverse all possible ray paths to find intersections that meet the conditions. This method is not only inefficient, but also prone to missed or erroneous judgments. However, these methods still have some limitations, such as being unable to handle complex ray overlapping situations. To address these issues, Liu [9] proposed a ray tracing algorithm based on intersection optimization and applied it to 3D interior design. To address these issues, this paper proposes a ray tracing algorithm based on intersection optimization and applies it to 3D interior design. For each ray, search for the order in which it intersects with all surfaces in the scene. The method based on intersection optimization can quickly find ray intersections that meet the conditions. Calculate the reflection and refraction of light based on the position and angle of the intersection, thereby obtaining the effect in the eyes of the observer. Renders the reflected and refracted light into an image, and adjusts the color, brightness, and other factors to obtain a realistic 3D indoor image. With the rapid development of global digital media technology, the animation industry is facing unprecedented challenges in creative methods, teaching methods, and other aspects. Especially in China, the innovation and integration of animation education has become a focus of attention in the industry and academia. Manan et al. [10] explored how to innovate the animation teaching system, integrate design thinking and creative methods into animation education practice, and conducted experimental research based on this as the starting point. Chinese animation education has developed rapidly in recent years, but there are still some problems. Design thinking refers to a way of thinking that puts users at the center, starts from problems, and seeks solutions to problems through observation, analysis, creativity, prototyping, and other processes. The creative method is a method in which creators follow certain laws and principles in the creative process to achieve the expression of their works. Integrating design thinking and creative methods into animation education can help cultivate students' independent thinking ability, innovation ability, and practical operation ability. With the rapid development of technology, high-performance computer graphics technology has been widely applied in the field of engineering due to its powerful computing and rendering capabilities. The application of this technology enables engineering projects to be designed and simulated in a more efficient, accurate, and intuitive manner, thereby improving the quality and efficiency of engineering projects. Peng [11] introduces the principles and implementation methods of high-performance computer graphics technology, analyzes its application in engineering through practical cases, and looks forward to future development trends and application prospects. High performance computer graphics technology is a technology based on high-performance computers and specialized graphics processors, mainly used for image generation, processing, and interaction. This technology converts complex 3D models into pixel and vertex data, and performs real-time rendering to achieve realistic 3D image display.

Perlin noise is a common noise model suitable for simulating random noise with fixed distribution characteristics. In laser profilometer measurement, Perlin noise can be used to simulate speckle noise. By simulating and processing the Perlin noise, we can better understand and analyze the measurement results of the laser profilometer, improve its measurement accuracy and reliability. In addition, using Perlin noise to simulate laser profilometer measurements with spots can also provide useful references for sensor design. In order to verify the effectiveness of laser profilometer measurements with speckle in the simulation of Perlin noise, Roos et al. [12] conducted a series of experiments. In the experiment, we first measured the standard surface using a laser profilometer and collected a large amount of measurement data. Then, based on the distribution characteristics of these data, a Perlin noise model was established. Next, we applied the model to the measurement data and generated simulated data with speckle noise. Finally, we extracted surface contour and shape features through analysis and processing of simulated data. With the continuous development of intelligent driving technology, automotive environmental perception technology has become a research hotspot. In the automotive environment, radar, as an important sensor, has broad application prospects. Schüller et al. [13] introduced a new type of real radar ray tracking simulator for large MIMO (Multi Input Multi Output) arrays in automotive environments, and explored its design principles, implementation methods, and application scenarios. Finally, the future development trends were prospected. The real radar ray tracking simulator for large MIMO arrays is a simulator based on MIMO technology and radar ray tracking technology. MIMO technology utilizes multiple antennas to simultaneously transmit and receive signals to improve radar detection performance and anti-interference capabilities. Radar ray tracking technology achieves accurate measurement of target position and velocity information by tracking the signals reflected back from the target. With the continuous development of technology, augmented reality (AR) technology has gradually integrated into people's daily lives. In the field of maintenance management, mobile augmented reality technology provides great convenience for maintenance personnel. By combining virtual information with real scenarios, maintenance personnel can more intuitively and efficiently complete maintenance tasks. The research on target recognition and tracking is of great significance in mobile augmented reality assisted maintenance, which helps to improve the accuracy and efficiency of maintenance work. Sun et al. [14] introduced the relevant theories, methods, and application cases of target recognition and tracking research in mobile augmented reality assisted maintenance. Mobile augmented reality technology combines AR technology with mobile devices, capturing real scenes through the camera of the mobile device, overlaying virtual information with the real scene, allowing users to see the enhanced reality.

In computer graphics, direct animation of surface models is a common animation production technique. This technology dynamically modifies the shape of a surface model to achieve animation effects. Traditional direct animation techniques require dynamic adjustment of the vertices of the surface model, which consumes a lot of computational resources and is difficult to ensure the smoothness of the animation effect. The direct animation technology based on shape matching element method can dynamically adjust the feature points of the surface model to achieve shape changes and achieve smoother animation effects. To verify the effectiveness of direct animation technology for surface models based on shape matching element methods, Trusty et al. [15] conducted a series of experiments. The experimental results show that this method can achieve efficient and smooth animation effects. Compared to traditional direct animation techniques, this method significantly reduces the consumption of computing resources while ensuring the animation effect. In addition, through the analysis of experimental results, we also found that this method has good robustness when dealing with complex surface models. In today's design field, interactive high-precision volume design and manufacturing are receiving increasing attention. In order to meet the high-precision requirements of products, designers constantly explore new design methods. Among them, function-based methods have gradually become the preferred choice for designers due to their unique advantages. At the same time, the development of graphics tools has also provided strong support for interactive high-precision volume design and manufacturing. Uchytil and Storti

[16] delved into functional based methods for interactive high-precision volume design and manufacturing, and introduced how to use graphic tools to achieve this process. Function-based methods play an important role in interactive high-precision volume design and manufacturing. This method treats the design space as a function space, and designers design by defining and manipulating this function space. Verykokou et al. [17] introduced a low-end device mobile augmented reality (AR) technology based on planar surface recognition and optimized vertex data rendering. This technology improves the performance of AR on low-end devices through methods such as flat surface recognition and optimized vertex data rendering, providing new ideas for the development of mobile augmented reality technology. Due to hardware performance limitations, the performance of AR technology on low-end devices is often unsatisfactory. The core of this technology is to improve the performance of AR on low-end devices by recognizing flat surfaces and optimizing vertex data rendering. Flat surface recognition is the use of image processing technology to identify flat surfaces in a scene, such as the ground, desktop, etc. Optimizing vertex data rendering involves optimizing and processing vertex data to reduce rendering complexity and improve the operational efficiency of low-end devices.

3 RAY TRACING TECHNOLOGY

Ray tracing is a technology to simulate the travel and bounce of light in 3D space in computer graphics. It can provide realistic illumination and reflection effects for animation rendering, thus greatly improving the realism and expressiveness of rendering. The basic principle of ray tracing technology is to emit light from a light source, simulate the propagation path of light, and calculate the intersection point between light and the surface of an object, and then calculate the lighting effects of the point according to the intersection point. Forward ray tracing starts from the light source and calculates the lighting effects of each intersection point in turn along the propagation path of light until it reaches the human eye or camera. Reverse ray tracing starts from human eyes or cameras, and calculates the lighting effects of each reflection surface in turn along the reflection path of light until it reaches the light source.

In animation rendering, ray tracing technology can obtain the surface lighting effects and shadow effect of each object by ray tracing calculation of objects in the scene, thus generating realistic images. Among them, global illumination is an important technology in ray tracing technology, which can simulate the global effect of light, including direct illumination, indirect illumination and reflection, so as to make the rendered image more natural and realistic.

4 DISTRIBUTED ALGORITHM

Distributed algorithm is a method to distribute computing tasks to multiple computing nodes for collaborative processing, so as to improve computing efficiency. In the field of animation rendering optimization, distributed algorithms can make full use of computing resources, reduce rendering time and improve rendering efficiency. Specifically, the application of distributed algorithm in animation rendering optimization is mainly reflected in the following aspects: ⊖ scene segmentation and merging: the scene is divided into multiple sub-regions, and then each sub-region is rendered separately. After the calculation is completed, the sub-regions are merged into a complete scene. This method can make full use of the parallel processing ability of distributed algorithms and improve rendering efficiency. ⊜Illumination calculation: the distributed algorithm is used to distribute illumination calculation tasks to multiple computing nodes for parallel processing. For complex illumination calculation, such as global illumination and shadow calculation, distributed algorithm can significantly shorten the calculation time. ⊛ Texture mapping: Texture mapping is an important technology in animation rendering, which needs to sample and process images. Using distributed algorithm, texture mapping tasks can be distributed to multiple computing nodes for parallel processing, which improves the processing speed and efficiency.

Common types of distributed algorithms include the following: ⊖ MapReduce: This is a widely used distributed computing model, originally developed by Google. In the Map stage, the input data is decomposed into a series of small data blocks, and each small data block is processed by different computing nodes to generate a series of key-value pairs. In the Reduce stage, all computing nodes aggregate key-value pairs and output the results. MapReduce model is characterized by easy programming and good expansibility, and is suitable for processing large-scale data sets. ⊜ MPI(Message Passing Interface): This is a widely used parallel computing model, which allows communication and synchronization between different computing nodes. In MPI, each computing node has its own memory and computing resources, and can perform independent computing tasks. Computing nodes communicate with each other through message passing to realize data exchange and synchronization. MPI model is characterized by low communication overhead and good scalability, which is suitable for processing large-scale data sets and high-performance computing. ⊛ Spark: This is a distributed computing model based on cluster, which allows rapid processing and analysis of large-scale data sets. Spark adopts a data structure called RDD (Resilient Distributed Datasets), which divides the dataset into a series of small data blocks and stores them in memory. Spark also provides a series of transformation and action operations, allowing users to perform various operations on RDD, including filtering, mapping and reduction. Spark is fast and easy to use, which is suitable for processing large-scale data sets and high-performance computing. ④ TensorFlow: This is a distributed computing model for deep learning, developed by Google. TensorFlow allows users to build complex neural network models and train and infer them. In TensorFlow, data and calculation are abstracted as tensors, and the calculation method of dynamic graph is supported. TensorFlow also provides a variety of parallel computing strategies, such as data parallelism, model parallelism and hybrid parallelism, to make full use of distributed computing resources. TensorFlow is characterized by supporting dynamic graph calculation, good usability and good expansibility, and is suitable for dealing with complex deep learning models and high-performance calculations.

In the design and implementation of distributed algorithm, the following problems need to be considered: ⊖ Task division: the rendering task is divided into multiple subtasks and distributed to different computing nodes for processing. Task division needs to consider the independence and parallelism of each subtask in order to make full use of computing resources. ⊜ Data communication: Distributed algorithms need to solve the problem of data communication between computing nodes. The quantity and speed of data communication directly affect the efficiency and performance of distributed algorithms. ⊛ Load balancing: Distributed algorithms need to ensure the load balancing of all computing nodes, and avoid the situation that some computing nodes are overloaded and others are idle.

5 APPLICATION OF CAD TECHNOLOGY IN ANIMATION RENDERING

CAD technology plays an important role in animation rendering. Through CAD technology, animators can create and edit animation scenes, characters and props on the computer, and use accurate data and powerful computing power to achieve high-precision rendering. CAD technology can be combined with ray tracing technology to achieve more realistic rendering effect. Ray tracing technology can provide more realistic lighting and reflection effects for animation rendering by simulating the propagation and rebound of light. And CAD technology can provide high-precision models and maps, and provide a better foundation for ray tracing technology. The combination of the two can make the animation rendering effect more vivid and realistic. In addition, CAD technology can also be combined with distributed algorithms to improve the efficiency of animation rendering. Distributed algorithm can distribute rendering tasks to multiple computing nodes for collaborative processing, and improve rendering speed. CAD technology can provide clear and accurate models and data, and provide a better application foundation for distributed algorithms. The combination of the two can make animation rendering more efficient and accurate. The positioning of the animation image on the 3D model is shown in Figure 1.

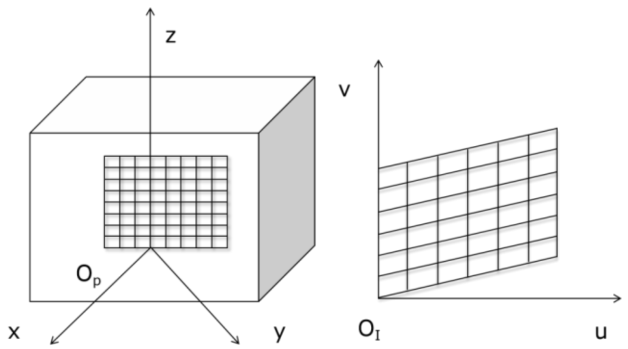

Figure 1: Localization of animation image on 3D model.

The application process of CAD technology in animation rendering is divided into the following steps: (1) Scene design. Scene design is one of the important links in animation rendering, which involves the visual effect and atmosphere of the whole animation. The application of CAD technology can help animators to design scenes with high precision, including the following steps: ⊖ Conceptual design: According to the theme and requirements of animation, conceptual design is carried out by using CAD software to determine the layout, scale and atmosphere of the scene. ⊜ Detailed design: On the basis of conceptual design, detailed design is carried out by using the modeling function of CAD software, and every element in the scene is accurately modeled, including terrain, buildings, props, etc. ⊛ Texture mapping: Using the texture editing function of CAD software, texture mapping is made for each element in the scene, including the mountain texture of the terrain and the external wall texture of the building. (2) Role modeling. Character modeling is one of the core links of animation rendering, which involves the shape, expression and action of animated characters. The application of CAD technology can help animators to build a high-precision role model, which includes the following steps: ⊖ Basic modeling: Basic modeling with CAD software, including the geometric shape, proportion and structure of the role. ⊜ Detail modeling: On the basis of basic modeling, using the detail processing function of CAD software, more details and features, such as muscles and hair, are added to the character. ⊛ Texture mapping: Use the texture editing function of CAD software to make texture maps for the characters, including skin, hair and equipment. (3) Props production. Prop making is one of the important links in animation rendering, which involves the shape, material and action of animation props. The application of CAD technology can help animators to make high-precision props, which specifically includes the following steps: ⊖ Basic modeling: Basic modeling with CAD software, including the geometric shape, proportion and structure of props. ⊜ Detail modeling: On the basis of basic modeling, more details and features, such as carvings and patterns, are added to props by using the detail processing function of CAD software. ⊛ Texture mapping: Use the texture editing function of CAD software to make texture maps for props, including materials and patterns.

6 ANIMATION RENDERING OPTIMIZES THE MODEL

The animation rendering optimization model proposed in this article is mainly based on ray tracing, distributed algorithm and CAD technology. This model aims to improve the efficiency and quality of animation rendering. Ray tracing can provide real illumination and reflection effects by simulating the propagation and rebound of light, thus improving the quality of rendering. Distributed algorithms can use the parallelism of computing resources to improve the efficiency of rendering. CAD technology can help animators to create and edit high-precision models and provide clear and accurate data, which provides a better application foundation for ray tracing and distributed algorithms. Firstly, this article divides the scene into several sub-regions, which can reduce the complexity of the scene and reduce the amount of calculation. Then, ray tracing calculation is carried out for each sub-region to obtain the lighting effects and reflection effect of the sub-region. Then, the rendering task is divided into several subtasks, and the subtasks are assigned to different computing nodes for parallel processing. This can make full use of computing resources and improve rendering efficiency. At each computing node, the high-precision model and map provided by CAD technology are used for ray tracing calculation. By parallel rendering, the whole rendering process can be accelerated. Finally, the rendering results on each computing node are merged into a complete scene. This can ensure the consistency and integrity of the rendering results.

Camera calibration is an important task in the field of computer vision. Its purpose is to know the parameters of camera lens distortion, scale, rotation and tilt by extracting geometric information from images, and then obtain 3D spatial information from two-dimensional images. Among them, pinhole model is a commonly used camera perspective projection model. It is assumed that light is projected onto the image plane through the camera center point. In the pinhole model, the points in the 3D world are projected onto the 2D image plane through the camera center. The pinhole model of the camera is shown in Figure 2.

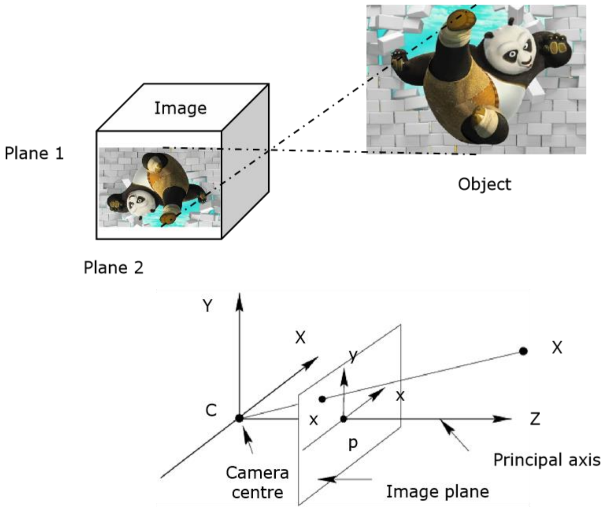

Figure 2: Pinhole model diagram of camera.

Let the normal vector of each triangle in the related triangle group of vertex v_i be n_k, the center x_k, and the area a_k. The plane formed by the normal vector and the center defined below is called the average plane of vertices:

$$N = \frac{\sum n_k a_k}{\sum a_k} \tag{1}$$

$$n = \frac{N}{|N|} \tag{2}$$

$$x = \frac{\sum x_k a_k}{\sum a_k} \tag{3}$$

The distance between the point P in 3D space and the mesh model TM is defined as:

$$d(P,TM) = \min\left(d(P,X)\right) \tag{4}$$

Where $d(P,X)$ is the Euclidean distance from point P to point X. When displaying the triangle mesh shadow model on the computer, the normal vector of each triangle vertex must be obtained. Take any triangular patch T_0 and record its three vertices as I_t, C_t and Q_t, then the unit normal vector of triangular patch T_0 can be expressed as:

$$R_t(p_{1t},Q_t) = p_{1t} \cdot \min(I_t + Q_t, D_t) - (p_{0t} \cdot Q_t + C_t \cdot AI_t) + R_{t-1} \tag{5}$$

The vertex normal vector I_{t+1} of C_t can be calculated by weighting the area of the normal vector of triangle patches in the first-order neighborhood of vertex I_t, and the vertex normal vector of vertex I_t can be calculated as follows:

$$I_{t+1} = I_t + Q_t - \min(I_t + Q_t, D_t) = \max(I_t + Q_t - D_t, 0) \tag{6}$$

After the normal vector of the vertex I_t is obtained, the curvature AI_t of the vertex can be calculated:

$$AI_t = \frac{(I_t + Q_t)}{2} \cdot \frac{(I_t + Q_t)}{D_t} \tag{7}$$

The optimization model of animation rendering is realized by the following steps: ㊀ Using CAD technology to create and edit high-precision models of characters, scenes and props, and generate maps. ㊁ Divide the scene into several sub-regions, and calculate the ray tracing for each sub-region to get the lighting effects and reflection effect of the sub-region. ㊂ Divide the rendering task into several subtasks, and assign the subtasks to different computing nodes for parallel processing. ④ At each computing node, ray tracing calculation is carried out by using high-precision models and maps provided by CAD technology. ⑤ Combine the rendering results on each computing node into a complete scene, and post-process it to get the final rendering result. The area for reconstructing the visual information of the regional 3D image is S'. In the edge contour of the blurred region 3D image, the edge feature point (x', y') is extracted, and the texture gradient decomposition is carried out. The texture distribution set of the blurred region 3D image is calculated as follows:

$$w(i,j) = \frac{1}{Z(i)} \exp\left(-\frac{d(i,j)}{h^2}\right) \tag{8}$$

Where $Z(i)$ is the first-order and second-order texture distribution operator. The parameters of visual communication constraints are analyzed:

$$W' = \frac{1}{2} f(x', y', z') + E \tag{9}$$

Where x', y', z' is the 3D coordinate value with visual constraints; E stands for the weighted component of data.

In this article, the scene is divided into several sub-regions, which reduces the complexity of the scene and the amount of calculation. By dividing the rendering task into multiple subtasks and assigning them to different computing nodes for parallel processing, the rendering efficiency is improved. Through the high-precision models and maps provided by CAD technology, more realistic rendering effects can be achieved. In addition, the proposed method can adapt to large-scale and high-complexity rendering scenes and has good scalability. The next section will carry out experimental verification.

7 SIMULATION EXPERIMENTAL ANALYSIS OF ANIMATION RENDERING OPTIMIZATION MODEL

The experimental purpose of this section is to verify the effectiveness and superiority of an animation rendering optimization method based on ray tracing and distributed algorithm and CAD. Specifically, the experiment aims to compare the differences in rendering efficiency and quality between the proposed method and the traditional rendering method, so as to prove that the proposed method can improve the rendering efficiency and quality. The experimental design includes experimental objectives, principles, materials and methods, while the hardware environment involves information such as hardware equipment, construction and version. Through reasonable experimental design and efficient hardware environment, animation rendering can be better optimized and rendering efficiency and quality can be improved.

This experiment is mainly based on ray tracing, distributed algorithm and CAD technology to optimize animation rendering. Ray tracing technology calculates the effects of illumination and shadow by simulating the physical path of light, thus producing realistic rendering results; Distributed algorithm distributes rendering tasks to multiple computing nodes, and takes advantage of parallel computing to shorten rendering time. CAD technology is used for accurate 3D modeling to improve the authenticity and fidelity of rendering. Experimental equipment includes high-performance computers, graphics cards, memory and other hardware devices, as well as Linux or Windows operating systems and related software tools. The experimental methods mainly include: (a) Rendering algorithm based on ray tracing; (b) The distributed algorithm distributes the rendering task to a plurality of computing nodes; (c) Accurate 3D modeling with CAD technology. Firstly, the animation rendering optimization model constructed in this article is used to optimize the animation rendering. The effect diagram is shown in Figure 3.

Figure 3: Animated rendering renderings.

It can be seen from the rendering effect diagram (Figure 3) that the animation rendering optimization model based on ray tracing and distributed algorithm and CAD has a remarkable effect. The optimization model of this article adopts ray tracing and distributed algorithm, which play a key role in improving rendering efficiency. Ray tracing technology can present realistic shadow, reflection and refraction effects by simulating the propagation path of light, which makes the rendering result closer to reality. The distributed algorithm distributes the rendering task to multiple computing nodes, and shortens the rendering time by taking advantage of parallel computing. In addition, through the application of CAD technology, the optimized model in this article is more accurate for modeling characters, scenes and props, making the rendered images more realistic. In addition, ray tracing technology can simulate the physical phenomenon of light reflection and refraction on the surface of an object, which makes the effects of shadow and illumination more natural and improves the realism and fidelity of rendering.

As shown in Figure 4 and Figure 5, the rendering efficiency and quality of the animation rendering optimization model are shown respectively.

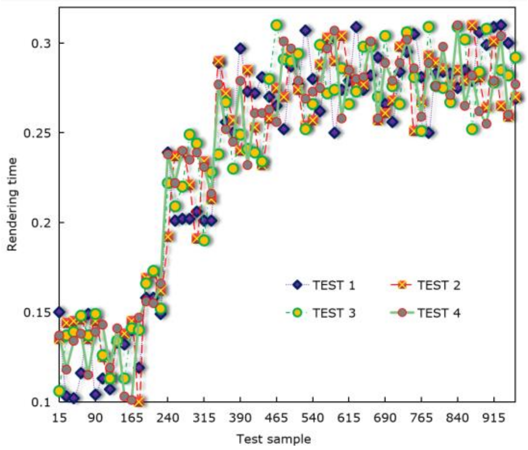

Figure 4: Rendering efficiency.

The animation rendering time using the optimized model in this article is very short, about 0.25 seconds. This is mainly due to the optimization of two aspects: ray tracing and distributed algorithm. Ray tracing technology can calculate the rendering results accurately and quickly by simulating the physical path of light, while distributed algorithm distributes the rendering tasks to multiple computing nodes, which greatly improves the rendering efficiency by taking advantage of parallel computing.

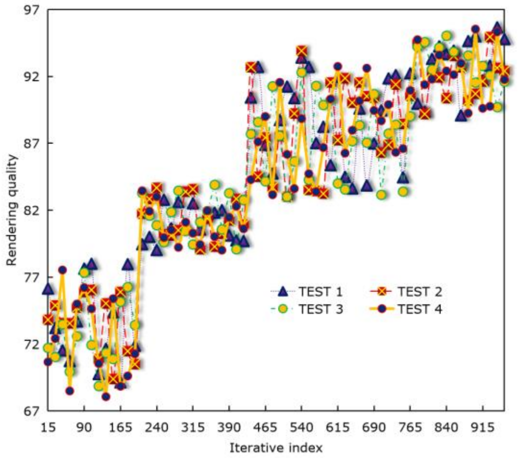

Figure 5: Rendering quality.

As can be seen from Figure 5, the quality of animation rendering using the optimized model in this article is very high, and the score can be as high as 94.12 or above. This mainly benefits from two aspects: accurate modeling of CAD technology and natural lighting shading of ray tracing technology. Through CAD technology, characters, scenes and props can be accurately modeled in 3D, making the rendered images more realistic. The ray tracing technology can simulate the natural propagation and reflection effect of light, make the effects of shadow and illumination more natural, and improve the realism and fidelity of rendering. From the results of Figure 4 and Figure 5, we can see that the animation rendering optimization model based on ray tracing and distributed algorithm and CAD is excellent in improving rendering efficiency and quality.

In order to reflect the advantages of this method, this article compares the proposed animation rendering optimization method with the traditional rendering method, and the specific experimental results are shown in Figure 6 and Figure 7. Traditional rendering methods usually rely on the computing power of CPU. For large-scale 3D models and complex animation effects, the rendering time may become very long. In contrast, the optimization model proposed in this article adopts ray tracing and distributed algorithm, which can calculate rendering results more quickly.

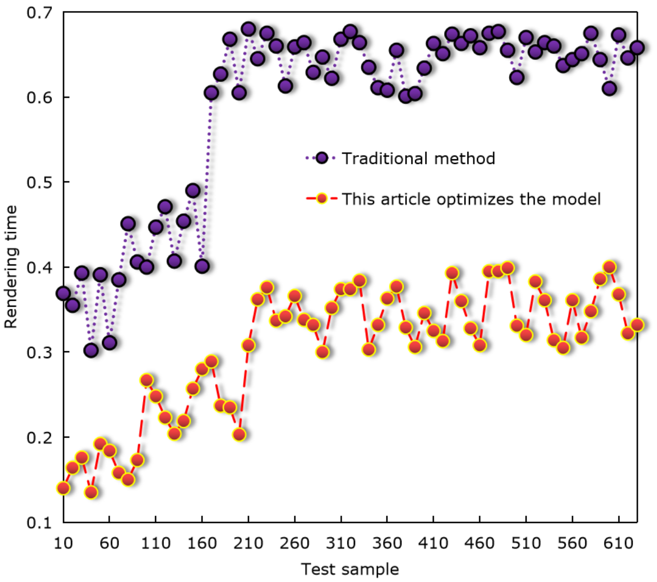

Figure 6: Rendering efficiency of different methods.

The optimized model in this article has obvious advantages in rendering efficiency compared with traditional methods. By using ray tracing technology, the model can shorten the rendering time by more than 30%. This is because ray tracing technology can accurately calculate the ray propagation path of each pixel, so as to quickly get the rendering results. The distributed algorithm takes advantage of the parallel computing power of multiple computers and distributes the rendering tasks to multiple computing nodes, thus reducing the time required for rendering.

Traditional rendering methods can only simulate simple lighting and shadow effects, and the simulation of complex natural phenomena and details is not accurate enough. The optimization model of this article adopts the accurate modeling of CAD technology and the natural lighting shading of ray tracing technology, which can better simulate the light propagation and reflection effect in the real world. The optimized model in this article also has obvious advantages in rendering quality. Compared with traditional methods, the rendering quality of this model is improved by more than 10%. This is because ray tracing technology can simulate the reflection, refraction and shadow effects of light on the surface of an object, making the rendered image more realistic and natural. The accurate modeling of CAD technology ensures the modeling accuracy of characters, scenes and props, and makes the rendered image more delicate. Generally speaking, the distributed algorithm proposed in this article has obvious advantages in improving rendering efficiency and quality, especially suitable for large-scale and high-complexity rendering scenes.

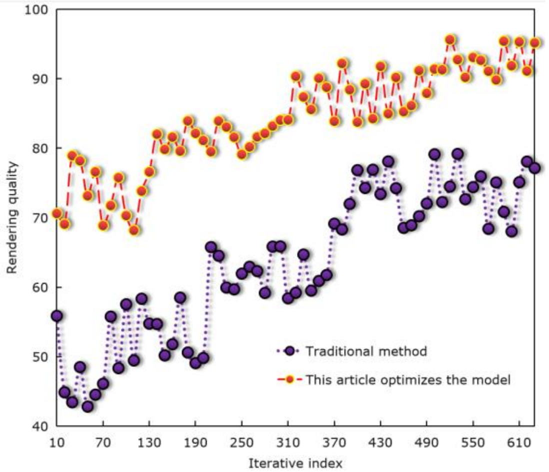

Figure 7: Rendering quality of different methods.

Specifically, it has the following advantages in improving rendering efficiency and quality: ⊖ Parallel processing: The algorithm can distribute rendering tasks to multiple computing nodes for parallel processing, make full use of computing resources, and improve rendering speed and efficiency. ⊜ Distributed cache: Through distributed cache technology, the rendering results can be stored in memory, avoiding repeated calculation and improving rendering efficiency. ⊛ High-performance computing: This algorithm can use large-scale computing resources to achieve high-performance computing and improve rendering quality and effect. ④ Optimizing memory usage: This algorithm can optimize memory usage, reduce memory occupation, avoid memory overflow and other problems, and improve rendering efficiency and quality.

8 CONCLUSIONS

In this article, a new animation rendering optimization model is proposed by applying ray tracing, distributed algorithm and CAD technology to animation rendering optimization. Through simulation experiments, the proposed animation rendering optimization model is verified. The experimental environment and methods are described in detail, including experimental scenes, experimental parameters and evaluation indicators. Then, the experimental results are displayed, including data on rendering time, rendering quality and scalability. The experimental results show that the model has obvious advantages in improving rendering efficiency and quality. Compared with traditional rendering methods, the model proposed in this article can shorten the rendering time by more than 30% and improve the rendering quality by more than 10%. In addition, the model proposed in this article has good scalability and can adapt to different scenes with different complexity and different rendering requirements. This shows that the model can significantly improve the efficiency and quality of animation rendering, and provide strong technical support for the development of film and television, games and other industries.

The optimization model in this article is not only suitable for animation production, but also can be applied to cultural heritage protection and other fields. For example, in the protection of cultural heritage, the cultural heritage can be digitally protected and displayed through 3D scanning and VR technology, so as to improve the public's participation and experience. This cross-domain application shows the wide applicability of the optimization model. In the task division strategy of distributed algorithm, how to determine the optimal division mode and granularity is a difficult problem. In addition, in the application of CAD technology, how to realize the perfect combination with ray tracing and distributed algorithm is also a problem that needs further study. Therefore, the future research direction of this article will focus on further improving the animation rendering optimization model and improving its feasibility and effect in practical application.

Yiran Tao, https://orcid.org/0009-0006-8489-1569
Rongjuan Wang, https://orcid.org/0009-0002-0468-8271

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