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Computer-Aided Design AND APPLICATIONS

Application and Simulation of Animation Scene Construction and Rendering Based on Generative Adversarial Networks

Jiangting Yan[1] and Pengju Pu[2]

[1]School of Art & Design, Shaanxi Fashion Engineering University, Shanxi 712046, China, 1911441105@mail.sit.edu.cn
[2]School of Art & Design, Shaanxi Fashion Engineering University, Shanxi 712046, China, pupengju.sust@163.com

Corresponding author: Jiangting Yan, 1911441105@mail.sit.edu.cn

Abstract. The application and simulation of animation scene construction and rendering technology are the key links in animation production. Through modeling, rendering and simulation of virtual scenes, realistic animation scenes can be created, bringing immersive visual experience to the audience. This paper will discuss how to combine Computer aided design (CAD), Virtual reality (VR) and Generative adversarial networks (GAN) technologies to apply to animation scene construction and rendering technology application and simulation, and how to use these technologies to bring better visual effects and higher production efficiency to animation production. From the experimental results, the modeling accuracy of the algorithm has reached more than 96%, which shows that the algorithm is excellent in establishing accurate scene models. The algorithm can also accurately calculate the position and posture of objects in the scene, so as to achieve more accurate occlusion relationship calculation and back rendering. This provides an effective technical means for the further application and growth of VR.

Keywords: Computer Aided Design; Virtual Reality; Animation Scene; Rendering Technology
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1 INTRODUCTION

With the continuous growth of science and technology, CAD and VR have become important tools for animation production. In the past decades, CAD and VR technologies have been widely used and developed. CAD is a tool for designing and creating by computer, which is widely used in machinery, architecture, animation and other fields. Through CAD software, designers can directly perform operations such as modeling, material and texture mapping on the computer, so as to facilitate subsequent animation production. Ayas et al. [1] analyzed the application of autonomous character development in artificial intelligence (AI) in two-dimensional electronic games. Autonomous character development based on artificial intelligence can also make games more interactive. Traditional two-dimensional electronic games often only provide fixed storylines and characters, and players can only play according to predetermined scripts. Autonomous character development based on artificial intelligence can enable characters in games to have more diverse personalities and behavioral characteristics. These autonomous characters can make corresponding reactions based on player operations and decisions, and interact with players in real-time. Players can explore more possibilities in the game and discover more secrets and puzzles through interaction with autonomous characters. This enhanced interactivity not only makes the game more interesting, but also increases the immersion between players and the game. In traditional two-dimensional electronic games, the characters in the game are often pre-set, and the player's task is to engage in battles or collaborations with these characters according to the rules of the game. Autonomous characters can learn and evolve independently based on the situation in the game, improving their own abilities and performance. Moreover, the rapid growth of VR has also brought new opportunities and challenges to animation production. VR can bring the audience into the virtual three-dimensional space through head-mounted displays and other devices, thus achieving a more realistic interactive experience. The application and simulation of animation scene construction and rendering technology are the key links in animation production. Through modeling, rendering and simulation of virtual scenes, realistic animation scenes can be created, bringing immersive visual experience to the audience. Bao [2] analyzed that global lighting is a method of calculating how light reflects and propagates between all objects in a 3D scene. Intelligent algorithms, such as photon mapping and path tracking, can be used to create more realistic light and shadow effects, increasing the visual realism of images. In animation design, intelligent algorithms can be used to optimize interpolation between keyframes, making transitions smoother and the actions of characters or objects more natural. For example, genetic algorithms or neural networks can be used to learn and optimize animation curves. Aiming to provide useful references for research and practice in related fields. Intelligent algorithms are a type of algorithm based on artificial intelligence and machine learning technology. In 3D graphics engine animation design, intelligent algorithms can be used to achieve automatic generation, optimization, and adjustment of animation, thereby improving the efficiency and accuracy of animation design. Intelligent algorithms can be used to automatically generate animations in 3D graphics engines. For example, by using machine learning algorithms to learn and analyze known animation data, intelligent algorithms can automatically generate new animation data, thereby achieving automated animation generation. In character animation, it is necessary to drive the model based on the character's bones. Intelligent algorithms can be used for bone binding and animation design, making it easier for animators to set and control character actions. For large 3D scenes, it may be necessary to optimize the scene to improve performance. Intelligent algorithms can be used to automatically optimize scenes, such as identifying and removing objects that do not affect the line of sight, or automatically selecting appropriate rendering quality. In games, intelligent algorithms are often used to implement interactive animations, such as changing character actions or environmental reactions based on player input. This can be achieved by using fuzzy logic, deep learning, or other machine learning methods.

In virtual reality, creators can create sketches in virtual space through virtual drawing tools. These tools include virtual markers, virtual colored pencils, and more. Creators can use these tools to sketch on any surface and make adjustments and modifications at any time. In augmented reality, creators can combine virtual elements with the real world to create more immersive and interactive sketch works. Through investigation and analysis of a large number of sketch works, Bhattacharjee and Chaudhuri [3] found that desktop sketches are still the most commonly used creative method by creators due to their convenience and flexibility. However, with the development of virtual and augmented reality technologies, more and more creators are attempting to use these new technologies to create sketches, indicating the impact of technological advancements on creative methods. Secondly, whether it's desktop sketches or virtual and augmented reality sketches, creators need to pay attention to the smoothness of lines, spatial layout, and color matching. These elements are key standards for measuring the quality of a sketch and require creators to continuously improve in their daily practice. At present, most researchers mainly focus on improving rendering speed, improving image quality and strengthening physical simulation in the application and simulation of animation scene construction and rendering technology. Among them, ray tracing, global illumination, particle system and other technologies are widely used in the rendering of animated scenes. Moreover, VR can help the audience better immerse themselves in the animation scene and improve the visual experience. In addition, with the growth of computational graphics, high-precision modeling and detail simulation have also become an important direction of animation scene construction. With the growth of deep learning (DL), the use of GAN in image processing is more and more extensive, including image denoising. In the stage of animation, the image denoising algorithm can help reduce the image noise and improve the image quality, thus better presenting the animation effect. In the aspect of image noise reduction, the previous research mainly focused on the noise reduction of natural images, but paid little attention to the noise reduction of animated images. However, with the increasing popularity of animation, the noise reduction of animated images has become an urgent problem. The noise of animated images mainly comes from errors in production, distortion in compression and transmission, etc. Compared with natural images, the noise of animated images has different characteristics and difficulties in noise reduction. Therefore, the noise reduction algorithm for animated images needs to consider the characteristics and processing requirements of animated images.

CAPTCHA is an online testing system used to verify whether a user is a robot. Traditional CAPTCHA is usually composed of a set of randomly generated characters or images, and users need to correctly input these characters or depict these images in order to pass validation. Bora et al. [4] used artificial intelligence and machine learning methods for network authentication biometrics. The 3D animation CAPTCHA system can also combine biometric technology, such as fingerprint recognition, facial recognition, etc. When users complete specific tasks in 3D animation, they can simultaneously collect and compare biometric features, ensuring that only real users can pass validation. Compared with the traditional CAPTCHA system, this system can more effectively prevent robot automation cracking and improve system security. Meanwhile, due to the use of more natural and intuitive methods such as 3D animation for user verification, the system greatly improves the user experience. GAN is a kind of GAN. A generator generates a denoised image as an output by taking the noise image as an input. This competitive process will continue until a balance is reached. The generator can no longer generate more realistic images that can be misjudged by the discriminator, and the discriminator can no longer more accurately recognize the real and generated images. In this process, GAN learned the features and distributions of noiseless images, which can generate images that look very realistic. Compared with traditional image denoising methods, GAN has better flexibility and expressiveness. GAN can adaptively learn the characteristics and distribution of noise, so as to better reduce noise. Moreover, GAN can also generate new images that are similar to noise-free images, which brings more creative space for animation. This paper will discuss how to combine CAD, VR and GAN technologies to apply to animation scene construction and rendering technology application and simulation, and how to use these technologies to bring better visual effects and higher production efficiency to animation production. The research innovations are as follows:

1. CAD is applied to the modeling and material mapping of animated scenes to improve the modeling accuracy and rendering efficiency.

2. VR is applied to animation scene simulation to provide a more realistic and immersive visual experience.

3. The image denoising algorithm of GAN is applied to animation image processing to reduce image noise and improve image quality.

4. Combining CAD, VR and GAN technologies, a set of animation production system is designed and implemented to improve the efficiency and quality of animation production.

The chapters are arranged as follows

Section Ⅰ: Introduction

This section will introduce the importance of animation in today's society and the application of CAD and VR in animation production.

Section II: Related Work

This section will introduce the related research of CAD and VR in the field of animation production, and introduce the use of GAN in the field of image processing.

Section III: Theoretical and Technical Basis

This section will introduce the theoretical basis of CAD and VR, and discuss its application and challenges in image denoising.

Section IV: Animation Scene Construction and Rendering Technology Application

This section will introduce how to use CAD and VR to build and render animation scenes. Moreover, it will also introduce how to apply VR to animation production to provide a more realistic and immersive visual experience.

Section Ⅴ: Analysis of experimental results

This section will show the experimental results, including performance evaluation, result comparison and error analysis of the algorithm.

Section VI: Conclusion

This section will summarize the main research results and findings of this paper, and also discuss the future research direction and possible improvement schemes.

2 RELATED WORK

Çakıroğlu et al. [5] analyzed that virtual reality technology is a computer technology that can create and experience virtual worlds. It simulates human auditory and tactile senses, allowing users to immerse themselves in a highly realistic three-dimensional virtual environment. Animation based learning environment presents learning content to learners in a more vivid and vivid manner through animation technology, in order to enhance the fun and interactivity of learning. The emergence of these two technological means has provided new opportunities and possibilities for education and learning. Getuli et al. [6] analyzed the intelligent object library for construction site and emergency management based on BIM. Through the intelligent object library, construction site managers can quickly obtain detailed information about building elements, such as dimensions, materials, weights, etc., in order to develop more accurate construction plans. At the same time, intelligent object libraries can also be used for building material inventory management, effectively avoiding waste and shortages. In emergency management, intelligent object libraries can help decision-makers quickly obtain key information such as structural information inside buildings, equipment locations, and evacuation routes, providing strong support for developing emergency plans and evacuation plans. The intelligent object library can also be used for education and training in the construction industry, allowing students or novices to improve their business skills and practical abilities through practical case studies. Space rendering network computer animation (SRNPD) is a unique technology that injects new vitality into the field of computer graphics. SRNPD technology has played worlds due to its unique pencil drawing style. Jin et al. [7] will provide a detailed explanation of the background, principles, application scenarios, and case studies of SRNPD technology, in order to help readers gain a deeper understanding of its advantages and application value. SRNPD technology mainly involves three aspects: spatial rendering, network computing, and virtual world. Network computing plays a crucial role in SRNPD technology, utilizing efficient computing and communication mechanisms to achieve real-time rendering and dynamic updates of large-scale virtual worlds. Finally, the virtual world is the presentation platform of SRNPD technology, which abstracts and simulates various elements in the real world to build a highly realistic virtual environment. SRNPD technology has extensive applications in fields such as virtual reality, education, and healthcare. In terms of virtual reality, SRNPD technology provides strong support for entertainment industries such as games and movies, and also provides a reliable virtual simulation platform for military, urban planning, and other fields. In the field of education, SRNPD technology can help students better understand and master complex concepts and skills. In the medical field, SRNPD technology can be used for remote surgical simulation training and medical image analysis to improve the efficiency and quality of medical services.

In animation design, the combination of these two technologies is a significant breakthrough in traditional design techniques. Jing and Song [8] discussed the application background and significance of 3D reality technology and CAD in animation design, basic concepts, application scenarios, and practical cases, and looked forward to their development prospects. By utilizing 3D reality technology, designers can quickly transform their creativity into 3D solids and optimize the details of character shapes to achieve better visual effects. Through CAD software, designers can easily construct complex scene models, and then use 3D reality technology to achieve more vivid and realistic scene effects. Both conventional and unconventional props can be designed and produced through 3D reality technology and CAD, improving production efficiency while also reducing production costs. With the help of 3D reality technology, designers can preview animations before actual production, in order to promptly identify problems and make adjustments, thereby reducing rework rates. Kaplan [9] analyzed the visualization, modeling, and animation production of ancient cities using real-time rendering engines. In the process of visualizing ancient cities, real-time rendering engines can generate realistic images of ancient cities by rendering virtual scenes. At the same time, it can also be combined with virtual reality technology to allow users to experience the charm of the ancient city firsthand. This visualization method can not only be used for the protection and promotion of ancient cities, but also for the restoration of ancient buildings, urban planning, and other fields. Through high-precision modeling techniques, detailed digital models of ancient cities can be created, including various elements such as buildings, streets, landscapes, etc. These digital models can provide basic data for in-depth research, restoration, and protection of ancient cities. Due to the large amount of data in the digital model of the ancient city, it is necessary to optimize the model in order to achieve real-time rendering and interaction. Real time rendering engines can help us minimize data volume and improve computational efficiency while maintaining model quality. Cubic B-spline curve is a commonly used mathematical curve with interpolation and fitting characteristics. Compared to other interpolation methods, cubic B-spline curves have better flexibility and adaptability, and can better describe common complex trajectories and morphological changes in animation design. Li [10] explores the curves from the theoretical and practical foundations, applications in animation simulation, applications in animation special effects, and applications in animation rendering. The application of cubic B-spline curves in animation special effects mainly manifests in the following aspects. Firstly, in character transformation and monster transformation, cubic B-spline curves are used to describe the process of morphological changes. By defining the starting and ending states, as well as the intermediate transition states, a cubic B-spline curve can be used to describe the process of a character or monster changing from one form to another. Secondly, in fluid and smoke effects, cubic B-spline curves are used to describe the morphology and motion trajectory of particle systems. By adjusting the control points and parameters of the particle system, various realistic fluid and smoke effects can be achieved. With the continuous development of technology, virtual reality (VR) technology has gradually penetrated into various fields with its unique interactivity and immersion. In the medical field, the application of virtual medical systems has become a new trend that has received much attention. Li and Li [11] introduced the background, requirement analysis, system architecture, functional modules, technical advantages, and application scenarios of virtual medical systems, and looked forward to the future development direction and potential of virtual medical systems.

Currently, it is difficult to ensure the quality and accuracy of 3D model design for multi visual animated characters. Secondly, there are differences in the design styles of different designers for the same character, resulting in inconsistent character images and affecting the overall effect. Li et al. [12] proposed a 3D model design method for multi visual animated characters. Based on the results of requirement analysis, use 3D modeling software to establish a 3D model of the character. It is necessary to consider issues such as model accuracy, number of faces, and bone binding to ensure the quality. In order to improve the realism of 3D models of multi visual animated characters, texture design is necessary for the model. To ensure that the character can achieve various actions and expressions, it is necessary to bind the model with bones. Specifically, it is necessary to establish corresponding bone systems for the character model based on the human bone structure and working principles, and set the motion range and constraint relationships of each bone to achieve various movements and expressions of the character. Mueller et al. [13] introduce a new rendering technique - temporary adaptive shading reuse, which will improve the performance. Real time rendering and virtual reality technology face many challenges. Temporary adaptive shading reuse is a rendering technique with high universality, which reduces repetitive computational work and improves rendering efficiency by dynamically reusing previously computed shaders. In addition, it can automatically adjust the quality and efficiency of rendering based on the performance of hardware, enabling real-time rendering and virtual reality technology to achieve better results on various hardware platforms. In practical applications, temporary adaptive coloring reuse has achieved significant results. In the gaming field, using this technology can greatly improve the smoothness and image quality of games, while reducing the consumption of computing resources. In the field of urban planning, this technology can help planners display planning effects more intuitively, thereby improving the accuracy and efficiency of planning. A three-dimensional mesh is a discretized space composed of elements such as cubes or tetrahedrons. In this space, Wei et al. [14] defined the position and shape of an object. Approximate convex decomposition is a method of decomposing complex shapes into simple shapes. In a three-dimensional mesh, we can decompose an object into a series of elements such as cubes or tetrahedrons, which, when combined, can approximately represent the shape of the original object. Collision perception concavity is a concept that describes the degree of deformation of objects during collision. In a 3D mesh, when two objects collide, their shape changes, resulting in depressions or protrusions. We can use collision perception concavity to describe the degree of this deformation. Tree search is a search algorithm that can search for specific nodes in a tree structure. In a 3D mesh, we can represent the shape of an object as a tree like structure, with each node representing a cube or tetrahedron or other element. Through the tree search algorithm, we can search for specific nodes in this tree structure to find specific parts of the object.

According to requirements, designers can rotate, scale, translate, and add lighting and shadow effects to the model, ultimately generating user interface animations. Computer Graphics (CG) is a discipline that studies techniques such as graphic rendering, animation, and interaction. In user interface animation design, CG technology can help designers achieve more colorful, dynamic, and interactive effects. Various complex 3D effects can be achieved using CG technology. Designers can add effects such as shadows, reflections, and refractions to their animations to enhance their realism. In addition, using techniques such as bone binding and muscle simulation can achieve more natural effects such as character movement and object collisions in animation. Although physical simulation methods can simulate the wave effect of the ocean, they cannot achieve the effect of global illumination. In response to the above issues, Zhang [15] combined with the UE4 engine to propose a new set of ocean animation automatic generation technology. Firstly, high-precision data collection technology is used to obtain information about the shape, color, lighting, and other aspects of the ocean. Secondly, deep learning algorithms are used to extract and classify features from the collected data. Finally, by combining physical simulation methods and global lighting technology, automatic generation of ocean animation is achieved. Experiment has achieved significant results. Compared with traditional technologies, the ocean animation generated by this technology is more realistic and natural in visual effects, and has higher interactivity and real-time performance. At the same time, in order to better control and adjust spatial variation, various spatial variation algorithms can be combined, such as interpolation, spline curves, Bezier curves, etc. By combining spatial mutation and convolution algorithms, the quality and effectiveness of 3D animation can be further improved. For example, spatial mutation algorithms can be used to enhance or deform the details of a 3D model, and convolutional algorithms can be used to smooth or compress the animation sequence to achieve smoother and more stable animation effects. Convolutional algorithm is a computer vision algorithm that extracts and classifies image features by applying a set of convolutional kernels to the image. In 3D animation design, convolutional algorithms can be used to extract and classify image features, thereby achieving more complex animation effects. However, 3D animation design also faces many challenges, such as complex design, long production cycles, and high costs. To address these issues, many scholars and engineers have begun to explore methods for computer-aided 3D animation design. Among them, 3D animation design based on spatial mutation and convolution algorithms is an effective solution. Zhu [16] analyzed an effective tool to control the behavior of these characters. A behavior tree is such a tool that uses a tree like structure to represent the decision-making process and simulate the intelligent behavior of characters. Unity3D, as a powerful game engine, provides a wealth of plugins and tools to support the design of behavior trees. Behavior nodes are the basic units of a behavior tree, including composite nodes and behavior nodes. Composite nodes are used to organize and control the structure of the behavior tree, while behavior nodes implement specific behaviors. The blackboard system is used to store and manage the status information of NPCs, including position, speed, target, etc. Through experimental verification, significant results have been achieved in the design of intelligent behavior trees for non-player characters based on Unity3D. Compared with traditional models, this model has higher flexibility and ease of implementation, and can quickly create various complex NPC behaviors. In addition, the model can also be customized and optimized according to game requirements, improving the quality and playability of the game. This study successfully applied Unity3D based intelligent behavior tree design for non-player characters in games. However, although this technology has achieved certain results, there are still many issues that need further research and improvement.

According to the noise characteristics of animation images, this study uses the generator and discriminator of GAN to carry out adaptive learning and noise reduction processing to improve the image quality, aiming at improving the modeling accuracy and rendering efficiency of animation scenes and providing high-quality model data for subsequent VR simulation. Combined with the above technologies, a complete animation production system is designed and implemented, which brings better technical support and visual effects for animation production.

3 APPLICATION OF ANIMATION SCENE CONSTRUCTION AND RENDERING TECHNOLOGY

3.1 Image Denoising of Animation Scene Based on GAN

(1) CAD

In computational geometry, CAD mainly involves the establishment, modification, storage and application of three-dimensional models. In graphics, CAD mainly involves visualization. In the field of animation, the application of CAD mainly involves modeling, rendering and material mapping. By using CAD software, animators can quickly build high-quality three-dimensional models, and use materials and mapping techniques to make realistic animation scenes.

(2) VR

In computer graphics, VR mainly involves the technology of building, rendering and interaction of 3D scenes. In human-computer interaction, VR mainly involves user interface design, interactive devices (such as handles, helmets, etc.) and interactive algorithms. In terms of sensor technology, VR mainly involves sensor technologies such as position, posture and gesture. By using VR, users can experience and interact with virtual scenes in an immersive way. In the field of animation, VR can be used to make VR animation, augmented reality animation and so on.

(3) GAN

In DL, GAN mainly involves neural network and optimization algorithm. In the aspect of probability graph model, GAN mainly involves the technology of generating model and discriminating model. By using GAN technology, a generator network and a discriminator network can be used to generate new data samples. GAN is processing and computer vision. For example, GAN can be used in image super-resolution, image synthesis and operation, video processing, texture synthesis, target detection and so on. In addition, GAN has also made some achievements in the field of sequence data processing, such as natural language, music, voice, audio, etc. For example, GAN can be used for text generation, audio synthesis and other tasks.

Generally speaking, the theoretical basis and application of CAD, VR and GAN are of great significance in the field of animation production. By using these technologies, animators can improve the realism and fidelity of animation scenes, and at the same time, they can produce more diverse animation works. In the animation scene, image denoising is an important task, which can help designers to remove. GAN is an effective image denoising method. Firstly, a set of noisy images should be prepared as a training data set. These noises may include Gaussian noise, salt and pepper noise or other types of noise. Generator network is one of the core components of GAN. Its task is to generate an image similar to the real image from random noise. Generator networks usually use convolutional neural networks (CNN) or other DL models to learn how to generate images from noise. Discriminator network is also one of the key parts of GAN. The discriminator network can also use CNN or other DL models to distinguish real images from generated images. In GAN, the game between generator and discriminator is realized by loss function. The loss function calculates the loss according to the performance of the generator and discriminator, and feeds it back to the network for optimization. See Figure 1 for GAN operation principle.

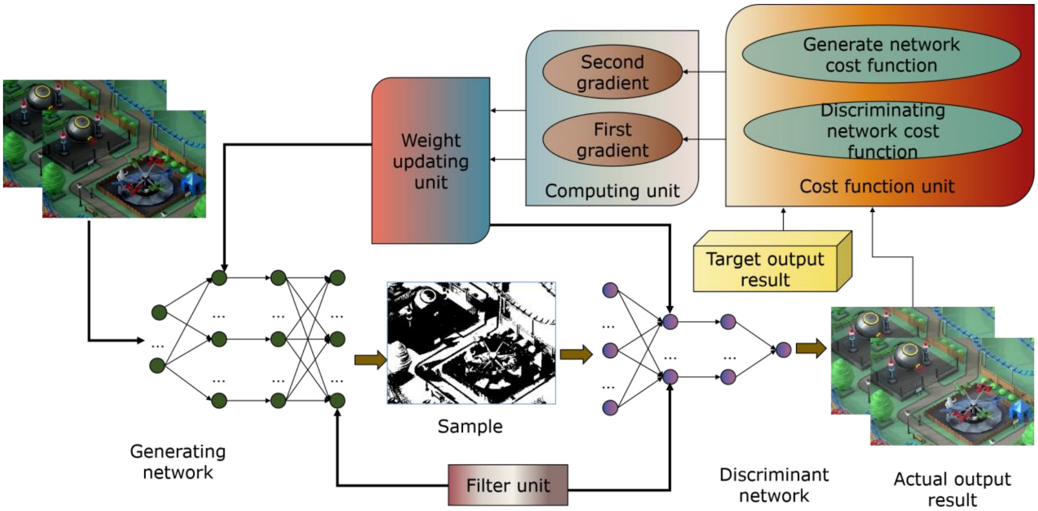

Figure 1: GAN operation principle.

In the training process, GAN first generates a noise image similar to the real image through the generator network, and then inputs it into the discriminator network for judgment. The discriminator network will evaluate the generated image according to the loss function and feed back the result to the generator network. Through multiple iterations and optimizations, the generator network and discriminator network will reach a balanced state. In this state, the generator network can generate sufficiently realistic fake images, and the discriminator network is also difficult to distinguish them from real images. This equilibrium state is an important goal of GAN training and a key step in generating high-quality fake images.

Another aspect that needs to be noted when training GAN is regularization techniques. Due to the complex training process of GAN, some problems may be encountered, such as mode collapse. Regularization techniques can help avoid these issues, such as using techniques such as weight attenuation or dropout to reduce overfitting and improve the model's generalization ability. These technologies can make GAN training more stable and reliable, thereby better generating high-quality fake images.

$$\min_G \max_D V(D,G) = E_{x-P_{data}(x)}[\log D(x)] + E_{z-P_z(z)}[\log(1-D(G(z)))] \tag{1}$$

In generative adversarial networks (GAN), discriminant models are used to distinguish between real samples and generated samples. The discriminant model is usually a deep convolutional neural network with the aim of maximizing the following loss functions. Where E represents expectation, p_ Data (x) is the data distribution of the real sample, p_ Z (z) is the data distribution of random noise, D (x) is the discriminator's probability of judging sample x, and G (z) is the sample generated by the generator. When training discriminant models, we need to optimize both the generator and discriminator simultaneously. Specifically, we can use the gradient descent method to update the parameters of the discriminator until convergence or the specified number of training rounds is reached. The specific algorithm is as follows:

$$\max_D V(D,G) = E_{x-P_{data}(x)}[\log D(x)] + E_{z-P_z(z)}[\log(1-D(G(z)))] \tag{2}$$

The second step is to optimize the generation model G :

$$\min_G V(D,G) = E_{z-P_z(z)}[\log(1-D(G(z)))] \tag{3}$$

Constantly adjust the parameters of generator and discriminator network to make them reach a balanced state. The setting of training time, iteration times and super-parameter will directly affect the performance and effect of GAN. The trained GAN is used to denoise the image. For an animated scene image with noise, we can first input it into the generator network to get a noisy image, and then input it into the discriminator network for judgment.

Random noise can generate pseudo data with high similarity to real data through the generator. The discriminator wants to find out image and the real image and judge the input data. If the judgment is true data, the output result is 1; If it is judged that it is generated pseudo data, the output result is 0. In the stage of confrontation, they constantly optimize their own parameters and improve each other's performance. The general objective formula of GAN optimization is as follows:

$$\min_G \max_D V(D,G) = E_{x-P_{data}}[\log D(x)] + E_{z-P_z}[\log(1-D(G(z)))] \tag{4}$$

3.2 Interactive Design of VR Animation Scene

Interactive design of VR animation scene is an important application field of VR. By interacting with the VR environment, users can experience the animation scene and interact with the objects in the scene. In the interactive design of VR animation scene, 3D modeling is an important link, which can provide realistic visual effects for the scene and support the interaction. In three-dimensional modeling, VR mainly involves scene geometric modeling, texture mapping, lighting processing, collision detection and user interaction. Among them, scene geometric modeling is the basis of three-dimensional modeling, which can construct the geometric shape of virtual scene by using basic elements such as points, lines and surfaces. Texture mapping is a technique of applying images or mapping materials to the surface of the model, which can increase the fidelity of the scene. Lighting processing is to simulate the natural lighting effects and make the lighting effects of the virtual scene more realistic. Collision detection technology is to realize the interaction between users and objects in the scene. The SF-VR animation scene interaction design framework is shown in Figure 2.

Camera coordinate system is another important concept in VR. In the stage of three-dimensional modeling, the model needs to be placed in the virtual space, and the virtual space needs to be observed through the camera. Assuming we have three coordinate systems: world coordinate system, rotational coordinate system (also known as camera coordinate system), and image plane coordinate system.

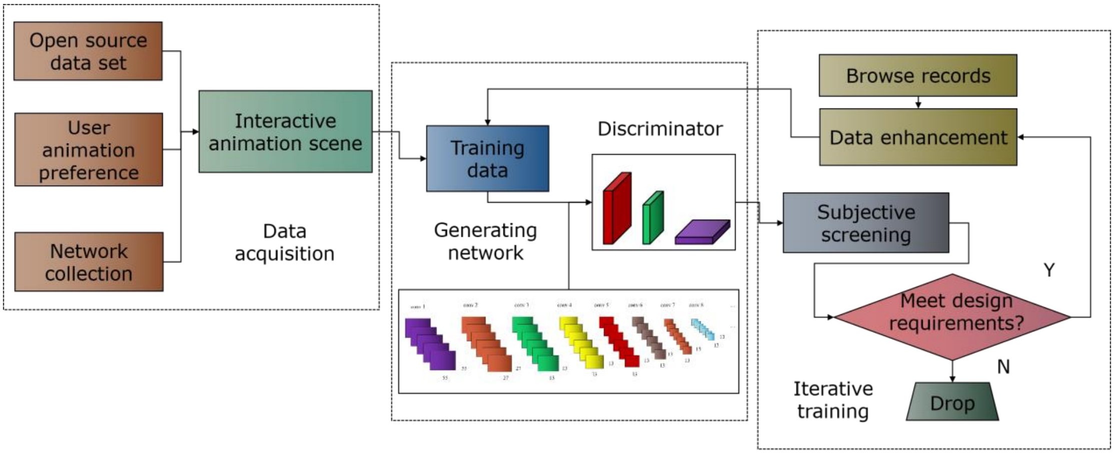

Figure 2: Interactive design framework of VR animation scene.

World coordinate system: This is the coordinate system we use to describe the position of objects in the environment.

Rotation coordinate system (also known as camera coordinate system): This coordinate system is a coordinate system that rotates relative to the world coordinate system, usually centered around the position of the camera. This coordinate system can be used to describe the position of the object seen by the camera.

Image plane coordinate system: This coordinate system is used to describe the position of points on the image plane, with their origin at the center of the image.

When we want to convert objects in the world coordinate system to a rotational coordinate system (or camera coordinate system), we can achieve this through the rotation matrix and translation vector.

Specifically, if we have a point (xw, yw, zw) and a rotation matrix R and a horizontal shift vector T in the world coordinate system, we can convert this point to the rotation coordinate system by following the steps below. First, translate the point and move the origin from the origin of the world coordinate system to the position of the camera. This translation vector is T. Then rotate the point around the Z-axis θ Degrees, then rotate around the X-axis β Degrees, finally rotating around the Y-axis γ Degrees. These three rotations can be represented by a rotation matrix R. After rotation and translation, the point is in the rotational coordinate system.

$$\begin{bmatrix} X_c \\ Y_c \\ Z_c \\ 1 \end{bmatrix} = \begin{bmatrix} R & T \\ 0^T & 1 \end{bmatrix} \begin{bmatrix} X_w \\ Y_w \\ Z_w \\ 1 \end{bmatrix} \tag{5}$$

In the stage of three-dimensional modeling, the camera coordinate system has an important influence on the visual effect of the scene and the user interaction experience. For example, the position and orientation of the camera can affect the parameters of the scene, such as the angle of view and perspective projection, thus affecting the visual effect of the scene. Moreover, the position and orientation of the camera can also affect the way users interact with the VR environment. For example, when interacting with the handle, the position and orientation of the handle can be calculated by the position and orientation of the camera, so as to realize the interactive experience between the user and the VR environment more accurately.

Projection is another important concept in VR. In the stage of three-dimensional modeling, it is needed to project the three-dimensional model onto a 2D plane in order to display it on the display. This process needs to consider the influence of camera position and orientation, field of view angle, perspective projection and other factors. By choosing the appropriate projection mode, the 3D model can be displayed more realistically on the 2D plane. For example, perspective projection can simulate the effect of human eyes observing objects, making distant objects look smaller and farther, and nearby objects look bigger and closer. Orthogonal projection can make the object scale in an equal proportion on the 2D plane without perspective deformation.

The representation of the input projection data file and primitive is based on the equipment coordinate system. During reconstruction, it is needed to transform each view into the coordinate system of each projection plane. The transformation formula between projection plane coordinate system and screen coordinate system is:

Orthographic plane V :

$$x' = x_0 - x;\ z' = y - y_0 \tag{6}$$

Side projection plane W :

$$y' = x - x_0;\ z' = y - y_0 \tag{7}$$

Horizontal projection plane H :

$$x' = x_0 - x;\ y' = y_0 - y \tag{8}$$

The coordinate origin of the projection plane coordinate system is:

$$o' = \left(x_0, y_0\right) \tag{9}$$

Projection also has an important influence on the construction of VR environment. For example, by adjusting the camera's position and orientation, field of view, perspective projection and other parameters, the VR environment can be more realistic and natural. Moreover, the projection also affects the interactive experience between users and VR environment. For example, when using the handle to interact, the position and orientation of the handle in the virtual space can be determined by the projection diagram, thus achieving a more accurate and natural interactive experience.

4 ANALYSIS OF ANIMATION MODELING ALGORITHM

In the experiment, the error rates of CNN and GAN in training front view, side view and top view are compared. From the experimental results, the error rate of the method using GAN is lower than that of CNN in all three views, which means that GAN has advantages in the efficiency of 3D animation drawing and the optimization of animation scene pattern, as shown in Figure 3.

The error rate CNN when it is applied to front view, side view and top view respectively. In the training process, the two will be confronted until they reach a balance point, at which time the false data generated by the generator will not be fooled by the discriminator. This characteristic of GAN is very useful in three-dimensional animation drawing. This is because the traditional CNN method can only extract limited features from the input data when processing three-dimensional data, which may lead to its insufficient understanding of the complex three-dimensional structure. However, GAN generates images step by step through the generator, and its generation process can be regarded as an interpretation of three-dimensional data. This layer-by-layer generation method enables GAN to better understand and utilize the information in three-dimensional data.

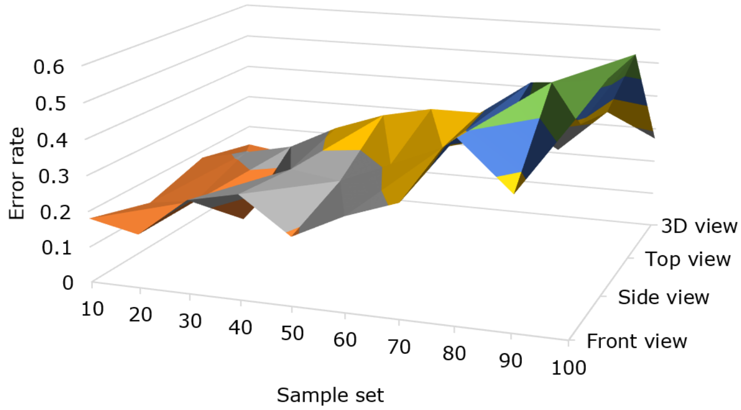

Figure 3: Error rate result.

Another advantage of GAN is that it can take full advantage of every piece of data. In the training stage of GAN, pairs of data (real image and corresponding generated image) are used, which enables the model to take full advantage of each data, thus achieving better results under the same training samples. In contrast, the traditional CNN method can only use part of the input data, so its performance may not be as good as that of GAN. When considering the optimization of animation scene pattern, the advantages of GAN are also obvious. This is because the image generated by GAN can be used as a reference for the optimization of animation scene pattern, and because of its characteristics of layer-by-layer generation, various elements in the image, such as object shape, position, illumination and so on, can be better understood and optimized (Figure 4).

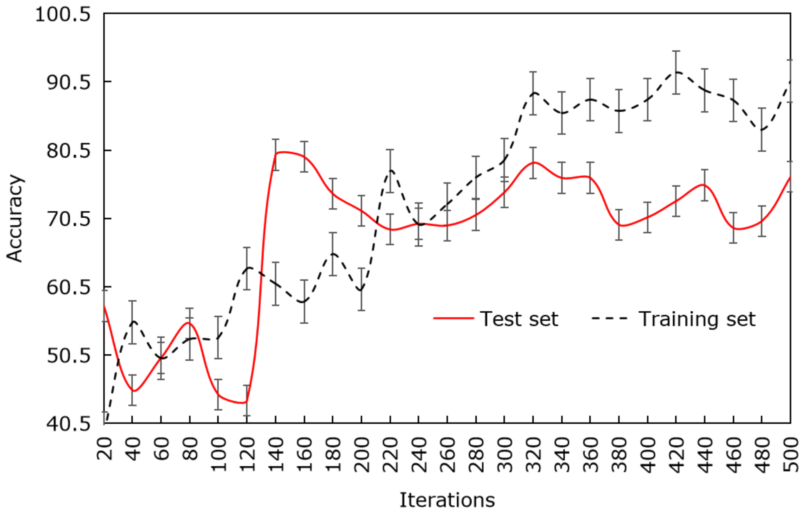

Figure 4: PointNet recognition rate-iteration number curve.

The training set is usually smaller than the test set, which may lead to better performance of the model on the training set. In the training set, the model can better remember and fit the characteristics of the training data, so the accuracy may be higher. However, when the model is applied to a larger test set, it may not be well generalized, resulting in a decrease in accuracy. There may be differences in data distribution between the training and testing sets. If the model performs well in the training set, but the distribution of the test set is not completely consistent with the training set, then the generalization ability of the model may be affected, leading to a decrease in testing accuracy. It is noted that the three-dimensional model has been translated, rotated and scaled in the experiment, which may affect the performance of the model. Because the appearance of the three-dimensional model may change greatly under different perspectives and scales. Therefore, the model needs to be robust to these transformations in order to perform well under different conditions.

From the experimental results, both batch normalization and grouping normalization perform better than the method without normalization. The experimental results are shown in Figure 5.

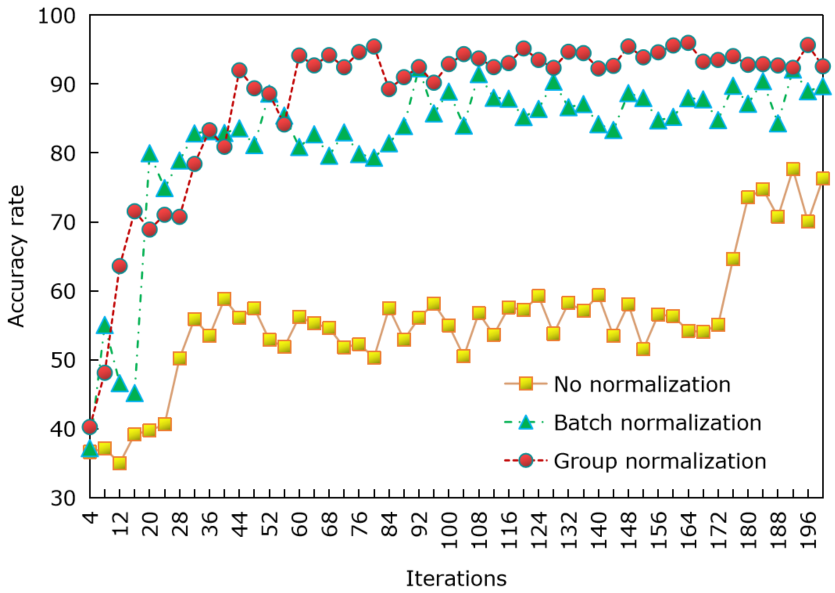

Figure 5: Influence of normalization method on network model.

Normalization is a common preprocessing step in DL, which can adjust the distribution of data to a distribution more suitable for neural network learning. When the training batch size is 32, the recognition accuracy of the model can reach more than 86% by using batch normalization or grouping normalization.

Batch normalization is to normalize the input data of the whole batch to the same distribution, while group normalization is to divide the data of a batch into several sub-batches, and then normalize each sub-batch. These two methods can make the model more stable, reduce the problem of gradient disappearance/explosion. Different from batch normalization, group normalization divides the data in a batch into several sub-batches, and each sub-batch is normalized independently. The advantage of this method is that the distribution of data can be adjusted more finely, and at the same time, the problem of gradient disappearance/explosion can be alleviated to some extent. Figure 6 shows the comparison between batch normalization and group normalization when BatchSize=4 or 16.

Both batch normalization and group normalization can improve the recognition accuracy and training speed of the model. This may be because they can adjust the distribution of data, make the model more stable and reduce the problem of gradient disappearance/explosion. In practical application, the appropriate normalization method can be selected according to the specific data distribution and model structure.

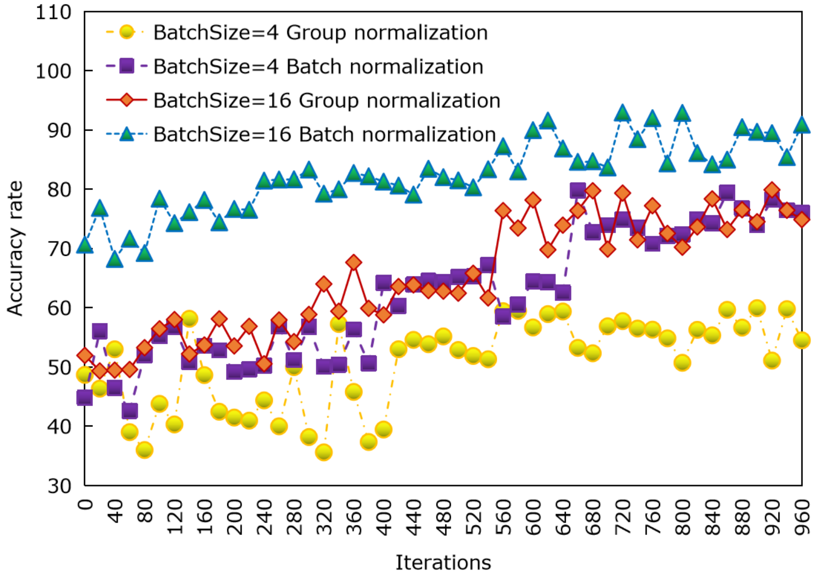

Figure 6: When BatchSize=4 or 16, the effect of batch normalization and group normalization is compared.

In this paper, the algorithm realizes high-precision animation drawing by establishing an accurate scene model, and optimizes the calculation efficiency. The modeling accuracy result of this algorithm is shown in Figure 7.

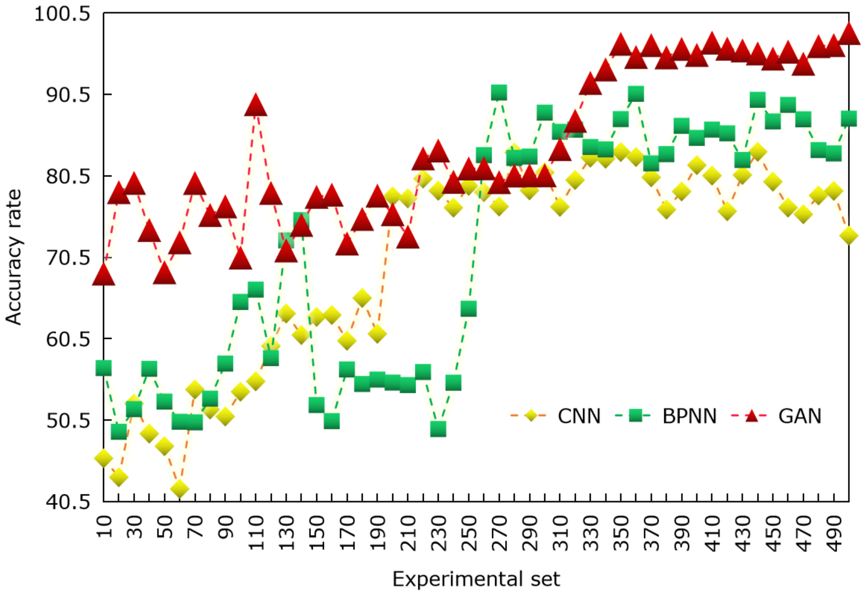

Figure 7: Comparison of modeling accuracy of algorithms.

From the experimental results, the modeling accuracy of the algorithm has reached more than 96%, which shows that the algorithm is excellent in establishing accurate scene models. The algorithm is also optimized by combining CAD, which is helpful to improve the efficiency and accuracy of the algorithm. CAD can provide accurate geometric information, and this algorithm uses this information to calculate the position and posture of objects in the scene, so as to achieve more accurate occlusion relationship calculation and back rendering.

5 CONCLUSION

The application and simulation of animation scene construction and rendering technology are the key links in animation production. Through modeling, rendering and simulation of virtual scenes, realistic animation scenes can be created, bringing immersive visual experience to the audience. This paper will discuss how to combine CAD, VR and GAN technologies to apply to animation scene construction and rendering technology application and simulation, and how to use these technologies to bring better visual effects and higher production efficiency to animation production. Through experiments, it is found that the modeling accuracy of this algorithm is above 96%, and the algorithm is also optimized with CAD, which is helpful to improve the efficiency and accuracy of the algorithm. In addition, the algorithm can also accurately calculate the position and posture of objects in the scene, so as to achieve more accurate occlusion relationship calculation and back rendering. This provides an effective technical means for the further application and growth of VR. Through the experiments and research in this paper, it is found that the 3D animation rendering and optimization algorithm of animation scene based on VR and CAD has high modeling accuracy and computational efficiency, which can provide effective support for the further application and growth of VR. The future research direction can be to further improve the algorithm, improve its adaptability and robustness, and explore more efficient calculation methods and optimization techniques.

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Jiangting Yan, https://orcid.org/0009-0006-2230-1965
Pengju Pu, https://orcid.org/0000-0002-2166-5816

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