# Computer Aided Animation Art Design and Production Based on Virtual Reality Technology

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**Abstract.** With the continuous growth of computer technology, the field of animation art design and production is also progressing. This article aims to explore the performance of animation art design and production model based on Virtual Reality (VR) technology. In order to achieve this goal, this article adopts an efficient real-time rendering algorithm and combines various graphics processing technologies to optimize the fluency and clarity of animation. Through the experimental test, it can be observed that with the increase of iterations, the model in this article performs well in animation fluency, can maintain a high frame rate, and effectively reduce the quantity of iterations in the production process. In addition, the clarity of the animated picture has also been significantly improved, showing high-quality picture quality and detail performance. The animation art design and production model based on VR has achieved satisfactory results in the experiment. This model combines efficient real-time rendering algorithm and graphics processing technology to generate realistic and fluent animation. Moreover, VR provides a brand-new interactive way, which enables the audience to participate in animation more deeply and improves the overall viewing experience.

**Keywords:** VR; Computer Aided Design; Animation Art Design; Animation Production; Immersive Experience
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## 1 INTRODUCTION

Traditional animation art design and production usually need a lot of manual production and cumbersome processes, so it is inefficient and costly. Due to the large amount of manual operation required for traditional animation production, the cost is very high. Animators, original artists, background painters, and others require long-term investment, and materials such as paper, pigments, film, and photography equipment also need to be constantly consumed and updated, which leads to high production costs. Traditional animation production techniques are difficult to achieve complex animation effects, such as scenes with complex physical movements and dynamic changes, or characters and scenes with special effects. This makes traditional animation production techniques have significant limitations in some difficult animation productions. Due to a large number of manual operations and cumbersome processes, it is difficult to ensure the quality of animation. Some details or technical errors are also difficult to be corrected and resolved in a timely manner, which leads to unsatisfactory quality of some animation works [1]. Computer assisted technology can enable artists to present dynamic effects on static canvases or screens. For example, artists can create dynamic images through painting software, or create dynamic images through image processing software. This combination of static and dynamic allows artists to express dynamic processes and changes more freely. This innovative form of expression not only enhances the artist's creative ability, but also enriches the audience's visual experience, bringing new opportunities and challenges to the development of animation art [2]. VR uses advanced hardware and software technologies to simulate people's sensory experiences such as audio-visual, tactile and so on, enabling users to enter a virtual world as if they were there. Virtual reality technology can provide an immersive learning environment, enabling students to understand and master knowledge in a more intuitive way. In addition to character design, virtual reality technology is also widely used in scene construction and special effects production. By simulating the real world or creating fantasy spaces, it visually gives people a strong impact and shocking feeling. By utilizing virtual reality technology for special effects production, various stunning visual effects can appear in the film, thereby enhancing the sensory impact that the storyline conveys to the audience. In addition, in the process of computer-aided animation art design and production, it is also necessary to master relevant programming knowledge and mathematical principles. For example, in terms of character motion control, it is necessary to use a physics engine to simulate parameters such as energy and speed; In terms of light and shadow rendering, it is necessary to have an understanding of complex algorithms such as ray tracing [3]. At the same time, students can gradually master the skills of 3D animation through repeated practice and experimentation, and transform their interests into practical skills and abilities.

The application of computer-aided design software has brought many conveniences and innovations to the teaching of animation art design. Through this software, students can more intuitively understand and master the techniques and principles of animation production. They can use various tools and functions to create, edit, and adjust animation effects to achieve the creativity they want to express. In traditional animation art and design teaching, students usually need to hand draw each frame of the image, and shoot and combine it one by one to form a complete animation segment. However, with the help of computer-aided design software, this process becomes more efficient and flexible. Students can use preset templates or draw elements such as characters and backgrounds themselves, and arrange, move, and zoom them through simple operations [4]. At the same time, they can also add audio, special effects, and transition effects to enhance the audio-visual experience. In addition, computer-aided design software also provides a rich and diverse library of materials and resource links, allowing students to easily access the required images, music, or other media materials. This not only saves time and energy, but also expands students' exposure to different styles and types of works. Moreover, VR, with its unique immersive experience, enables users to interact with the virtual world and observe and operate objects from different angles and scales. CAD and 3D reality technology provide designers with a powerful platform to implement and optimize complex shapes. Jing and Song [5] explored the application of 3D reality technology and CAD in animation design. CAD provides various precise modeling tools that can help designers create complex animation shapes. Smooth surfaces can be created using surface modeling tools, while precise 3D solids can be created using solid modeling tools. CAD allows designers to add various materials and textures to the model, making the shape more realistic. By adjusting the properties of materials such as reflection, refraction, and diffuse reflection, various unique effects can be created. CAD also provides various animation design tools, such as keyframes, path animations, etc., which can help designers create dynamic and interesting animation effects. Use CAD for modeling, and then import it into 3D reality technology for editing and adjustment. For example, 3D reality technology can be used to add special effects such as smoke and flames to the scene, thereby enhancing the visual effect of the animation. By combining 3D reality technology and CAD, interactive animation effects can be created. For example, viewers can control the movements or changes in the scene of animated characters through gestures or sounds, thereby enhancing their sense of participation and experience. In the field of animation art design and production, VR can be used as a powerful tool to help artists create better. In the fields of computer graphics and animation production, facial animation has always been an important research direction. Human facial expressions are one of the most important expressions in nonverbal communication, as they can convey rich emotional and intentional information. Fine facial animation details play a crucial role in enhancing the visual clarity and realism of animation. Johnson [6] explored how to enhance visual clarity through fine facial animation details. By defining keyframes, describing changes in facial expressions, and then using interpolation techniques to generate intermediate frames. This method requires a lot of manual adjustment and post processing. Simulate real facial expressions and movements by simulating the movements of facial muscles and skin. This method requires complex mathematical models and calculations, but can generate more natural and realistic facial animations. Generate facial animation by training machine learning models. This method requires a large amount of training data and computational resources, but can generate high-quality facial animations. Artists can interact and adjust in real time through VR in order to better realize their creativity.

The combination of VR and CAD can further expand the application scope of animation art design and production and improve the production efficiency [7]. By combining VR with CAD, artists can simulate animation scenes and the actions of characters more realistically, so as to design and make animations better. The purpose of this article is to discuss the related issues of computer-aided animation art design and production based on VR. By constructing a model of animation art design and production and conducting simulation research, it is expected to provide some useful ideas and methods for future animation art design and production. Its innovations are as follows:

⊖ In this article, an efficient real-time rendering algorithm is proposed and adopted, which can significantly improve the rendering speed while ensuring the animation quality. This optimization enables the animation art design and production model based on VR to generate smooth and high-quality animation in real time.

⊜ By carefully designing and optimizing the rendering process, the algorithm in this article effectively reduces the quantity of iterations in the production process. This innovation is of great significance for improving the efficiency of animation production and reducing the consumption of computing resources.

This article first introduces the importance and application prospect of VR in the field of animation art design and production; The purpose and significance of this article are expounded. Then an animation art design and production model based on VR is constructed. The real-time rendering algorithm and graphics processing technology used in this article are introduced in detail. Finally, the experimental analysis is carried out, and the advantages and limitations of this method are discussed, and the future research direction is prospected.

## 2 RELATED WORK

With the continuous development of computer technology, computer-aided animation art design has been widely applied in various fields such as film and television, games, and advertising. The rise of virtual reality technology has provided new ideas and methods for computer-aided animation art design. Virtual reality technology can create more realistic and immersive animation scenes and characters, enabling audiences to better feel the charm of animation [8]. With the continuous development of technology, 3D animation and immersive technology have provided people with a new way to experience the world. They can bring us into various environments, allowing us to experience and experience the charm firsthand. In this article, Kumar et al. [9] explored how to rediscover traditional UNESCO World Heritage sites through 3D animation and immersive technology. 3D animation technology can be used to create panoramic views of ancient cities, restoring the architectural style and social life of the time. People can gain a deeper understanding of the history and culture of these cities by watching these animations. In addition, 3D animation can also create replicas of ancient artworks, allowing people to more intuitively appreciate the charm of these artworks. Combining 3D animation with immersive technology can create a richer and more realistic virtual environment, allowing people to have a deeper understanding and experience of World Heritage sites. For example, creating 3D animated movies of ancient cities, allowing people to appreciate the city's history and culture in cinemas. In addition, immersive technology can be combined with virtual reality technology, allowing people to experience history and culture firsthand in a virtual environment. In computer-aided animation design, the smoothness and continuity of curves are important criteria for evaluating the quality of animation [10].

Efficient real-time rendering algorithms refer to computational methods that can quickly generate realistic and smooth animation effects in a short period of time. These algorithms optimize graphics processing technology to ensure that the animation remains stable and free from stuttering during playback, while also providing more delicate and accurate visual representation. In order to achieve the goal of efficient real-time rendering, various graphics processing technologies have been applied in animation production. This includes techniques such as ray tracing, shadow mapping, and texture mapping. Ray tracing can simulate the interaction between light and objects in the real world, thereby enhancing the realism of the scene; Shadow mapping can produce realistic shadow effects, allowing objects to present accurate and hierarchical projections under different lighting conditions; Texture mapping can add various details and textures to the surface of objects, further improving the quality of animation [11]. Animation based on virtual reality technology can create realistic and interactive scenes. Park et al. [12] used methods such as animation image processing and pattern recognition to automatically extract features from input data, and accurately identify and locate existing targets. This technology can not only be applied in entertainment industries such as game development and film and television production, but also has broad application prospects in industrial production, medical image analysis, and other fields. Computer vision animation object detection based on virtual reality technology still faces some challenges. The first is how to improve the system's ability to accurately detect and track multiple targets in complex scenarios simultaneously. Secondly, how to solve the problem of interference caused by factors such as light changes, occlusion, and posture changes on target detection results. In addition, it is also necessary to consider issues related to user experience, such as how to design user-friendly and cognitive friendly interactive interfaces. The World Skills Professional Standards, as an international standard for measuring professional skills, set clear requirements for the application of engineering CAD software. Reshetnikova et al. [13] explored how to use geometric modeling and computer graphics methods based on this standard to enhance the application level of engineering CAD software. Build a 3D solid model by defining the various faces and edges of an object. This method can clearly express the shape and structure of objects, and is easy to perform Boolean operations and material mapping. Represent the shape and structure of an object as a parametric equation, and modify the shape and structure of the object by changing the parameters. This method has significant advantages in dealing with complex shapes and structures. Generate realistic 3D model images by simulating the process of light illuminating objects. Rendering technology can enhance the realism and texture of models, and can also be used for virtual reality and augmented reality applications. Generate animated videos by simulating the motion process of objects. Animation technology can be used to represent complex workflow, equipment operation status, etc., making design schemes more intuitive and understandable. By designing a user-friendly interface, users can improve their efficiency and comfort when using engineering CAD software. User interface design should consider factors such as ease of use, readability, and operability. Seritan et al. [14] introduced a GPU accelerated electronic structure package for large-scale ab initio molecular dynamics. This electronic structure package is based on density functional theory for electronic structure calculations, and utilizes the high parallelism and computing power of GPU to accelerate computational tasks. By adopting some optimization techniques, this electronic structure package can significantly improve computational speed and reduce computational costs. The application examples show that the electronic structure package can be effectively applied to large-scale AIMD simulations.

GPU acceleration and optimization techniques in electronic structure packages can play an important role in the field of scientific computing, improving computational efficiency and reducing computational costs. The further development of these technologies will bring more progress and breakthroughs to the field of scientific computing in the future. In electronic structure packages, using the atomic center extension method can reduce computational complexity and improve computational efficiency. This method reduces computational complexity by focusing the calculation of electronic structure near the atomic center, thereby reducing computational time and memory requirements. In addition, the electronic structure package also adopts efficient parallel algorithms to achieve GPU acceleration. These algorithms can utilize the parallel processing capabilities of GPUs to allocate computing tasks to multiple GPU cores for parallel execution, thereby achieving faster computing speed and higher computational efficiency. Shi et al. [15] explored how to use deep neural networks to achieve real-time realistic 3D holography. Holographic technology is a technique for recording and reconstructing interference patterns of object vibrations. In 3D holography, by shining light on an object and using interference patterns to record the three-dimensional shape and color information of the object. Then, by reconstructing the interference pattern, a 3D image can be generated without actual objects. Deep neural networks have achieved significant results in fields such as image processing, computer vision, and 3D modeling. In 3D holography, deep neural networks can be used to learn and predict the shape, color, and texture information of objects, thereby generating more realistic holographic images. Clean, denoise, and standardize the collected data for the training of neural networks. Train a deep neural network using preprocessed data to learn the mapping relationship between three-dimensional shape and color information. The holographic image data predicted by neural networks can be converted into actual 3D holographic images. Perform image rendering through GPU or specialized hardware devices to achieve real-time display. With the rapid development of new media, visual communication technology has gradually become an important means of communication. The emergence of computer-aided design (CAD) and application software has greatly changed the way and effectiveness of visual communication. Wang [16] explored the computer-aided interaction between visual communication technology and art in new media scenarios, as well as the application of computer-aided design. By using computer image processing software, images can be processed in various ways, such as adjusting colors, changing sizes, applying filters, etc., to create unique visual effects. Through 3D modeling software, artists can create realistic 3D scenes and objects, thereby achieving more vivid and three-dimensional visual communication. By utilizing computer animation technology, various dynamic visual effects can be created, such as dynamic graphics, videos, etc., to enhance the attractiveness and expressiveness of visual communication. With the development of technology, understanding and depicting the real world has become a key requirement in many fields, especially in urban planning, navigation systems, virtual reality, and augmented reality. In these fields, real-time panoramic map modeling methods have high value. A real-time panoramic map modeling method based on multi-source image fusion and 3D rendering can not only improve the accuracy and real-time performance of the map, but also enhance the information content and immersion of the map.

Xu et al. [17] explored the specific implementation steps and advantages of this method. The commonly used methods for fusing preprocessed images include region-based fusion, transform domain-based fusion, and deep learning based fusion. These methods can be selected or combined according to actual needs. By using computer vision and machine learning techniques, three-dimensional information is extracted from the fused image to construct a three-dimensional model of the entity. Based on the lighting conditions of the actual scene, perform light and shadow processing on the 3D model to achieve a more realistic light and shadow effect. Map image textures onto 3D models to provide more realistic surface details. By adjusting rendering parameters such as perspective, color, transparency, etc., the 3D model is made more vivid and immersive. The real-time panoramic map modeling method based on multi-source image fusion and 3D rendering is an advanced technology that can improve the accuracy and real-time performance of the map, increase the information content and immersion of the map, and improve the user experience. The introduction of computer image processing technology has brought many changes to painting creation. Firstly, it greatly expands the artist's creative space. Zhao et al. [18] explored the application of computer image processing technology in painting creation and how it changes our way of artistic creation. Through digital painting and 3D modeling, painters can create almost anything they can imagine on a computer. In addition, computer image processing technology has also made the creative process more flexible and efficient. Painters can modify and improve their works anytime and anywhere without worrying about damaging the original work. Finally, this technology also makes art more democratic. Nowadays, almost anyone can express their artistic views and innovative spirit by using computer image processing software. Digital painting is the process of drawing using computers and specialized drawing boards. Painters can use various brushes and pigments to create works similar to traditional painting, but with more possibilities and flexibility. Computer image processing technology can also be used to create three-dimensional models. These models can be used for various purposes, including creating animated movies, or creating virtual reality and augmented reality scenes.

Although some progress has been made, there are still some problems in the current research. For example, the existing automation technology can not completely replace the artistry and creativity of manual production; VR still has some limitations in real-time interaction and adjustment; The evaluation methods and techniques need to be further improved. Therefore, this article aims to discuss the related issues of computer-aided animation art design and production based on VR, in order to provide some useful ideas and methods for future animation art design and production.

## 3 VR AND CAD FOUNDATION

The combination of virtual reality (VR) and computer-aided design (CAD) can bring many advantages and possibilities in animation art design and production. Through VR technology, designers and animators can view their designs in real-time in a virtual environment. This real-time preview can help them identify problems during the production process and provide timely feedback and modifications, thereby improving work efficiency. CAD software is typically used to create detailed 3D models and scenes. By combining VR technology, these models can be displayed in a realistic virtual environment, providing designers with a more realistic and intuitive design environment. VR technology can provide users with a completely immersive experience, allowing them to delve deeper into the design and observe and experience it from different angles and distances. This immersive experience can help designers better understand and evaluate their designs. In the VR environment, designers can see design changes in real-time, allowing for faster design iterations. This efficient design iteration process can save time and cost, while improving the quality of the design. Combining CAD and VR technology can also provide strong support for the application of augmented reality (AR). Designers can view and test their designs in the real world through AR technology, which is very helpful for evaluating and understanding designs in the real environment. The combination of VR and CAD can also be used for training and education, providing students with a more realistic and intuitive learning environment. For example, students can learn and practice CAD design in a VR environment, thereby improving their skills and understanding. The combination of VR and CAD brings more possibilities for animation art design and production, from preview and feedback, environment creation to design and testing, which can greatly improve efficiency and quality. And help artists to better realize creativity and reduce production costs. See Table 1 for details.

| *Superiority* | *Describe* | *Illustrate* |
|---|---|---|
| Immersive experience | Provide users with an immersive experience. | Users can feel the action of animation scenes and characters more truly, so as to understand and appreciate animation works more deeply. |
| Increase efficiency | Through the combination of the two, artists can design and make animations more efficiently. | Artists can interact and adjust in real time in the virtual environment, so as to realize the design intention and optimize the animation effect quickly. |
| Cut the cost | The cost of animation can | By simulating the action of animation scenes |

| | | |
|---|---|---|
| | be reduced. | and characters, artists can find problems and make adjustments before the actual shooting, thus avoiding the waste and cost increase in the shooting process. |
| Expand creativity | It can provide more creative space and possibilities for artists. | Artists can experiment and innovate through VR to explore more unique animation expressions and effects. |
| Enhanced communication | It can make artists communicate and cooperate more conveniently. | Artists in different regions or countries can interact and cooperate in real time through VR to complete an animation work together. |

**Table 1**: Advantages of the combination of VR and CAD.

In addition, the combination of VR and CAD can achieve the following functions:
3D modeling: CAD can create more realistic and detailed 3D models, while VR can provide a more immersive 3D scene experience.

Animation simulation: Using the animation design function in CAD software, we can simulate the action of the role and the transformation of the scene. And VR can present these animation simulations in front of users, so that users can feel the animation effect more intuitively.

Real-time interaction: Using the real-time characteristics of VR, designers can adjust and modify animation works in real time. Moreover, artists can also interact and communicate in real time through VR to improve production efficiency and quality.

## 4 ANIMATION ART DESIGN AND PRODUCTION MODEL CONSTRUCTION BASED ON VR

### 4.1 Animation Art Design and Production Process

The design and production of animation art is a highly comprehensive process, involving many links such as creative conception, technical realization and post-processing. The design and production process of animation art based on VR in this article includes the following main stages:

1. Project preparation and pre-planning

Before the animation project starts, the team usually carries out a series of preparatory work and preliminary planning. This includes determining the objectives, audience, budget and timetable of the project. This stage also involves the preliminary conceptual design of story lines, characters and scenes.

2. Script and storyboard creation

At this stage, animators and screenwriters will cooperate to create animated scripts and storyboards. The script describes the storyline, characters and dialogue of the animation, while the storyboard is a series of sketches showing the key scenes, actions and photography angles of the animation.

3. Role and scene design

According to the requirements of the storyboard, the designer will begin to design the characters and scenes. This includes creating the appearance, personality and background story of the character, and designing various scenes, props and backgrounds in the animation. Designers usually use tools such as painting, sculpture or digital modeling to express their designs.

4. Animation production

In the animation production stage, the animator will start making animation according to the storyboard and character design. This involves using professional software to create key frames (that is, key actions in animation) and then generating intermediate frames to smooth the actions. This stage also includes special effects production, such as flame, water flow, light and shadow.

5. Dubbing, sound effects and music production

Dubbing artists record dialogues for characters, sound designers create various sound effects, such as action sounds and ambient sounds, while composers create and record animation soundtracks. These elements add emotion and atmosphere to animation and enhance the audience's viewing experience.

6. post-processing and synthesis

At this stage, the post-processing team will edit, color correct and enhance the animation. They will also combine dubbing, sound effects and music with animation to ensure that all elements are perfectly integrated. Finally, the animation will be rendered into the final output format, such as movie, TV or network streaming media.

7. Testing and feedback

After the animation is completed, there is usually an internal test or an external preview to collect feedback from the audience and stakeholders. This helps to find problems and make necessary adjustments to ensure the highest quality and audience satisfaction when the animation is finally released.

Through the above process, the design and production of animation art has become a collaborative process that integrates various artistic and technical elements, aiming at creating fascinating and creative animation works.

### 4.2 Animation Art Design and Production Model Construction Based on VR

In the field of animation art design and production, modeling based on VR is an innovative and complex process, involving the integration of multiple components and algorithms. This article first creates a virtual environment as a place for animation design and production. This environment should simulate the physical rules and sensory experience of the real world to provide an immersive creative environment. Therefore, this article uses VR engine and modeling tools to construct a virtual scene containing lighting, texture, shadows and other elements. Next, import animation elements such as characters, scenes and props into the virtual environment. These elements can be created by 3D modeling software and imported into the VR environment in a common FBX file format. After importing, these elements should be able to display correctly in the virtual environment and interact with users.

In order to realize the interaction between animation elements and the production of animation effects, a series of algorithms need to be introduced. Skeleton animation algorithm is a widely used algorithm in computer graphics, especially in 3D animation and games. The algorithm simulates the motion mode of human skeleton system, and realizes the natural movements and expressions of characters by controlling the parameters such as rotation and displacement of bones. In skeletal animation, the model of a character usually consists of a series of interconnected bones. Each bone has its own coordinate system, which can be rotated and translated relative to its parent bone. This hierarchy allows animation to be created and edited in a more intuitive and natural way. The synthesis of virtual human bone road animation is shown in Figure 1.

In this article, we first define the hierarchy of bones by creating a bone tree, that is, which bone is the child of another bone. In which the root skeleton is located at the top of the tree and the leaf skeleton is located at the bottom of the tree. Then the animator sets the parameters such as the rotation and displacement of the bone at a specific time point (key frame). These key frames define the main stages of animation. When calculating the middle frame of animation, the skeletal animation algorithm uses linear interpolation or spherical linear interpolation to smoothly transition the parameters between key frames. This ensures the fluency of animation. In addition, the movement of bones needs to be transmitted to the surface of the model, a process called skinning. The skinning algorithm calculates the new position of each vertex under the influence of bone motion, so that the model surface is deformed with bone motion. In complex animation (walking and turning animation of characters), it is necessary to fuse multiple animations together. Skeleton animation algorithm can calculate the weights between different animations to achieve smooth animation transition and blending.

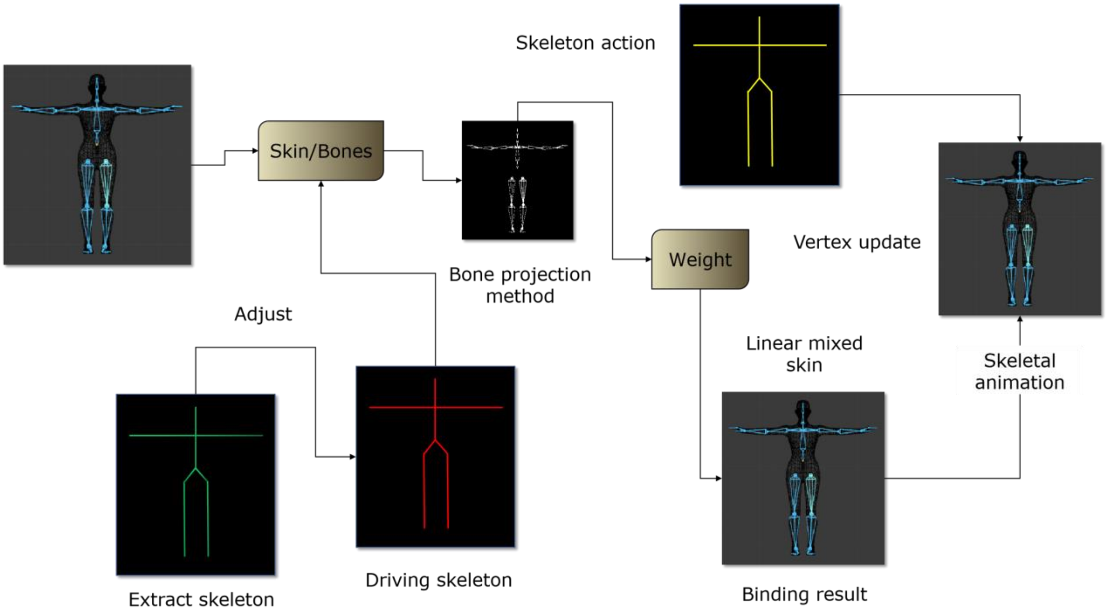



**Figure 1**: Synthesis of animation of virtual human bone road.

Because it is the bones that influence the final global coordinates of model vertices in skeletal animation, it is necessary to let the corresponding bone paths determine the global coordinates of vertices. Multiply the position of the skin vertex in the initial state with the inverse matrix of the global transformation matrix of the initial state bone, and the expression is as follows:

$$V^{Local} = C_i^{-1} \cdot V^{World} \tag{1}$$

Where $C_i^{-1}$ represents the inverse matrix transformation of skeleton $i$ from local coordinate system to global coordinate system; $V^{World}$ represents the position of skin vertex affected by bone $i$ in global coordinate system; $V^{Local}$ indicates the position of the vertex in the local coordinate system of bone $i$. The global transformation matrix of the bones in the $i$ segment can be calculated by the following formula:

$$M_i = M_{root} \cdots M_{grandparent} \cdot M_{parent} \cdot M' \tag{2}$$

Where $M'$ represents the local transformation matrix of the current skeleton; $M_{parent}$ represents the local transformation matrix of the parent bone of the current bone; $M_{grandparent}$ represents the local transformation matrix of the parent bone of the current bone; $M_{root}$ represents the local transformation matrix of the root node. Then, when the skin vertex is only influenced by the skeleton $i$, the new coordinate $V'$ of the vertex is:

$$V' = M_i \cdot C_i^{-1} \cdot V^{World} \tag{3}$$

Define that each vertex is associated with at most three bones. Based on the distance between the vertex and the bone, the following formula is used to calculate the weight:

$$w_{i,j}=\begin{cases}1.0 & if\ \frac{1}{6}\le\frac{v_i-s_j}{\left|d_j-s_j\right|}\cdot\frac{d_j-s_j}{\left|d_j-s_j\right|}\le\frac{5}{6}\\ \frac{1.0}{n_{jo\,\text{int}\,s}} & other\end{cases} \tag{4}$$

Where $s_j$ and $d_j$ are the positions of the parent-child joints of the bone $j$ closest to $v_i$, and $n_{jo\,\text{int}\,s}$ is the quantity of bones closest to $v_i$. In this method, the vertex far from the end joint of the bone is strictly influenced by only one bone, and the vertex near this joint is influenced by the bone in this area. Assuming that the vertices are influenced by $n$ bones, the corresponding weights are:

$$\omega_1,\omega_2,\omega_3,\ldots,\omega_n \tag{5}$$

And satisfy the following formula:

$$\sum\omega_i=1 \tag{6}$$

The new coordinate $V''$ after vertex update can be calculated by the following formula:

$$V''=\sum\omega_i M_i C_i^{-1}V^{World} \tag{7}$$

In this article, the motion displacement is determined by finding the corresponding relationship of brightness invariant patterns on animated images. Can be characterized by the following formula:

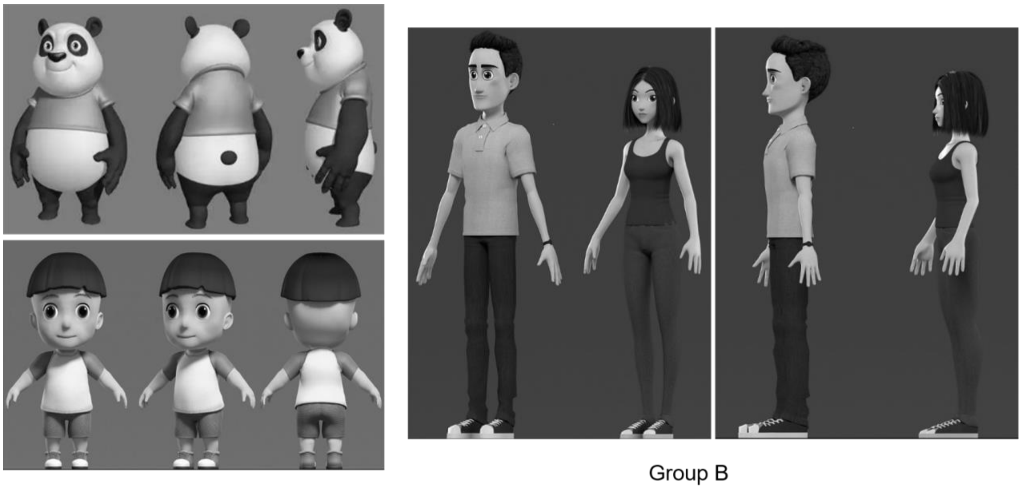
$$I\ x+u,y+v,t+\Delta t\ =I\ x,y,t \tag{8}$$

$I\ x,y,t$ stands for animation image sequence, $x,y\ ,t$ stands for spatial position coordinates and time respectively, and $\Delta t$ stands for the time interval between two consecutive animation images. $u,v$ represents the movement displacement of the pixel point at the spatial position and force at the $t$ moment in unit time. Equation (5) is often described as a vector:

$$I\ x+v,t+1\ =I\ x,t \tag{9}$$

Where $x=\ x,y$ is the spatial position and $v=\ u,v$ is the displacement vector in unit time.

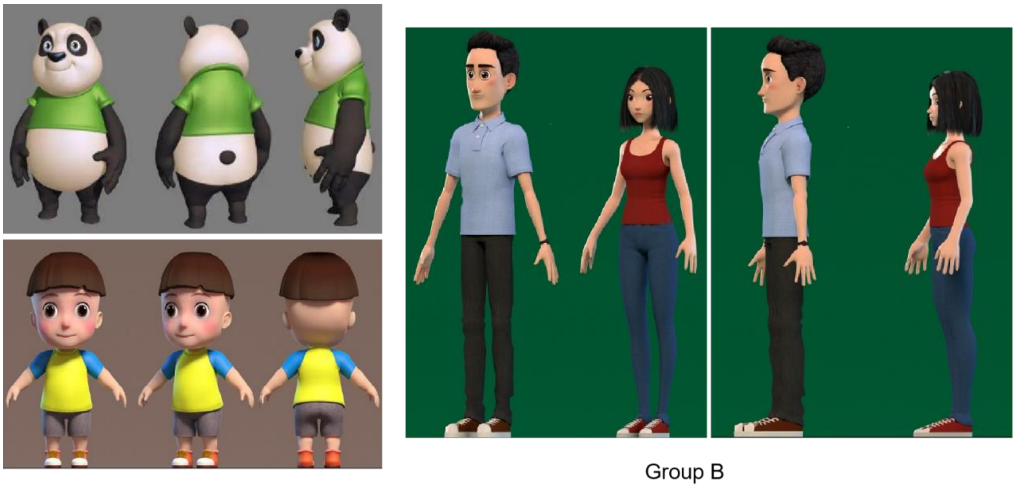
In order to provide a smooth user experience, real-time rendering is needed. This involves the use of efficient graphics rendering algorithms, such as raster-based rendering or ray-based rendering. Real-time rendering is based on rasterization, which generates images by converting geometric figures in virtual scenes into pixels. Its main goal is to generate high-quality images in a limited time to ensure a smooth interactive experience. In this article, real-time rendering is mainly divided into three steps: geometric processing, rasterization and output merging. Geometric processing is the first step of real-time rendering, which is responsible for processing geometric figures in virtual scenes. In real-time rendering, a technique called clipping is used to deal with complex geometry in the scene. This technology can divide the geometric figures in the scene into several small parts, and deal with each part separately, thus greatly reducing the difficulty of dealing with complex geometric figures. Rasterization is the second step of real-time rendering, which is responsible for converting geometric figures into pixel forms. In this article, the scanning line filling algorithm technology is used in the rasterization process. This technology can determine the color value of each pixel in the scene. Output merging is the last step of real-time rendering, which is responsible for merging all pixels in the scene into a complete image. In the process of output merging, this article uses template testing technology to deal with the transparency effect in the scene, so as to determine the transparency of each pixel and merge the color values of transparent pixels into the final image. Figure 2 shows the original animation picture, and Figure 3 shows the animation picture after real-time rendering.



Group B

Group A

**Figure 2**: Original animation picture.



Group B

Group A

**Figure 3**: Animation picture after real-time rendering.

In addition, in order to increase the detail and realism of the scene, this article uses texture mapping, that is, paste the image on the surface of 3D object; Shaders are used to process image data at different stages of the graphics pipeline to achieve various visual effects. In order to achieve a realistic effect, this article applies some graphic processing techniques such as shadow mapping, illumination calculation and post-processing.

Finally, the finished animation works can be exported from the virtual environment for viewing on non-VR devices. This usually involves converting animation data in VR into traditional video or image format, while maintaining high-quality rendering effect and interactive experience. The animation model in this article also introduces a new interactive way. Animators can interact with characters and scenes in the virtual environment in real time through gesture recognition, sound control, etc., which brings more rich expression techniques and creative space for animation production.

## 5 RESEARCH ON ANIMATION ART DESIGN AND PRODUCTION SIMULATION BASED ON VR

In this section, the design and production process of animation art based on VR will be studied and discussed through simulation experiments. Through the simulation experiment, I hope to deeply understand and optimize the process, so as to improve the quality and efficiency of animation works. The simulation experiment will be divided into three main parts: first, the animation art design stage, which will use 3D modeling software to design the characters and scenes; Secondly, the animation production stage will use animation production software to edit animation and add special effects; Finally, the rendering stage will use VR for rendering and output. During the experiment, the operations in different stages are recorded and analyzed in detail to understand the characteristics and needs of each stage. In addition, the experimental results are evaluated quantitatively and qualitatively to understand the efficiency and effect of the experiment.

In order to test the modeling speed of the algorithm, a series of experiments are carried out in this section, and the time spent on modeling is recorded. The following are the specific settings of the experiment: Datasets: Datasets with different scales and complexities are selected for testing to verify the modeling speed of the algorithm in different situations. The data set contains various elements and parameters needed for animation art design and production. Hardware environment: Experiments are conducted on high-performance computers to ensure that the algorithm can make full use of computing resources and reduce other potential bottlenecks. Algorithm parameters: the default parameter settings of the algorithm are used without additional tuning. This can reflect the performance of the algorithm in practical application more truly. After preparing the experimental environment, run the algorithm to model, and use the timer to record the start and end time of modeling. By repeating the experiment for many times and taking the average value, the modeling speed of the algorithm as shown in Figure 4 is obtained.

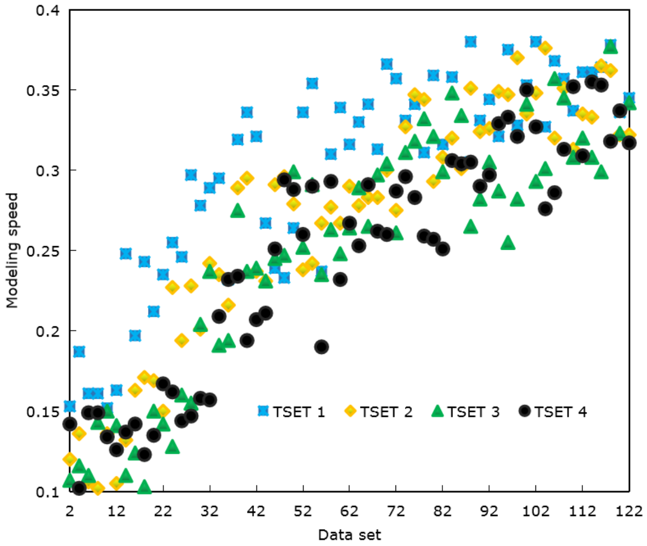



**Figure 4**: Algorithm modeling speed.

According to the results of Figure 4, it is verified that the modeling speed of the algorithm is faster and the modeling time is less. This shows that the algorithm has high efficiency in the process of animation art design and production, and can quickly generate the required model. This rapid modeling speed can save time and cost for animators, improve work efficiency, and promote the animation production process to be more efficient and smoother.

In order to test the rendering speed, this section selects several animation scenes with different complexity and characteristics. These scenes include various lighting conditions, shadow effects, texture details, etc. to comprehensively evaluate the performance of the algorithm. The experiment starts from the moment when the algorithm starts to render, until the whole animation scene is completely rendered and displayed on the screen. This process is repeated many times to avoid accidental errors and ensure the accuracy of the results. Figure 5 shows the rendering speed of the algorithm.

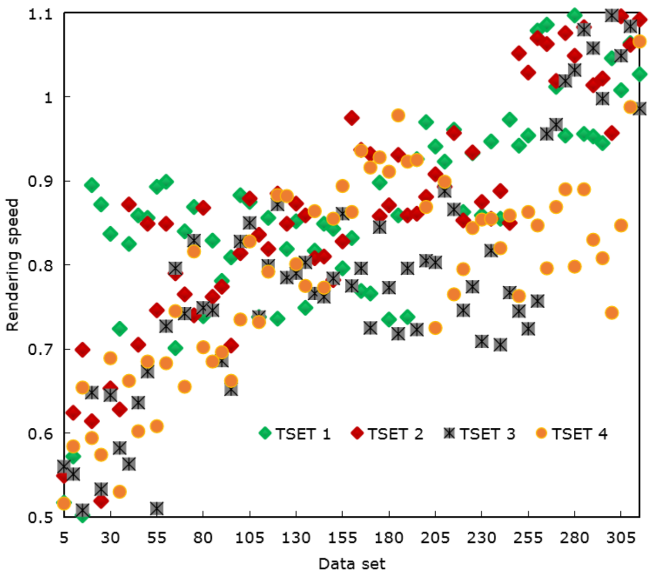



**Figure 5**: Rendering speed of algorithm.

The real-time rendering algorithm in this article is faster for animation rendering. This is because the real-time rendering algorithm has been carefully designed and optimized, so that it can make full use of the capabilities of modern computer hardware, such as GPU parallel computing, thus accelerating the rendering process. Moreover, the real-time rendering algorithm in this article adopts the strategy of parallel processing, which enables the algorithm to handle multiple rendering tasks at the same time, greatly improving the overall processing speed.

In order to test the performance of animation art design and production model based on VR, in this section, different iterations are set, from less iterations to more iterations, to observe its influence on animation fluency and clarity. In this article, the animation scene with complex content and rich action is selected for testing, which can better show the performance of the algorithm in different situations. For animation fluency, the frame rate (FPS) is used as the evaluation standard to observe whether the frame rate is stable with the increase of iterations. For the definition of animation, the quality evaluation criteria are adopted, such as resolution, color accuracy and detail expression. With the increase of iterations, the fluency and clarity of animation pictures made in real time by using the animation art design and production model based on VR are shown in Figure 6 and Figure 7.

Fluency analysis: As shown in Figure 6, with the increase of iteration times, the animation pictures made by using the animation art design and production model in this article have higher fluency. This is because the model adopts efficient rendering algorithm and parallel processing technology, which makes it possible to maintain a high frame rate while increasing the quantity of iterations. In addition, the model has excellent prediction and optimization ability, which can reduce unnecessary rendering work and further improve fluency.

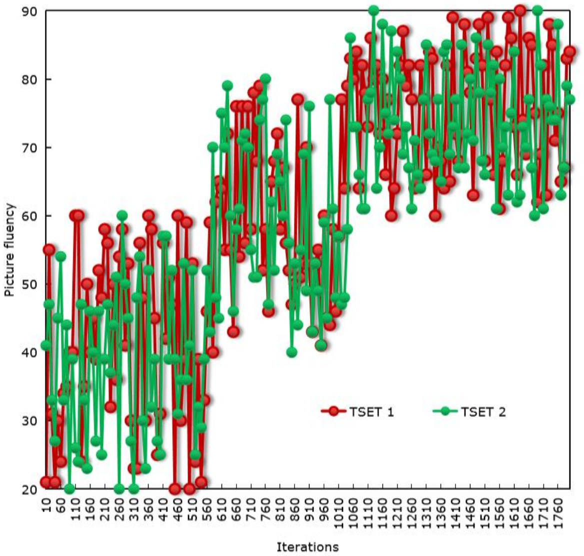



**Figure 6**: Smoothness of animation picture.

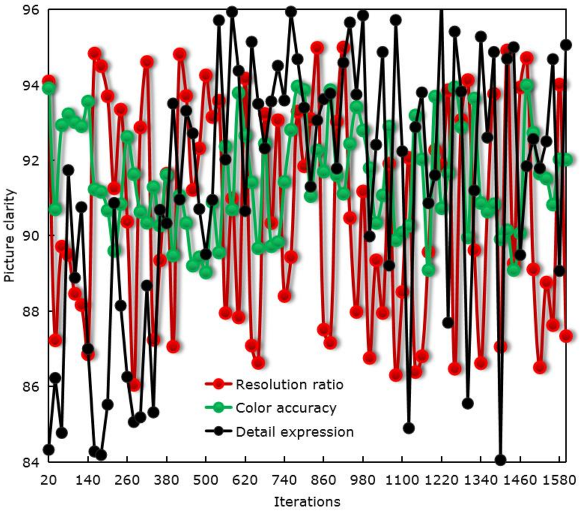



**Figure 7**: Animation picture definition.

Sharpness analysis: As shown in Figure 7, the animation picture has high definition and excellent picture quality. This is because the model adopts high-quality graphics processing technology and rendering algorithm, which can generate animated pictures with high resolution and accurate color. Moreover, the model also has excellent detail processing ability, which can keep the clarity and detail expression of the picture in complex scenes.

Generally speaking, the animation pictures produced by using the animation art design and production model in this article are fluent, and the algorithm can effectively reduce the quantity of iterations in the production process; Moreover, the animation picture has high definition and excellent picture quality, which further reflects the superior performance of animation art design and production model based on VR in this article.

## 6 PRACTICAL APPLICATION OF ANIMATION ART DESIGN AND PRODUCTION BASED ON VR

Experimental flow: First, create a virtual environment and import animation elements. Then, the skeleton animation algorithm is used to design the character animation, and the path planning algorithm is used to plan the motion trajectory of the character. In the process of real-time rendering, efficient raster rendering technology is adopted, combined with graphic processing technologies such as shadow mapping, illumination calculation and post-processing to enhance the realism of the scene. Finally, the output result is exported as an animated picture as shown in Figure 8.

Character animation

Scene animation

**Figure 8**: Animation model output.

As shown in Figure 8, the animation generated by the animation art design and production model based on VR has the following characteristics: ⊖ Realism: Through efficient raster rendering and graphics processing technology, the scene presents a high sense of reality. The surface texture, lighting and shadow effects of the character model is very realistic, which enhances the audience's immersion. ⊜ Fluency: The real-time rendering algorithm ensures the smooth playback of the animation, and there is no obvious jam or delay. This is essential to provide a good user experience. ⊛ Interactivity: VR allows viewers to interact with animation in a more natural way. The audience can change the visual angle through the movement of the helmet, further explore the scene and interact with the animation elements in real time. To sum up, the animation art design and production model based on VR has achieved satisfactory results in the experiment. This model combines efficient real-time rendering algorithm and graphics processing technology to generate realistic and fluent animation. Moreover, VR provides a brand-new interactive way, which enables the audience to participate in animation more deeply and improves the overall viewing experience.

## 7 CONCLUSIONS

This article discusses the related problems of computer-aided animation art design and production based on VR, and constructs a model of animation art design and production. Moreover, an efficient real-time rendering algorithm is adopted. Through the experimental test and analysis, it can be concluded that the algorithm can significantly improve the rendering speed while ensuring the animation quality, and the animation with high fluency and excellent definition can be produced by using the animation art design and production model in this article. This result fully shows the potential and application value of animation art design and production model based on VR in the field of real-time animation production. With the improvement of computer hardware performance and the optimization of rendering algorithm, the real-time rendering speed and quality of VR will be further improved. This will make the animation art design and production based on VR more efficient and smoother.

The animation art design and production model construction based on VR has brought a brand-new creative way and user experience to the animation industry. Through the immersive creative environment and real-time preview and adjustment, the model greatly improves the quality of animation design and production. Moreover, the characteristics of breaking through the traditional restrictions have also brought greater freedom and creative space for animation creation. With the continuous development and improvement of VR in the future, as a researcher, there is reason to believe that the design and production of animation art based on VR will become the mainstream trend of the animation industry, bringing more rich and immersive animation works to the audience.

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