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Computer-Aided Design AND APPLICATIONS

Animation Character Generation and Optimization Algorithm Based on Computer Aided Design and Virtual Reality

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Abstract. In this article, an animation character generation and optimization algorithm based on CAD (Computer aided design) and VR is proposed, and its effectiveness and feasibility are verified by simulation research. In this article, the basic model of the character based on CAD technology is first established, and then the action design and scene interaction of the character are realized by VR, and the shape, action and the character are optimized by optimization algorithm. Finally, in order to verify the effectiveness of the animation character generation and optimization algorithm proposed in this article based on CAD and VR, a series of simulation experiments are carried out. Experimental results show that the algorithm can generate high-quality character models and realistic actions, and has high real-time performance and user satisfaction. By combining advanced computer technology and algorithm design, this article brings many innovations to the field of animation character generation, and provide users with a more immersive visual experience.

Keywords: Computer Aided Design; Virtual Reality; Animation Role Generation; Genetic Algorithm
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1 INTRODUCTION

Animation art design and production is a comprehensive art form involving many fields, which combines the characteristics of painting, sculpture, film, music and other art forms and is realized by computer technology. Microelectronic circuit design is an important course for electronic engineering and microelectronics majors, covering various types such as analog circuits, digital circuits, and mixed signal circuits. Traditional design methods mainly rely on manual labor, which is inefficient and prone to errors. With the development of computer technology, Abugharbieh and Marar [1] allowing designers to save a significant amount of time throughout the entire design process. From high-level abstraction level HDL code descriptions to physical level layout and wiring, all can be automated. By

using simulation and mixed signal tools for functional verification and signal integrity verification, errors in the design can be identified and corrected in advance, thereby improving the overall quality of the design. Designers can invest more time and energy into innovative designs, rather than tedious low-level designs. This helps improve the designer's innovation ability. Different design requirements may require different computer-aided design tools. Designers can choose appropriate tools based on actual needs to meet diverse design needs. With the rapid growth of animation industry, animation character design and production has become one of the most core and key links in the animation production process. The 3D graphics engine is a software system used to generate 3D graphics. It usually includes functional modules such as modeling, materials, lighting, animation, etc. In terms of animation design, the application of intelligent algorithms can help designers create animations more efficiently, improve the quality and expressiveness of animations.

Bao [2] trains a neural network to learn the mapping relationship between lighting and texture, and then applies this neural network to objects in animation scenes to generate more realistic lighting and texture effects. For example, the keyframe sequence of an animation can be considered as a gene sequence and evaluated based on a certain fitness function. Then, genetic algorithms are used to select, cross, and mutate gene sequences. Finally, an optimal gene sequence is obtained, which is the optimal animation keyframe sequence. An excellent animated character should not only have a unique appearance and personality, but also have vivid movements and expressions to arouse the audience's resonance and emotional input. Buyukdemircioglu and Kocaman [3] explored the development and future trends of the concept of smart cities in virtual reality environments. Through virtual reality technology, a highly realistic urban model can be constructed to provide decision-makers with more comprehensive and intuitive data support. Decision makers can make decisions on urban planning and management based on simulation results, improving the scientificity and accuracy of decision-making. In a virtual reality environment, the emergency response capability of cities can be improved by simulating various disasters and emergencies. At the same time, through intelligent monitoring systems, various operational conditions of the city can be monitored stability of the city. Through and the Internet of Things technology, an intelligent transportation system can be built. This system can perceive traffic conditions through sensing devices and dispatch and control traffic flow through control centers. This can improve their transportation efficiency. Through virtual reality technology and energy management systems, effective management and control of urban energy use can be achieved. By rational allocation and scheduling of energy, energy consumption can be reduced and environmental pollution can be reduced.

However, there are many problems in the traditional animation character design and production methods. The Augmented Reality Visualization Rapid Development Kit (AR-VSDK) provides a new and more efficient way of working in factory environments. By integrating powerful AR technology, real-time data collection and analysis, and visual operation interfaces, we have reason to believe that the application of AR technology in factory environments will become increasingly widespread, bringing more innovation and value to the manufacturing industry. In factory environments, AR technology can provide a new and more efficient way of working. Chen et al. [4] introduced an augmented reality visualization rapid development toolkit (AR-VSDK) specifically designed for factory environments.

Through AR technology, maintenance personnel can intuitively understand the internal structure and fault location of the equipment, improving maintenance efficiency. At the same time, the AR-VSDK can also record the repair process and provide reference for subsequent work. By collecting real-time production data, AR-VSDK can help managers identify bottlenecks in the production process and optimize production plans. AR-VSDK can present product quality data to quality inspectors in an intuitive manner through visualization technology, improving quality inspection efficiency and quality. On the one hand, traditional methods are usually based on hand drawing or sculpture, and the production process is cumbersome and time-consuming, and requires superb skills and experience. The introduction of virtual reality technology has shifted human-computer interaction from traditional two-dimensional interfaces to three-dimensional immersive environments. Guo and Ma [5] explored the implementation and application: hardware equipment, software system, and interaction interface. Hardware devices include high-performance computers,

VR helmets, handles, etc.; The software system includes CAD software and VR engine; The interactive interface is the bridge between humans and computers. On the other hand, it is difficult for traditional methods to realize the fine design and adjustment of character movements and expressions, and it often takes many times of trial and error and iteration to achieve the ideal effect. Guo et al. [6] in manual assembly and maintenance scenarios, virtual reality technology can effectively optimize ergonomic design and evaluate its impact on ergonomics. Create a three-dimensional virtual environment using virtual reality technology, which should simulate actual assembly and maintenance scenes as much as possible. This includes simulation workbenches, tools, parts, and any other elements that may be related to ergonomics. Import one or more human models in a virtual environment. These models should be able to simulate workers of different body types and characteristics, in order to evaluate the impact of different ergonomic designs on various workers. In a virtual environment, simulate various assembly and maintenance tasks that need to be executed. These tasks should cover various possible work activities, from simple parts replacement to complex assembly processes. By simulating the actual operation process, virtual reality technology can reveal the problems in ergonomic design and provide improvement suggestions. Ergonomic design starts from the physiological and psychological characteristics of humans, studying how to coordinate machines, environments, and others with humans, and provide safe, comfortable, and efficient working conditions for humans. Ergonomic design is particularly important in manual assembly and maintenance scenarios. Good ergonomic design can reduce worker fatigue, improve work efficiency, and ensure worker safety. The evaluation method of optimizing ergonomic design using virtual reality is an effective tool that can help us improve work efficiency and reduce worker fatigue in manual assembly and maintenance scenarios. By simulating manual assembly and maintenance processes, analyzing worker actions and tool usage, evaluating ergonomic design and making improvements, and then verifying the effectiveness of the improvements. We can continuously optimize ergonomic design to provide workers with a safer and more comfortable working environment. Therefore, exploring an efficient and convenient algorithm for animation character generation and optimization has become an urgent need in the field of animation art design and production.

In recent years, with the rise and growth of VR, the design and production of animated characters based on VR has gradually attracted the attention of researchers. VR can provide immersive visual experience, so that designers can intuitively feel and adjust the actions and expressions of characters in the virtual environment. Moreover, VR can also be combined with CAD technology, and the rapid generation and optimization of character models can be realized by using the powerful computing power and graphics processing technology of computers. This brings new ideas and methods for the design and production of animated characters. This article will combine CAD technology to discuss the animation character generation and optimization algorithm based on VR, and verify its feasibility through simulation research. The innovation of this article mainly includes the following aspects:

A. This article proposes to combine CAD technology with VR for animation character generation and optimization. CAD technology provides accurate modeling ability, while VR allows designers to intuitively design actions and interact with scenes in an immersive environment.

B. This article designs an optimization algorithm for animation character generation, which combines multiple objectives such as shape optimization, action authenticity optimization, real-time performance optimization and user interaction optimization. It can efficiently generate high-quality animated characters.

C. In order to enhance the action authenticity of animated characters, this article introduces physical simulation to optimize the action. By adjusting the physical parameters and constraints, the actions of the characters are more in line with the physical laws of the real world.

This article first introduces the importance and challenges of animation character design and production, and summarizes the research background, purpose and significance; Then the animation character generation method based on CAD and VR is discussed in detail. And focus on the design and implementation of optimization algorithm in the process of animation character generation; Then, the proposed animation character generation and optimization method is simulated and the results are deeply analyzed. Finally, the results are discussed and the full text is summarized.

2 RELATED WORK

Hao [7] applying case teaching method to computer-aided design teaching of art and design, students' learning interest and motivation can be effectively enhanced, helping them better understand and master the essence of design. At the same time, this teaching method can also cultivate students' innovative thinking and practical abilities, laying a solid foundation for their future career. Traditional art and design computer-aided design teaching focuses on imparting software operation skills, often neglecting the cultivation of students' innovation and practical application abilities. Meanwhile, due to the disconnect between theoretical knowledge and practical application, students often find it difficult to apply the knowledge they have learned to practical design. Therefore, introducing case teaching method can better solve these problems. As an important urban infrastructure, urban pipeline networks cover multiple fields such as water supply, drainage, gas, electricity, communication, etc. Their large scale and complex structure pose great challenges to management. The traditional management method of urban pipeline networks is usually in the form of paper maps and tables, which not only fails to update in a timely manner, but also makes it difficult to achieve comprehensive and effective information sharing and computer and network technology, web-based visualization technology provides new solutions for the management of urban pipeline networks. Hu et al. [8] used 3D modeling software to establish a 3D model of the urban pipeline network based on the collected data. In this process, pipeline bending, crossing, and connection. Through the web interface, users can edit and query various attribute information of pipelines, such as material, size, burial depth, etc. At the same time, these attributes can also be statistically and analyzed, it is necessary to establish a comprehensive data update and maintenance mechanism. By regularly collecting and processing data from the pipeline network. By combining these two, designers can more effectively create unique and precise animation shapes. Computer aided design (CAD) plays a crucial role in animation design. It provides an efficient, precise, and flexible design tool that enables designers to transform their creativity into attractive and realistic animated shapes. Through the application of CAD, designers can create and modify complex character models and environments in a short period of time, improving production efficiency and reducing errors. In addition, CAD can also assist designers in providing real-time feedback and evaluation, in order to identify problems and make improvements in the early stages. Jing and Song [9] discussed the importance of computer-aided design and application. Designers can create character models with rich details and realism through 3D reality technology. This technology can ensure that the character maintains a natural and smooth posture during movement, which can be used to create various environments in animation, including backgrounds, props, buildings, etc. Designers can create a rich and diverse environmental atmosphere through precise modeling and mapping, enhancing the visual effect of animation. 3D reality technology can be used to create various special effects, such as fire, water, smoke, etc. These special effects can increase the realism of the animation and enhance the audience's viewing experience. In animation design, the smoothness and continuity of curves are key factors that affect the animation effect.

Cubic B-spline curves, as an interpolation technique, have high flexibility and controllability, making them. Li [10] explored the actions and expressions of characters need to have a natural and smooth effect. The use of cubic B-spline curves can easily interpolate the actions and expressions of characters, thereby generating smooth character animations. By adjusting the control points, designers can easily modify the actions and expressions of characters to achieve the best animation effect. Cubic B-spline curve is an interpolation technique that can generate a smooth curve between given control points. Unlike traditional interpolation methods, cubic B-spline curves have higher continuity and smoothness because they consider the trend of curve changes between each control point. Cubic B-spline curves have been widely used in fields such as computer graphics, computer-aided design, and animation design. Liu and Yang [11] explored the exploration and practice of a creative centered computer-assisted teaching model for contemporary art. In contemporary art computer-aided design teaching, attention should be paid to cultivating students' creative thinking ability. Creative thinking is an innovative and unique way of thinking that can help students examine problems from different perspectives and discover new ideas and solutions from them. Regularly organize technical lectures or seminars to enable students to timely understand the

latest technologies and application prospects of computer-aided design, and help them master cutting-edge technical means. By offering relevant art courses and lectures, we aim to enhance students' artistic literacy and aesthetic abilities, enabling them to have the ability and awareness to integrate technology with art. Regularly organize student work exhibition activities, invite industry experts and scholars to evaluate and guide students' works, help them understand their shortcomings and make improvements. Virtual reality modeling and fractal deformation technology provide animation designers with a brand-new creative approach. Wang et al. [12] explored how to use these two technologies for animation design, as well as their advantages and applications in animation design. Fractal deformation technology is a technique that utilizes the principles of fractal geometry for shape transformation. This technology can be used to create unique and complex shapes and patterns, providing more creative space for animation design. Designers can use fractal deformation technology to transform the shape of characters or objects, creating unique artistic effects. For example, through fractal deformation technology, a smooth shape can be transformed into a shape with complex details. Fractal deformation technology can also be used to generate complex textures and patterns. Designers can use this technology to transform a simple shape or pattern into a texture with rich details and variations. Fractal deformation technology can also be used to create dynamic effects. For example, designers can use fractal deformation technology to achieve dynamic effects such as water surface fluctuations and flame combustion, increasing the realism and attractiveness of animation.

The use of these two technologies can greatly improve the creative efficiency of animation designers. Through fractal deformation technology, designers can quickly transform and adjust shapes and textures. These two technologies can create more realistic and attractive visual effects. For example, through virtual reality modeling technology, more precise and realistic scene and character models can be constructed; And through fractal deformation technology, unique and complex shapes and textures can be generated. In today's digital age, visual communication design has become an indispensable part of various media, from advertising, movies, television programs, to social media, digital games, and virtual reality, all of which reflect the importance of visual communication. And computer-aided design (CAD) and its application, as a product of technological progress, play a crucial role in visual communication and expression. Yang and Liu [13] explored print advertising design, computer-aided design can be used to create various forms of advertising, including posters, brochures, advertising videos, etc. Designers can use elements such as graphics, images, and colors to create attractive visual effects, while also utilizing the dynamic functions in the software to create various forms of animation effects. Designers can use software tools for rapid drawing, image processing, and model rendering, greatly shortening the design cycle and improving design efficiency. Computer graphics can simulate real natural light and material properties through software tools, thereby creating more realistic visual effects. Designers can use image assisted design technology to combine graphics with real scenes, presenting more vivid and realistic visual effects, thereby enhancing the expressive power of the design. Zhang and Rui [14] utilize computer graphics and image assisted design techniques to create vivid and vivid multimedia courseware, showcasing the skills and essence of design to students. For example, computer technology cannot completely replace some traditional manual painting and sculpture skills. In addition, excessive reliance on computer technology may lead to students neglecting their pursuit and understanding of art itself. Firstly, they should pay attention to the cultivation of traditional art skills and improve students' artistic literacy. Secondly, it is necessary to guide students to use computer technology as an auxiliary tool, emphasizing the importance of innovative thinking and artistic expression. Finally, students should be encouraged to engage in interdisciplinary learning and communication, expanding their artistic horizons and skill ranges.

Ocean animation, as an important means of showcasing the marine environment, ecology, and phenomena. Zhang [15] explores automatic generation technology in ocean animation. The automatic generation technology of 3D animation is a technology that utilizes computer graphics and artificial intelligence technology to automatically generate 3D animation. It can automatically build fine models, rendering, and animations based on input data and parameters, with the characteristics of efficiency, accuracy, and realism. In ocean animation, 3D animation automatic generation

technology can be used to simulate complex ocean phenomena such as waves, tides, ocean currents, and schools of fish. By simulating and analyzing mathematical models of ocean phenomena, combined with computer graphics technology, realistic ocean animations can be generated, providing powerful visualization tools for scientific research. By utilizing 3D animation automatic generation technology, ocean animation can be applied to virtual reality environments. Users can experience the marine environment firsthand through virtual reality devices, which has marine scientific research, marine resource development, and marine environmental protection. In film production, ocean animation can be used to simulate real ocean scenes such as waves and tides, adding realistic visual effects to the movie screen. By using 3D animation automatic generation technology, the efficiency and effectiveness of film production can be greatly improved. With the advancement of technology, especially in the teaching of hematology medicine, this technology provides powerful teaching tools for teachers and students with its unique advantages. Zhang and Chen [16] explored the animation can vividly demonstrate complex processes in hematology medicine, such as the generation of red blood cells, the activity of white blood cells, and the formation of blood clots. This enables students to have a more intuitive understanding of these processes and improve their mastery of knowledge. In the teaching of hematology medicine, mastering operational skills is crucial. Computer assisted animation technology can simulate the experimental operation process, enabling students to clearly see the standard operating steps, thereby helping them master the correct operating skills. Through computer-aided animation technology, teachers can monitor students' learning progress and effectiveness in real-time, provide timely feedback and guidance. Compared to traditional static images or textual descriptions, animations can vividly and vividly display the dynamic process of hematology medicine, thereby attracting students' attention and increasing their interest in learning. Students can choose to watch different animated content based on their learning progress and interests, achieving personalized learning. With the help of computer-aided animation technology, students can engage in interactive operations during the learning process, such as simulating experimental operations, observing virtual slices, etc., to increase the fun of learning. Intelligent computers can use image processing technology to perform style recognition, color processing, and other operations on agricultural product photos, thereby integrating artistic styles into packaging appearance design. Zhao et al. [17] extracted representative artistic elements by analyzing the color, texture, shape and other features of photos, and applied these elements to packaging design. Meanwhile, through virtual rendering technology, packaging effects under different lighting and environments can be simulated, helping designers better grasp the artistic style and expressive power of packaging design. Intelligent computers can utilize machine learning technology to automatically generate personalized design solutions that meet the requirements of designers by learning and analyzing a large amount of agricultural product packaging design data. Intelligent computer-aided design plays an important role in the artistic style and appearance design of agricultural product packaging. By utilizing techniques such as image processing, 3D modeling, virtual rendering, and the application of machine learning and big data analysis, designers can better grasp the artistic style and expressiveness of packaging design, improve design efficiency and innovation awareness.

3 REALIZATION OF ANIMATION CHARACTER GENERATION AND OPTIMIZATION ALGORITHM

3.1 Animation Character Generation Method Based on CAD and VR

CAD is a design technology using computer technology. It uses advanced software tools and hardware equipment to help designers design, simulate and analyze products. It introduces in detail the application of CAD technology in character modeling, mapping, bone binding and so on, and verifies the effectiveness and efficiency of animation character making based on CAD technology through experiments. This article introduces how to use CAD software for scene layout, character design and props production, and discusses the advantages and limitations of CAD in film and television animation production. Based on CAD, artists can use CAD software for role modeling, scene

layout, role generation and other tasks. Moreover, artists can create more efficiently and improve the quality and effect of animation works.

VR is a computer technology that can create and experience virtual worlds. The main features of this technology include: immersive experience: users can devote themselves to the virtual world and feel the virtual environment through a variety of senses such as vision, hearing and touch. Interactivity: Users can operate and change the virtual environment through VR to realize human-computer interaction. Real-time: VR can update and respond to users' operations in real time, so that users can get a smoother experience. VR has a wide range of applications, including games, education, medical care, architecture, tourism and many other fields. In the field of animation character generation design, VR can also be used as a powerful tool to help artists create better.

Animation character generation technology is an important research direction in computer graphics and animation field. It involves many sub-fields and technologies, and aims to automatically generate animated characters with realistic actions and expressions through algorithms and computer tools. Generally speaking, animation character generation technology includes the following contents: ⊖ Role modeling. Character modeling is the basic step of animation character generation. It usually uses three-dimensional modeling software or scanning technology to build the geometric model of the character. This model usually consists of thousands to millions of polygons to capture the details and expressions of the characters. ⊜ Bones are bound to animation. ⊛ Motion capture and synthesis. ④ Expression generation. ⑤ Physical simulation and rendering. This includes simulating effects such as cloth, hair, gravity and collision. Rendering is the process of transforming characters and their scenes into two-dimensional images, taking into account factors such as illumination, shadows and materials, so as to provide visual realism. Animation character generation technology is a comprehensive process, involving modeling, bone binding, motion capture, expression generation, physical simulation and rendering. These technologies work together to make the generated animated characters more realistic and vivid, and can show outstanding performance in various media and applications. The method proposed in this section combines CAD and VR to generate animated characters. The overall framework of the method includes the following main steps: (1) role-based modeling with CAD tools; Conduct action design and scene interaction of characters in VR environment; By combining the fine modeling of CAD with the real-time interaction in VR, realistic and dynamic animated characters are generated. The goal of this framework is to combine the accurate modeling ability of CAD with the immersive interaction characteristics of VR.

In the CAD environment, advanced modeling tools can be used to create the basic model of animated characters. The technologies involved in this step include: 3D modeling: accurate 3D modeling with tools in CAD software to determine the basic shape and structure of the character; Texture mapping: add detailed texture to the character model to enhance its visual authenticity; Material and lighting: adjust the material properties and lighting conditions of the character through CAD tools to make it more realistic visually.

Before modeling, conceptual design is usually needed to determine the basic appearance, personality characteristics and background story of the character. After the conceptual design is completed, you can use CAD software to start building the basic mesh of the character, and then start adding details and surface treatment. In order to make the character move, it is necessary to bind the bones. This involves creating a skeletal system and weight-binding the vertices of the model with the bones. Moreover, in order to make the character look more realistic, you need to add materials and maps to it. The last step is to set the lights and render them. By adjusting the color, intensity and position of the light, the required shadow and lighting effects can be obtained. Rendering is the process of combining models, materials and lights to generate the final image. You can use the rendering engine of CAD software for real-time preview or final rendering output to see the final effect of the character. Through CAD tools, a fine and accurate character model can be obtained, which provides a basis for the subsequent action design and scene interaction in VR environment.

When the character model created in CAD is imported into VR environment, the following operations can be performed: Action design: In VR environment, designers can directly manipulate the character model and design various actions for it. These actions can be captured and recorded in

real time as part of character animation. Motion capture and animation generation: VR devices usually have the function of motion capture, which can record the designer's actions in the virtual environment and transform them into the animation data of the characters. This enables designers to generate realistic and natural animations for characters with reference to their own action performances. Scene interaction: In addition to the actions of the character itself, you can also design the interaction between the character and the scene. For example, how the character picks up an object and interacts with other elements in the scene. Real-time preview: VR allows designers to preview the actions and interactions of characters in real time during design, which is very important for timely adjustment and optimization of design. Iteration and adjustment: In VR environment, designers can preview and adjust the actions of characters and the interactive effects of scenes in real time. This means that designers can quickly iterate and improve the design until the ideal effect is achieved. Through constant adjustment and optimization, we can ensure the fluency, naturalness and verisimilitude of character action and scene interaction.

3.2 Design and Implementation of Optimization Algorithm

In the process of animation character generation, in order to obtain high quality and efficient results, optimization algorithm plays a core role. The general idea of the optimization algorithm proposed in this section is: first, determine the optimization goal of role generation, then design the appropriate optimization strategy, and finally gradually approach the optimal solution through iteration.

In the process of role generation, many aspects need to be optimized to achieve better results. Common optimization goals include: geometric shape optimization: making the shape of the character more natural and smoother, and reducing unnecessary geometric complexity. Action authenticity optimization: make the action of the role more realistic and conform to the physical laws and ergonomics in the real world. Real-time performance optimization: under the premise of ensuring quality, reduce the computational complexity of the generation algorithm, so that it can generate animation in real time or near real time. User interaction optimization: in VR environment, enhance the interactive experience between users and roles, and make the operation more intuitive and easier to control. In order to achieve the above-mentioned optimization goal, this article adopts shape optimization based on multi-objective GA: using GA's global search ability, the geometric shape of the character is iteratively optimized for several rounds, and the individual is evaluated according to fitness function in each round, and a new generation of individuals is generated through selection, crossover and mutation operations.

$$P_c = \begin{cases} k_1 \ \dfrac{s_{\max} - s}{s_{\max} - \overline{s}}, & s \geq \overline{s} \\ k_3, & s < \overline{s} \end{cases} \tag{1}$$

$$P_m = \begin{cases} k_2 \ \dfrac{s_{\max} - s}{s_{\max} - \overline{s}}, & s \geq \overline{s} \\ k_4, & s < \overline{s} \end{cases} \tag{2}$$

Among them:

$$k_1, k_2, k_3, k_4 \leq 1 \tag{3}$$

Before using GA for optimization, it is necessary to encode the geometry of animated characters. This coding process will transform the geometric shape of the character into a series of parameters, which can describe the shape characteristics of the character. In this article, matrix coding is adopted. The elements of the matrix are called x_{ij}. If the merchant passes by e_{ij}, and the coding matrix of $n*n$ is obtained for the traveling salesman problem with n vertices. Its form is as follows:

$$A=\begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nn} \end{bmatrix} \tag{4}$$

Fitness function is a function used to evaluate the fitness of each individual in the population. In the process of optimizing the geometric shape of an animated character, the fitness function may evaluate the geometric shape of the character according to factors such as the aesthetic appearance of the character's shape and the fluency of movement. In this article:

$$f=\frac{\sqrt[a]{n}}{\sum_{i\neq j} d_{ij}x_{ij}} \tag{5}$$

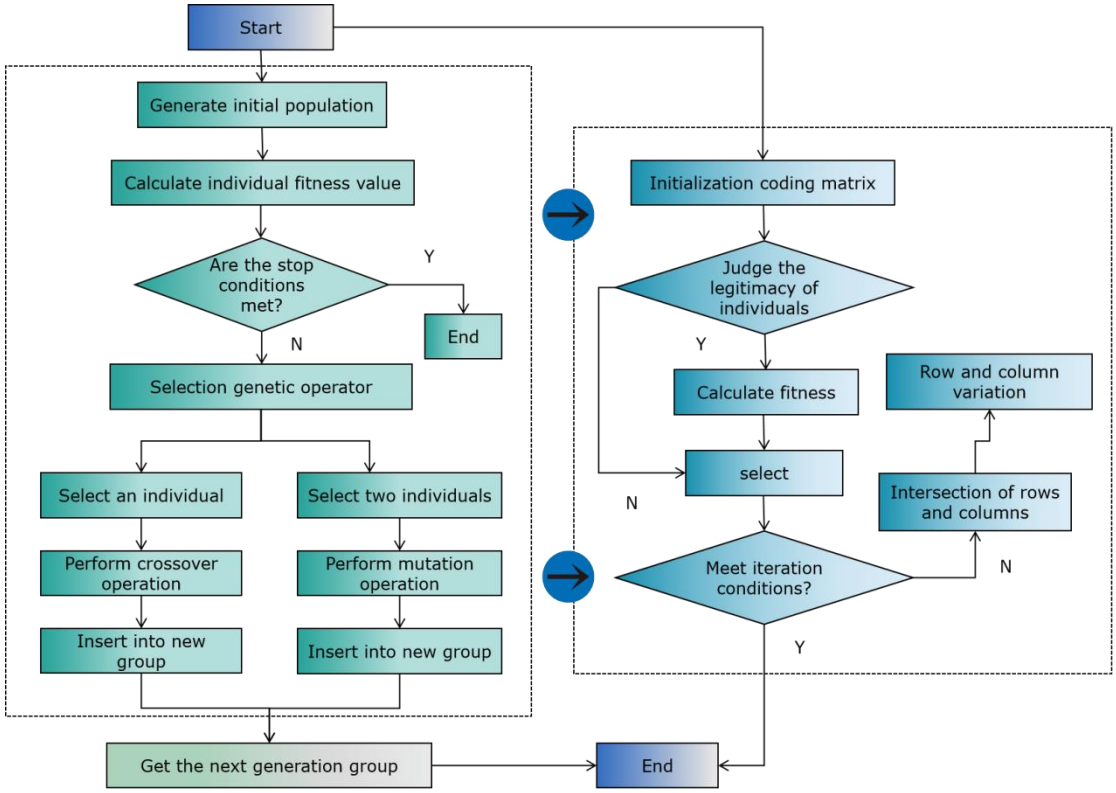

Figure 1: Improved GA process.

Figure 1 shows the improved GA process. Crossover and mutation are two main operations in GA, which are used to generate new individuals. Cross operation will exchange some genes of two individuals to generate new individuals. Mutation operation will randomly change some genes of an individual. Both of these operations can introduce new shape features and increase the diversity of the population. Because of the common mutation operation, problems outside the range specified by users may appear in chromosomes. In this article, conditional mutation operator is adopted, and the adaptive mutation probability is:

$$p_m = \begin{cases} p_{m1} - \dfrac{p_{m1} - p_{m2}}{f_{\max} - f_{avg}} \dfrac{f_{\max} - f_m}{} & f_m \geq f_{avg} \\ p_{m1} & f_m < f_{avg} \end{cases} \tag{6}$$

$$f_{m1} = 0.1 \quad f_{m2} = 0.001 \tag{7}$$

Among them, $f_{\max}, f_{avg}$ is the maximum fitness value and average fitness value in the parent, and f_m is the fitness value of the individual to be mutated. When GA is used to optimize the parameters, the fitness function f is set as:

$$f = 1 - \sqrt{\frac{\sum_{j=1}^{l}\sum_{k=1}^{m} desired_{jk} - actual_{jk}^{\ 2}}{l \cdot m}} \tag{8}$$

$$actual_j = \left[\sum_{i=1}^{n} w_i x_i^p\right]^{1/p} \tag{9}$$

In addition, this article introduces the physical engine to simulate the actions of the characters, and makes the actions more in line with the laws of the real world by adjusting the physical parameters and constraints. On the premise of ensuring visual effect, unnecessary calculation is reduced by pruning strategy; Moreover, it captures the user's operation in VR, analyzes his preference for role behavior and action, and then integrates these feedbacks into the generation algorithm to make the role more in line with the user's expectations.

3.3 Analysis of Characteristics and Advantages of Algorithm Model

The model in this article has the following characteristics: interactivity: the model has strong interactivity, and designers can directly interact with animation elements through VR, adjust design parameters in real time, and realize a more intuitive and flexible design process. Immersion: Through VR, the model can provide immersive immersion, so that designers can fully and deeply experience the process of animation character design and production, thus improving the accuracy and creativity of design. Efficiency: This model integrates many links in traditional animation character design into a virtual environment, which greatly simplifies the workflow and improves the efficiency of animation character design and production.

In addition, the animation character production process based on VR pays more attention to real-time and interactivity than traditional animation character production. In the virtual environment, the animator can directly design the action of the character and preview the action effect in real time through VR equipment. This way of real-time preview can not only reduce the number of iterations in the production process, but also make the animator feel the dynamic performance of the role more intuitively, thus adjusting a more vivid and natural animation effect.

4 SIMULATION RESEARCH AND RESULT ANALYSIS

4.1 Experimental Results and Analysis

In order to verify the effectiveness of the animation character generation and optimization algorithm proposed in this article based on CAD and VR, a series of simulation experiments are carried out in this section. As shown in Table 1, the hardware and software environment needed to run the animation art design and production model based on VR is presented. Among them, the hardware environment includes computers and VR helmets with high-performance graphics processing units, while the software environment uses special VR development tools and SDK, and integrates various rendering algorithms and graphics processing technologies. The use of these environments and tools

is helpful to improve the efficiency and quality of animation character design and production, while providing an immersive visual experience.

Category	*Illustrate*	*Example*
Hardware environment	Computers using high-performance graphics processing units	Ensure the fluency of real-time rendering
	VR helmet	Oculus Rift, HTC Vive
Software environment	Specialized VR development tools	Unity, Unreal Engine
	VR SDK	Software development kit for interacting with VR devices
	Integration of rendering algorithm and graphics processing technology	Provide high-quality graphics rendering and processing capabilities

Table 1: Hardware environment and software environment.

In the experiment, several data sets are selected, including different kinds of character models, motion capture data and scene descriptions. These data sets are used to test the performance and adaptability of the algorithm in different situations. Firstly, in order to evaluate the performance of this algorithm, this section selects several classic and latest animation character generation methods as comparison methods. These methods include rule-based methods and traditional machine learning algorithms. In terms of evaluation index, this article mainly considers the geometric quality of generated characters, the authenticity of actions, the real-time calculation and the satisfaction of user interaction. Figure 2 presents the real-time results of the algorithm.

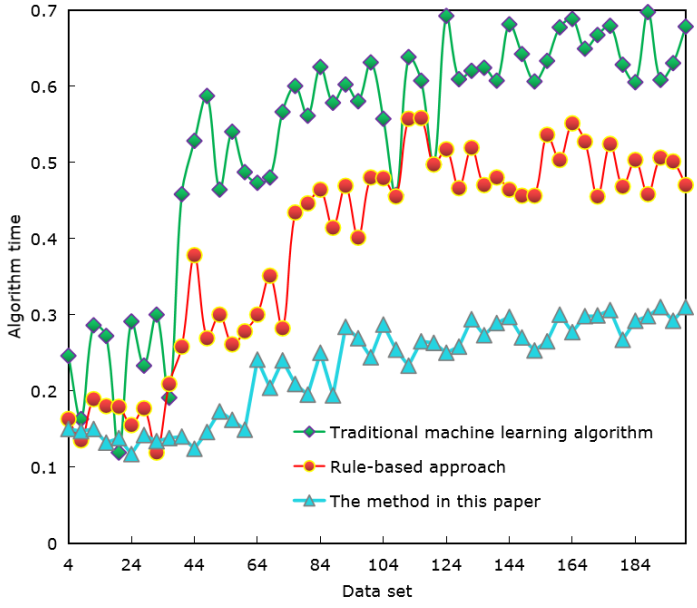

Figure 2: Real-time result of algorithm.

The algorithm proposed in this article can maintain high real-time performance when dealing with complex scenes and roles, and meet the requirements in practical applications. Moreover, the algorithm optimizes the calculation efficiency in the process of character generation and effectively

improves the frame rate. This shows the effectiveness and efficiency of the algorithm in design and implementation. The accuracy of the algorithm is shown in Figure 3.

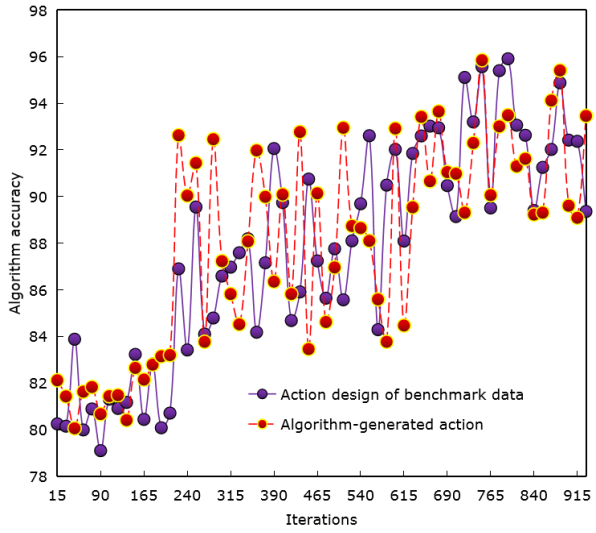

Figure 3: Accuracy of the algorithm.

As shown in Figure 3, it can be observed that the algorithm is excellent in action accuracy. By comparing the action design of benchmark data with the action generated by the algorithm, it is found that the algorithm in this article can generate a natural and smooth action sequence, which is highly consistent with the action of benchmark data. This proves the effectiveness of the algorithm in character action design and optimization. As shown in Figure 4, the scoring results of the geometric quality of the character and the authenticity of the action generated by the traditional machine learning algorithm are presented. As shown in Figure 5, the scoring results of the geometric quality of the character and the authenticity of the action generated by the algorithm in this article are presented.

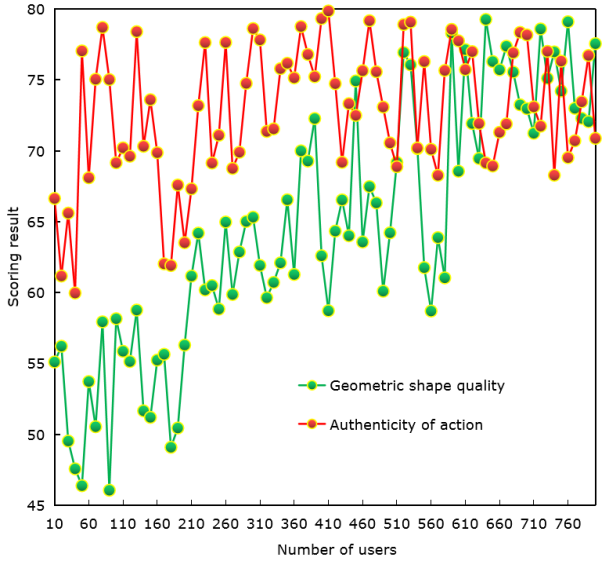

Figure 4: Grading results of traditional methods.

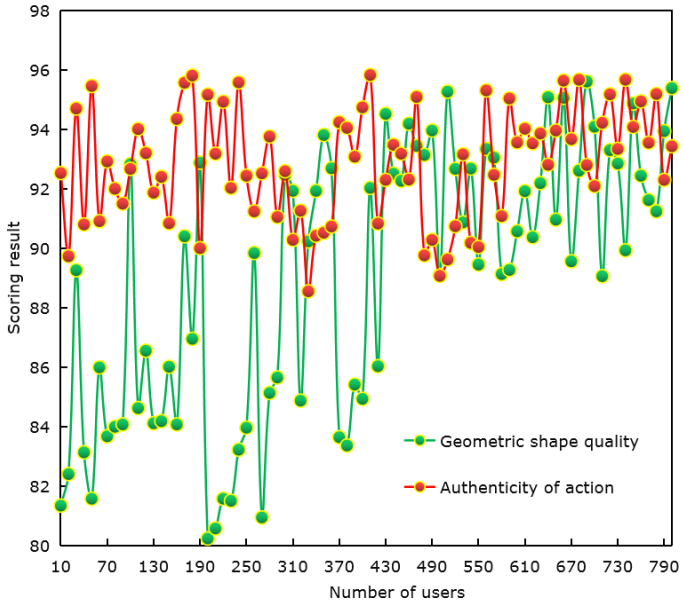

Figure 5: The method in this article scores results.

This section uses CAD software to model the role model. Through accurate modeling tools, animated character models with high quality geometric details and textures can be created. This process involves fine adjustment of character shape, proportion, clothing and other aspects to ensure that the generated model is consistent with the reference model. As shown in Figure 6, an animated character generated by an animated character generation method combining CAD and VR is presented.

(A) Before optimization

(B) After optimization

Figure 6: Animation character situation.

It can be seen that by combining the technologies of CAD and VR, animated characters with high-quality geometric shapes, realistic actions and immersive interactive experience have been successfully generated. Specifically, from Figure 6(B), we can see that the generated animated characters have clear outlines, detailed texture maps and vivid expression actions. These characteristics make animated characters look more real, three-dimensional and expressive. The experimental results prove the effectiveness and advantages of combining CAD and VR in animation character generation.

In addition, this article uses the method of user questionnaire to make quantitative evaluation and count the satisfaction of user interaction. Firstly, the target group is determined, including animation designers, VR users, gamers and other groups that have experience needs for animation role interaction. Then, a questionnaire containing multiple questions is designed, which covers all aspects of user's interaction with animated characters, such as the fluency of character movements, the immersion of VR environment, and the intuition of interaction methods. Each question provides different satisfaction options, such as very satisfied, satisfied, average, dissatisfied, etc. Distribute the questionnaire to the selected target population and encourage them to choose the corresponding satisfaction options according to their real experience. In order to increase participation, this article also sets up a certain reward mechanism. Finally, after collecting a sufficient number of questionnaire data, the data are statistically analyzed, including calculating the average satisfaction of each question and finding out the most satisfied and dissatisfied aspects of users. Figure 7 presents the satisfaction results of the user questionnaire.

It can be seen that the satisfaction of user interaction is high. Specifically, most users are very satisfied with the fluency of animated characters and the immersion of VR environment. This means that the animation character generation and optimization algorithm based on VR adopted in this article has achieved success in providing natural and smooth character movements and immersive experience. In addition, the user also gave a high satisfaction evaluation for the intuition of the interaction mode. This shows that the interactive design adopted in this article can effectively let

users intuitively perceive and operate animated characters, and improve the user's experience and efficiency.

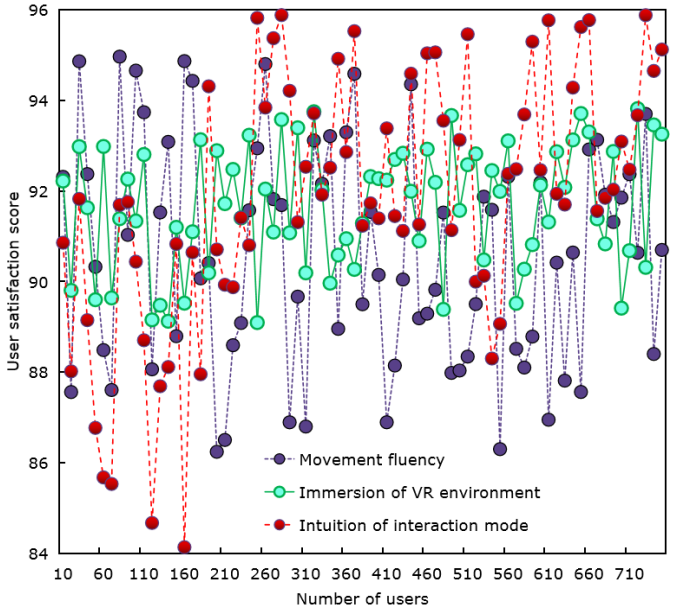

Figure 7: Satisfaction of user interaction.

A large number of experiments are carried out in this section, and the proposed algorithm is compared with the comparison method. Experimental results show that this algorithm has achieved remarkable advantages in all aspects of role generation. Specifically, the generated character shapes are more natural and smoother, the actions are more realistic, the calculation is more real-time, and the satisfaction of user interaction has also been significantly improved.

4.2 Results Discussion and Suggestions

Through the analysis of the results, some useful discussions and inspirations can be obtained. First of all, the comprehensive performance of this algorithm in the process of character generation is excellent, which proves the effectiveness of combining CAD and VR. Secondly, through comparative analysis, it is found that the algorithm in this article is unique in some aspects, such as the optimization strategy combining GA and physical simulation, which has certain reference value for the subsequent research work. In addition, through the simulation experiment, it is found that in the animation character design stage, using 3D modeling software can effectively and quickly create high-quality character and scene models. However, at this stage, designers are required to have high skills and experience in 3D modeling. In the animation character generation stage, animation editing and special effects can be easily added by using animation production software. However, this stage requires a lot of time and energy, and the skills of producers are also high. In the stage of rendering optimization, using VR can achieve high-quality rendering and output. But this stage needs high-performance computer hardware support, otherwise the rendering process may be slow.

According to the experimental results and analysis, this article puts forward the following optimization suggestions: in the design stage, designers' 3D modeling skills can be improved by strengthening training and practice. In addition, we can consider using some mature 3D modeling tools and plug-ins to simplify the design process and improve efficiency. In the production stage, we can reduce the workload of producers by introducing more automatic and intelligent editing tools. For example, you can use some tools to automatically track and match movements to simplify the animation process. In the stage of rendering optimization, the speed and quality of rendering can be

improved by using higher performance computer hardware and optimizing rendering algorithms. Moreover, you can also consider using some cloud rendering services to distribute rendering tasks to multiple computers for parallel processing. Through the above optimization measures, I hope to further improve the efficiency and effect of animation character generation and optimization based on CAD and VR. This will provide artists with more creative space and possibilities, and also meet the audience's demand for high-quality animation works.

5 CONCLUSIONS

In theory, this article deeply discusses the combination of CAD technology and VR in the design and production of animated characters, reveals its mechanism in the process of character generation and optimization, and promote the innovation and growth of animation industry. Moreover, through the detailed description of experimental settings, comparison methods and evaluation indicators, as well as the analysis and discussion of experimental results, the effectiveness of the animation character generation and optimization algorithm proposed in this article is verified. Experimental results show that the algorithm can generate high-quality character models and realistic actions, and has high real-time performance and user satisfaction. This laid a solid foundation for the subsequent application and further research.

Through a series of research work in this article, it is expected to provide an efficient and convenient method for role generation and optimization in the field of animation art design and production, and promote the rapid growth of animation industry. In addition, the research results of this article can also be applied to game design, film and television special effects, online education, VR interaction and other related fields to promote technological progress and industrial development in these fields. In the future animation art design and production field, the animation character generation and optimization algorithm based on VR will play an increasingly important role. With the continuous improvement and innovation of the algorithm, it is believed that the design and production of animated characters will be more efficient, detailed and vivid, bringing more rich and immersive visual experience to the audience.

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