www.cad-journal.net
Computer-Aided Design AND APPLICATIONS

Innovative Application of CAD Technology in Animation Design and Its Integration with Visual Teaching

Jingyue Wang[1] and Piwen Xu[2]

[1,2] School of Computer Science and Technology, Tiangong University, Tianjin 300387, China, [1]goodayear@163.com, [2]xupiwen@tiangong.edu.cn

Corresponding author: Piwen Xu, xupiwen@tiangong.edu.cn

Abstract. This study utilized cutting-edge computer-aided design (CAD) technology to construct an innovative animation design algorithm model. After careful planning, implementation, and optimization processes, the functionality of this model has become increasingly sophisticated. In order to further verify the application value of this model in the actual teaching environment and the potential impact on students' learning effectiveness, we carefully planned and executed a series of simulation tests. When designing these simulation tests, we specifically selected animation design tasks with varying degrees of difficulty and invited students from multiple majors to participate. To ensure the comprehensiveness and objectivity of the evaluation, we have developed evaluation standards that include multiple dimensions such as task completion time, quality of design results, and student satisfaction. Experimental data shows that compared to traditional methods, students who use CAD-based animation design algorithm models exhibit higher efficiency in completing tasks, and the quality of their work has also been significantly improved. In addition, most students gave high praise to this novel visual teaching method, believing that it is very beneficial for improving learning interest and efficiency.

Keywords: CAD; Animation Design; Innovation; Visual Teaching
DOI: https://doi.org/10.14733/cadaps.2024.S27.229-244

1 INTRODUCTION

With the rapid progress of digital technology, computer-aided design (CAD) has become an irreplaceable assistant in many aspects, such as engineering design, architectural design, and product design. The application of CAD technology has become increasingly broad, and its application in the animation design industry has gradually revealed its unique value and huge potential—especially the application of 3D simulation and simulation technology. Amura et al. [1] developed a 3D graphics engine animation system that combines practicality and efficiency. However, due to the complexity of 3D graphics technology, the design of 3D graphics engine animations and the rendering of animation scenes in the engine have become a challenge in modern graphics. Due to the practicality and specificity of 3D graphics engine technology, it has been widely applied in the entire field of graphics processing. In various computer graphics development processes, 3D graphics are rarely created on API low-level graphics but are developed using 3D graphics engine technology. The rational and scientific use of 3D graphics engine technology can save graphics developers a lot of time, and the reusability of engine code makes the production of 3D graphics intelligent and simple. Bao [2] analyzed the application characteristics of current mainstream 3D graphics engines based on existing research results on 3D graphics. And the engine structure was divided. Functional module implementation analysis and research were conducted on the Romans engine. The system has studied the difficulties in large-scale vegetation rendering technology for current 3D graphics, including vegetation modelling, shadows, lighting, and batch rendering. It adopts Imposter graphics processing technology and points out algorithmic ideas for solving the difficulties faced in the process of 3D graphics engine animation production. And integrated a production algorithm system applied to 3D graphics engine animation drawing, pointing out the rendering solution of the system for large-scale vegetation, etc. Not only did we study and implement the 3D graphics engine animation system, but we also conducted in-depth discussions on the key technologies.

The 3D graphics engine is the latest technology in computer hardware and software development, characterized by real-time performance, interactivity, and powerful roaming capabilities. Real-time character animation is an important indicator for evaluating the quality of a graphics engine [3]. Animation design, as a brilliant gem of digital media art, involves numerous graphic creations, model building, and dynamic simulations in its creative process. In the past, animation design techniques often relied on hand drawing or two-dimensional design software. Although these methods can breed works with great artistic charm, there are certain shortcomings in speed and accuracy. The integration of CAD technology has brought new creative paths and tools to animation designers, making the entire design process faster and more accurate, while easily achieving cool 3D animation effects. Based on existing research on 3D graphics, Brehmer et al. [4] analyzed the structural system and functional construction of 3D animation engines and divided the system application characteristics under different structures. Different contents were constructed by referencing different three-dimensional areas. Functional module implementation analysis and research were conducted on the Romans engine. The system has studied the difficulties in large-scale vegetation rendering technology for current 3D graphics, including vegetation modelling, shadows, lighting, and batch rendering. It adopts Imposter graphics processing technology and points out algorithmic ideas for solving the difficulties faced in the process of 3D graphics engine animation production. And integrated a production algorithm system applied to 3D graphics engine animation rendering. It points out the rendering solution for large-scale vegetation by the system. Not only did we study and implement the 3D graphics, but we also conducted in-depth discussions on the key technologies of 3D graphics engine animation.

Cao et al. [5] provided graphic and image processing for upper-level graphic applications in the form of APIs using a 3D engine. And the research on 3D engine technology is crucial for the development of graphic applications. As a core technology, the 3D graphics engine provides a fundamental platform for the development of upper-level graphics applications, determining the quality of the developed 3D graphics. The realism and actual effect of 3D graphics are closely related to the robustness of the backend engine. Chandra et al. [6] conducted in-depth research on several implementation techniques for character animation in 3D graphics engines. By analyzing the advantages and disadvantages of several methods, a joint animation solution based on inverse kinematics and an implementation plan for bone skin animation were proposed. In the implementation of skeletal skin animation, attribute-based mesh optimization techniques and hardware-supported approaches were utilized. Based on this, provide an animation blending method that utilizes existing animation sequences to generate new animations. Through implementation, it has been demonstrated that character animation using this animation technology fully utilizes several advantages of existing animation technologies, and has realistic and vivid display effects. At the same time, it has good real-time performance, as well as good scalability and portability. Using this technology to drive animation will add a lot of colour to game engines.

3D graphics engine technology, in simple terms, is the technique of organizing reusable parts of a 3D graphics program into exquisite modules, standardizing and optimizing them, in order to facilitate program reuse. The 3D graphics engine is currently widely used in many fields. Such as military simulation combat systems and 3D online games. The development of 3D graphics engines represents the latest technology in computer hardware and software development, with real-time performance, interactivity, and powerful roaming capabilities as its main characteristics. A graphics engine refers to a series of API functions that are pre-programmed for game development, including initialization, graphics processing, character control, collision detection, and more. It is equivalent to a development toolkit for game programmers, and some commercial graphics engines also provide level and character editors [7]. But this is just the tip of the iceberg for CAD in animation design. Under the wave of information technology education, intuitive teaching has become a key way to improve education quality and ignite student interest. CAD technology, with its excellent 3D modelling and visual presentation capabilities, injects rich content and diverse teaching methods into intuitive teaching. Integrating CAD technology with intuitive teaching can not only help students more intuitively understand the essence and skills of animation design, but also awaken their learning enthusiasm and innovative spirit, thus achieving a leap in teaching quality. The core objective of this exploration is to construct an animation design algorithm model based on CAD technology and explore its potential application in the field of education. This move is not only aimed at improving the speed and accuracy of animation design but also aims to help students grasp the core concepts and technical essentials of animation design more clearly through visual educational methods. In the digital age, image processing technology has become an indispensable tool, especially in the analysis of complex geometric shapes, where image measurement models play a crucial role. Đurić et al. [8] discussed in detail the techniques, applications, and future development trends of complex geometric two-dimensional shape analysis based on image measurement models. Traditional 3D modeling and animation techniques often require professional skills and complex operations, which poses a certain threshold for ordinary users. Therefore, in recent years, single view methods have received widespread attention and application as a simplified 3D modeling and animation technology. Dvorožňák et al. [9] introduced a single view method for leisure 3D modeling and animation, helping readers understand the principles, characteristics, and application prospects of this technology.

The contributions of this paper can be summarized as follows:

Enhance the precision and efficiency of animation design: With the power of CAD technology, animation creators can more finely control every detail of animation, thereby improving the overall level of animation. Meanwhile, the automation and batch processing capabilities of CAD will also bring unprecedented efficiency to animation design.

Reform of teaching methods and improvement of educational quality: Traditional animation design teaching methods often focus on theoretical teaching, with limited opportunities for practical operation. The algorithm model constructed in this study will serve as a new educational tool, enabling students to understand and master the essence of animation design through hands-on practice, thereby improving educational effectiveness.

Optimizing and accelerating animation design education through visual teaching methods and efficient algorithm models. Students will be able to accumulate richer knowledge and skills in a shorter period, thereby achieving the optimization and acceleration goals of animation design education. Secondly, we have successfully integrated this algorithm model into visual teaching, opening up new perspectives and paths for the field of animation design education.

The structural layout of this study is as follows: In the introduction at the beginning, the research background, objectives, and innovations will be analyzed in depth. Next, in the second part, the system introduces the basic concepts of CAD technology and animation design. Enter the third part to provide a detailed analysis of the construction and implementation process of animation design algorithm models based on CAD technology. The following fourth part will explore how to combine CAD technology with visual teaching methods. In the fifth part, the practical value of this study is verified through simulation experiments. The conclusion section will comprehensively summarize our research findings and provide prospects for future research directions.

2 OVERVIEW OF THE INTEGRATION OF CAD TECHNOLOGY AND ANIMATION DESIGN

Traditional animation systems require modelling and creating specific animations for each character, even if they perform the same actions. This method requires a considerable amount of work for animation production personnel and also requires a significant amount of resources (hard disk, memory) [10]. Therefore, in the initial planning stage, it was hoped that different models could share a set of animations, and as long as there were identical actions in the animation, they could be reused. In this way, no matter how much the workload of animation production is, it will only be done once. And by adding new modelling, namely roles, the system's scalability is almost infinite. On the contrary, if every additional modelling requires creating corresponding animations, the workload is even more unimaginable, and in fact, it is almost impossible. Kang et al. [11] improved the traditional bone skin animation method to achieve the goal of sharing animation while ensuring the animation effect. Computer vision animations run smoothly in network environments, therefore geometric animation methods cannot be used. Because this method has a large amount of data animations cannot be shared. The data storage of traditional bone skin animation mainly involves the relative positional relationships between various joints. This correspondence is fixed for specific modelling, but directly sharing animation information can result in joint overlap or disconnection, which cannot fully meet the requirements. The improved bone skin animation method can well meet the requirements of smooth animation projection and has a small amount of data. In terms of data storage, the use of vertex indexing greatly reduces the amount of data. The new method has greatly improved the real-time character animation performance in 3D graphics engines and has a driving effect on domestic graphics engines [12].

Nowadays, 3D graphics engines can make animations more quickly by judging the lighting of modified model scenes. The 3D graphics engine has real-time rendering technology, which facilitates real-time modification of light and shadow effects, material texture, and special effects. Li [13] analyzed the big data art design of multi-core processors and computer vision. It can save a lot of rendering time and cost, thereby improving the time for judging and modifying light and shadow materials, making it easier to obtain excellent works. The traditional 3D animation production process is a process that uses Maya as the production platform with the assistance of other DCCs and renderers, and this process is adopted by most animation companies. This process, in brief, involves a series of sequential processes including modelling, binding, animation, materials, lighting, and rendering. Maya is the main process, while other DCCs assist in creating a linear and non-destructive process. Studying 3D engines is a meaningful attempt, and now some universities and research institutes have joined the ranks of researching 3D engines. This undoubtedly has played a positive role in the progress of China's 3D engine. A large amount of research and development funds are invested in the development of game engines, and it is believed that such great momentum will inevitably promote the rapid development of engine technology. Domestic game developers can quickly get in touch with new engine technologies. For the skeletal animation system in this project, both domestic and foreign developers of Xueduo 3D game engines are actively researching it. The goal is to find an algorithm that requires a smaller amount of data, but so far there is no comprehensive optimization algorithm for bone animation. Li [14] studied the technology of real-time character animation in 3D engines and improved the current implementation schemes of skeleton animation both domestically and internationally. It uses different modelling to share the same set of animations and can be reused as long as there are identical actions in the animation.

Liu et al. [15] designed and implemented a 3D graphics engine animation system. The research mainly focuses on the architecture design, functional module implementation, soft shadow algorithm, and high dynamic range lighting technology of the 3D graphics, with a certain degree of innovation. Then a detailed introduction was given to the implementation of the system's functional modules. Emphasis has been placed on addressing issues related. Finally, the application and implementation of soft shadow algorithms and high dynamic range lighting technology in 3D engine animation systems were studied. We have mainly made relevant improvements to existing soft shadow algorithms, improving the rendering effect of the system. Research has been conducted on the implementation methods of joint animation, and the forward kinematics joint animation system based on motion capture is relatively mature. Tang et al. [16] conducted research on joint animation based on inverse kinematics and provided solutions. In response to the inherent shortcomings of joint animation, it proposes using bone skin animation to solve the problem, provides the implementation process of bone skin animation, and implements bone skin animation according to the process. We have optimized and expanded the skeletal skin animation and optimized the mesh based on the attribute table when drawing the mesh. In order to improve rendering speed, hardware support methods are adopted during the implementation process. It adopts an animation blending method to generate animations that are not available from existing animations.

Yadav et al. [17] introduced the main methods of animation playback in 3D graphics engines and the current research status at home and abroad. It briefly describes the basic knowledge of 3D graphics engines and the techniques of character animation in game engines, as well as the classification of current animations and the advantages and disadvantages of various animations. At the same time, the research methods for joint animation were provided, and the implementation method of joint animation based on reverse dynamics was discussed in detail. It provides a detailed introduction to the head and eight characters of the Skeleton Family Skin Blade Painting, captured from Koutian Yuandong Pu to Falihua. This includes mesh simplification, hardware support, and animation blending that cannot be achieved through motion capture. Yu et al. [18] introduced all animation algorithms in computer joint animation and bone skin animation techniques. Including forward motion law and reverse motion law. And it proposed its own animation method. The small amount of data greatly reduces the workload of graphic designers and meets the requirements of the project. At present, the development of 3D graphics engines in China is relatively backward, without its own brand engine. Most of the games developed are imported game engines from Europe, America, South Korea, and Japan. The core code of foreign game engines is not publicly available. Therefore, studying 3D engines is a meaningful attempt, and now, some universities and research institutes have joined the ranks of researching 3D engines. This undoubtedly has played a positive role in the progress of China's 3D engine.

3 CAD-BASED ANIMATION DESIGN

When building this model, we focus on the core elements of animation design and the technical advantages brought by CAD. The model takes the basic composition of animation as the starting point, covering character shaping, scene design, action arrangement, and timeline layout, and fully utilizes the advantages of CAD in precise modelling and data analysis. Our algorithm model consists of three main layers: the input layer, the processing layer, and the output layer. Specifically, the input layer is mainly responsible for receiving the designer's creative ideas and initial parameter settings, such as the initial form of the character and the preliminary layout of the scene. The processing layer constructs animation elements, designs actions, and plans timelines based on these input data. Ultimately, through the output layer, we will obtain a complete and dynamic animation work. The entire process can refer to Figure 1 for a detailed understanding.

In the process of building our animation model, we comprehensively explored and applied the high-precision modelling and deep data analysis capabilities of CAD technology. By utilizing advanced CAD tools, we can not only create exquisite 3D models of animated characters and scenes but also fine-tune action designs and meticulously plan timelines through CAD's advanced data analysis capabilities. Our goal is to create natural and smooth animation effects. These rules play a crucial role in our algorithm, enabling the final generated animation to conform to people's visual habits and motion perception.

Faced with the complexity of animation design, a series of innovative data structures have been designed to store and manage various animation elements. For example, we have designed exclusive data structures for animated characters and scenes, which can record various information, such as shape, material, texture, etc., in detail. In terms of algorithm design, after careful consideration, multiple core links, including character modeling, scene construction, action design, and timeline setting, have been planned. Each step has corresponding algorithms to handle specific tasks, ensuring that each step is precise and error-free.

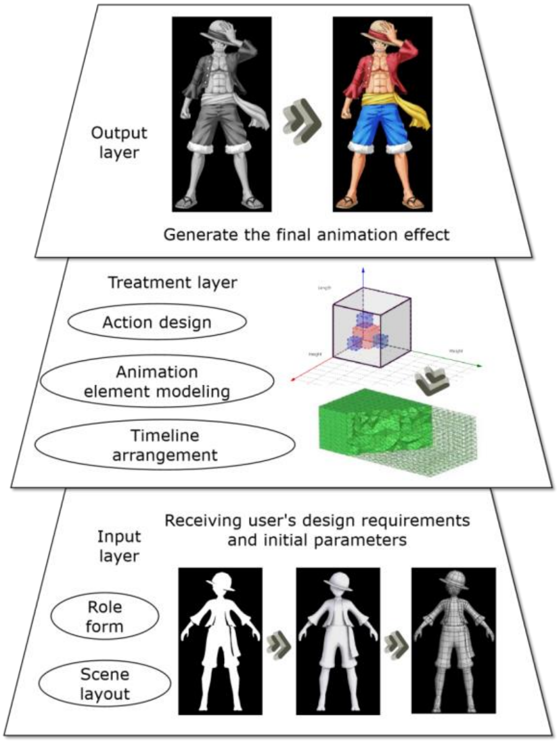

Figure 1: Algorithm framework.

In the process of character modelling, the parameterized modelling technology of CAD is utilized to efficiently and quickly construct a 3D model of the character. In addition, we also delved into the production of skeletal animations. By precisely manipulating the transformation of bones and joints, we have successfully simulated various actions of the character. In order to further improve the smoothness of the animation, we used quaternion $\mathrm{Quaternion}$ to represent the position changes of the bones, which greatly reduces the complexity of rotation calculation. We have refined the specific calculation formula to ensure that each frame of the animation can achieve the best visual effect:

$$\mathrm{Quaternion}\ \mathrm{q_w,q_x,q_y,q_z} = \begin{bmatrix} q_w^2+q_x^2+q_y^2+q_z^2 \\ 2\ \mathrm{q_x \cdot q_y - q_w \cdot q_z} \\ 2\ \mathrm{q_x \cdot q_z - q_w \cdot q_y} \\ 2\ \mathrm{q_y \cdot q_z - q_w \cdot q_x} \end{bmatrix} \tag{1}$$

$$\mathrm{Force} = \mathrm{Stress} \times \mathrm{Area} \tag{2}$$

$$\vec{N} = \frac{\vec{U} \times \vec{V}}{\left\| \vec{U} \times \vec{V} \right\|} \tag{3}$$

In this context, $\vec{U}$ and $\vec{V}$ represents vectors of two adjacent edges closely connected to the vertex.

Ray casting algorithm, as a direct volume rendering technique, its core lies in using a series of images for rendering. These images are similar to volumetric textures and are composed of a series of two-dimensional images. During the implementation process, the algorithm will sample these images one by one to capture their respective colour data. Please refer to Figure 2 for a detailed understanding.

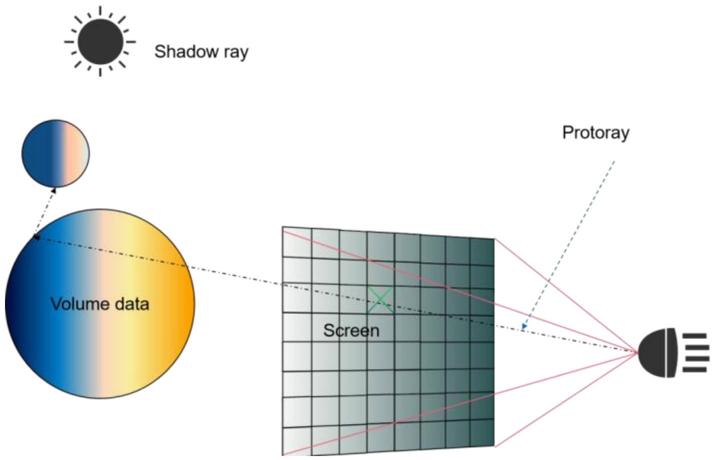

Figure 2: Ray casting principle.

By projecting volume data in $l = l_1, \cdots, l_5$, the length of the trajectory of the light passing through the cube can be obtained, denoted as m. Based on this length, we can derive the following conclusion:

$$t = t_{start} + d \cdot delta \tag{4}$$

$$\theta = \theta_0 + \Delta\theta \cdot \sin\ 2\pi ft + \varphi \tag{5}$$

This expression θ_0 represents the magnitude of the amplitude, which determines the maximum deviation of the fluctuation; $2\pi ft$ represents angular frequency, reflecting the speed of fluctuations; φ and represents the initial phase, which is the initial state at which the wave begins.

Physics engine computation: inferring the velocity and displacement of an object based on its mass and acceleration. The specific calculation formula is as follows:

$$\Delta p = a \cdot \Delta t \tag{6}$$

In dynamic simulations, we use Newton's second law to calculate forces. The specific formula is as follows, where Δp represents the updated velocity, Δt represents the current velocity, and a represents acceleration. Through these parameters, we can accurately simulate the motion state of objects.

$$F = m \cdot a \tag{7}$$

In this description, F represents the total force acting on the object, m is the mass of the object, and a reflects the acceleration of the object.

When conducting bone tracking, due to various unfavourable factors such as noise interference and hardware performance constraints, the movements of characters may appear less smooth. Especially when there is a significant change in the position of bone joints between consecutive frames, it may cause adverse effects such as tremors or jumps, which undoubtedly impairs the realism of virtual actions. To address this challenge, we adopted the Holt exponent smoothing technique and cleverly integrated it into the processing of motion data. Holt exponent smoothing not only includes two core smoothing formulas but also incorporates a prediction formula. The specific forms of these formulas are listed below as coefficient formulas. With this technology, it is possible to significantly enhance the smoothness and realism of virtual actions.

$$A_t = \alpha P_t + (1-\alpha)(A_{t-1} + I_{t-1}) \tag{8}$$

$$I_t = \gamma (A_t - A_{t-1}) + (1-\gamma) I_{t-1} \tag{9}$$

$$\hat{P}_{t+T} = A_t + I_t T, T = 1,2,\cdots,n \tag{10}$$

This formula, α,γ represents the smoothing coefficient; P_t is the actual observation value at the t th time point; T represents the predicted lead time; t and represents the current time period value; A_t, A_{t-1}, it involves utilizing historical data from the previous t or t-1 periods; I_t, I_{t-1} is an estimate of trend increment, based on data from the pre t or pre t-1 periods; Finally, $\hat{P}_{t+T}$ uses data from the previous t periods to predict the value of the $t+T$ th period.

During the development process, this article will transform the carefully designed algorithm principles and data structures into actual code, and verify its accuracy through repeated testing and adjustment. In terms of improving algorithm performance, we have implemented a series of improvement measures. In order to implement the algorithm model, we have chosen an efficient programming language and framework. When writing code, we emphasize the clarity and sustainability of the code, so that it can be easily modified and expanded in the future.

The rendering process was optimized with the aim of accelerating the rendering speed of the animation and improving its visual quality. Figures 3 and 4 respectively compare the accuracy and execution efficiency of the algorithm before and after optimization.

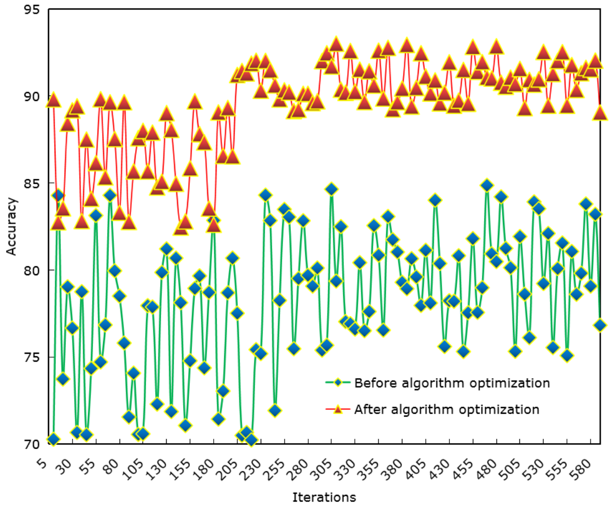

Figure 3: Accuracy before and after optimization.

The improvement of structured logic in data is attributed to the effective improvement of algorithm accuracy. By processing the accuracy of data structures and the logical processing of parallel technology's structural layers, the accuracy of predictions is constructed.

The significant improvement in efficiency is attributed to comprehensive optimization measures in various aspects. Firstly, the data structure has been refined and improved, which not only reduces memory usage but also significantly improves data reading speed, thereby directly shortening the running time of the algorithm. Secondly, through parallelization technology, algorithms can better utilize the powerful computing power of multi-core processors, achieving a rapid increase in computing speed.

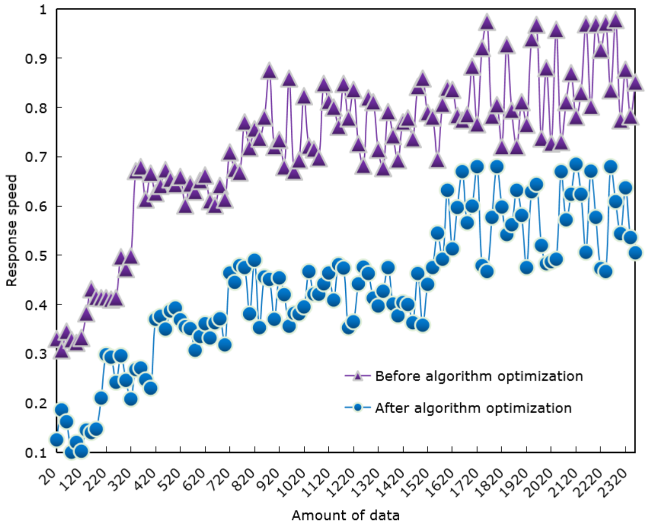

Figure 4: Efficiency before and after optimization.

Furthermore, the process of graphic rendering has also been deeply optimized, which has produced very positive effects in applications related to graphic processing. Overall, these diverse optimization methods have collectively driven significant improvements in the accuracy and efficiency of algorithms. These improvements not only enhance the performance of the algorithm but also significantly enhance its efficiency and stability in practical operations.

4 THE INTEGRATION OF CAD TECHNOLOGY AND VISUAL EDUCATION

4.1 Practice of CAD Technology in Visual Teaching

Visual teaching is an educational method that mainly relies on visual information to impart knowledge, and its supporting theories deeply integrate multiple fields such as cognitive psychology, education, and multimedia technology. Education advocates for the subjectivity and practicality of students in the learning process, and visual teaching can create an intuitive and interesting learning environment, thereby stimulating students' enthusiasm and autonomy for learning. Meanwhile, with the advancement of multimedia technology, visual teaching has received strong technical support and teaching content can be presented in more diverse and vivid forms. CAD technology, as an excellent visual presentation method, has shown a broad application space in visual teaching, as shown in Table 1.

Application scenarios	*Specific application scenarios*	*Advantages and Effects*
Presentation of abstract concepts	Introducing CAD software to present complex 3D design models	Enable students to have a clearer understanding of the construction and operation mechanism of mechanical components
simulation experiment	By utilizing advanced CAD technology, an immersive virtual experimental space has been	Enable students to conduct experimental operations on computers, thereby enhancing their hands-on practice and

	created for students	innovative thinking
Virtual Practice	Guide students to use CAD for simulated assembly and disassembly operations	Deepen students' comprehensive understanding and control skills of mechanical systems
Teaching animation production	Created captivating teaching animations using CAD technology	Make teaching content more attractive, thereby enhancing students' learning enthusiasm and classroom participation
Interactive courseware production	Combined with CAD technology, a series of interactive teaching courseware have been developed	Providing students with a more diverse and interactive learning experience helps them better understand and grasp knowledge

Table 1: Application of CAD.

4.2 The Implementation of CAD Technology Driven Animation Design in Visual Education

Animation created using CAD technology exhibits unique value in visual teaching. Animation can present teaching content through dynamic visual presentation, making it easier for students to understand and grasp key knowledge points. Taking physics courses as an example, teachers can use CAD technology to generate animations that vividly display mechanical laws, optical phenomena, etc., which helps students understand these obscure and difficult concepts more intuitively. In addition, animation design can ignite students' enthusiasm and creativity for learning. Inviting students to participate in the animation creation process can stimulate their imagination and innovative thinking. Meanwhile, students can also exercise their observation and analytical abilities while watching and analyzing animations.

5 EXPERIMENTAL SIMULATION AND IN-DEPTH ANALYSIS

5.1 Planning of Experimental Simulation

In order to thoroughly examine the effectiveness of CAD technology-driven animation design algorithm models and their practical application effects in visual education, a series of experimental simulations were carefully planned in this section. Firstly, we carefully selected animation design challenges at various difficulty levels, covering simple object dynamics, complex character animations, and even full scene animations; Secondly, we invited students from different disciplinary backgrounds to participate in this experiment, in order to evaluate the specific impact of visual teaching on different student groups; Finally, we have clarified the evaluation criteria for the experiment, which involve multiple dimensions such as the completion speed of animation design, the quality of the work, and student satisfaction.

5.2 Implementation of Experimental Simulation

During the implementation of the experimental simulation, the experimental design was strictly followed and multiple rounds of experiments were conducted. In each round of experiments, guide students to use CAD-based animation design algorithm models to complete preset animation design tasks, while recording in detail their operating steps, difficulties encountered, and the time required to complete the tasks. During the progress of the experiment, closely monitor the real-time performance and feedback of students, and flexibly adjust the experimental conditions and teaching methods according to the actual situation to ensure the authenticity and effectiveness of the experimental data. Figure 5 vividly illustrates the design quality of students facing animation design tasks of different difficulty levels before adopting this model.

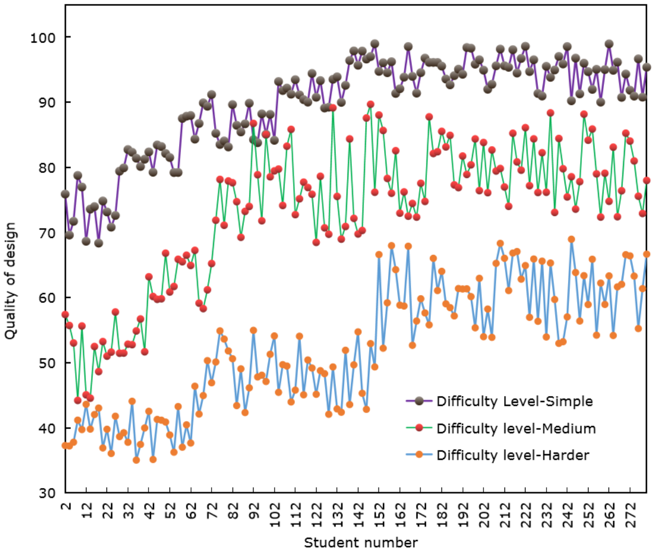

Figure 5: Design quality before the facelift.

Figure 6 clearly shows the quality of the works created by students for animation design tasks of different difficulty levels after adopting CAD technology-driven animation design algorithm models. Through this model, students can more effectively cope with various design challenges, thereby improving the overall quality of their animation design.

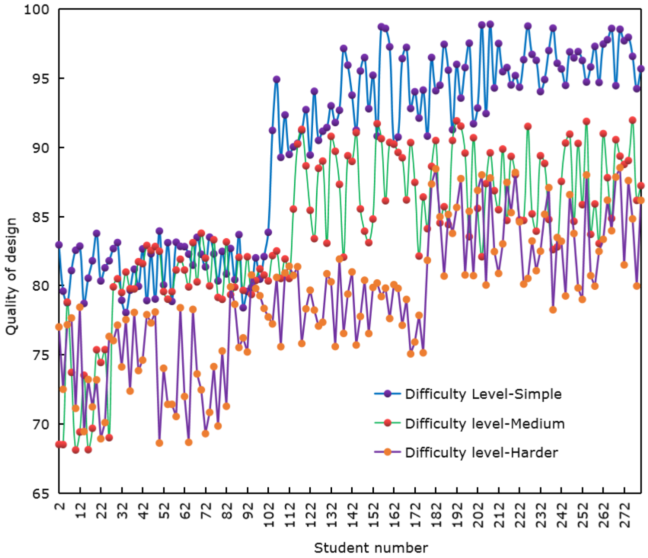

Figure 6: Improved design quality.

Figure 7 shows in detail the time required for students to complete animation design tasks of different difficulty levels before adopting the model proposed in this article. This chart clearly reveals the correlation between task difficulty and completion time, providing us with in-depth insights into the efficiency of student animation design.

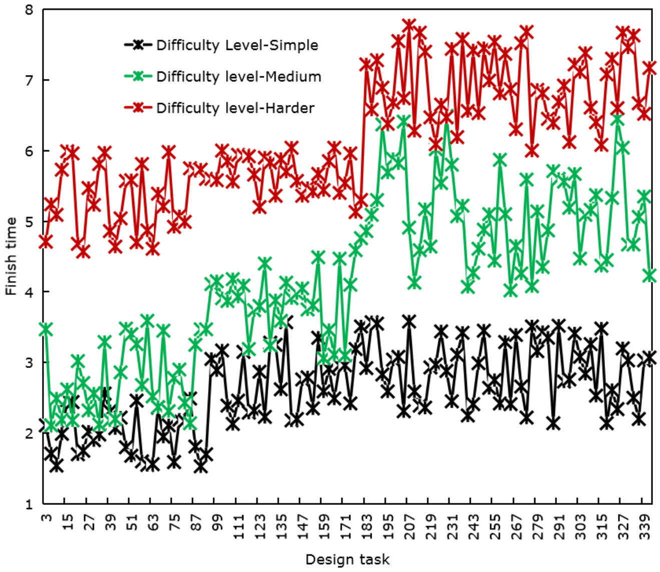

Figure 7: Time before improvement.

Figure 8 vividly depicts the completion time of students facing various difficulty levels of animation design tasks after using CAD-based animation design algorithm models. Through this chart, we can visually see how the model helps students improve efficiency and shorten the time required to complete animation design.

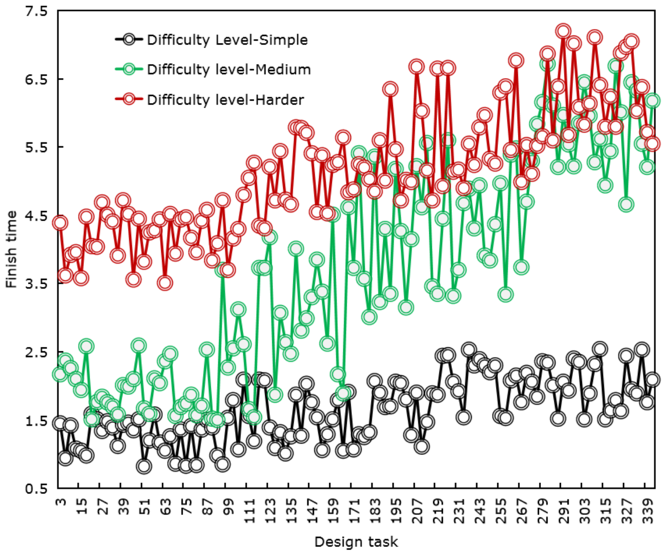

Figure 8: Improved time.

In addition, this article also comprehensively collected feedback from students on the effectiveness of visual teaching. By asking them about their depth of understanding of the teaching content, familiarity with animation design algorithm models, and recognition of this visual teaching method. The specific feedback from the students has been compiled in Table 2 for detailed reference.

Student ID	*Understanding the level of teaching content*	*Mastery of Animation Design Algorithm Models*	*Acceptance of Visual Teaching Methods*	*Student Feedback Summary*
S1	8	7	9	The course content is organized and easy to understand. Using animation to illustrate algorithms is really helpful, and visual teaching methods make me feel that learning is both interesting and intuitive.
S2	10	8	10	I am particularly satisfied with the visual teaching methods, which greatly assisted me in gaining a deeper understanding and mastery of animation design algorithms. The overall teaching content is also quite easy to understand.
S3	7	6	8	Although visual teaching has been helpful to me, I personally think there is still room for improvement in animation design, which can better serve learning.
S4	9	9	7	I have a good interest and understanding of algorithms for designing and simulating teaching animations. At the same time, we hope that teaching can contribute to the diversity of teaching under visual effects

Table 2: Specific feedback on the effectiveness of student visualization teaching.

Figure 9 presents in detail the evaluation results of students' satisfaction with teaching. Through this chart, we can intuitively understand the feedback of students on the effectiveness of visual teaching, providing strong data support for optimizing teaching methods and content.

5.3 Discussion of Results

After a series of carefully designed simulation experiments, this study has accumulated a large amount of experimental data and real feedback from students. In terms of task completion time, students who use CAD technology-driven animation design algorithm models completed animation design work more quickly compared to students who use traditional methods. In terms of quality evaluation, the animations created by students applying the new model appear smoother and more realistic, and the errors that occur during the production process are significantly reduced. In addition, from the feedback of student satisfaction, the vast majority of students hold a positive attitude towards visual teaching methods and firmly believe that this method is very beneficial for improving learning enthusiasm and efficiency.

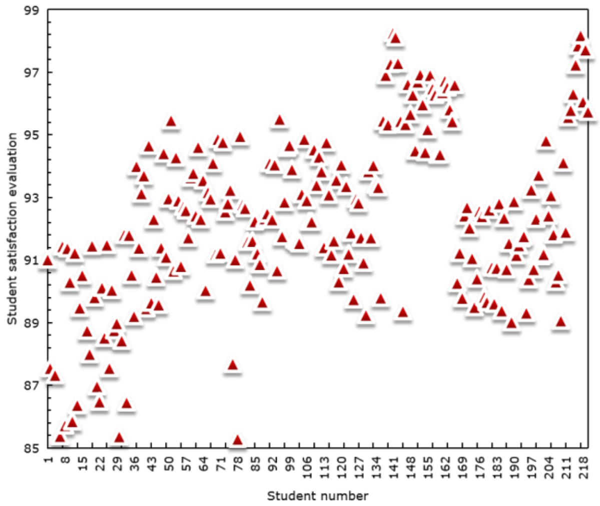

Figure 9: Satisfaction evaluation.

The animation design algorithm model based on CAD technology has obvious advantages and broad application space in the field of visual education. It not only significantly improves the speed and quality of animation design, but also invisibly ignites students' learning passion and stimulates their innovative thinking.

6 CONCLUSIONS

This study successfully developed an animation design algorithm model with CAD technology as the core and successfully applied it in visual teaching. Through detailed simulation experiments, the practicality and efficiency of CAD animation design algorithm models in visual teaching have been fully confirmed. The experimental data reveals that students who adopt the new model can complete animation design tasks more quickly, and their work quality is significantly improved. At the same time, students showed a high level of recognition and satisfaction with visual teaching methods.

The main contribution of this study is to inject new vitality into animation design education. By utilizing CAD technology and visual teaching methods, a new path has been opened up for the field of animation design education, providing methodological guidance. This not only improves teaching effectiveness, but also ignites students' enthusiasm for learning, taps into their creativity, and is expected to provide more outstanding talents for the animation design industry.

Although this study has achieved initial results, there is still room for improvement. For example, in the experimental planning stage, more elements and variables may be included to ensure the meticulousness and accuracy of the experiment. At the level of model application, there is also room for algorithm optimization and performance improvement.

Looking ahead to the future, this study will continue to focus on the in-depth exploration of CAD animation design algorithm models and their widespread application in visual teaching. The focus of future work will be on expanding model functionality, improving performance, and innovating teaching methods. At the same time, we have also carried out structured integration applications for future new animation algorithm education. We have innovated our concepts through the use of innovative anime design.

Jingyue Wang, https://orcid.org/0009-0009-5102-5973
Piwen Xu, https://orcid.org/0009-0001-8301-7777

REFERENCES

[1] Amura, A.; Aldini, A.; Pagnotta, S.; Salerno, E.; Tonazzini, A.; Triolo, P.: Analysis of diagnostic images of artworks and feature extraction: design of a methodology, Journal of Imaging, 7(3), 2021, 53. https://doi.org/10.3390/jimaging7030053

[2] Bao, W.: The application of intelligent algorithms in the animation design of 3d graphics engines, International Journal of Gaming and Computer-Mediated Simulations, 13(2), 2021, 26-37. https://doi.org/10.4018/IJGCMS.2021040103

[3] Berson, E.; Catherine, S.; Stoiber, N.: Intuitive facial animation editing based on a generative RNN framework, Computer Graphics Forum, 39(8), 2020, 241-251. https://doi.org/10.1111/cgf.14117

[4] Brehmer, M.; Lee, B.; Isenberg, P.: A comparative evaluation of animation and small multiples for trend visualization on mobile phones, IEEE Transactions on Visualization and Computer Graphics, 26(1), 2019, 364-374. https://doi.org/10.1109/TVCG.2019.2934397

[5] Cao, Q.; Zhang, W.; Zhu, Y.: Deep learning-based classification of the polar emotions of" moe"-style cartoon pictures, Tsinghua Science and Technology, 26(3), 2020, 275-286. https://doi.org/10.26599/TST.2019.9010035

[6] Chandra, D.; Hegadi, R.; Karmakar, S.: Facial expression synthesis images using hybrid neural network with particle swarm optimisation techniques, International Journal of Biomedical Engineering and Technology, 31(1), 2019, 64-83. https://doi.org/10.1504/IJBET.2019.101052

[7] Chowdary, B.-V.; Jaglal, D.: 3D CAD model reconstruction and fast prototyping of rotational parts: a reverse engineering approach, Journal of Engineering, Design and Technology, 21(5), 2023, 1520-1544. https://doi.org/10.1108/JEDT-07-2021-0365

[8] Đurić, I.; Obradović, R.; Vasiljević, I.; Ralević, N.; Stojaković, V.: Two-dimensional shape analysis of complex geometry based on photogrammetric models of iconostases, Applied Sciences, 11(15), 2021, 7042. https://doi.org/10.3390/app11157042

[9] Dvorožňák, M.; Sýkora, D.; Curtis, C.; Curless, B.; Sorkine, H.-O.; Salesin, D.: Monster mash: a single-view approach to casual 3D modeling and animation, ACM Transactions on Graphics (ToG), 39(6), 2020, 1-12. https://doi.org/10.1145/3414685.3417805

[10] Guo, Z.: Application of computer 3D animation technology in the construction industry, In Journal of Physics: Conference Series, 1574(1), 2020, 012088. https://doi.org/10.1088/1742-6596/1574/1/012088

[11] Kang, N.; Bai, J.; Pan, J.: Interactive animation generation of virtual characters using single RGB-D camera, The Visual Computer, 35(6-8), 2019, 849-860. https://doi.org/10.1007/s00371-019-01678-7

[12] Lan, X.; Shi, Y.; Wu, Y.; Jiao, X.; Cao, N.: Kineticharts: augmenting affective expressiveness of charts in data stories with animation design, IEEE Transactions on Visualization and Computer Graphics, 2022(1), 2022, 28. https://doi.org/10.1109/TVCG.2021.3114775

[13] Li, J.: Big data public art design based on multi-core processor and computer vision, Microprocessors and Microsystems, 81(3), 2020, 103777. https://doi.org/10.1016/j.micpro.2020.103777

[14] Li, L.: Application of cubic b-spline curve in computer-aided animation design, Computer-Aided Design and Applications, 18(S1), 2020, 43-52. https://doi.org/10.14733/cadaps.2021.S1.43-52

[15] Liu, Q.; Xu, S.; Xiao, J.; Wang, Y.: Sharp feature-preserving 3D mesh reconstruction from point clouds based on primitive detection, Remote Sensing, 15(12), 2023, 3155. https://doi.org/10.3390/rs15123155

[16] Tang, J.: Graphic design of 3D animation scenes based on deep learning and information security technology, Journal of ICT Standardization, 11(3), 2023, 307-328. https://doi.org/10.13052/jicts2245-800X.1135

[17] Yadav, S.-P.; Zaidi, S.; Mishra, A.; Yadav, V.: Survey on machine learning in speech emotion recognition and vision systems using a recurrent neural network (RNN), Archives of Computational Methods in Engineering, 29(3), 2022, 1753-1770. https://doi.org/10.1007/s11831-021-09647-x

[18] Yu, G.; Akhter, S.; Kumar, T.; Ortiz, G.-G.-R.; Saddhono, K.: Innovative application of new media in visual communication design and resistance to innovation, Frontiers in Psychology, 13(1), 2022, 940899. https://doi.org/10.3389/fpsyg.2022.940899