Implementation of Animation Character Action Design and Data Mining Technology Based on CAD Data

Baoshan Zhang[1] and Lu Weng[2]

[1]School of New Media Art, Xi'an Polytechnic University, Xi'an, Shaanxi 710048, China, 20040739@xpu.edu.cn
[2]School of New Media Art, Xi'an Polytechnic University, Xi'an, Shaanxi 710048, China, wenglu1204@163.com

Corresponding author: Baoshan Zhang, 20040739@xpu.edu.cn

Abstract. In the traditional animation character design process, designers need to spend a lot of time and effort on handcrafting. Now, with professional 3D design software, designers can quickly create basic models and then make detailed adjustments, greatly shortening the production cycle. Thanks to the precise control of computer technology, designers can modify character models at the micro level, achieving precise adjustments in facial expressions, body proportions, and hair details. How to endow characters with vivid and realistic actions based on these static computer-aided design (CAD) data is a challenging problem. This article utilizes precise 3D models provided by CAD data, combined with data mining (DM) technology, to extract motion features, making character action design more efficient. The results show that compared to the SVM algorithm, our algorithm exhibits significant advantages in modeling error and modeling accuracy. They are indicating its stronger ability to fit data and more accurate prediction results. In addition, in terms of response speed, the algorithm presented in this article also exhibits fast characteristics, which makes it more competitive in processing large-scale datasets or applications that require real-time feedback.

Keywords: CAD Data; Animated Characters; Action Design; Data Mining
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1 INTRODUCTION

With the rapid development of computer graphics, CAD, and DM technology, animation character action design has gradually changed from traditional manual production to data-driven and intelligent generation. Especially in recent years, advanced algorithms in the fields of graphic image processing and pattern recognition have provided new ideas for animation character action design. Deformable objects, such as characters, animals, or any object with morphological changes, occupy an important position in computer animation. Numerical simulation of the actions and behaviors of these objects can make the animation more realistic and bring a stronger sense of immersion to the audience.

Numerical simulation technology calculates and predicts the physical behavior of objects through mathematical models and algorithms, thereby achieving precise animation effects. Ascher et al. [1] provided a numerical simulation of deformable object action behavior and explored its future development trends. Numerical simulation technology is based on physical laws and mathematical models to simulate the behavior of objects. This includes the application of principles such as particle system dynamics, elasticity, and fluid mechanics. By establishing mathematical equations for object motion, such as motion equations and dynamic equations, combined with time-stepping algorithms, the position, velocity, and acceleration parameters of the object at each moment are gradually calculated. The methods for numerical simulation of deformable object motion behavior mainly include the finite element method, finite difference method, and particle system dynamics method. These methods each have their own advantages and disadvantages, and appropriate methods should be selected based on specific needs and scenarios. The animation role action design is based on CAD data and the realization of DM technology in order to provide new ideas for the innovation and development of the animation industry. As a unique art form, animation presents dynamic visual effects through continuous pictures and has become an indispensable part of multimedia industries such as movies, games, and advertisements. The actions of animated characters are important elements that drive the development of the story. Reasonable action design can better showcase the character's personality, emotions, and plot development of the story. For example, the body language and micro-expressions of a character can effectively convey their inner state and enhance the expressive power of the story. Excellent interactive animation character action design can allow the audience to participate more deeply in the story. Through interaction with characters, the audience can feel the emotional changes of the characters and the development of the story, thereby enhancing the viewing experience. Cai et al. [2] utilize deep learning models to train and learn a large amount of actual motion data, thereby obtaining a deep understanding of the actual motion laws. This model can automatically adjust the action parameters of animated characters to make them more natural and realistic. By installing sensors on animated character models, real-time motion data can be obtained and input into artificial intelligence algorithms for real-time adjustment and optimization. This method can achieve more precise action control and real-time feedback. The traditional animation character action design mainly depends on the designer's manual production and experience accumulation, which is not only time-consuming and laborious but also requires the designer's professional skills and creative level.

The precision and realism requirements for controlling character behavior in animation production are increasing. Maya is an animation production software widely used in the field of digital media, and its powerful modeling, animation, and rendering functions are deeply loved by professionals in the industry. The Maya digital media animation character behavior analysis and control technology based on CAD data provide a new solution for animation production. Cui and Sharma [3] demonstrated its application in actual animation production through case analysis. The Maya character behavior analysis and control technology based on CAD data mainly utilizes structural data such as bones and muscles obtained from CAD software and simulates and controls character behavior through Maya's animation module. This technology can provide more precise and realistic character action effects for animation production. It is a challenging problem how to endow the role with vivid and realistic actions on the basis of these static CAD data.

Virtual simulation of facial movements is an important technical link in the fields of virtual reality, game development, and film production. By simulating real facial movements, the realism and interactivity of virtual characters can be enhanced, enhancing the audience's immersion. However, traditional methods for virtual simulation of facial movements often require professional equipment and cumbersome processes, and accuracy and real-time performance are difficult to ensure. The implementation technology of virtual simulated facial movements based on artificial intelligence provides new ideas for solving these problems. Hou et al. [4] collected a large amount of facial images and expression data, including various expressions and emotional states of different people. These data can be obtained through professional facial capture devices, as well as through image or video capture. During the training process, the algorithm will automatically learn various facial features and patterns and generate corresponding models. Process and analyze input facial images or expression data using trained models to generate corresponding virtual simulated facial actions. The generated virtual simulated facial actions can be output in real-time to systems such as virtual reality, game development, and movie production to achieve real-time animation effects. Three-dimensional reality technologies provide animation designers with a new creative platform. These technologies allow animators to create in three-dimensional space, providing a more intuitive and free environment for character and scene design. Jing and Song [5] discussed and analyzed in detail the advantages and impacts it brings. Through case studies, the article demonstrates how this combination provides animators with more intuitive and precise design tools, thereby creating more attractive and realistic animation works. Virtual reality and augmented reality technology provide animators with an immersive creative environment, allowing designers to design and modify shapes directly in three-dimensional space. This real-time interactive feature enables designers to iterate and optimize design solutions faster, thereby improving design efficiency. Complex algebra is an important branch of mathematics with extensive applications in computer animation. Complex dynamic systems and animation effects can be described and controlled through complex algebra. Meanwhile, computer animation also requires precise data to control character actions, object motion trajectories, and scene rendering effects. Therefore, combining CAD-based computer animation behavior with complex algebra can provide more powerful technical support for animation production. Larin [6] demonstrated how to combine CAD-based computer animation behavior with complex algebra to achieve more realistic and dynamic animation effects. Firstly, we use CAD software to model the character model accurately and obtain its geometric data and motion parameters. Then, we import this data into a computer animation system and use complex algebra methods to control the actions of the characters precisely. Through functions and algorithms in complex algebra, we can describe and control the movement trajectory, posture, and facial expressions of characters. Meanwhile, we can also utilize the properties and theorems of complex algebra to optimize and adjust animations for more realistic and smooth dynamic effects. By training a large quantity of motion data, the deep learning model can generate realistic role actions and even synthesize new actions that meet specific requirements according to input conditions or constraints. The action design of animation characters based on CAD data and the realization of DM technology are the fields of animation production. It can not only significantly improve the efficiency and quality of animation production but also provide a broader creative space for animation designers through data-driven and intelligent generation methods.

Hybrid reality technology combines the characteristics of virtual reality and augmented reality, providing users with an immersive interactive experience. Digital animation and multimedia information synthesis are important parts of modern multimedia content creation, while voice data provides rich emotional and semantic information. Combining these three can bring a richer and more authentic audio-visual experience to the audience. Hybrid reality technology provides new possibilities for digital animation and multimedia information synthesis. Li and Wang [7] discussed how to use to enhance the interactivity and immersion of multimedia content. It uses 3D modeling software to create realistic 3D models and scenes, combined with animation production techniques, to make characters and objects have vivid actions and expressions. Real-time interaction between users and virtual environments is achieved through mixed-reality technology. Users can interact with virtual characters and objects through gestures, voice, and other means, creating a rich interactive experience. Integrate various media information such as digital animation, audio, and text to provide users with a comprehensive audio-visual experience. Enhance user perception and understanding through the collaborative effect of multimodal information. Through the comprehensive application and research of CAD data, DM technology, and deep learning algorithms in animation character action design, we can further reveal the inherent laws and characteristics of motion data and promote the optimization of related algorithms and models. The innovations of this research include:

(1) This article combines CAD data with DM technology and applies it to animation character action design. Traditional animation character design mainly depends on manual production, but the method proposed in this article can use the accurate 3D model provided by CAD data and combine DM technology to extract motion features, which makes the character action design more efficient.

(2) This article uses deep learning technology to learn and simulate complex motion patterns. By training a large quantity of motion data, the deep learning model can generate realistic and specific character actions, which increases the flexibility of animation character action design.

(3) Different from the traditional manual production or action design based on experience, the method in this article is data-driven. This means that the action design of animated characters is based on the analysis and mining of real motion data, thus making the generated actions more natural and realistic.

Firstly, this article introduces animation character design; secondly, it discusses the concrete realization method and technical details of DM technology in animation character action design; and finally, the practical application action design based on CAD data and DM technology is demonstrated by examples.

2 APPLICATION OF CAD DATA AND DM IN ANIMATION CHARACTER DESIGN

Animation special effects design is an important part of animation production, which can add unique visual effects and artistic style to animation works. However, traditional animation special effects design methods are often required to achieve diverse artistic styles. The emergence of AI-based style transition algorithms has brought new possibilities for animation special effects design. The style transition algorithm based on artificial intelligence is a machine learning technique that can transfer one artistic style to another image, thereby creating unique animation effects. This algorithm learns a large number of artworks with different styles, extracts style features from them, and applies these features to another image to achieve style transfer. The style conversion algorithm first needs to extract features from the source image, including color, texture, shape, etc. The extracted features need to represent the stylistic characteristics of the source image. Once features are extracted from the source image, the algorithm applies these features to the target image. By adjusting the pixel values of the target image to match the style of the source image, style conversion of the target image can be achieved. Finally, the algorithm optimizes and adjusts the converted image to ensure that it is consistent with the style of the source image and visually natural and harmonious [8]. Liu [9] utilizes light image enhancement technology to personalize animated character images according to different needs. For example, adding special effects to characters, changing clothing colors, or adjusting facial expressions to meet the needs of specific scenes or audience tastes. In interactive animations or games, real-time rendering performance is crucial. Light image enhancement technology can optimize rendering performance, reduce computational burden, and improve rendering efficiency while ensuring image quality. However, due to factors such as shooting conditions and equipment limitations, the original image may have issues such as insufficient lighting and low contrast. To address these issues, we need to perform light image enhancement on the images. It can improve the problem of insufficient or overexposed lighting, making the image more natural and clear. The brightness adjustment algorithm based on embedded image systems has the characteristics of being fast and accurate. Contrast enhancement is an important means of improving image detail representation. By adjusting the dynamic range of pixels, it is possible to enhance the sense of hierarchy and detail expression of the image. The contrast enhancement algorithm based on embedded image systems can quickly and accurately achieve this goal. Color correction can improve the color representation of images, making character images more vivid and vivid. The color correction algorithm based on embedded image systems can be personalized and adjusted according to actual needs, achieving precise color control.

Manan et al. [10] explored through experimental research how to effectively integrate CAD-based animation system design thinking and creativity. Through integrated optical image enhancement technology, various production processes can work together more smoothly. Designers, animators, and renderers can share a unified image standard to ensure that each step can work according to the same visual requirements, reducing rework caused by differences in understanding. CAD data provides designers with rich creative materials and inspiration, which helps stimulate their creativity and imagination. Through the sharing and communication of CAD data, team members can collaborate and communicate more conveniently, reducing repetitive work and conflicts. The integration of CAD-based animation system design thinking and creative methods can help improve the artistic expression and viewing value of animation works and meet the aesthetic needs of the audience. The experimental results show that by integrating CAD-based animation system design thinking and creative methods, the collaboration and standardization of the animation production process can be significantly improved, production costs can be reduced, and the artistic expression and aesthetic value of animation works can be enhanced. Regenerative medicine is a medical field that studies how to repair, replace, or enhance the function of human cells, tissues, or organs. In animation production, knowledge and techniques of regenerative medicine can be used to create more realistic human models and movements. Perez and Mejia [11] analyzed and optimized the actions of a specific animated character. It uses CAD software to finely model character models, including structures such as bones, muscles, and skin. Next, combining the knowledge of regenerative medicine, the model is subjected to biomechanical simulation to achieve more natural and realistic movement performance. In this process, we referred to real human motion data and biomechanical principles to control the skeletal movement, muscle deformation, and skin stretching of animated characters accurately. In order to further enhance the realism of the animation, computer tomography (CT) technology was adopted. By conducting CT scans on real human bodies, detailed internal anatomical structure data was obtained. These data are used to optimize the bone and muscle models of animated characters, making them closer to the physiological structure of the real human body. In addition, CT data can also help improve texture mapping and lighting effects in animations, enhancing visual quality. Traditional 3D animation character action design often relies on the experience and skills of animators, but this method has some problems. Firstly, animators need to spend a lot of time and effort to complete the design. Secondly, due to human subjectivity and differences in experience, there may be differences in the actions designed by different animators, which can affect the unity and quality of the animation. Therefore, we need a more effective method to optimize the training of 3D animation character action design. Reinforcement learning, as a machine learning method, can learn the optimal behavioral strategy through trial and error without a clear goal or reward function. Shi [12] proposed a reinforcement learning-based training optimization method for 3D animated character action design, which trains the behavior of 3D animated characters through reinforcement learning algorithms to make them more in line with natural human behavior and motion laws. The reward function is an important component of reinforcement learning, which determines the quality of the learning process. In 3D animation character action design, the reward function can be defined as the degree to which the realism and naturalness of an animated character's execution of a certain action are improved.

The character action design in film and television animation production is a crucial link. Traditional animation action design methods often rely on the performance of actors and the shooting skills of photographers, but this method has certain limitations. The emergence of VR and IoT technology has provided new possibilities for character action design. Through VR technology, virtual previews of character animation actions can be performed before shooting in order to better adjust and optimize action design. VR helmets and motion tracking technology can capture the actions of actors in real-time and convert them into digital model actions. This technique can be used to shoot some difficult or dangerous movements to avoid causing harm to actors. Through VR technology, actors can rehearse in a virtual environment to better understand the rhythm and expression of actions. This rehearsal method can greatly improve the performance level and filming efficiency of actors. In order to verify the application effect of VR and IoT technology in character action design, Song and Wook [13] conducted the realism and expressiveness of character action design, which have been significantly improved. At the same time, the application of these technologies has greatly improved shooting efficiency and the performance level of actors. Dynamic expression capture and 3D animation generation are important steps in animation production, and they play a crucial role in improving the realism and expressiveness of animation. Traditional methods for dynamic expression capture and 3D animation generation often require professional equipment and cumbersome processes, and accuracy and real-time performance are difficult to ensure. Wang and Shi [14] collected a large amount of facial expression capture data, including various expressions and emotional states of different people. These data can be obtained through professional facial expression capture devices, as well as through image or video capture. It preprocesses the collected data, including denoising, standardization, frame extraction, etc., to improve the accuracy and efficiency of subsequent learning. During the training process, the algorithm will automatically learn various features and patterns of expressions and generate corresponding models. Using trained models to process and analyze real-time collected facial data, achieving high-precision dynamic expression capture. The captured expression data can be transmitted in real time to the 3D animation generation system to achieve real-time animation generation. Machine learning-based 3D dynamic image modeling technology is a method of modeling 3D dynamic images using machine learning algorithms. Through machine learning algorithms, it is possible to learn information about the shape and motion patterns of objects from a large amount of 3D dynamic image data and automatically generate 3D models. Machine learning-based 3D dynamic image modeling technology mainly utilizes machine learning algorithms to learn and model 3D dynamic images. Among them, a deep learning algorithm is one of the most commonly used algorithms. Deep learning algorithms automatically extract information such as the shape, texture, and motion patterns of objects by training and learning from a large amount of 3-D dynamic image data and generate corresponding 3D models. Machine learning-based 3D dynamic image modeling technology can automatically generate high-quality 3D models and adjust the details and accuracy of the models as needed [15].

Wang et al. [16] explored how to use real-time virtual filming technology for film and television animation to improve the accuracy and real-time performance of multi-person motion capture, bringing more possibilities to film and television production. Multi-person motion capture technology plays an important role in film and television production, as it can provide animators with real and accurate character motion data, thereby creating dynamic and natural animation effects. However, traditional multi-person motion capture techniques have some problems, such as complex equipment, high cost, and low capture accuracy. Therefore, researching new multi-person motion capture techniques is of great significance. It combines the high precision of optical positioning with the real-time performance of inertial attitude sensors, providing animators with more accurate and real-time action data. By setting up multiple high-definition cameras at the shooting site, the target is photographed from multiple angles, and computer vision algorithms are used for real-time tracking and positioning of the target. This technology can provide high-precision position and posture information, providing animators with more accurate motion data. 2D animated films have been an important form of entertainment and artistic creation for people in the past few decades. However, with the increasing demand for visual experience from audiences, traditional methods of producing 2D animated films are no longer able to meet market demand. The emergence of deep neural networks has brought new breakthroughs to the visual representation of two-dimensional animated films. Xu et al. [17] utilized deep neural networks to learn the characteristics and styles of characters from a large amount of data, thereby generating richer and more diverse character images. By adjusting the parameters of the neural network, dynamic changes in characters can also be achieved, bringing more creative space to character design. Traditional 2D animation movie scene rendering methods are usually relatively simple and lack realism. Through deep neural networks, more complex texture, lighting, and color information can be learned, resulting in more realistic scene rendering effects. In addition, deep neural networks can also be used to achieve dynamic rendering of scenes, improving their vividness and expressiveness. Deep neural networks can learn the expression and features of emotions by analyzing a large amount of emotional data. How to accurately capture and reproduce real human dynamic behavior is the core challenge in this field. Yuan et al. [18] proposed a simulation method for 3D human animation visual technology based on enhanced machine learning algorithms, aiming to improve the realism and fluency of 3D human animation through machine learning methods. 3D human animation is an important branch of computer graphics, which involves various aspects such as human modeling, motion capture, and dynamic simulation. The traditional method of creating 3D human body animation often relies on professional equipment and complex manual operations, and the effect is difficult to achieve at a realistic level. Traditional motion capture techniques require specialized equipment and venues, while methods based on enhanced machine learning can automatically extract human pose and motion information by analyzing video or image sequences. By combining physical simulation technology, more natural and smooth motion performance can be achieved. Through deep learning techniques, subtle facial expressions can be captured and simulated, enhancing the emotional expression of three-dimensional human animation. In addition, enhanced machine learning algorithms can also be used to generate realistic skin textures, fur, and other detailed effects.

3 APPLICATION OF DM TECHNOLOGY IN ANIMATION CHARACTER ACTION DESIGN

3.1 Overview of DM Technology

Through CAD software, designers can create 3D character models with high detail and complexity. These models can include the geometric shape, texture, material, and other attributes of the character, providing a solid foundation for the subsequent animation. CAD data allows designers to control and adjust every detail of the character model accurately. This means that designers can express the shapes, proportions, and movements of characters more accurately, thus improving the visual experience of animation works. Compared with traditional manual production, role design based on CAD data can significantly improve work efficiency. Designers can use the automation tools and functions of CAD software to quickly create, edit, and modify role models. DM technology provides new possibilities and solutions for animation character action design. DM technology can extract motion features from the existing animation data, such as the trajectory, speed, and acceleration of the character. These characteristics can provide valuable reference and basis for new role action design and help designers understand the movement rules and styles of different actions. Through the analysis and mining of a large quantity of motion data, DM technology can identify different action patterns. These patterns can be general movement laws or unique action styles of specific characters. Based on the existing motion data and the mined action patterns, DM technology can predict the future actions of characters or synthesize new actions that meet specific requirements. This ability of prediction and synthesis makes the action design of animated characters more flexible and can be optimized according to the needs of the plot or the preferences of the audience.

Combining CAD data with DM technology can provide more comprehensive and accurate support for animation character action design. Based on the accurate 3D model provided by CAD data, combined with the motion characteristics and action patterns extracted by DM technology, designers can design and adjust the actions of characters more accurately. This accuracy can not only improve the quality of animation works but also enhance the audience's immersion and viewing experience. Through automation tools and functions, CAD software can significantly improve the efficiency of role modeling, And DM technology can help designers quickly find suitable action patterns and motion characteristics, thus accelerating the process of action design. Based on the motion features and action patterns extracted by DM technology, designers can create more diverse role actions. These movements can not only meet the specific needs of the plot or audience preferences but also show unique artistic style and creative expression. In the action design of animated characters, DM technology can help designers find hidden motion rules and patterns from existing animation data and provide valuable references for new action designs. DM technology includes many methods, such as classification, clustering, association rule mining, sequential pattern mining, and so on. In animation character action design, commonly used DM methods mainly include cluster analysis and sequence pattern mining. Cluster analysis can gather similar action data together to help designers identify different action patterns. However, sequential pattern mining can find the time series relationship in action data, which provides a basis for action synthesis and prediction.

3.2 Pretreatment and Feature Detection of Action Data

Before applying DM technology, the original motion data should be preprocessed and feature extracted. The main purpose of preprocessing is to remove the noise and redundant information in the data and make the data more suitable for the subsequent mining tasks. Feature detection is used to extract features related to action design from the original data, such as motion trajectory, speed, acceleration, and so on. Action synthesis refers to the generation of character actions that meet the requirements according to a given action description or reference video. In traditional animation production, action synthesis usually requires the animator to manually adjust the parameters of the character's bones, joints, and so on to achieve the required action effect. This method is not only time-consuming and labor-intensive but also difficult to use to ensure the precision and naturalness of the action. The simulation process of animated character action is shown in Figure 1.

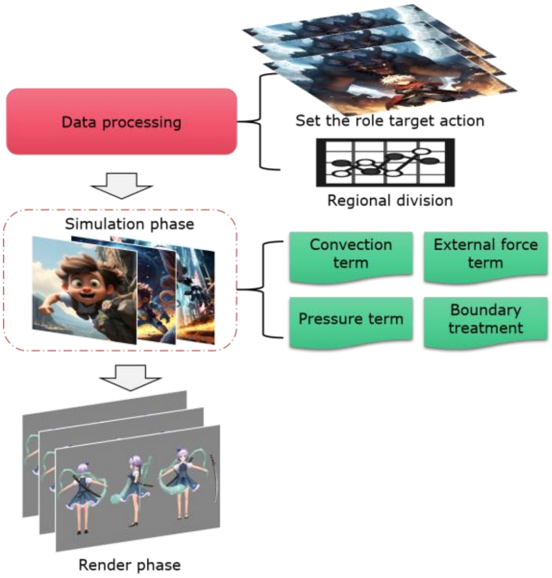

Figure 1: Schematic diagram of the simulation process.

CNN extracts local features of input data through convolution operation and gradually abstracts high-level features through multi-layer convolution, pooling, and other operations, which are finally used for classification, regression, and other tasks. In the action design of animated characters, CNN can be applied to action recognition, action synthesis, and other aspects to improve the efficiency and quality of action design. By training the CNN model, we can realize automatic recognition and classification of role actions. Specifically, the action video or image sequence of the character can be used as CNN input, and after multi-layer convolution, pooling, and other operations, the characteristic representation of the action can be obtained. Then, add a full connection layer and a classifier at the top of CNN to classify the actions. In this way, CNN can learn the subtle differences between different actions, thus improving the precision of action recognition. The CNN infrastructure is shown in Figure 2.

The movement of 3D characters depends on the movement of the skeleton. The more detailed and complex the skeleton structure, the more delicate and rich the movement posture that 3D characters can express. For simplicity, in this article, the skeleton structure of a 3D character is represented as 15 limb segments connected by 16 joint points, as shown in Figure 3.

The action synthesis method based on CNN can learn the rules of action generation from the existing action data and then use these rules to synthesize new actions. In the process of training, a large quantity of action data can be used to train the CNN model so that it can learn the characteristics and generation rules of actions. When generating a new action, you can use the required action description or reference video as input and generate the corresponding role action through the CNN model. This method can significantly improve the efficiency and quality of motion synthesis and reduce the workload of animators.

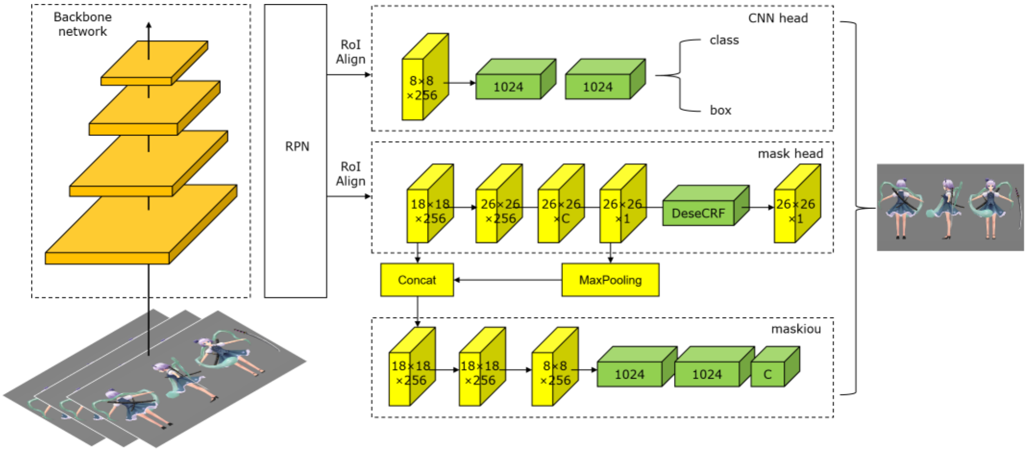

Figure 2: CNN infrastructure.

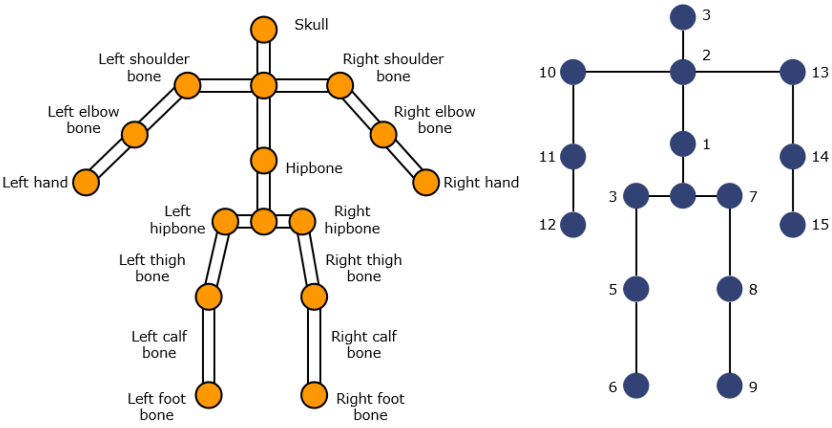

Figure 3: 3D character skeleton structure.

The 3D coordinates of human joints in animated figures can be represented through the sequential transformation of vectors in numerous local coordinate systems, which can be expressed in the second matrix form as:

$$\left[x,y,z\right]^T = T^0T^1,\cdots,T^n\left[x^{'},y^{'},z^{'}\right]^T \tag{1}$$

$$T^{'} = \sum_{i=1}^{n} w_i H_i T \tag{2}$$

$$P^t_{root}\ x,y,z\ = M^t_{root}R^t_{root}P^{t-1}_{root}\ x,y,z \tag{3}$$

$$P^t_i\ x,y,z\ = M^t_{root}R^t_{root}M^t_1R^t_1,\cdots,M^t_1R^t_1P^t_0\ x,y,z \tag{4}$$

3.3 Generation and Optimization of Role Action Based on DM

After preprocessing and feature detection of action data, we can use DM technology to generate and optimize the action of the role. DM methods, such as cluster analysis, are used to identify and classify the preprocessed action data. Through this step, designers can identify different action patterns and provide the basis for subsequent action synthesis and optimization. Based on the recognized action patterns and the extracted features, DM technology can be used to synthesize new role actions or predict the future actions of the role. This ability of synthesis and prediction makes the action design of animated characters more flexible and can be adjusted and optimized according to the needs of the plot or the preferences of the audience.

$$\begin{bmatrix} x_{11} & \cdots & x_{1q} \\ \vdots & \ddots & \\ x_{p1} & \cdots & x_{pq} \end{bmatrix} \tag{5}$$

Measuring similarity in clustering involves assessing the resemblance between objects, typically using the distance between them as the criterion for evaluation:

$$d\ i,j\ =\sqrt{\left|d\ x_{i1},x_{j1}\right|^2+\left|d\ x_{i2},x_{j2}\right|^2+\cdots+\left|d\ x_{iq},x_{jq}\right|^2} \tag{6}$$

In which, $i=\ x_{i1},x_{i2},\cdots,x_{iq}\ ,j=\ x_{j1},x_{j2},\cdots,x_{jq}$ respectively, is a q -dimensional data object.

SVM introduces the loss function, which adopts the new loss function type ε proposed by Vapnik, insensitive loss function $L\ y,f\ x$, and the expression of insensitive loss function is as follows:

$$L_\varepsilon\ y,f\ x\ =\begin{cases} 0 & if\left|y-f\ x\right|\le\varepsilon \\ \left|y-f\ x\right|-\varepsilon & \text{otherwise} \end{cases} \tag{7}$$

Where ε is the insensitive coefficient?

If there are vectors $a_1,\cdots,a_n$, $a_1^T,\cdots,a_1^T$ they can be obtained by connecting them together. The optimization problem of 3D reconstruction can be expressed by the following formula:

$$\min\sum_{k=1}^{m}\sum_{i=1}^{n}D\ m_{ki},P_kM_i\ ^2 \tag{8}$$

Where k is the quantity of photos taken at different positions; P_k is the projection matrix of the k image; The coordinates of the i 3D point denoted by M_i ; m_{ki} is the 2D coordinates of the i 3D point on the k image.

After synthesizing new role actions, DM technology can be used to optimize and adjust the actions. For example, by analyzing the action data of similar characters, we can find a more natural and smooth action expression. Or, by comparing the advantages and disadvantages of different action modes, choose an action mode that is more in line with the character and scene requirements. The generation and optimization of role actions based on DM is an iterative process. Designers need to constantly adjust and optimize the generated actions until they meet specific requirements or achieve ideal results.

4 RESULT ANALYSIS AND DISCUSSION

Figure 4 shows nine frames of original animation for feature detection of animated character action images. These animation frames capture the continuous dynamic process of the character when performing a specific action, which provides rich information for the subsequent image feature detection. In these three frames, it can be observed that the body posture and expression of the character begin to change, which indicates the upcoming action. The muscles of the character begin to tense, and they are ready for the next action. Frames 4-6 show the peak stage in the process of action execution. At this stage, the action range of the role is the largest, and the coordination of all parts of the body is also the most obvious. Through these three frames of animation, we can clearly see the dynamic changes in the character's body, such as the extension of limbs and the rotation of the body. Frames 7-9 show the ending stage of the action and the regression process of the role. At this stage, the action of the character gradually slows down and returns to the initial state. Through these three frames of animation, we can observe the gradual relaxation process of various parts of the character's body, as well as the return of expression and eyes.

Figure 4: 9 frames of original animation extracted from action images of animated characters.

Through careful observation and analysis of these nine original animations, we can find that they contain rich, dynamic information and detailed features. These features are very important for accurately recognizing and understanding the actions of the characters. Through image feature detection technology, we can extract key features related to actions from the original animation, such as body posture, motion trajectory, expression changes, and so on. These features can be used for subsequent tasks such as action recognition, classification, and synthesis and provide more accurate and efficient support for animation character action design.

Figure 5 shows the stippling effect generated under different density functions. In the evenly distributed example, the points are evenly distributed throughout the canvas. Under this distribution mode, the density of points is the same in all regions, and there is no obvious aggregation or sparseness. Therefore, the generated stippling presents a peaceful and stable visual effect. Different from uniform distribution, points under normal distribution present a bell-shaped curve distribution on canvas. In exponential distribution, the density of points decreases exponentially with the increase of the distance from a reference point. Points gather more on one side (usually left or right) and are very sparse on the other side. The distribution of points can be flexibly adjusted according to specific requirements or design goals under the self-defined distribution of graphs. For example, the distribution density of points can be defined according to the contour or color information of the image so as to generate stippling works with unique visual effects and expressive force.

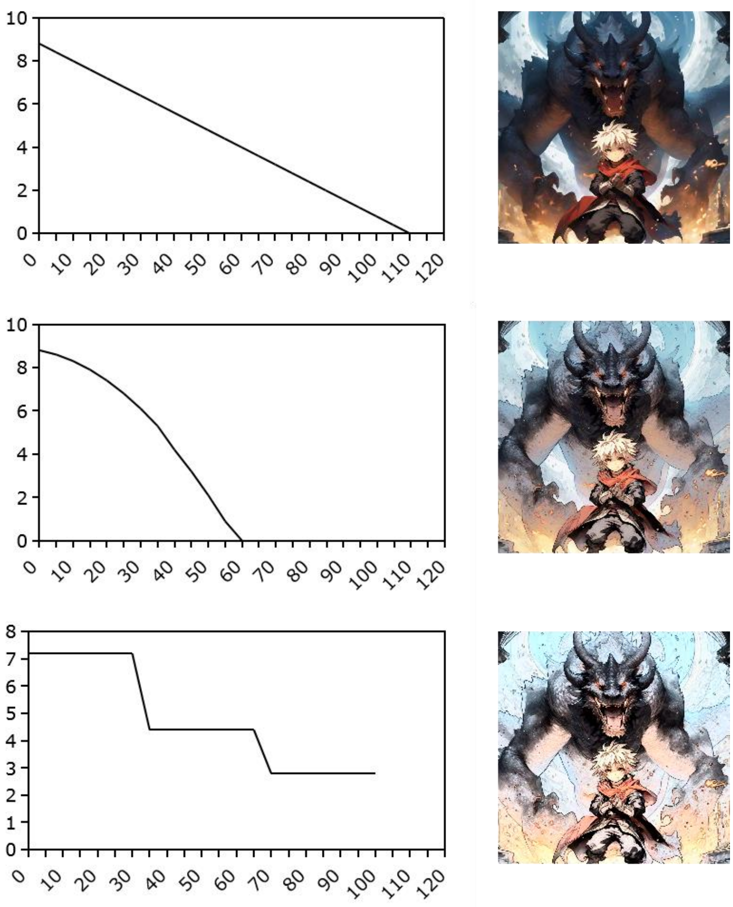

Figure 5: Stippling effect generated by different density functions.

Number of hidden layer nodes	*Average accuracy rate*	*Average recall rate*
25	55.7%	58.4%
50	57.8%	52.3%
100	59.4%	57.6%
150	62.5%	58.8%
200	65.2%	63.1%
250	60.5%	57.7%
300	58.5%	55.2%

Table 1: The results of the first layer self-encoder in the feature detection of animated character action images.

According to the data analysis in Table 1, when the quantity of hidden nodes in the first layer of the self-encoder is 200, the average precision and recall of feature recognition reach 65.2% and 63.1%, respectively, which are the highest values among all self-encoders, indicating that the encoder at this time has the best expression ability. When the quantity of hidden nodes is small, the network may not fully express all the information of the image, resulting in the loss of the original information. On the contrary, too many hidden nodes may produce redundant or useless information, which may lead to errors in feature classification or feature matching. Therefore, we set the quantity of nodes of the first layer self-encoder to 200 and train the second layer self-encoder on this basis. See Table 2 for the experimental results of the second layer self-encoder.

Number of hidden layer nodes	*Average accuracy rate*	*Average recall rate*
25	56.4%	55.5%
50	57.6%	52.4%
100	58.7%	59.1%
150	63.4%	62.1%
200	62.3%	61.2%
250	61.7%	57.7%
300	57.8%	56.5%

Table 2: The results of the second layer self-encoder in the feature detection of animated character action images.

According to the analysis in Table 2, when the quantity of hidden nodes of the second layer self-encoder is set to 150, the average precision and recall of feature recognition reach 63.4% and 62.1%, respectively, which are the highest values among all self-encoders, showing the superior expressive ability of the encoder at this time. Therefore, we fixed the quantity of nodes of the second layer self-encoder at 150 and trained the third layer self-encoder on this basis. See Table 3 for the experimental results of the third layer self-encoder.

Number of hidden layer nodes	*Average accuracy rate*	*Average recall rate*
25	56.1%	55.5%
50	57.2%	54.4%
100	58.7%	59.1%
150	63.1%	61.9%
200	62.1%	60.5%
250	60.2%	57.9%
300	57.8%	57.1%

Table 3: The results of feature detection of animated character action images by the third layer self-encoder.

According to the data analysis in Table 3, when the quantity of hidden nodes of the third layer self-encoder is set to 150, the average precision and recall of feature recognition reach 63.1% and 61.9%, respectively, which are the highest values among all self-encoders, indicating that the encoder at this time has the best expressive ability. Therefore, we fixed the number of nodes of the third layer self-encoder at 150. To sum up, when the quantity of nodes in the first, second, and third self-coding layers is 200, 150, and 150, respectively, the effect of feature detection by neural network is optimal. With the increase of network layers, the feature recognition ability of the system is gradually improved.

Figure 6 shows the error comparison between the SVM algorithm and this algorithm in the modeling process. The error curve of this algorithm is below the SVM algorithm as a whole. This means that under the same experimental conditions, the algorithm in this article has lower modeling errors. The low error usually means that the model has a stronger fitting ability to the data and can capture the internal law and structure of the data more accurately.

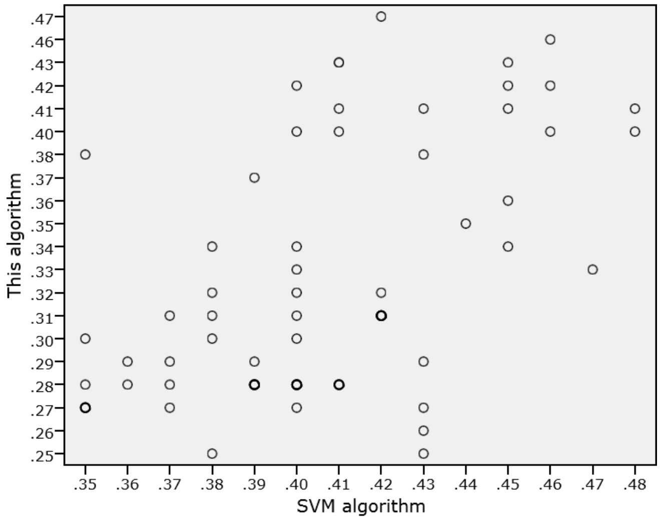

Figure 6: Error situation of the algorithm.

Figure 7 shows the comparison of the two algorithms in modeling precision. The precision curve of this algorithm is always higher than the SVM algorithm. High precision means that the model can identify the characteristics and patterns of data more reliably so as to make more accurate prediction and classification.

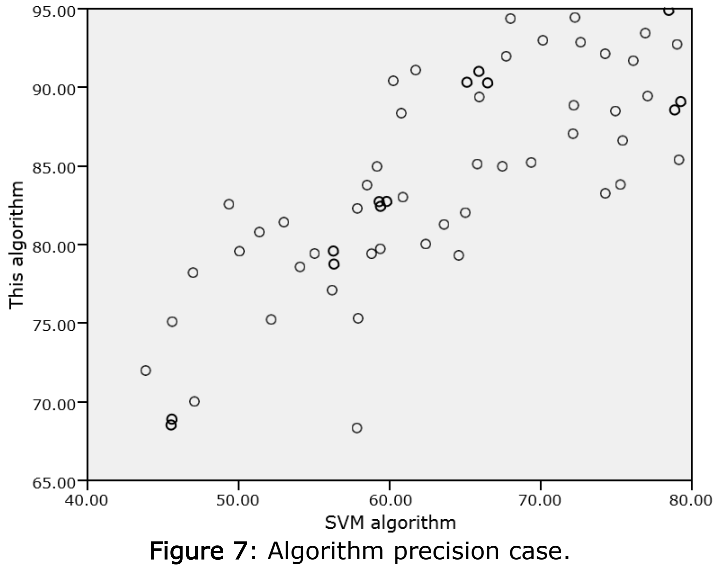

Figure 7: Algorithm precision case.

Compared with the SVM algorithm, this algorithm shows lower error and higher precision in the modeling process. This shows higher advantages in dealing with similar problems.

Figure 8 shows the specific comparison between the SVM algorithm and this algorithm in response speed. The response speed is one of the important indexes to evaluate the performance of the algorithm, especially in a scene that needs real-time processing or large-scale data processing. The response curve of this algorithm is steeper than that of the SVM algorithm, which means that this algorithm can give a faster response at the same time. This fast response ability makes it advantageous in dealing with large-scale data sets or applications that need real-time feedback.

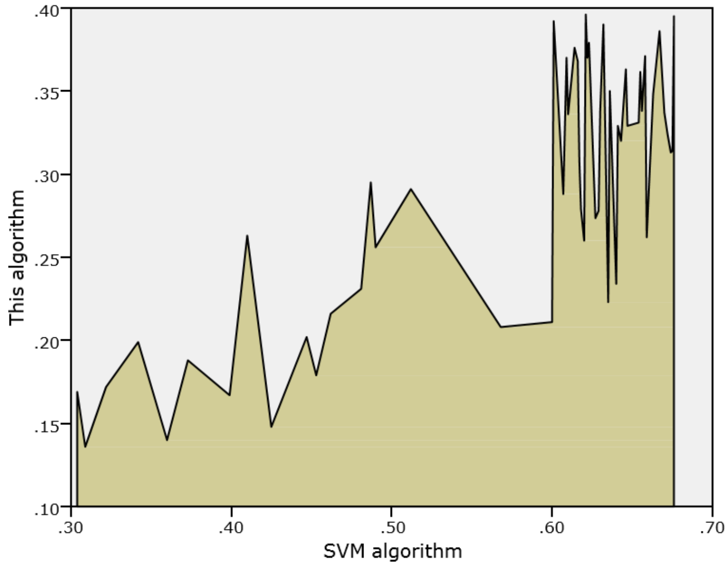

Figure 8: Comparison results of algorithm response speed.

Compared with the SVM algorithm, this algorithm shows obvious advantages in response speed. This fast response makes it practical applications, especially in scenes with high requirements for operational efficiency.

5 CONCLUSION

As a unique art form, animation presents dynamic visual effects through continuous pictures, which have become an indispensable part of multimedia industries such as movies, games, and advertisements. In this article, CAD data and DM technology are combined and applied to animation character action design. By training a large quantity of motion data, the deep learning model can generate realistic and specific character actions, which increases the flexibility of animation character action design. In the aspect of modeling error, this algorithm has a lower error than the SVM algorithm. In terms of modeling accuracy, the algorithm in this article also shows superiority. In response speed, the algorithm in this article shows obvious fast response characteristics. The realization of these advantages benefits from the innovation and improvement of the algorithm in data structure, calculation logic, or optimization strategy. Through more effective data structure, simpler calculation logic, or more efficient optimization strategy. The algorithm in this article not only improves prediction accuracy but also significantly improves operation speed, thus showing stronger competitiveness in practical applications.

Compared with the SVM algorithm, this algorithm has obvious advantages in modeling error, modeling accuracy, and response speed. These results provide strong support for further theoretical analysis and practical application, as well as new ideas for research and development in related fields.

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Baoshan Zhang, https://orcid.org/0009-0003-6808-436X
Lu Weng, https://orcid.org/0009-0008-2458-9725

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