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Computer-Aided Design AND APPLICATIONS

Digital Remodeling of Dance Based on Multimodal Fusion Technology

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Abstract. This paper aims to explore the application of computer-aided multimodal fusion technology in the digital remodeling of dance art so as to realize high-precision digital expression and innovative development of dance art. In this paper, a complete 3D reconstruction algorithm of dance art is designed and implemented, including key technologies such as multimodal data collection and processing, dance movement capture and recognition, 3D model reconstruction and optimization, and multimodal fusion strategy of dance scenes. Through the processing of experimental data sets and the demonstration of application cases, the advantages of this method in reconstruction accuracy, realism, action consistency, and scene fusion are proved. In the simulation experiment, the realism score is 9.4, the action consistency score is 9.7, and the scene fusion score is 9.1. At the same time, in terms of reconstruction accuracy, the proposed algorithm reaches 0.98. In terms of running time, the algorithm can also achieve a faster processing speed (0.28ms). The research results show that the designed algorithm can provide new technical support for the digital inheritance and innovation of dance art.

Keywords: Dance Art; Digital Remodeling; Three-Dimensional Reconstruction Algorithm; Multi-Modal Fusion; Computer-Aided Technology
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1 INTRODUCTION

Computer-aided technology refers to the technology of using computer hardware and software to assist with specific tasks. In the field of dance art, computer-aided technology is mainly used in the capture, analysis, and reconstruction of dance movements [1]. Through high-precision motion capture equipment, the dancer's motion data can be obtained in real-time, and then the motion can be analyzed and reconstructed by a computer algorithm to realize the digital expression of dance art. Multi-modal fusion technology refers to the technology of fusing information from different sensors or data sources to obtain more comprehensive and accurate information [2]. In the digital reconstruction of dance art, multimodal fusion technology can be applied to the reconstruction of dance scenes and the synchronous capture of dancers' expressions and movements. By fusing the information of different modes, the realism and expressiveness of digital remodelling of dance art can be improved [3]. In the past decade, the field of computer vision has shown a high level of research enthusiasm for analyzing visual information of human behaviour. Among them, visual-based human action recognition (HAR), as the core link of human behaviour analysis, has shown a wide range of needs in many application scenarios. This method focuses particularly on achieving precise recognition of individual dance movements from skeletal data composed of 3D positions of body joints [4]. The introduction of this concept aims to reduce the difficulties in recognition caused by unusual dance action structures and further improve the accuracy of recognition. The effectiveness and superiority of this method in the field of digital recognition of dance movements have been fully validated through extensive experiments conducted on two widely recognized benchmark datasets - MSR Action Pairs and MSR Daily Activity3D [5]. The introduction of this concept aims to reduce the difficulties in recognition caused by unusual dance action structures and further improve the accuracy of recognition. Traditionally, HAR mainly relies on image data captured by traditional cameras. However, with the advancement of technology, depth sensors have now been used as auxiliary information sources for cameras, injecting new vitality into HAR. In order to further optimize the performance of the model, this article innovatively proposes the concept of "meta paths" in complex networks. In response to this development trend, scholars in this section have proposed an innovative method aimed at extracting features of RGB-D information through complex networks, in order to significantly improve the performance of digital recognition of dance movements. These experimental results not only demonstrate the technical value of the method but also lay a solid foundation for its promotion in practical applications [6].

IMU devices can capture real-time multi-dimensional data such as dancer's body posture, rotational speed, and acceleration, combined with IoT technology. This instant feedback mechanism helps students quickly adjust their actions and improve learning efficiency. Ensuring the accuracy of data collected by IMU devices and synchronizing data between devices is the primary challenge. Need to optimize the equipment calibration process, use high-precision sensors, and develop efficient data synchronization algorithms [7]. These data are wirelessly transmitted to the processing centre to achieve precise digitization of dance movements. This lays a solid foundation for subsequent action analysis, comparison, and evaluation. This flexibility ensures the application value of the system in different dance fields. Furthermore, by extending the algorithm model (such as combining deep learning techniques such as CNN), it is possible to effectively identify and evaluate dance styles that contain large, high-energy features. By comparing the differences between student dance movements and the teacher's demonstration or standard dance database, the system can autonomously identify deviations and deficiencies in student movements and provide targeted improvement suggestions. Our proposed DAR (Intelligent Dance Activity Recognition) framework is not only applicable to dance forms known for their softness and fluency [8]. The diversity and complexity of dance movements, especially those involving rapid transformation and fine control, place extremely high demands on the accuracy of recognition algorithms. This requires optimizing the data processing process, reasonably allocating computing resources, and exploring new computing models such as edge computing. The system needs to have the ability to process large amounts of data in real time to meet the demand for real-time feedback in dance teaching. It is necessary to continuously iterate the algorithm model, introduce more advanced deep learning techniques, and improve the ability to capture complex action features [9].

Dance, as an art form that combines artistic expression with body language, has strict requirements for recognition systems due to its highly dynamic and diverse movements. It aims to deeply analyze video data through advanced image processing and classification recognition technology, in order to achieve precise capture and understanding of complex and variable human motion patterns. In the vast field of computer vision, high dynamic dance motion recognition is undoubtedly a highly challenging task [10]. As a cutting-edge exploration in this field, digital recognition of dance movements not only requires us to capture and analyze the external form of dance movements, but also to deeply understand their internal rhythm, power, and emotional expression. Multi-feature fusion, as the name suggests, refers to the effective integration of feature information from different dimensions and levels in video data to more comprehensively and meticulously depict the complex characteristics of dance movements. Audio features, such as rhythm and pitch, are used to reflect the synchronization and emotional resonance between dance and music. The introduction of video multi-feature fusion technology provides strong support for achieving this goal [11]. The optical flow direction histogram (HOF) feature is used to analyze the motion patterns of pixels or feature points between consecutive frames. These features may include but are not limited to directional gradient histogram (HOG) features, which are used to capture gradient distribution information in local areas of the image. Under the framework of "Digital Recognition of Dance Actions", we focus on researching a high-dynamic dance action recognition method based on video multi-feature fusion. This model can not only capture the subtle differences in dance movements, such as the gentle waving of hands and the light jumping of feet but also understand the internal relations and logical sequence between actions, so as to achieve a comprehensive identification and analysis of highly dynamic dance behaviours [12].

Today, with the rapid development of digitalization, dance art, as an important part of traditional culture, is also facing the needs and challenges of digital remodelling. At present, the digital remodelling of dance art has made some achievements, such as virtual reality dance performances and digital dance museums. However, there are still many challenges, such as high-precision capture and reconstruction of dance movements, realistic expression of dance scenes, and interaction between dancers and the virtual environment. In order to solve these challenges, we need to constantly explore new technologies and methods, and promote the deep integration of technology and art.

The continuous innovation of computer-aided technology and multimodal fusion technology provides new possibilities for the digital reconstruction of dance art. The purpose of this study is to explore how to use these advanced technologies to digitally reshape dance art in order to realize the inheritance, innovation and development of dance art. This not only helps to enrich the expressions of digital culture and art but also provides a new way for the popularization and promotion of dance art. The innovation of this paper is mainly reflected in the following aspects:

(1) Computer-aided multimodal fusion technology is introduced into the digital reconstruction of dance art, which realizes the high-precision synchronization and fusion of dance movements, expressions, sounds and virtual scenes, and significantly enhances the sense of realism and immersion of reconstruction.

(2) A complete three-dimensional reconstruction algorithm of dance art is designed and implemented. The algorithm is innovative in data processing flow, calculation strategy and model optimization, which effectively improves the reconstruction accuracy and operation efficiency, and makes the reconstructed dance model more realistic and more coherent.

(3) The experimental data set including various dance types, different dancers and various scenes is constructed, and a comprehensive evaluation index system is established, which provides an objective and comprehensive standard for the performance evaluation of the three-dimensional reconstruction algorithm of dance art.

(4) This paper expands and explores the application scenarios of digital remodelling of dance art, which is not only applied to virtual reality dance performances but also covers digital dance museums, dance teaching and other fields, fully demonstrating the potential and value of digital remodelling of dance art.

To sum up, this paper has made many innovations in the field of digital remodelling of dance art, which not only promoted the development of related technologies but also provided new technical support and ideas for the inheritance, innovation and development of dance art.

This paper is divided into seven sections, and systematically studies the related technologies and applications of digital remodeling of dance art. The first section expounds the research background and significance, defines the research content and objectives, and introduces the organizational structure of the article. The second section summarizes the relevant research status and the specific content of this paper. The third section to the fifth section is the core part, which introduces the design idea and implementation process of the three-dimensional reconstruction algorithm of dance art proposed in this study in detail and analyzes the experimental results in depth. The sixth section verifies the effectiveness and application effect of the algorithm in the digital remodelling of actual dance art through application cases and demonstrations. The seventh section summarizes the research achievements and shortcomings, which provides a reference for the follow-up research.

2 RELATED WORK

In the context of digital recognition of dance movements, existing keyframe-based motion synthesis techniques have shown certain effectiveness in generating cyclic and short-term movements such as walking and running. However, when faced with complex and varied dance performances and highly improvised martial arts movements, the resulting movements often appear mechanical, lacking natural fluency and diversity. To address this challenge, Reshma et al. [13] proposed an innovative dance action generation network based on multiple constraints, which deeply integrates the concept of dance action number recognition. The LSTM unit is responsible for encoding dance pose information from historical frames into latent space, extracting key action features and dynamic patterns. The core of this method lies in its unique network architecture design, which combines the sequence modelling ability of recursive neural networks and the global context capture advantage of Transformer architecture. The second LSTM unit predicts and generates the next frame's human pose based on this encoding information, ensuring the coherence and rationality of the actions. Specifically, our network architecture is based on a layered RNN module, which consists of two Long Short-Term Memory (LSTM) units. Su et al. [14] utilized the powerful self-attention mechanism of the Transformer to capture and understand the movement trajectory of dancers throughout the entire performance process, ensuring that the generated dance movements are spatially coordinated and consistent. The controller focuses on constraining the speed factor, finely adjusting the speed changes of actions, making the generated dance more expressive and emotional, and more closely linked to the improvisation and changes of real dance. This is mainly because these traditional methods are difficult to capture and reproduce the inherent rhythm, rhythm, and dynamic changes of high-dimensional nonlinear dance action data. It aims to achieve highly diverse and natural dance synthesis by learning rich dance data.

The rapid development of Internet of Things technology is profoundly changing people's way of life, and its importance in dance data management is self-evident. Based on these rich data resources, Tan and Yang [15] utilized computer-aided technology to deeply analyze the biomechanical parameters of dance movements, thereby constructing a more refined dance motion capture system. This system can not only capture complex movements such as rotations and jumps of dancers in real-time, but also extract multidimensional features of dance movements in terms of time, space, gravity, and smoothness through advanced algorithms. Under the framework of dance action digital recognition, IoT technology achieves a comprehensive and accurate collection of dance action data through ubiquitous sensor networks. On this basis, it established a digital description model for human dance movements and defined the characteristics and structure of dance movements in formal language, providing a solid theoretical basis for accurate recognition and scientific analysis of dance movements. These features not only reflect the external form of dance movements but also reveal the inherent laws of motion and aesthetic value of dance movements. The implementation of dance action number recognition not only provides new perspectives and tools for dance teaching but also promotes innovation and optimization of training methods. These data cover every subtle movement of the dancer, from the position and speed of the limbs to the distribution of strength, all of which are carefully recorded. The construction of the Internet of Things not only greatly promotes the intelligent and efficient management of dance data, but also injects new vitality and standards into the field of dance teaching, leading to the deep integration of dance art and modern technology. At the same time, this technology also provides unlimited possibilities for dance creation and arrangement, allowing dance art to integrate more modern elements while maintaining traditional charm, presenting a more diverse and rich appearance. By analyzing the data characteristics of dance movements, Wang and Dong [16] tailored personalized training plans for dancers to help them better master dance techniques and improve their performance level.

In order to explore the innovative impact of artificial intelligence in the field of dance robot choreography, Xu and Zheng [17] focused on constructing a dance choreography imagination model for bipedal humanoid robots. The core of this model lies in using deep learning algorithms to simulate human creative thinking processes. It can not only accurately analyze and identify existing dance action data, but also creatively imagine and generate new dance elements on this basis. This model deeply integrates digital recognition technology for dance movements, psychological construction concepts, and advanced human-computer interaction (HCI) strategies. Analyze the multidimensional characteristics of dance movements, such as posture, rhythm, and intensity, to provide rich data support for subsequent imagination and choreography. This model can effectively extract keyframe information from massive dance videos by integrating digital recognition technology for dance movements. On this basis, the model utilizes the powerful capabilities of deep learning networks to simulate the fusion, recombination, and innovation of dance elements by human dancers during the choreography process, achieving automatic generation and optimization of dance movements. To further validate the effectiveness of the model, Yang [18] designed a series of simulation experiments and invited senior dance professionals to evaluate the dance postures imagined and generated by robots.

At present, some achievements have been made in the application of computer-aided technology in the field of dance art, such as dance action capture and virtual reality dance performance. At the same time, multi-modal fusion technology is constantly developing, which provides more possibilities for the digital remodelling of dance art. However, how to effectively apply relevant technologies to the digital remodelling of dance art and realize the perfect combination of technology and art is still an important topic of current research. In the future, with the continuous progress of technology, the digital remodelling of dance art will be more in-depth and bring a more colourful visual experience to the audience. The main contents of this study include: exploring the application of computer-aided technology and multimodal fusion technology in the digital remodelling of dance art; Designing and implementing a three-dimensional reconstruction algorithm of dance art based on these technologies; The algorithm is verified by experiments and its effect and performance are analyzed. The research objectives are as follows: (1) to propose an effective digital remodelling method of dance art to realize high-precision capture and three-dimensional reconstruction of dance movements; Through multi-modal fusion technology, the realism and expressiveness of digital remodelling of dance art are enhanced; Provide new technical support for the inheritance, innovation and development of dance art.

3 THREE-DIMENSIONAL RECONSTRUCTION OF DANCE ART

This section aims to design a 3D reconstruction algorithm for dance art based on computer-aided multimodal fusion technology. The overall framework of the algorithm includes the key steps of multimodal data collection and processing, dance movement capture and recognition, 3D model reconstruction and optimization, and multimodal fusion strategy of dance scenes. Through this framework, it is expected to realize the high-precision digital remodelling of dance art and bring a more real and vivid visual experience to the audience.

Multi-modal data acquisition and processing

In the multi-modal data acquisition stage, this section uses high-precision motion capture equipment, depth camera, audio acquisition equipment, etc., to synchronously collect multi-modal data such as dancers' movements, expressions, sounds, and scene environment. These data will serve as the basis for subsequent 3D reconstruction and multimodal fusion. In the data processing stage, preprocessing operations such as denoising, synchronization, and registration will be carried out on the collected data to ensure its accuracy and consistency.

Denoising usually involves removing the random noise in the signal, and the commonly used methods include moving average, median filtering, and Gaussian filtering. Moving average denoising:

$$\text{Denoised Signal} = \frac{1}{N}\sum_{i=1}^{N} x_i \tag{1}$$

Where x_i is the i value of the original signal and N is the window size.

Median filtering denoising: for an input signal sequence, take a fixed window, sort all the values in the window, and take the median as the output.

Gaussian filtering denoising;

$$\text{Denoised Signal} = \frac{1}{K}\sum_{i=1}^{K} e^{-\frac{(i-M)^2}{2\sigma^2}x_i} \tag{2}$$

Where x_i is the i value of the original signal, K is the window size, M is the index value of the window centre, and σ is the standard deviation of the Gaussian function. Scaling is a method of linear interpolation in two directions. Assuming that four points $Q_{11}, Q_{12}, Q_{21}, Q_{22}$ are known, we need to interpolate to point $P(x,y)$:

$$f(P) \approx \frac{f(Q_{11})(x_2-x)(y_2-y)\, f(Q_{21})(x-x_1)(y_2-y) + f(Q_{12})(x_2-x)(y-y_1)}{(x_2-x_1)(y_2-y_1)} \tag{3}$$

Normalization is an important step in data preprocessing. Its purpose is to scale the data to a small range in order to improve the performance and convergence speed of the algorithm. In machine learning and data analysis, normalization is usually used to standardize the scale of features so that the model will not be strongly affected by the size of feature values. Normalization Scales the value of a feature to the range of [0,1]:

$$X_{\text{norm}} = \frac{X - X_{\min}}{X_{\max} - X_{\min}} \tag{4}$$

Where X_{norm} is the original data, $X_{\min}$ and $X_{\max}$ are the minimum and maximum values in the data set respectively.

Capture and recognition of dance movements

The capture of dance movements is a key step in the three-dimensional reconstruction of dance art. This section uses computer vision technology and machine learning algorithms to capture and identify the collected dance movement data in real-time. Specifically, this paper uses the optical flow method to track the movement of pixels in the image, identify actions by feature extraction, and classify keyframes with a convolutional neural network (CNN). You can get the results of action recognition.

The optical flow method is used to track the motion of pixels in images. It works by calculating the motion vector of each pixel in an image between two consecutive frames. The core of the optical flow method is to calculate an optimization problem, which is usually solved by the gradient descent method:

$$\vec{v} = \arg\min_{v}\sum_{p}\left\|\vec{u}(p,t) - \vec{u}(p,t-1) + \vec{v}(p)\right\|^2 \tag{5}$$

Where $\vec{v}$ is the optical flow field, $\vec{u}(p,t)$ and $\vec{u}(p,t-1)$ are the image positions of time t and $t-1$ point p, respectively; $\|\cdot\|^2$ stands for the square of Euclidean distance.

In dance action recognition, feature extraction is to extract information from the image that is helpful to identify the action. In deep learning, a convolutional neural network (CNN) is often used to extract features automatically. CNN is a deep learning model, especially suitable for image recognition tasks. It learns feature representation through multiple convolutions and pooling layers and fully connected layers and finally classifies them. In dance action recognition, CNN can be used to classify keyframes to identify specific actions. The basic operations of CNN include convolution and pooling.

Convolution operation: convolution of the convolution kernel and the input image to obtain a feature map:

$$F = \text{\convolution} \ \text{I,K} \tag{6}$$

Where F is the feature map, I is the input image, and K is the convolution kernel?

Pooling operation: Downsampling the feature map to reduce the spatial dimension of the feature;

$$P = \text{\pooling} \ F \tag{7}$$

Where P is the characteristic diagram after pooling? Activation functions, such as ReLU, are used to increase the nonlinearity of the model:

$$A = Max \ \ 0, X \tag{8}$$

Where A is the activated feature and X is the input feature. The fully connected layer linearly transforms the features and applies the activation function:

$$O = \theta^T A + b \tag{9}$$

Where O is the output, θ and b are the weights and offsets, respectively?

By extracting key frames, tracking motion trajectories, and other technical means, we can accurately capture every subtle movement of the dancer and provide accurate data support for subsequent 3D model reconstruction.

3D model reconstruction and optimization

In the stage of three-dimensional model reconstruction, according to the captured dance movement data, the dancer's body, clothing, props, and so on are accurately reconstructed by using computer graphics technology and three-dimensional modeling software. The three-dimensional modelling of dancers is shown in Figure 1.

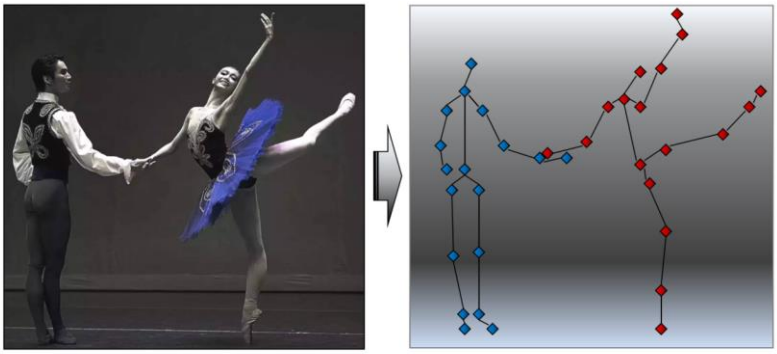

Figure 1: Three-dimensional modeling of dancers.

At the same time, this paper also optimizes the reconstructed model, including improving the detail expression of the model, optimizing the texture and lighting effects of the model, etc., to ensure the realism and vividness of the model.

Multi-modal fusion strategy of dance scenes

In order to achieve the perfect integration of dance art and virtual environment, this section adopts multimodal fusion technology. Specific strategies include: synchronizing the dancer's movements, expressions and sounds with the virtual scene in real time; Using deep learning and computer vision technology to realize the interaction between dancers and the virtual environment; By optimizing the rendering technology, the realism and immersion of the dance scene are improved. Through the implementation of these strategies, we can create an immersive digital experience of dance art for the audience.

4 THE REALIZATION OF THE THREE-DIMENSIONAL RECONSTRUCTION ALGORITHM OF DANCE ART

This section will introduce the realization process of the 3D reconstruction algorithm of dance art in detail.

In terms of hardware, this paper adopts high-precision motion capture equipment, depth camera and audio acquisition equipment to ensure the accuracy and real-time performance of data acquisition. In terms of software, professional 3D modelling software, computer vision library and machine learning framework are selected to support the development and implementation of the algorithm. Data preprocessing is an important step to realize the algorithm. We have achieved data denoising, synchronization, registration and other preprocessing operations to ensure the consistency and accuracy of the collected multimodal data. At the same time, a data visualization tool is developed to analyze and evaluate the preprocessed data intuitively.

In the stage of dance action analysis and modelling, this paper uses computer vision technology and machine learning algorithms to deeply analyze and process the preprocessed dance action data. By extracting key frames, tracking motion trajectories and other technical means, we can accurately capture every subtle movement of the dancer. Subsequently, the dancer's body, clothes and props were accurately reconstructed by using three-dimensional modelling software.

The three-dimensional reconstruction module is the core part of algorithm implementation. In this paper, the three-dimensional reconstruction of dancers is realized according to the captured dance action data and three-dimensional modelling results. At the same time, the reconstructed model is optimized, such as improving the detail expression of the model, and optimizing the texture and lighting effects of the model, as shown in Figure 2.

Figure 2: Comparison before and after optimization treatment.

Through the realization of this module, we have successfully obtained a realistic and vivid three-dimensional model of dancers.

In order to realize the perfect fusion of dance art and virtual environment, this paper adopts multi-modal fusion and rendering technology. We synchronized the dancer's movements, expressions and sounds with the virtual scene in real-time, and realized the interaction between the dancer and the virtual environment. At the same time, the rendering technology is optimized to improve the realism and immersion of the dance scene. Through the implementation of these technologies, an immersive digital experience of dance art has been successfully created.

5 EXPERIMENTAL RESULTS AND ANALYSIS

In order to comprehensively evaluate the performance of the designed 3D reconstruction algorithm of dance art, this section constructs an experimental data set containing various dance types, different dancers, and various scenes. These data sets cover a wealth of dance movements, expressions, and sound information, as well as the corresponding scene environment data. In the aspect of the evaluation index, several dimensions such as reconstruction accuracy, realism, action consistency, scene fusion degree and algorithm running time are selected to ensure the comprehensive evaluation of algorithm performance.

Figure 3 shows the reconstruction accuracy.

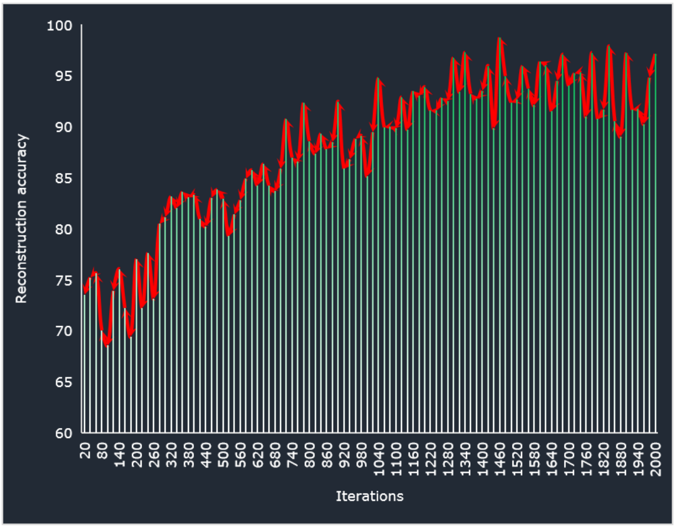

Figure 3: Reconstruction accuracy.

Table 1 shows the scores of realism, action coherence and scene fusion.

Evaluation Metric	*Score (out of 10)*	*Evaluation Description*
Realism	9.4	The reconstructed dancer model appears realistic with detailed textures, natural lighting and shadowing effects, smooth dynamic effects, and high similarity to the real dancer.
Motion Coherence	9.7	The reconstructed dance movements are smooth and natural, with seamless transitions between actions and no obvious stuttering or discontinuity, highly consistent with the original dance movements.
Scene	9.1	The dancer's movements harmoniously coordinate with the

Fusion	elements in the virtual scene. The scene layout is reasonable, and the integration of sound and scene is natural, providing viewers with an immersive viewing experience.

Table 1: Realism, action coherence and scene fusion score.

By analyzing the contents of the table, we can draw the following conclusions:

Realistic score:

The score is 9.4, which shows that the reconstructed dancer model performs well in appearance, texture, lighting and shadow effects, and has high similarity with the real dancer. This shows that the algorithm has done a good job in capturing and reconstructing the details of dancers, and can present realistic dynamic effects.

Action consistency score:

The score is 9.7, which is the highest among the three evaluation indexes. This shows that the reconstructed dance movements are smooth and natural, the transition between movements is smooth, and there is no obvious jam or fracture. The algorithm is excellent in maintaining the continuity of dance movements and can accurately restore the essence of the original dance movements.

Scene fusion score:

The score is 9.1, which is also relatively high. This shows that the dancer's movements are in harmony with the elements in the virtual scene, the scene layout is reasonable, and the integration of sound and scene is quite natural. The algorithm performs well in the fusion of dance movements and virtual scenes, which can bring an immersive viewing experience to the audience.

To sum up, the three-dimensional reconstruction algorithm of dance art performs well in realism, movement coherence, and scene fusion and has a high score. This fully proves the effectiveness and practicability of the algorithm and provides new technical support for the digital remodelling of dance art. Figure 4 shows the running time of the algorithm.

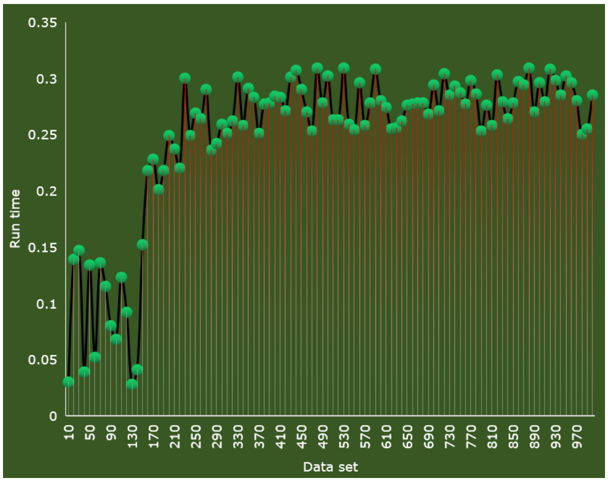

Figure 4: Algorithm running time.

By processing the experimental data set, the three-dimensional reconstruction model of the dancer is obtained. From the perspective of reconstruction accuracy, the model can accurately capture the details of the dancer's movements and body contours, which is highly consistent with the original dance movements. In the aspect of realism, the reconstructed dancer model presents a realistic appearance and dynamic effect by optimizing the texture, lighting and shadow effects of the model. At the same time, the evaluation of movement consistency also shows that the reconstructed dance movements are smooth and natural, and there is no obvious jam or fracture.

In the aspect of multimodal fusion, this paper synchronizes and fuses the dancer's movements, expressions and sounds with the virtual scene in real-time, and the result is shown in Figure 5.

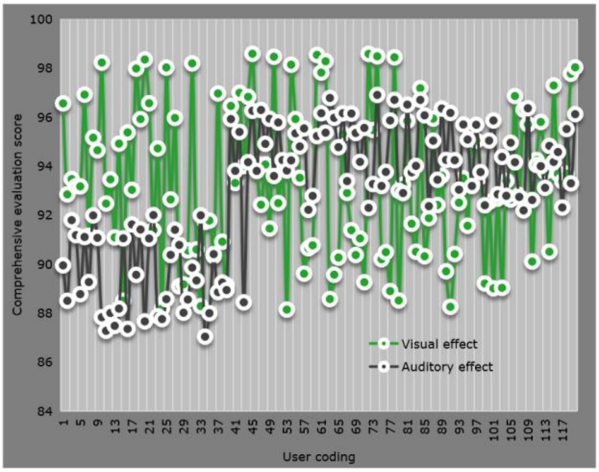

Figure 5: Comprehensive evaluation results of visual effect and auditory effect.

Through the comprehensive evaluation of visual effects and auditory effects, it can be found that the fused dance scene has a high degree of realism and immersion. The dancer's movements echo each other with the elements in the virtual scene, forming a harmonious whole. At the same time, the integration of sound and scene further enhances the audience's immersion experience.

The performance of the designed algorithm is compared with the existing three-dimensional reconstruction algorithm of dance art.

The comparison of reconstruction accuracy is shown in Figure 6.

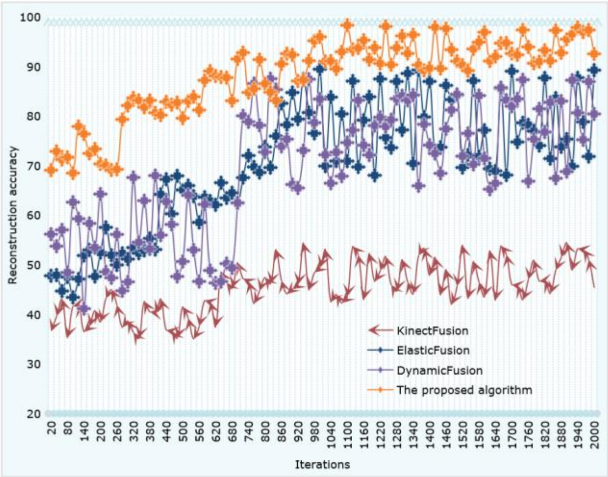

Figure 6: Comparison of reconstruction accuracy.

The running time comparison of the algorithm is shown in Figure 7.

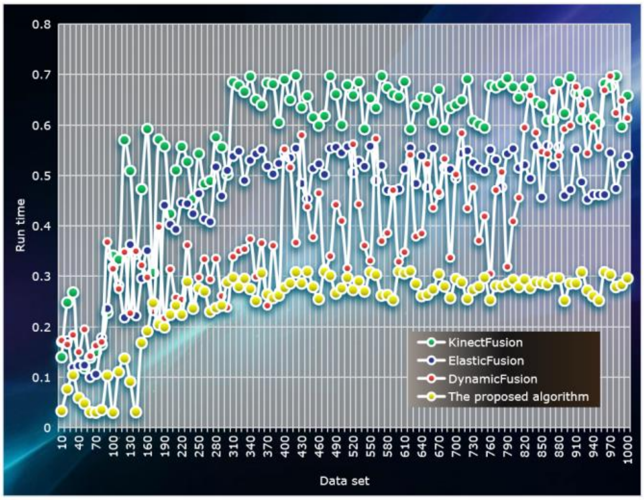

Figure 7: Comparison of algorithm running time.

It can be seen that the proposed algorithm achieves 0.98 in terms of reconstruction accuracy, showing obvious advantages. At the same time, in terms of the running time of the algorithm, the algorithm in this paper can also achieve a faster processing speed (0.28ms) on the premise of ensuring the reconstruction quality. This is due to the optimized data processing flow and efficient calculation strategy in this algorithm.

6 APPLICATION CASES

6.1 Typical Case Analysis

The application scenarios of digital remodelling of dance art are extensive and diverse. It can be applied to the virtual reality dance performance, bringing the audience an immersive viewing experience. It can also be used in the digital dance museum to show the history and development of dance through the three-dimensional reconstructed dancer model. It can also be used in dance teaching to help students better understand and master dance movements.

This section takes the virtual reality dance performance as an example for in-depth analysis. In this case, we use the designed algorithm to reconstruct the dancer's movements, expressions and sounds with high precision and fuse them with the virtual scene in real-time. The audience can watch the dance performance through the virtual reality equipment and feel every subtle movement and expression change of the dancer (as shown in Figure 8). This application case fully demonstrates the potential and value of digital remodelling of dance art.

6.2 Achievement Display And Evaluation

In this paper, the results of the designed three-dimensional reconstruction algorithm of dance art are comprehensively displayed. Through the processing of several experimental data sets and the simulation of various application scenarios, the advantages of the algorithm in reconstruction accuracy, realism, action consistency and scene fusion are fully demonstrated. At the same time, this section also invited professional dancers and computer experts to evaluate the algorithm, and the specific evaluation contents are shown in Table 2.

Figure 8: Interception of dance performance content.

Evaluator Type	*Evaluation Content*
Professional Dancer	This algorithm is innovative in the field of dance art digital reconstruction, providing new technical support for the inheritance, innovation, and development of dance.
	The reconstructed dance movements have a strong sense of realism and are able to capture the essence of dance well.
	The reconstructed dance movements have good continuity and look very natural when viewed.
Computer Expert	This algorithm excels in 3D reconstruction with high reconstruction accuracy.
	The algorithm performs exceptionally well in scene fusion, seamlessly integrating dance movements with virtual scenes.
	The algorithm is highly practical, easy to operate, and suitable for various dance art digital application scenarios.

Table 2: Evaluation of professional dancers and computer experts.

From Table 2, we can clearly see the evaluation of professional dancers and computer experts on the three-dimensional reconstruction algorithm of dance art, which fully demonstrates the advantages of the algorithm in many aspects. Most professional dancers and computer experts believe that the algorithm is innovative and practical in the field of digital remodelling of dance art, which provides new technical support for the inheritance, innovation and development of dance art.

7 CONCLUSIONS

This study is devoted to exploring the application of computer-aided multimodal fusion technology in the digital remodelling of dance art, aiming at realizing high-precision digital expression and innovative development of dance art. Through an in-depth study of key technologies such as multi-modal data collection and processing, dance movement capture and recognition, 3D model reconstruction and optimization, and multi-modal fusion strategy of dance scenes, a complete 3D reconstruction algorithm of dance art is designed and implemented. The simulation results show that the realism score is 9.4, the action consistency score is 9.7, and the scene fusion score is 9.1. The above results show that the three-dimensional reconstruction algorithm of dance art performs well in realism, movement coherence and scene fusion, and has a high score. This fully proves the effectiveness and practicability of the algorithm and provides new technical support for the digital remodelling of dance art.

The potential influence and value of digital remodelling of dance art are enormous. It can not only bring a more real and vivid dance-viewing experience to the audience but also provide new technical support for dance teaching, creation, and inheritance. With the continuous development of technology, the digital remodelling of dance art is expected to be applied in more fields, opening up a new way for the popularization and promotion of dance art. The main contribution of this study is to propose a 3D reconstruction method of dance art based on computer-aided multimodal fusion technology, which shows remarkable advantages in reconstruction accuracy, realism, action consistency, and scene fusion. In the future, we will continue to optimize the performance of the algorithm, improve the reconstruction effect in complex scenes, and explore more combinations of dance art and virtual reality to promote the digital inheritance and innovation of dance art.

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