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Intelligent Error Correction System for Ballet Basic Skills Based on Computer Vision Algorithm

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Abstract With the development of computer vision information processing technology, the method of visual parameter recognition is used to establish an image analysis model for the acquisition of visual information of ballet basic skill error movements. Distributed preprocessing of image features is carried out on the collected images of ballet basic skill error movements. The traditional multi-scale decomposition is improved, and the multi-dimensional wavelet scale decomposition method is applied to decompose the image at the pixel level. Then extract the three-dimensional feature quantity of the ballet basic skill error movement, and according to the three-dimensional contour feature decomposition method, realize the three-dimensional modeling detection of the ballet basic skill error movement, and guide the ballet basic skill training. Equipped with the LAMP network architecture, design the ballet basic skill error movement correction system, and draw the overall functional modules of the system. Analyzing the use of the ballet basic skill intelligent error correction system, after the intelligent error correction system is put into use, the ballet college students' sports overall injury risk is reduced, and the movement flexibility and stability are improved.

Index Terms visual information, multi-scale decomposition, three-dimensional modeling detection, intelligent error correction system, wrong movement

I. Introduction

Ballet is a kind of European classical dance, because one of its important features is that the actress performs with her toes pointing to the ground, so it is also known as pointe dance [1]. In contemporary society, human favor of ballet is not only limited to the appreciation level, more and more people focus on learning ballet or imitating related body movements to shape their own physical beauty and cultivate their own elegant temperament. Due to the increase in market demand for ballet dance teaching has put forward a serious test. How to ensure that students have a good learning effect in the basic ballet exercises has become a contemporary ballet teaching must face the problem.

The process of students learning dance is accompanied by the process of constantly correcting “problems”. Problems occurring in training vary from person to person, some of which are formed by their own conditions, some of which are caused by the technical understanding of the movements in the previous training [2], [3]. Because in ballet dance training, students' wrong movements are difficult to avoid, and if they are not corrected in time, it will not only reduce the effect of dance expression, but also directly related to the improvement of sports performance [4]. Therefore, a dance movement correction system based on computer vision algorithms is proposed to realize the correction of erroneous movements through image recognition, which can not only correct the dancer's dance posture and assist the dancer's training, but also produce an important value for the analysis of dance technique and promote the development of sports dance [5]-[7]. However, due to the complexity of ballet dance movements and the variety of movements, the difficulty of image recognition is high, so much so that the image signal-to-noise ratio obtained by traditional image processing methods is low and the visual effect is poor, which does not satisfy the user's requirements for the accuracy of the recognition of erroneous movements [8]-[10]. Further research needs to be carried out with the goal of increasing the image signal-to-noise ratio and improving the image effect.

A large number of scholars have studied the implementation of computer vision technology in dance video image action recognition and established error feedback mechanisms for students' dance training actions. Literature [11] adopts local adaptive triangular segmentation technology to visualize the dance movements that meet the user's needs, and combines the intelligent assisted training system based on digital feature recognition technology to conduct comparative analysis of the movements in the dance to realize the correction of the wrong training movements. Literature [12] designed a multimedia image action real-time acquisition algorithm to extract the personalized features of dance movements, and combined with data enhancement technology to improve the generalization performance of the action recognition system, which plays an important role in the correction process of students' incorrect movements. Literature [13] proposes a sports dance movement correction method based on binocular stereo imaging model and 3D convolutional neural network, which can effectively correct students' incorrect movements in training by accurately recognizing and predicting dance movements. Literature [14] applies the action posture recognition system based on IoT intelligent sensors to dance training, and by establishing a comparison model between standard dance postures and students' training movements, it can provide students with timely feedback on errors and help improve the quality and level of dance training. Literature [15] integrated deep learning technology to establish a Web-based real-time dance movement prediction platform, which analyzes and evaluates the dancer's movements in real time through key point detection, and can provide error feedback and improvement suggestions for dance training. Literature [16] utilized the Microsoft Kinect motion sensor to capture students' dance movements in real time, compare them with standard dance movements, and output error movement commands to form feedback for students' dance training. Literature [17] studied the posture recognition method based on the angle of human skeletal joints, and applied it to the dance training intelligent assistance system, which can analyze and evaluate the training movements according to the coordinates and angles of the students' three-dimensional joints of movement, so as to provide trainers with intuitive error correction tips. It can be seen that the intelligent dance training error correction system based on computer vision will definitely provide more powerful technical support for dance teaching, will promote the in-depth change of ballet teaching mode, and set up a new concept of dance education under the new teaching environment.

In this paper, by constructing the image information fusion model for collecting visual information of ballet basic skill error movements, extracting the characteristic information components of ballet basic skill error movements, and combining with the spatial sampling technology, we carry out the reconstruction and recognition of ballet basic skill error movement visual information collection images. Preprocess the image features of the ballet basic skill error movement, and use the multidimensional wavelet scale decomposition method to decompose the image at the pixel level. Design the gray scale contour model of ballet basic function error movement, and perform 3D modeling and detection of error movement according to the regularity of the gray scale contour model of ballet basic function error movement. Design a multi-functional module of ballet basic skill error movement correction system. Analyze the application of multi-dimensional wavelet scale decomposition, three-dimensional modeling and detection technology of ballet basic skills and intelligent error correction system.

II. Ballet basic skills wrong movement detection and system design

II. A. Visual information acquisition and pre-processing of basic ballet movements

II. A. 1) Error Motion Visual Information Acquisition

Construct the information fusion model of ballet basic skill error action visual information acquisition image, combined with the information feature retrieval method, to establish the ballet basic skill error action visual information model. Combined with the distribution of ballet basic skill wrong action visual information, the local fuzzy features of ballet basic skill wrong action visual information acquisition image are analyzed, and through spatial visual information fusion, the local fuzzy features of ballet basic skill wrong action visual information acquisition image are analyzed again to realize the correction of wrong action.

The structure of ballet basic skill error movement correction realization is shown in Figure 1.

Assume that the length of the edge contour of the ballet basic skill error movement visual information acquisition image is: $E = u_{\max} - u_{\min}$. Constructing the video dynamic tracking detection for ballet basic skill error movement visual information acquisition image detection correction, the image gets the width of the spatial region as $C = O_{\max} - O_{\min}$. Combined with the fuzzy edge region reconstruction method, the fuzzy degree reorganization of the ballet basic skill error action visual information acquisition image is carried out, and the edge distribution sequence of the action visual information acquisition image is obtained as:

$$\begin{aligned} OP &= ak(x)(1-sr) + tk(x)(1-sr) \\ &= t(a,b)\frac{tk(x)+EC}{ak(x)} \end{aligned} \tag{1}$$

where sr is the dimensionality of the contour curve distribution of the visual information acquisition image of the ballet fundamental error action. $ak(x)$ is the visual information acquisition image detection component. $tk(x)$ is the visual information acquisition image blurriness. $t(a,b)$ is the edge feature component.

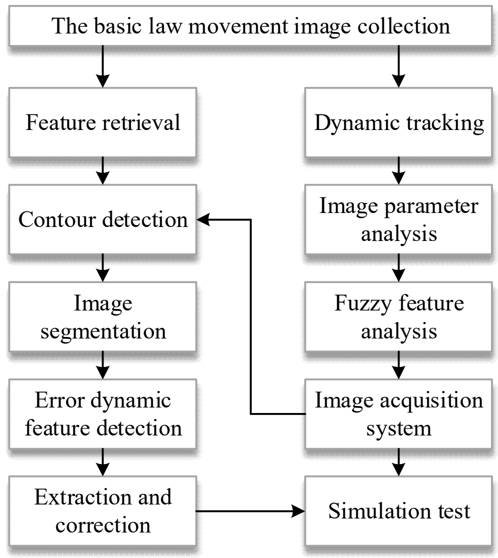


Figure 1: Ballet basic skill error action corrective implementation structure

Combining the fuzzy information fusion tracking recognition method, the feature recognition of the visual information acquisition image of the ballet basic error action is carried out. Based on the chunked region feature detection method of the key action, the distributed template matching function of the ballet basic skill error action visual information acquisition image is constructed as $BD(a,b) \in \{-1,0,1\}$, and the spatial region localization is performed for the visual information acquisition image of the ballet basic skill error action, and the feature information component of the ballet basic skill error action is obtained as:

$$f(|x_i - x_j|) = \begin{cases} \dfrac{R\sin tk(x)(1-sr)}{4}, & BD(a,b) = -1 \\ 1 - \dfrac{R\sin tk(x)(1-sr)}{2}, & BD(a,b) = 0 \\ \dfrac{R\cos tk(x)(1-sr)}{4}, & BD(a,b) = 1 \end{cases} \tag{2}$$

where R is the sampling threshold for the distribution of visual information characterizing the movement of ballet basics errors, $0 \le R \le 3$. Using the method of vector quantization detection, the

Carry out the quantized distribution reorganization of the fuzzy region of the ballet basic skill error movement visual information acquisition image, and get the matching set of ballet basic skill error movement features with mean value 0 and variance 2 R. Combined with the spatial sampling technique, we carry out the reconstruction and recognition of the visual information acquisition image of ballet basic skill error movement.

II. A. 2) Image pre-processing

The video dynamic tracking detection method is used to establish a feature analysis model for detecting and correcting the image acquisition of visual information of ballet basic movement errors, and then build a joint parameter recognition model. In the image preprocessing, the grayscale histogram of the distribution of ballet basic kungfu movement regions is [18], [19]:

$$G_{hard} = f(|x_i - x_j|)\left\{\frac{t(a,b)^2}{2}\right\} \tag{3}$$

where x_i is the number of columns and x_j is the number of rows of the pixel distribution of the visual information acquisition image of the ballet's basic error action. The sequence of blurriness reorganization distribution is derived as:

$$K=\left(\frac{\sum_{i=1}^{r}G_{hard}(i,1)}{R}+\frac{f(|x_i-x_j|)}{R}\right) \tag{4}$$

Take the fuzzy degree feature quantity of the visual image of the ballet basic movement, and use linear correlation feature analysis to extract the visual fuzzy set of the visual information acquisition image of the ballet basic movement error, and the fuzzy degree function of the ballet basic movement trajectory is:

$$\begin{aligned}&K(x,y;t)=G(x,y;t)+X\vec{f}(\vec{x})\\&e_1=\{i\mid i\in S\}\\&e_2=\{\{i,i\}\mid i\in N_i, i\in S\}, E=e_1\cup e_2\end{aligned} \tag{5}$$

where e_1 is the associated pixel point of the distribution of the visual information of the ballet basic skill error movement, and e_2 is the difference degree of the visual error of the ballet basic skill error movement. In the region of $\vec{x}f(\vec{x})$, the local correlation frames of the ballet basic skill error movement visual information acquisition image are obtained, and according to the above analysis, the local fuzzy features of the ballet basic skill error movement visual information acquisition image are extracted, and the distributed preprocessing of image features is realized.

II. B.Optimization of three-dimensional modeling detection method for wrong movements in ballet basic skills

II. B. 1) Gray Scale Contour Modeling of Error Actions

On the basis of using machine vision image processing method for ballet basic skill behavior analysis and constructing the image acquisition model of ballet basic skill error movement, the optimization design of ballet basic skill error movement three-dimensional modeling detection algorithm is carried out, and a three-dimensional modeling detection method of ballet basic skill error movement based on three-dimensional contour feature decomposition is proposed. The collected ballet basic kungfu error movement images are decomposed at the image pixel level using the multidimensional wavelet scale decomposition method, and the reconstructed contour length of the ballet basic kungfu error movement images is:

$$E=\theta E^{LBF}+(1-\theta)E^{LGF}+vL(\varphi)+\mu P(\varphi) \tag{6}$$

where θ is the grayscale weight coefficient of the neighborhood of each ballet basic error action pixel, and $L(\varphi)$ is the edge contour length constraint term of the error action in ballet basic. Combined with the smoothing filtering method, the global affine invariant domain model definition of the error movement image in ballet basic is obtained as follows:

$$L(\varphi)=\int_{\Omega}\delta(\varphi)|\nabla\varphi|\,dx \tag{7}$$

where $P(\varphi)$ is a sparse regular term, the global gray-scale quantization information of the ballet basic skill error movement image is used to build a local gradient feature decomposition model, so as to effectively differentiate between the error movement and the correct movement in the 3D image. The $f_1(x)$ and $f_2(x)$ are used to denote the gray scale values of the reconstructed error movement image in ballet basic. The $f_1(x)$ and $f_2(x)$ are correlated in the level set of pixel distribution in the background region. According to the correlation of the two, image segmentation is performed, and the 3D data field information of the image of the erroneous movement in ballet basic skill is read to obtain the 3D Textrue and 3DArray coordinate system number of the reconstruction of the erroneous movement in ballet basic skill. Construct the gray scale contour model of the error movement in ballet basic skill, and perform template matching according to the image 3D modeling detection results, described as follows:

$$H_{\varepsilon}(z)=\frac{1}{2}\left[1+\frac{2}{\pi}arctan\left(\frac{z}{\varepsilon}\right)\right] \tag{8}$$

$$\delta_{\varepsilon}(z)=\frac{1}{\pi}\cdot\frac{\varepsilon}{\varepsilon^2+z^2}, z\in R \tag{9}$$

Corner point labeling of the sequence of error action images in the ballet basics in the moving state yields the following Gaussian distribution of the error actions in the entire affine invariant domain of the image distribution:

$$P(\varphi)=\int\frac{1}{2}(|\nabla\varphi|-1)^2\,dx \tag{10}$$

where E^{LBF} is the local grayscale information of the erroneous movements in ballet basic kungfu, and E^{LCF} is the local gradient energy term of the erroneous movements in ballet basic kungfu, from which the grayscale profile model of the erroneous movements in ballet basic kungfu is constructed, and the three-dimensional modeling and detection of the erroneous movements are carried out according to the regularity of the grayscale profile model of the erroneous movements in ballet basic kungfu.

II. B. 2) Multi-scale decomposition

A multiscale segmentation of an image F from whole to local is performed to obtain image sub-blocks $F_{i,j}$ of different scales. Where $i=1,2,\ldots,d$ denotes the segmentation scale, and $j=1,\cdots,4^{i-1}$ denotes the number of sub-blocks in each scale.

The segmentation method is as follows: the overall image is the sub-blocks $F_{1.1}$ obtained after the 1st scale decomposition. The overall image is first divided into 4 sub-blocks $F_{2.1},F_{2.2},F_{2.3},F_{2.1}$, each of which is referred to as a sub-block of the 2nd scale. The sub-blocks of the 2nd scale are then divided until the set maximum scale is reached.

Since the traditional multiscale decomposition belongs to the fixed-size chunking method [20], [21]. In order to improve the performance better, the multiscale decomposition is improved in this paper. The improved multidimensional wavelet scale decomposition of an image is to divide a square image into four equal-sized square blocks, and then determine whether these four square blocks satisfy the homogeneity criterion. If the current block satisfies, it is kept unchanged, otherwise it continues to decompose it into 4 square blocks and determines whether the criterion is satisfied or not until all the squares satisfy the given criterion as above. Its decomposition criterion is:

$$|P_i-P_{ave}|>(g_l-1)\times\gamma \tag{11}$$

where P_i and P_{ave} represent the grayscale value and the average pixel grayscale value of any pixel in the square block, respectively, g_l represents the number of grayscale levels of the pixel, and γ is a decimal with a value range of [0,1].

The criterion is that when the absolute value of the difference between the gray value of any pixel in the square block and the average pixel gray value is greater than $(g_l-1)\times\gamma$, the square needs to continue to be divided.

From the point of view of the chunking method, it belongs to the indeterminate size of the image division. From the results of the division, the pixels in the image blocks obtained from its decomposition have high homogeneity. The minimum block size specified in the algorithm of this paper is 4*4.

The size of each image block after decomposition by multi-scale is $2^{(2+n)}\times2^{(2+n)}$, and $n\in\{0,1,2\cdots,7\}$, which can be converted into binary form of the size information of each block. Each sub-block obtained from the decomposition is encoded according to the size of the sub-block. The scale coding of the image chunks after multiscale decomposition is shown in Table 1.

The sub-blocks of the image obtained through multi-scale decomposition are sorted (from top to bottom and from left to right), and the scale information of each block is recorded sequentially according to the sorting result, thus constituting the decomposition information of the original image q. In view of the small number of blocks of larger size obtained from decomposition, the length of the image decomposition information can be further shortened by using $Huffman$ coding, which is denoted as $Huf(q)$. In order to ensure the security of the algorithm, the length of the parameter $Huf(q)$ and the encoding table are sent to the receiver in a key.

Table 1: Multi-scale decomposition of the scale encoding of a block

Size/pixel	Coding	Size/pixel	Coding
4*4	000	64*64	100
8*8	001	128*128	101
16*16	010	256*256	110
32*32	011	512*512	111

II. B. 3) 3D Modeling Detection of Erroneous Actions

Under the condition of bounded continuity, combine the wavelet kernel space matching method to carry out the correlation feature matching of the error movement in ballet basic kungfu, and construct the mapping function of the error movement in ballet basic kungfu. In the boundary layer of the physical sub-region, calculate the value of the ballet basic skill machine vision information acquisition template, fix the ray direction φ in the template, and find the intersection coordinates of the feature moving frames of the error movement images in ballet basic skill, respectively. For $f_1, f_2, |\nabla f_1|, |\nabla f_2|$ minimization computation, this constructs the three-dimensional data field of the erroneous movements in the ballet basics, which is described by the Euler-Lagrange equation as:

$$\begin{aligned}\frac{\partial\varphi}{\partial t} &= -\delta(\varphi)[\theta(\lambda_1 e_1^{1.3F} - \lambda_2 e_2^{1.3F}) + (1-\theta)(\lambda_1 e_1^{1.6F} - \lambda_2 e_2^{1.6F})] \\ &+ v\delta(\varphi)\, div\left(\frac{\nabla\varphi}{|\nabla\varphi|}\right) + \mu\left(\nabla^2\varphi - div\left(\frac{\nabla\varphi}{|\nabla\varphi|}\right)\right)\end{aligned} \tag{12}$$

where $e_1^{LBF}, e_2^{LBF}, e_1^{LGF}, e_2^{LGF}$ is calculated as:

$$\begin{cases} e_1^{LBF} = \int_\Omega K_\sigma(y-x)\,|I(x) - f_1(y)|^2\,dy \\ e_2^{LBF} = \int_\Omega K_\sigma(y-x)\,|I(x) - f_2(y)|^2\,dy \end{cases} \tag{13}$$

$$\begin{cases} e_1^{LGF} = \int_\Omega K_\sigma(y-x)\,|I^c(x) - f_1^c(y)|^2\,dy \\ e_2^{LGF} = \int_\Omega K_\sigma(y-x)\,|I^c(x) - f_2^c(y)|^2\,dy \end{cases} \tag{14}$$

Under the external indeterminate interference, through the wavelet scale decomposition of the edge contour feature points of the ballet basic form, the machine vision recognition component of the ballet basic wrong movement is obtained as:

$$c = \left[\sum_{1\in i,j\in\mu} m_{i,j}\cdot x'_{i,0}\cdot x'_{j,1} + \sum_{1\le i,j\le\mu} b'_{i,j}\cdot\Pi_{i,0}\cdot\Pi_{j,1} + \sum_{1\in i,j\in\beta} b_{i,j}\cdot x_{i,0}\cdot x_{j,1}\right]_{x_0} \tag{15}$$

According to the uniform traversal addressing, adopt field local binary fitting method for ballet basic skill machine vision information acquisition and action vector library reconstruction, the regional pixel information of the image of ballet basic skill under computer vision is:

$$L = J(w,e) - \sum_{i=1}^{N} a_i\{w^T\varphi(x_i) + b + e_i - y_i\} \tag{16}$$

where a_i denotes the bit pattern sequence of the standard action, $J(w,e)$ is the repeated pixel point of the ballet basic kung fu position under machine vision, and $\varphi(x_i)$ is the contour feature distribution function in the vector library of the standard action. According to the above analysis, the gray scale contour model of the ballet basic skill error movement is constructed, the 3D feature quantity of the ballet basic skill error movement is extracted, and the 3D modeling detection of the ballet basic skill error movement is realized according to the 3D contour feature decomposition method.

II. C.Ballet basic skills intelligent error correction system design

II. C. 1) Design objectives

The three-dimensional modeling detection method of ballet wrong movement based on computer vision technology is referenced into video-based ballet dance auxiliary training to provide auxiliary guidance for ballet teams of major universities.

Through the collection of basic ballet data and the comparative analysis of the data, in individual training, users upload the ballet video of a single person, and assist the dancers to train for the standardized movements by extracting the 3D skeleton information and analyzing it in comparison with the skeleton information of the standard movements.

In team competitions, complete competition videos are uploaded and analyzed by the introduced recognition algorithm, which provides feedback on each dancer's movements as well as their positions, and gives tactical guidance to the coach.

Before the development of the system, it is necessary to analyze the feasibility of the system to be developed, including economic feasibility, technical feasibility, operational feasibility and so on, the following is the specific analysis content.

II. C. 2) Overall design

During the overall design phase, all requirements analysis tasks need to be integrated into the system to achieve a common system design plan. In the system design, minimize the logical problems in the development process, etc., and design each module should be in a black-box state to better define the relationship type between modules. This paper discusses two main aspects: system architecture design and generic system design. This system uses LAMP network architecture.

The system should be deployed in AliCloud, and the system management platform defines unified data and interface specifications. Users added and authenticated by the background administrator can view dancer data and player data, as well as dancer training data and dancer's ability evaluation through interface requests. The system performs data collection and storage, data analysis and data presentation.

The functional structure of Ballet Basic Error Correction System is shown in Fig. 2, which is mainly divided into the following main modules, schedule management module, dancer management module, training management module, data analysis management module, and system maintenance module.

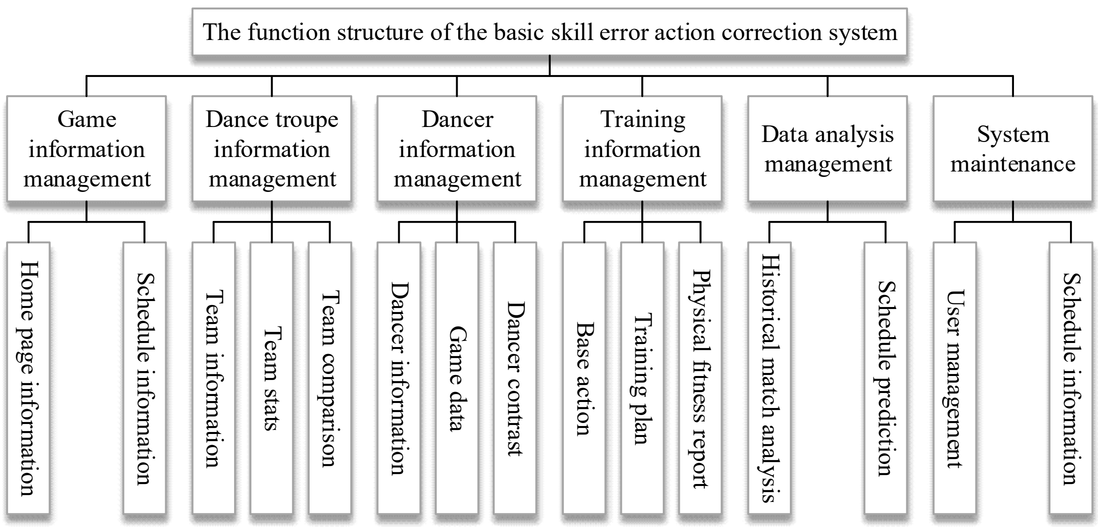


Figure 2: The function structure of the basic skill error action correction system

III. Ballet basic skills intelligent error correction system application

III. A. Experimental environment

The hardware and software platform configuration parameters used for all the analog simulation experiments conducted in this chapter are specified in Table 2.

Table 2: Hardware and hardware configuration platform parameters

Experimental platform parameters	Parameter value
CPU	Intel(R) Xeon(R) Silver 4116
Main frequency	2.10GHz
Memory	128G
Operating system	64-bit Windows 10
Programming software	Pycharm2019
Programming language	Python3.6

III. B. Experimental results and analysis

III. B. 1) Comparison and analysis of experimental performance with different number of decomposition layers

When wavelet decomposition is performed on action images, different decomposition layers also have an effect on the extraction ability of the model and the feature information obtained. When the number of decomposition layers is too high, the obtained image will lose some details or local features, which will have an impact on the final classification results. However, when the number of decomposition layers is too low, it is difficult to obtain high quality and low redundancy image data for 3D images. Therefore, in order to determine the optimal decomposition level, the comparison experiments with different number of decomposition layers are designed in this section.

The experimental performance comparison and analysis of different decomposition layers are shown in Fig. 3, and it can be seen from the bar presentation in the figure that the four-level wavelet decomposition performs best in this model, and the OA, AA and Kappa evaluation indexes achieve the highest results, which are 99.13%, 99.52%, and 99.24%, respectively, and the results of the evaluation indexes are all above 99%.

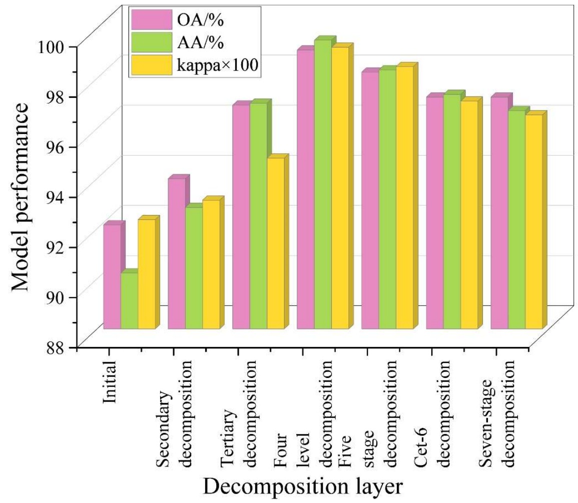


Figure 3: Experimental comparison and analysis of different decomposition layers

III. B. 2) Comparison and Analysis of Experimental Performance of Improved Wavelet Decomposition

In this section the improved wavelet decomposition module, i.e., multidimensional wavelet scale decomposition, is discussed to compare and analyze the performance of the models. In the general method of 3D image classification, firstly, the high dimensional image data need to be downscaled before extracting the features, and the traditional wavelet decomposition is unable to downscale the hyperspectral 3D image, which ultimately leads to poor classification results and a long overall classification time. Therefore, the multidimensional wavelet scale decomposition module proposed in this chapter not only downscales the original hyperspectral image, but also downscales the image without the need for separate downscaling to obtain the low-frequency downscaled component and the high-frequency downscaled component, which improves the classification accuracy and reduces the overall classification time of the model.

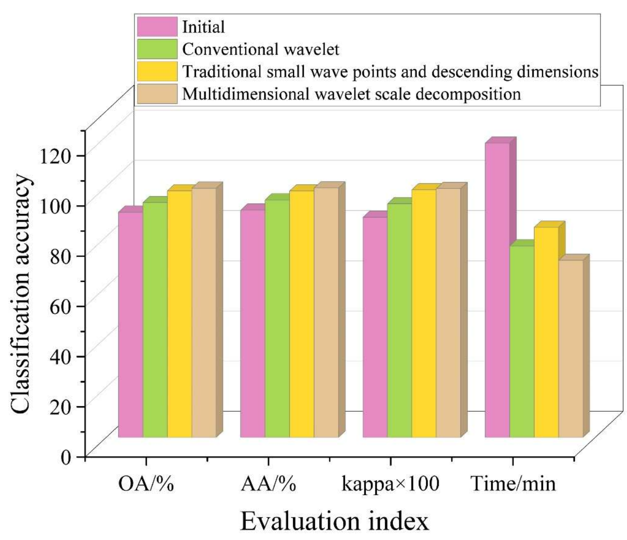


Figure 4: Classification accuracy in data concentration

In order to verify the effectiveness of multidimensional wavelet scale decomposition, experimental comparisons are performed on the dataset in four different ways no wavelet decomposition, traditional wavelet decomposition, traditional wavelet decomposition + dimensionality reduction and multidimensional wavelet scale decomposition. The classification accuracy of multidimensional wavelet scale decomposition on the dataset is shown in Figure 4.

The multidimensional wavelet scale decomposition has 1.05%, 1.19%, and 0.51% more in OA, AA, and Kappa evaluation metrics each compared to the traditional wavelet decomposition + dimensionality reduction. From the experimental results, it can be seen that the multidimensional wavelet scale decomposition exhibits better performance, achieving the highest OA, AA and Kappa evaluation indexes. And the overall classification time is speeded up by 5.77min than the traditional wavelet decomposition.

III. B. 3) Analysis of image fusion effect of multidimensional wavelet scale decomposition

Traditional multiscale fusion algorithms include discrete cosine transform with variance computation (DCT+var), discrete cosine transform with variance computation and consistency validation (DCT+var+cv), discrete cosine harmonic wavelet transform (DCHWT), wavelet with adaptive block (DWT+AB), cross-bilateral filtering (CBF), and guided filtering of the image (GFF).

In order to measure the fusion effect of each algorithm more objectively, seven objective evaluation criteria, namely, spatial frequency (SF), mutual information (MI), information entropy (H), fusion symmetry, normalized correlation coefficient (NC), structural similarity (SSIM), and peak signal-to-noise ratio (PSNR), are used for analytical evaluation.

SF shows how well the fusion result maintains the information of the source image; the larger the value, the clearer and more active the fused image is.MI is used to measure the amount of information interacting between the source image and the fused image, and thus evaluates the effect of fusion. The larger its value, the better the fusion effect, i.e., the richer the amount of information the fused image obtains from the input image.H describes the richness of the content contained in the image, and the larger the value, the more information the image contains, and the better the effect.FS is used to indicate the degree of contribution of the source image to the fused image, and if the two source images contribute equally to the fused image, the value of FS is close to 2, and therefore the fused image will have a NC can reflect the degree of similarity of spectral features between the source image and the fused image, the larger the value, the larger the correlation of spectral features between the fused image and the two source images, the better the quality of fusion.SSIM is a comparative measure of the index of similarity of the two images from the point of view of the original image's contrast, structural information, and luminance, and the structural similarity is in the range of 0 to 1, and if there are two If two images are identical, the value of SSIM is 1. PSNR is an image objective evaluation metric based on the error between the corresponding pixel points, i.e., based on error-sensitive image quality evaluation, the larger the value indicates the smaller the distortion.

The objective quality evaluation of fused images is shown in Table 3. The multidimensional wavelet scale decomposition method has an increase of 6.41, 1.36, 3.24, and 0.091 over the CBF method in SF metrics, MI metrics, PSNR metrics, and PSNR metrics, respectively.The DCT+var method outperforms the other algorithms in H metrics, and PSNR metrics, but there is still a subtle gap between the method and the multidimensional wavelet scale decomposition method proposed in this paper.

From the various objective quality evaluation indexes in the table, the fusion effect of the multidimensional wavelet scale decomposition method in this paper is the best, and all the evaluation indexes of the image are higher than the other fusion algorithms, which indicates that the fusion results have the best detail and edge description and the highest clarity.

Table 3: Objective quality evaluation of fusion image

Algorithm	SF	MI	H	FS	NC	PSNR	SSIM
GFF	25.26	8.59	7.223	2.03	0.976	37.55	0.933
CBF	23.86	8.01	7.215	2.05	0.985	35.69	0.901
DCHWT	23.73	7.35	7.369	2.09	0.983	37.28	0.934
DWT+AB	24.05	8.39	7.248	1.99	0.977	35.09	0.925
DCT+var+cv	25.69	9.22	6.923	2.01	0.972	34.13	0.843
DCT+var	25.83	9.01	6.995	2.02	0.976	35.82	0.847
Multidimensional wavelet scale decomposition	30.27	9.37	7.463	2.10	0.989	38.93	0.992

III. B. 4) Experimental performance analysis of models with different scaled training sets

In this section, the performance of 3D modeling detection techniques for ballet basic skill error movements with different proportions of training sets is discussed. The dataset is divided into 50% training set and 50% testing set, 40% training set and 60% testing set, 30% training set and 70% testing set, etc., to conduct experiments on the 3D modeling detection technique of ballet basic skill error movements. The classification accuracy of the model under different percentage of training sets is shown in Fig. 5.

The 3D modeling detection technique maintains high classification accuracy in 20% training set, but the accuracy decreases and the classification effect is not good when the training set is increased to 50%, but it still maintains more than 90% classification accuracy, which meets the demand for error correction of ballet basic skills movements.

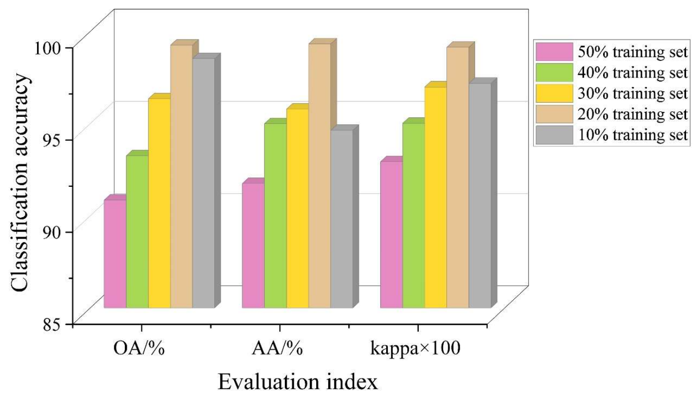


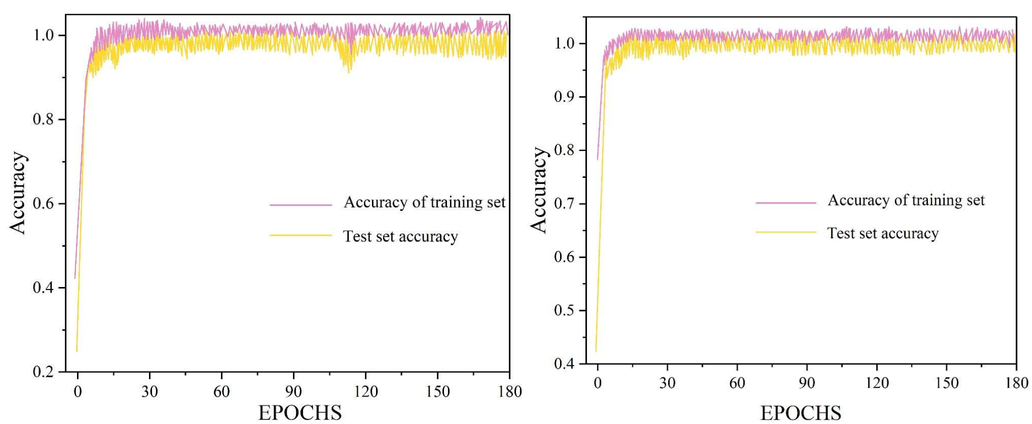
Figure 5: Classification accuracy of models in different proportional training sets

III. B. 5) Accuracy and loss rate of model classification results

The accuracy curves of the proposed 3D modeling detection technique for ballet basic error movements for the training and validation sets on different datasets after iterative training with epochs=180 rounds of data are shown in Fig. 6.

Fig. (a) In dataset 1, the model of this paper shows small fluctuations in the epochs=105~120 interval. The model always converges to 1.0.

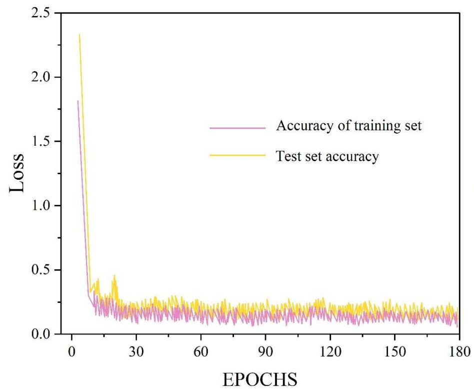
In Fig. (b) dataset 2, the accuracy of the training set of the model is slightly higher than that of the validation set.



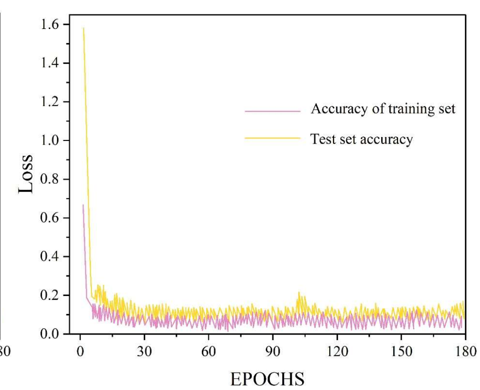
(a) Data set 1 (b) Data set 2

Figure 6: Accuracy in different data sets

The loss rate curves of the model on different datasets are shown in Fig. 7. From the curve in the figure, it can be seen that the model in this paper starts to converge around nearly 10 epochs, which indicates that the model has the ability of fast convergence, high computational efficiency and high performance classification. In Figure (b) dataset 2, the model fluctuates at epochs=105, when the model loss rate is about 0.2.



(a) Data set 1



(b) Data set 2

Figure 7: The loss rate curve of the model on different data sets

III. C. Corrective training effects

III. C. 1) Research process

1) Pre-experiment

In order to ensure that the various test methods can be used correctly and skillfully before the formal experiments, and to reduce the possibility of errors, pre-experiments were conducted before the formal experiments.

(1) Pre-experiment time: December 25-28, 2024

(2) Pre-experiment location: a dance academy complex building 511 auxiliary training room, mechanics laboratory.

(3) Pre-experiment content: Height test, body composition test, FMS test and YBT-LQ test for 8 dance majors based on the corresponding test methods. The experimental design, the use of measurement tools and methods were thoroughly evaluated and examined, and specific problems encountered in the process were recorded and solved by the literature method or expert interview method.

2) Experimental Test

(1) Purpose of the test: to test the practicality of the ballet basic skills error movement correction system constructed in this paper.

(2) Experimental time: January 8-11, 2025

(3) Testing place: 511 auxiliary training room in the comprehensive building of a dance academy.

(4) Test method: analyze the injury risk of ballet college students based on the perspective of functional movement system through FMS test. YBT test is also one of the contents of functional movement system. Research has shown that the accuracy of predicting potential injury risk is better than using a single test method when combining the two test methods, FMS test and YBT-LQ. Based on this, targeted training on the weak links shown in the test can improve the effect of injury prevention work. Therefore, the experimental tests in this study were conducted using a combination of the FMS test and the YBT-LQ test.

3) Corrective training program

The training program can be divided into three phases, each phase corresponds to the training of a test movement, namely, corrective training for rotational stability movement, corrective training for trunk stabilization push-up movement, and corrective training for over-the-head squat.

In terms of training period, the proposed training program had a total duration of 10 weeks. The second phase of the corrective training for trunk stabilization push-ups was estimated to be 5 weeks, while the other two phases were 3 weeks. This is due to the fact that ballet students as a whole showed poorer functional movement performance in the trunk stabilization push-up test. Also, there is less training related to shoulder stability in the daily training of ballet college students, and the training and improvement of this component is expected to take a longer period of time. In terms of the load of training, corrective training emphasized more on the correct movement pattern, so a lower load was chosen to ensure the quality of movement.

In the part of corrective training for ballet basic skills incorrect movements, the 30 subjects who were screened as suitable for corrective training were mainly analyzed for the overall injury risk results of the movements, movement flexibility, etc. of the subjects after the training.

III. C. 2) Results and analysis

(1) Results and analysis of overall injury risk of movement

The total FMS scores and the scores of each item and the YBT-LQ test results of 30 ballet college students were organized and summarized, and the average values were calculated as shown in Table 4.

Based on the relevant theories of functional movement system, the FMS test score of 14 is usually regarded as the threshold of higher injury risk, and a score lower than 14 indicates a higher risk of motor injury.

Before and after the ballet basic skills intelligent error correction system was put into use, the total FMS score of 30 ballet college students showed a difference of about 3 points. Through the use of the intelligent error correction system, the overall risk of motor injury in basic ballet college students was reduced. It indicates that the risk of sports injury caused by wrong movements is reduced.

Table 4: Results of the FMS scores and YBT-LQ results of ballet students

FMS scores	Before the wrong action is corrected	Overhead squat	Hurdle step	Straight leg squat	Shoulder flexibility
		1.38 ± 0.66	2.16 ± 0.15	2.05 ± 0.85	2.61 ± 0.99
		Active knee lift	push-ups	Rotational stability	Total score
		2.95 ± 0.46	0.82 ± 0.43	0.99 ± 0.38	12.96 ± 1.96
	After the wrong action is corrected	Overhead squat	Hurdle step	Straight leg squat	Shoulder flexibility
		2.11 ± 0.57	2.25 ± 0.33	2.22 ± 1.01	3.52 ± 0.93
		Active knee lift	push-ups	Rotational stability	Total score
		3.16 ± 0.42	1.35 ± 0.48	1.47 ± 0.59	16.08 ± 1.57
YBT-LQ results	Before the wrong action is corrected	Forward (left)	Back inside (left)	Posterior lateral (left)	Forward (right)
		63.25 ± 4.52	91.25 ± 7.02	96.89 ± 7.08	61.59 ± 4.58
		Back inside (right)	Back outside (right)	The anterior double side difference (A)	The left/right side of the score (CS)
		92.63 ± 7.25	95.86 ± 6.75	2.19 ± 1.6	95.36 ± 7.65 /95.63 ± 5.28
	After the wrong action is corrected	Forward (left)	Back inside (left)	Back inside (right)	Forward (right)
		69.85 ± 3.85	93.68 ± 7.21	96.22 ± 7.01	62.63 ± 4.25
		Back inside (right)	Back outside (right)	The anterior double side difference (A)	The left/right side of the score (CS)
		93.65 ± 3.58	96.47 ± 7.85	2.48 ± 1.98	99.18 ± 8.59 97.57 ± 6.38

(2) Analysis of flexibility movement performance and stability movement performance

Among the seven basic movement patterns of the FMS screening, two items belonging to the flexibility movement test were active straight knee raise and shoulder flexibility test. The two items belonging to stability movement test are rotational stability and trunk stabilization push-up.

The specific scores, the number of people with each score, and the distribution of the 30 female ballet undergraduates in the FMS flexibility test movements were summarized and counted.

Table 5: Results of the results of the FMS flexibility/stability action test of ballet students

FMS	Project	Mean±SD	Proportion (%)			
			0	1	2	3
Flexibility action test	Active knee lift	3.16 ± 0.57	0	3.33	3.33	93.33
	Shoulder flexibility	2.64 ± 0.99	16.67	0	6.67	76.66
Stability performance	Rotational stability	3.13 ± 0.42	3.33	0	13.33	83.33
	Stable push-ups	2.82 ± 0.55	0	3.33	20	76.67

The results of the FMS flexibility/stability movement test for ballet college students are shown in Table 5. The average scores of the active straight knee raising and shoulder flexibility tests of the ballet majors were 3.16 ± 0.57 and 2.64 ± 0.99, respectively. Twenty-eight of the ballet undergraduates (93.33%) scored a 3 on the active straight knee raise. No ballet undergraduates had pain problems with a percentage of 0. Overall, female ballet undergraduates performed better in agility movements, especially the active straight leg raise.

The mean scores of rotational stability and trunk stability push-up test of ballet college students were 3.13 ± 0.42 and 2.82 ± 0.55 respectively. After correction of incorrect movements, ballet undergraduates completed the rotational stability test with improved scores, and ballet undergraduates had better trunk energy transfer, neural control of muscles, and stabilization in multiple dimensions.

IV. Conclusion

In this paper, by collecting visual information of ballet basic movement, designing three-dimensional modeling and detection technology of ballet basic movement errors, and constructing ballet basic movement intelligent error correction system by carrying information management and other modules. The ballet basic skill intelligent error correction system is applied to the training of ballet college students, and its corrective training results are analyzed.

(1) Multi-dimensional wavelet scale decomposition has certain advantages in evaluation indexes OA, AA and Kappa compared with traditional wavelet decomposition + dimensionality reduction, and comparing the overall classification time of the two, the time spent on multi-dimensional wavelet scale decomposition is 70.51 min, which is 13.16 min faster than traditional wavelet decomposition + dimensionality reduction method.Multi-dimensional wavelet scale decomposition method has the best integration effect compared with several traditional multi-scale fusion algorithms, the fusion effect is the best, and all the evaluation indexes of the image are higher than other fusion algorithms. The three-dimensional modeling and detection of ballet basic skill error movements performs better in the four-level decomposition, and the experimental performance is optimal at 20% of the training set.

(2) Erroneous movements have a not insignificant impact on the overall injury risk, and the changes in the overall injury risk of ballet college students' movements were analyzed by FMS test and YBT-LQ test. The FMS score was 16.08 ± 1.57 after the correction of the wrong movement, which was 14 points higher, and the ballet college students' overall injury risk was reduced, and the flexibility and stability of the movement was improved.

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