Computer Fraud and Security
ISSN (online): 1873-7056

Application of Computerized 3D Human Model Training Technology in Sports Movement Correction

Li Baofeng
College of Taiji Martial Arts, Jiaozuo University, Jiaozuo 454002,Henan, China

Abstract:

In order to improve the ability of judging and correcting wrong movements in sports training, a 3d modeling and detection method of bad movements based on computer-aided 3d human body model feature decomposition is proposed. The motion behavior is analyzed by using machine vision image processing method, and the image acquisition model of motion error actions is constructed. The multi-dimensional wavelet scale decomposition method is used to decompose the collected motion error action images at pixel level, and the gray outline model of motion error actions is constructed, and the three-dimensional feature quantity of motion error actions is extracted. The three-dimensional modeling detection of motion errors is realized according to the three-dimensional human model feature decomposition method. The simulation results show that the accuracy of the 3d modeling detection of sports error actions is high, the detection error rate is low, and the real-time correction capability of the error actions is strong.

Key-words: Computerized,Sports; Motion correction; 3D modeling

1 INTRODUCTION

In various sports, the technical specifications of the movements are more complex, especially for some technical sports, requiring correct movements for standardized and improved sports training. With the development of computer image technology, image processing technology has been used for information fusion and 3d feature modeling of moving images, 3d visual analysis of moving images, feature reconstruction of incorrect actions in motion, and improvement of adaptive reconstruction of moving images and false activity detection. Using three-dimensional modeling and image processing technology, the feature decomposition and detection of motion error images can realize the three-dimensional modeling and integrity check of motion error, and improve the corrective performance of motion normalization to sports training. The research of motion error detection methods has important significance in sports training and physical education. The related research on 3d modeling and detection methods of error actions in sports the research on 3d modeling detection methods for sports errors has received significant attention.

The research on 3d Modeling and Detection of Wrong Actions in Motion Based on feature extraction and adaptive 3d contour detection of moving images, combined with image fusion methods to collect moving image and complete 3d modeling and detection can effectively improve the ability to correct wrong actions in motion. The traditional 3d modeling and detection techniques for motion error actions mainly include 3d modeling and detection method for motion error images based on edge contour feature extraction, the 3d modeling and detection method for motion error images based on corner feature matching, and the 3d modeling and detection method for motion error images based on 3d visual feature extraction. Accurate real-time monitoring technology is used to collect moving images, and the collected images are subjected to feature decomposition and multi-wavelet analysis, and combined with the feature extraction results, three-dimensional modeling and detection of wrong actions in motion are performed. Literature [4] puts forward a 3d modeling and detection method of motion error motion images with missing background information, which adopts the idea of edge contour reconstruction to repair missing information, and carries out adaptive positioning and detection of motion error motion through zero-point intersection feature segmentation and corner detection methods, thus realizing image classification and screening of motion and improving detection and recognition of motion error motion. However, this method has poor accuracy in detecting false motion images in motion. In the literature [5], an error action image reconstruction method in sports based on feature moving frame disparity scanning and adaptive compensation is proposed to perform infrared projection. Edge contour feature is extracted from the collected false motion images in motion, and the block filtering method is used to filter the images to improve the accuracy of image detection. However, this method is easily affected by disturbance, which leads to a higher error rate of false motion detection.

A 3d modeling detection method for wrong actions in sports based on 3d contour feature decomposition is proposed to address the above problems. Firstly, image is collected, the motion behavior is analyzed by using machine vision image processing method, and the image collection model of motion error action is constructed. The captured motion error action image is decomposed at pixel level by using multi-dimensional wavelet scale decomposition method, and then the 3d feature quantity of improper motion action is extracted. According to the three-dimensional contour feature decomposition method, the three-dimensional modeling and detection of motion errors are realized. Finally, the superior performance of this paper in improving 3D modeling and detection of motion errors is verified by simulation experiments.

2 RELATED WORK

The biomechanical movement of sports displayed in the computer is based on a three-dimensional biomechanical analysis of sports images. The three-dimensional machine has a complex human-computer dialogue function, and can also feedback three-dimensional form of animation, so that athletes or coaches can directly analyze the image, thus serving sports. To create an intuitive three-dimensional sports biomechanics movement technology, not only do we need to build a human sports technology movement model, but we also need to use computer three-dimensional programming technology.

In most sports biomechanics research, the main issues are: (1) technical refinement measures; (2) athlete body characteristics, structure and motor skills; and (3) optimal movement techniques. These issues are all related, which means that there is a need to explore better techniques for examining athletes' motor functions and body structure, so the research on techniques related to sports biomechanics becomes an important direction.

In the study of technical movements of sports, it is necessary to obtain information about the movement of each part of the athlete, but in the actual test operation, it is not possible to analyze directly on the athlete, so it is necessary to accept certain photographic techniques, such as: software systems for biomechanical analysis of images, using computers for the test. Currently, the most used motion analysis systems are those developed by the American company Ariel Dynamics and the German company SIMI. Biomechanical analysis software systems allow for the measurement of technical movement capabilities to obtain common parameters of joint motion. With the development of sports and athletics, more and more attention is being paid to the measurement of sports data and the creation of three-dimensional movement models of the human body, and the use of this technology is still relatively widespread in the diagnosis of biomechanics, which can be performed by computer for three-dimensional dynamic three-dimensional display.

Three-dimensional computer motion biomechanics motion technology action three-dimensional display, the first need for biomotor mechanics analysis, the establishment of a relative complex bearing system, from the miscellaneous people miscellaneous people and the realization of the three feeds, the machine dimensional animation fast against the conversation relay motor technology action directly displayed. This method is the use of data dialogue following the movement, curve and three with the collaboration, the use of dimensional images a three-dimensional image, direct feedback visual information, so as to guide the training of athletes. By performing data analysis, the analysis of parameters related to athletes' technical movements can be carried out precisely. Using curves, parameters such as angles and trajectories of each athlete's movements can be reflected.

At the University of SheffHallam in the United Kingdom, researchers have proposed a sports simulation system for gymnastics research, which can show the athletes' performance, which will help them to improve their movement techniques. Gymnasts can also directly virtual apparatus contact, so that the computer can better athletes human action simulation, so as to output three-dimensional three-dimensional results, which not only can know the movement to carry out action perfection, but also can greatly improve the movement technology level of sports.

In the process of establishing a three-dimensional computer stereo display, the following operations need to be completed:

(1) Based on the human model theory, establish a simple human model for a certain type of action;

(2) Capture the technical movements of athletes from different angles through multiple cameras to complete the

live camera;

(3) To get the joint coordinates and other motion parameters of the human body in 3D space by analyzing the image software;

(4) Constrain the technical movements of the human body on the computer through the skeleton diagram, rigid body diagram, stick diagram and solid body diagram.

In establishing the entire three-dimensional stereo display, the first thing is to carry out the selection of the human body model, for a certain type of simple action to establish the model. In sports, the split is more complex sports action is the analysis of the person, are generally carried out to simplify is the human body, mostly the choice of rigid body system to constitute the human body model movement corresponding mathematical model mechanics model.

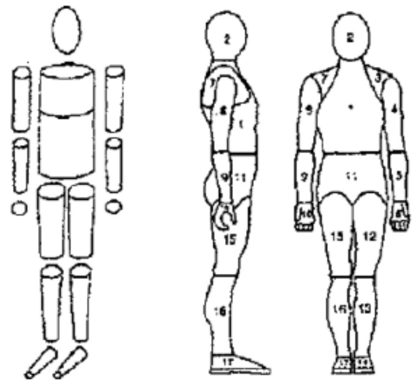


Figure 1 Hanavan and Hatze models

The human model in the form of a rigid body is usually chosen to represent some cylindrical, spherical or vertebral body. In 1984, Hanavan researchers proposed a navanHa model, in which he divided the human body into 15 solid bodies of different rigidity. This model is relatively easy to use, and the dimensions of each of the masses and collective links in the model can be determined by establishing regression equations based on measurements of 25 parameters of the human body. This model allows rapid calculation of data related to the center of mass, weight, and inertia of rotation of the moving links in the human body. The simulation of the athlete's cartwheel was presented by VanGheluwe et al. who showed that the hip distortion and the asymmetric swing of the arm affect the entire cartwheel movement. initial state, etc.

After the completion of the simple human movement model, the impact analysis needs to refer to certain data so as to obtain the kinematic related parameters. Therefore, the three-dimensional computer display of the human rigid body model by computer is related to the three-dimensional reproduction technology and the computer three-dimensional graphics language. Currently, the most used 3D languages are: Java3D, OpenGL, VRML, Direct3D, etc. These languages help in the construction of 3D models and in the creation of a wide variety of 3D graphics, thus enabling the interaction of data in 3D graphics. The main techniques used to build graphics in these 4 languages are: shading techniques, inverse walk, object drawing techniques, transformations, lighting modeling techniques, blending techniques, handling of transparency and translucency techniques, interactions, fogging techniques, and texture reflection techniques.

3 APPLICATION OF COMPUTERIZED 3D HUMAN MODEL TRAINING TECHNOLOGY IN SPORTS MOVEMENT CORRECTION

3.1 IMAGE ACQUISITION AND PRE-PROCESSING OF ERRONEOUS MOVEMENTS IN SPORTS

3.1.1 Machine vision image 3D reconstruction method

In order to realize the modeling and detection of wrong action images in sports, firstly, 3D vision scanning and holographic video tracking recognition techniques are used for wrong action images in sports acquisition, to realize the wrong action images in sports to be reconstructed and image pre-processing, machine vision image 3D image reconstruction methods commonly used such as Cell Projection and Splatting, using The randomness and irregularity of the distribution of the wrong action images in sports [6], choose any pixel value starting from l1 as the initial value of the parameter of the wrong action image acquisition in sports, set the corresponding attenuation coefficient of the wrong action image acquisition in sports, perform the rank permutation of the wrong action images in sports, and use the matrices Q、 Q^r and Q^{rc} to represent the regular vector of the wrong action images in sports of M×N, Q^r and Q^{rc}, respectively. The matrices Q, Q^r and Q^{rc} represent the rule vector, the grayscale edge feature vector and the sub-template chunk structure vector of the M×N wrong action images in sports, respectively. The motion sequence of the wrong action images in sports is corner-labeled and 3D template matched according to the data field, and the wrong action images in sports are reconstructed. Template calibration is performed on the image edge contours, and the digital hologram localization method is used to compensate the feature moving frame difference for motion feature volume alignment, and the discrepancy feature volume of the wrong action images in sports is constructed [7], and the sparse linear equation system for template matching of wrong action images in sports is derived as:

$$g(x,y) = h(x,y) * f(x,y) + \eta(x,y)$$

where h(x, y) is the video tracking parallax function of the wrong action in sports image, and the symbol * denotes the convolution. According to the pixel-level parallax function of the wrong action image in sports for feature weighting, the solution obtains the distribution domain of the wrong action in sports of Statistical Shape Model (SSM) [8], and combined with the associated pixel feature decomposition, the video tracking parallax of the sports image is obtained as:

$$g(x,y) = f(x,y) + \eta(x,y)$$

where η(x, y) is the difference feature component of image reconstruction and shape contour, and the intersection weight map overlay model is used to analyze the sports wrong action pixel features contained in each subinterval information [9-10], to calculate the data term and smoothing term for wrong action image feature extraction in sports in the moving state, and then to obtain the sports wrong action edge pixel The estimated values are:

$$\hat{f}(x,y) = \beta F(x,y) + (1-\beta)\, m_l + \delta_l^2$$

Where F(x, y) is the pixel value of the grayscale pixel set of sports error action imaging about the video scan point (x, y) point, m_l is the Taubin smooth pixel set, and $\delta^2{}_l$ is the local variance.

Based on the feature sampling points of the sports error action image and the matching degree of the grid model vertices, the gray scale quantization decomposition is performed, and the fuzzy vector set of the sports error action image is obtained as:

$$E^{cv}(c_1, c_2) = \mu \cdot Length(C) + \nu \cdot Area(inside(C)) + \lambda_1 \int_{inside(C)} |I - c_1|^2 \mathrm{d}x\mathrm{d}y + \lambda_2 \int_{outside(C)} |I - c_2|^2 \mathrm{d}x\mathrm{d}y$$

where c1 and c2 denote the pixel feature distribution primitives of the target and background regions of the wrong-action image reconstruction in sports, respectively, Length(C) denotes the contour length of the distribution of the wrong-action image reconstruction region, Area(inside(C)) denotes the luminance of a pixel, μ, ν, λ1 and λ2 denote the spatial sampling weight coefficients of the neighborhood of each pixel, all of which are greater than 0 constants. Combined with the gradient information decomposition method of local images, the spatial scanning of sports images is performed to realize the 3D reconstruction of sports error action images under machine vision [11].

3.1.2 Multi-dimensional wavelet scale decomposition

Based on the sports behavior analysis score using machine vision image processing methods, the captured sports wrong action images are decomposed at the image pixel level using a multidimensional wavelet scale decomposition method to extract sports features under human-computer interaction, and infrared projection and edge contour feature extraction are calculated for the captured wrong action images in sports. The

Denavit-Hartenberg (D-H) spatial distribution vector [12] for solving the human posture distribution in sports is introduced into the closed curve C with the wrong action primitives in sports, represented by a smooth time lag function as C = { (x, y) ∈ Ω: φ(x, y) = 0}, in the the active region of the contour line, the background image B of the sports scene is used as the reference set of regular images to obtain the wavelet multidimensional scale decomposition coefficients of the wrong action images in sports (the coefficients ν are usually 0, here they take the value 0 :

$$E^{cv}(c_1,c_2) = \mu\int_\Omega \delta(\varphi(x,y))\ |\nabla\varphi(x,y)|\mathrm{d}x\mathrm{d}y + \\ \lambda_1\int_\Omega |I - c_1|^2 H(\varphi(x,y))\,\mathrm{d}x\mathrm{d}y + \\ \lambda_2\int_\Omega |I - c_2|^2 (1 - H(\varphi(x,y)))\,\mathrm{d}x\mathrm{d}y$$

Where, H(z) and δ(z) denote the modular sub-blocks of 3D image visual modeling of sports actions, respectively, and the error actions in sports are divided into (W/2) × (H/2) sub-blocks using the chunk matching method, and the moving frame matching of error sports actions performed by multidimensional wavelet scale decomposition [13], and the multidimensional wavelet scale function of error actions in sports is obtained by using the difference matching method as follows:

$$E^{\mathrm{LBF}}(\varphi,f_1,f_2) = \mu\int \frac{1}{2}(\ |\nabla\varphi| - 1)^2\mathrm{d}x + v \cdot Length(C)\ + \\ \lambda_1\int [\int K_\sigma(x-y)\ |I - f_1(x)|^2 H(\varphi)\,\mathrm{d}y]\,\mathrm{d}x + \\ \lambda_2\int [\int K_\sigma(x-y)\ |I - f_2(x)|^2 (1 - H(\varphi)\,\mathrm{d}y)\ ]\,\mathrm{d}x$$

where λ1, λ2, ν, μ are nonnegative constants, Kσ is the two-box standard deviation of edge contour matching and feature fusion, and σ is the weighting coefficient, and the amount of edge contour features of the sporting error action image is adjusted by choosing the magnitude of the weighting coefficient σ. The image is decomposed into two regions R1 and R2 in the 3D data field, and the sampled point-type matching point neighborhood is calculated, which is combined with the gradient information extraction method of the local image for 3D reconstruction of the image [14].

3.2 OPTIMIZATION OF 3D MODELING DETECTION METHOD FOR WRONG MOVEMENTS IN SPORTS

3.2.1 Gray-scale contour model of sports error movements

Based on the analysis of sports behavior by machine vision image processing method and the construction of the image acquisition model of sports error actions, the optimization design of 3D modeling detection algorithm of sports error actions is carried out, and a 3D modeling detection method of sports error actions based on 3D contour feature decomposition is proposed. A multi-dimensional wavelet scale decomposition method is used for the pixel-level decomposition of the acquired images of wrong actions in sports [15], and the contour length of the reconstructed images of wrong actions in sports is :

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

where θ is the gray weight coefficient of each sports wrong action pixel neighborhood, L(φ) is the edge contour length constraint term of sports wrong action, and the global affine invariant domain model of wrong action images in sports is obtained by combining with the smoothing filtering method as follows:

$$L(\varphi) = \int_\Omega \delta(\varphi)\ |\nabla\varphi|\mathrm{d}x$$

where P(φ) is the sparse regular term, and the global gray scale quantization information of the wrong action image in sports is used to build a local gradient feature decomposition model, so as to effectively distinguish the wrong action from the correct action in the 3D image. f1(x) and f2(x) are used to represent the gray scale values of the wrong action image reconstruction in sports. f1(x) and f2(x) are correlated in the horizontal set of the pixel distribution in the background region. According to the correlation between the two, the image segmentation is performed, the 3D data field information of the wrong action image in sports is read, the 3D Textrue and 3D Array coordinate coefficients of the wrong action reconstruction in sports are obtained, the gray scale contour model of the wrong action in sports is constructed, and the template matching is performed according to the image 3D modeling detection results, which is described as follows:

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

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

The corner point labeling is applied to the sequence of wrong action images in sports in the moving state, and the Gaussian distribution of the wrong action in the whole image distribution affine invariant domain is obtained as follows:

$$P(\varphi) = \int \frac{1}{2}(|\nabla \varphi| - 1)^{2}\mathrm{d}x$$

Where E^{LBF} is the local gray scale information of the wrong action in sports, E^{LG} is the local gradient energy term of the wrong action in sports, thus the gray scale contour model of the wrong action in sports is constructed, and according to the regularity of the gray scale contour model of the wrong action in sports, the 3D modeling and detection of the wrong action is carried out.

3.2.2 3D modeling detection of motion error movements

Under the continuity bounded condition, the correlation feature matching of the wrong action in sports is combined with the wavelet kernel space matching method to construct the mapping function of the wrong action in sports. In the boundary layer of the physical sub-region, the value of the template of the machine vision information acquisition in sports is calculated, the ray direction φ in the fixed template is fixed, the coordinates of the intersection of the feature moving frames of the wrong action image in sports are found respectively, the intersection of f1, f2, |∇f1|, |∇f2| is minimized and calculated, and this constructs the 3D data field of the wrong action in sports, which is described by the Euler-Lagrange equation as:

$$\frac{\partial \varphi}{\partial t} = -\delta(\varphi)\ \left[\theta(\lambda_1 e_1^{LBF}-\lambda_2 e_2^{LBF}) + (1-\theta)\ (\lambda_1 e_1^{LGF}-\lambda_2 e_2^{LGF})\ \right] +$$

$$v\delta(\varphi)\ \mathrm{div}\left(\frac{\nabla \varphi}{|\nabla \varphi|}\right) + \mu\left(\nabla^{2}\varphi - \mathrm{div}\left(\frac{\nabla \varphi}{|\nabla \varphi|}\right)\right)$$

where $e^{LBF}1$, $e^{LBF}2$, $e^{LGF}1$, $e^{LGF}2$ are calculated as:

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

$$\begin{cases} e_1^{LGF} = \int_{\Omega} K_{\sigma}(y-x)\ |I^{G}(x)\ - f_1^{G}(y)\ |^{2}\mathrm{d}y \\ e_2^{LGF} = \int_{\Omega} K_{\sigma}(y-x)\ |I^{G}(x)\ - f_2^{G}(y)\ |^{2}\mathrm{d}y \end{cases}$$

Under the external uncertain interference, the wavelet scale decomposition of sports form edge contour feature points is used to obtain the machine vision recognition component of sports error movements as:

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

According to uniform traversal addressing, local binary fitting method is used for sports machine vision information acquisition and action vector library reconstruction, and the regional pixel information of sports images under computer vision is :

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

Where, ai denotes the bit shape sequence of standard action, J(w, e) is the sports position repetition pixel point under machine vision, and φ(xi) is the contour feature distribution function in the standard action vector library. According to the above analysis, the gray-scale contour model of sports error action is constructed, the 3D feature quantity of sports error action is extracted, and the 3D modeling detection of sports error action is realized according to the 3D contour feature decomposition method.

4 Simulation experiment results and analysis

In order to test the performance of this paper in the implementation of 3D modeling and detection of sporting errors, simulation experiments were conducted using Visual C++ and Matlab 7, with WindowsXP as the operating system, Tomcat 5.5 as the server, 2.0 GHz CPU, 4 GB RAM and 7 200 rpm hard disk. The design was completed. The spatial location grid partitioning of the sports area was calibrated in 5×5 and 7×7 chunks, the machine vision image sampling frequency was 1 200 kHz, and the frame length of the sports dynamic features sampling was 1 024 frames.

Figure 2 Original sports action imagess

Taking the sports image shown in the figure above as the test object, the machine vision image processing method is used to analyze the sports behavior, construct the gray-scale contour model of the wrong sports action, extract the 3D feature quantity of the wrong sports action, and realize the 3D modeling detection of the wrong sports action, and the detection results are shown in the figure below.

Figure 3 3D modeling detection of wrong movements in sports

Analysis of the above figure shows that the accuracy of 3D modeling detection of erroneous movements in sports using the method of this paper is good, and the accuracy of different angles for erroneous movement detection is tested and the results are shown in the figure below.

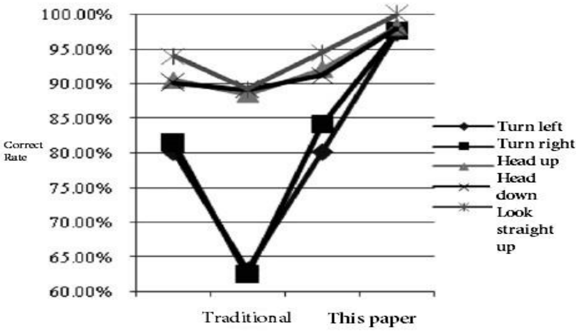
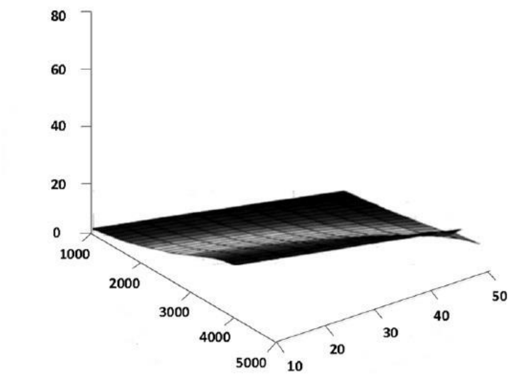


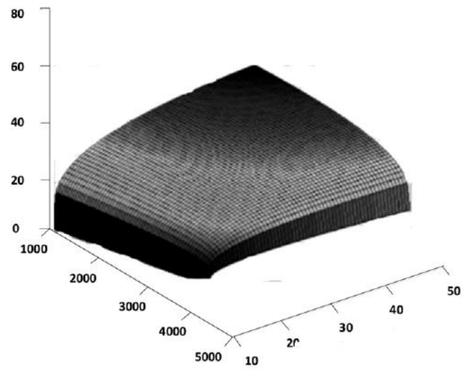
Figure 4 Comparison of detection accuracy

Analyzing the above figure, we know that the accuracy of 3D modeling detection of right-turn, left-turn, head-up, and head-down errors using this method is 97%, and the accuracy of 3D modeling detection of head-on errors is 100%; while the accuracy of 3D modeling detection of right-turn and left-turn errors using the traditional method is 63%, 88% for head-up errors, 89% for head-down and head-on errors. The accuracy rate of 3D modeling detection of head-up error is 88%, and the accuracy rate of head-down and front-view error is 89%. It shows that the accuracy of 3D modeling detection of sports errors is high by using this method.

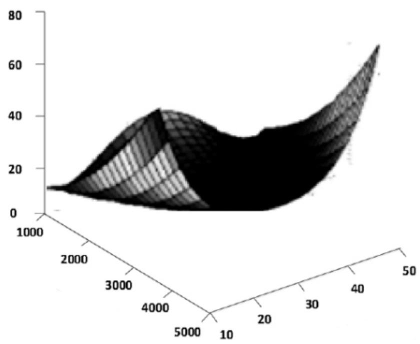
In order to further verify the effectiveness of the method in this paper, the error rate of the 3D modeling detection of sports errors by the method in this paper, the method in literature [4] and the method in literature [5] were compared and analyzed, and the results of the comparison are shown as follows:



(a) Error rate of 3D modeling detection of the method in this paper



(b) Error rate of 3D modeling detection of the method in literature [4]



(c) Error rate of 3D modeling detection of the method in literature [5]

Figure 5 Comparison results of the error rate of the three methods

According to the above figure, the highest error rate of sports error modeling detection by this method is 20%, the highest error rate of sports error modeling detection by the method of literature [4] is 60%, and the highest error rate of sports error modeling detection by the method of literature [5] is 70%. It shows that the error rate can be controlled within a reasonable range when the method of this paper is used for 3D modeling detection of sports errors.

5 CONCLUSION

Image processing technology is used for information fusion and 3d feature modeling of moving images, 3d visual analysis of moving images and feature reconstruction of wrong actions in motion, so as to improve the adaptive reconstruction of moving images and detection of wrong actions. Aiming at the wrong actions in motion, a 3d modeling detection method based on 3d contour feature decomposition was proposed. The motion behavior is analyzed by using machine vision image processing method, and the image acquisition model of motion error actions is constructed. The collected motion error action image is decomposed at pixel level by using multi-dimensional wavelet scale decomposition method, and the gray contour model of motion error actions is constructed, and the three-dimensional feature quantity of motion error actions is extracted. The three-dimensional model detection of motion errors is realized according to the three-dimensional contour feature decomposition method. It is known that the accuracy of this method for 3d modeling detection of wrong actions in sports is high, and the detection error rate is low, which can effectively detect the false movements of sports players.

REFERENCES

[1] Lu Xinghua, Zhang Xiaojun. Multi-person cross-area prevention during personnel image tracking Loss metho. Computer Simulation, 2014, 31(9): 243-246.

[2] Hu Peng, Shi Huijuan. Video watermarking algorithm based on visual masking model. Electricity Sub-Measurement Technology, 2014, 37(12): 36-40.

[3] Wang Xiaoyu, Zhang Yazhou, Chen Deyun. Based on multi-block local binary mode feature sum Face detection based on eye positioning. Chinese Journal of Scientific Instrument, 2014, 35 (12):2739-2745.

[4] Kiran Thapaliyaa，Jae－Young Pyuna，Chun－Su Parkb，et al．Level set method with automatic selective local statistics for brain tumor segmentation in MR images．Computerized Medical Imaging and Graphics，2013，37(1) : 522－537．

[5] Jiang Xin，Zhang Ren－jie，and Nie Sheng－dong．Image segmentation based on level set method．Physics Procedia，2012，33(6) : 840－845．

[6] Ahmed D，Kamal H，and Moussa D．Fast multilevel thresholding for image segmentation through a multiphase level set method．Signal Processing，2013，93(7) : 139－153.

[7] Tu Chaoping, Xiao Jinsheng, Du Kanghua, et al. Based on the anisotropic thermal diffusion equation Multi-focus image fusion algorithm. Acta Electronica Sinica, 2015, 43(6):1192-1199.

[8] Liu Yongchun, Wang Guangxue, Li Ping et al. Based on two-dimensional probability density function comparison SAR image change detection method. Journal of Electronics and Information, 2015, 37(5): 1122-1127.

[9] Huang Weiguo, Gu Chao, Shang Li, et al. Target recognition based on contour hierarchical description Algorithm research. Acta Electronica Sinica, 2015, 43(5): 854-861.

[10] Yu Runtian, Fang Yuefa, Guo Sheng. Design of Rope Driven Parallel Ankle Joint Rehabilitation Mechanism And sports performance analysis. Robot, 2015, 37(1): 53-62, 73.

[11] Lin Suzhen, Zhu Xiaohong, Wang Dongjuan, etc. Multi-scale based on embedded multi-scale transform Band image fusion. Computer Research and Development, 2015, 52(4): 952-959.

[12] Rong Desheng, Hu Jushuang, Zhao Junjun, etc. Based on data fusion IGA-RGRNN Low-rank coal-to-methane production prediction model. Journal of Power Supply, 2018, 16(1): 178-184.

[13] Deng Gangfeng, Huang Xianxiang, Gao Qinhe, etc. Virtualization based on improved genetic algorithm Solving method of inverse kinematics of human upper limb kinematic chain. computer application, 2014, 34(1): 129-134, 174.

[14] Chen Wei. Application of motion capture technology in 3D computer animation production. Automation and Instrumentation, 2017, (12): 143-144.

[15] Zhang Teng, Cao Chen, Zhang Jing, et al. Probability hypothesis density filtering for low detection probability Wave algorithm. Journal of China Academy of Electronics, 2018, 13(1): 36－41.