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Construction of Sports Training Model and Optimization of Health Assessment System Based on CAD

Zhenzhen Bie[1], Qianqi Zhao[2] and Yang Li[3]

[1] Department of Physical Education, Tongji University, Shanghai 200092, China, 01095@tongji.edu.cn
[2,3] Department of Sports Art, Hebei Institute of Physical Education, Shijiazhuang 050041, China, [2]2004011@hepec.edu.cn, [3]1993009@hepec.edu.cn

Corresponding Author: Qianqi Zhao, 2004011@hepec.edu.cn

Abstract. This article aims to explore the method of constructing an exercise training model and enhancing the exercise health evaluation system utilizing computer-aided design (CAD). Addressing the limitations of current sports training models and health assessment systems, it introduces CAD technology to enhance the precision of sports training and the efficacy of health evaluations. The approach involves two key steps: initially, leveraging CAD's accurate modelling and simulation capabilities to create a detailed human motion model and establish a diverse database of training actions. Secondly, by processing and analyzing sports data, the article optimizes the sports health evaluation system, enabling real-time monitoring and feedback functions. The results show that the exercise training model and health assessment system based on CAD has obvious advantages in terms of recognition rate, high-dimensional sports action recognition, action analysis, and health risk assessment. Compared with traditional methods, this method improves the accuracy and effectiveness of sports training and provides more powerful support for athletes' health management.

Keywords: CAD Technology; Sports Training Model; Health Assessment System; Optimization Method
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1 INTRODUCTION

The concept of "computer-aided sports training" can serve as a framework that deeply integrates sports science and sports training with other disciplines such as information technology, statistical analysis, simulation, and biomechanics. As a core component of modern sports training systems, the formulation and arrangement of scientific training plans heavily rely on comprehensive, accurate, and scientific detection and analysis of sports training information. This process not only involves fine detection and in-depth analysis of motion technology [1]. It also involves comprehensively considering and evaluating athletes' physiological and psychological status, nutritional intake, recovery status, and environmental factors. improving training efficiency. Based on this, summarize the scientific training methods, which is an important component of achieving comprehensive control over the sports training process. At the same time, the research and development of this system will inevitably promote the comprehensive improvement of sports training level, and also promote the continuous development of other disciplines in related fields [2]. Conduct horizontal research and vertical tracking on the technical and physical training of athletes, to achieve scientific research support for the training of high-level sports teams at Tsinghua University and make breakthroughs in the construction and scientific research of sports disciplines. Using relevant scientific theories and methods to process and analyze the obtained data, establish standards for evaluating the effectiveness of sports training, and then control the training process based on the analysis results, and predict and simulate the training design. By using computers to collect, store, and analyze various training data, coaches can manage daily training information, assist in training decisions, and simulate sports results [3]. Therefore, some scholars plan to cultivate high-level athletes in China and around the world from their perspectives. The "computer-aided sports training system" dedicated to research and development is a deep integration of sports training and computer applications.

For example, based on the user's physical fitness level, health condition, and preferences, the game difficulty and training content can be dynamically adjusted to achieve truly personalized training. Convolutional neural networks, recursive neural networks, and grey wolf optimization algorithms have demonstrated excellent performance in feature extraction, classification, and optimization [4]. This feature enables the sports training model to accurately guide users to perform correct sports postures and gestures in virtual reality games, effectively avoiding sports injuries and improving training effectiveness. This not only helps users self-evaluate but also provides a reference for professional coaches to adjust training plans. Based on the evaluation results, an innovative real-time feedback mechanism is designed, such as real-time guidance, achievement badges, health reports, etc. in virtual reality games, to motivate users to maintain a positive attitude towards exercise and continuously optimize training plans based on feedback [5]. These algorithms can be further applied in sports health evaluation systems to achieve accurate analysis of user exercise quality, such as posture accuracy, exercise efficiency, etc. Gesture recognition and depiction technology is not limited to the fitness field, but can also be widely applied in multiple fields such as crime detection, healthcare, and online learning. The CAD-based sports training model and sports health evaluation system can also be extended to multiple segmented markets such as elderly rehabilitation, professional athlete training, rehabilitation training, etc., to meet the health needs of different populations [6].

Video-based human motion recognition has become one of the hotspots and has been widely used in intelligent human-computer interaction and virtual reality [7]. Due to the current use of datasets such as NTU-RBD and Kinect Skeletons, which are based on human daily activities, there is currently no publicly available dataset related to basketball basic movements. To solve the above problems, some scholars have proposed a method of integrating 3D pose estimation and action recognition for action recognition and classification. The 2D recognition method extracts real-time position features of the 2D plane, which limits the network model to only learn position contours or colour information, making it difficult to reflect the essence of motion directly. This is also the reason for the low recognition accuracy of such methods [8]. A basketball sports auxiliary training system was designed and implemented using the action recognition method proposed in this article, which combines algorithm analysis and data analysis functions. Using a method based on 3D skeletal data information, a network model is used to learn the spatial information of joint coordinate positions and the temporal changes in joint spatial positions, achieving classification results. Traditional single-action recognition methods often rely on single features in video frames or static image analysis, making it difficult to capture the high-speed and continuous dynamic changes in basketball movement. By combining human pose estimation and action recognition methods, it is possible to track the positions of various parts of the athlete's body in real-time and more accurately identify complex basketball technical movements. This high-precision recognition ability provides coaches and athletes with more detailed and accurate feedback, which helps to accurately correct technical movements and improve training quality [9]. Therefore, led by myself and assisted by members of the laboratory team, basketball sports videos were collected and processed through multiple channels to create a basketball sports dataset, which can be publicly used as a reference for other researchers in the future. Replace the input of the spatiotemporal graph convolutional neural network algorithm model with 3D skeleton data [10]. And converted it into 3D skeleton information. By uploading basic action videos and basketball game videos, we provide players with basic action training, physical fitness testing reports, and other services to help them identify deficiencies and improve their scoring rate.

2 RELATED WORK

The stability and accuracy of object recognition in the visual system, as well as the rationality of task allocation and the efficiency of path planning, are the core elements to ensure the successful application of the system in the fields of motion training and health assessment. By combining an intelligent motion vision system with CAD models, the system can more accurately simulate and predict athletes' motion trajectories and mechanical performance in different postures, providing a more scientific basis for sports health assessment. When constructing a CAD-based sports training model, fully utilize the high-precision modelling capability of CAD technology to provide personalized training guidance for athletes. Especially in response to the common challenges of uneven brightness and sudden changes in sports competition scenes, some scholars have proposed an innovative dynamic template mechanism to solve the problem of target recognition errors. By introducing time control factors into the SVM classifier, the adaptability of the recognition algorithm to sudden changes in brightness has been effectively improved. To improve the training efficiency and performance of the classifier, Wang and Zheng [11] chose the Adaboost algorithm as the core machine learning method and focused on fast feature selection and dual-threshold decision optimization. This optimization strategy not only accelerates the feature extraction process but also improves the accuracy of classification decisions through fine dual threshold settings, providing effective support for the system to process large amounts of motion data. It also cleverly combines the advantages of CAD (computer-aided design) technology in the construction of sports training models, further optimizing the entire sports health assessment system. This dynamic template mechanism can adjust template parameters in real time to match target features under current lighting conditions, significantly reducing recognition errors. At the level of target recognition algorithms, the correlation between data features and environmental changes has been thoroughly considered. At the same time, the classification strategy designed in combination with the unsupervised clustering method achieves real-time target discrimination when the environmental brightness changes rapidly, further improving the robustness and recognition accuracy of the system.

To address the issue of incomplete training data encountered in traditional supervised learning in TS, Wynters et al. [12] innovatively introduced CAD-assisted methods to generate high-quality training data. These strategies aim to improve the adaptability of TS learners to different multipath delays in real wireless channels, thereby enhancing their statistical efficiency and generalization performance. Data not only solves the bottleneck of real-world data collection but also enables us to test and optimize TS algorithms within a wider range of parameters. In OFDM systems, CAD technology can accurately generate channel impulse response (CIR) data containing various multipath delays and interference conditions by simulating the complex multipath effects of wireless channels. Yan et al. [13] designed a training strategy based on loose and flexible constraints using rough information such as the root mean square (r.m.s) delay of CIR data generated by CAD. Specifically, CAD technology can simulate the motion characteristics of athletes' muscles, bones, and joints in different motion states, generating high-precision training data. Real-time monitoring of athletes' athletic performance, physical condition, and potential health risks provides a scientific basis for their health management. Based on the data generated by these CAD, Yao et al. [14] constructed a more refined and personalized sports training model to provide athletes with customized training plans and feedback. On this basis, the TS network based on an Extreme Learning Machine (ELM) exhibits excellent robustness and accuracy, achieving precise timing synchronization even in complex and constantly changing communication environments.

In response to the above issues, Zhang et al. [15] proposed a remote upper limb exercise training assistance system based on Field Programmable Gate Array (FPGA). Perform similarity analysis on upper limb training movements and display the analysis results on the front-end page. We developed a system server based on the Spring Boot framework using Java language, which enables remote collection and visualization of upper limb training movement data. The system is capable of remote collection and cloud storage of upper limb training data. Utilize upper limb mechanical structures to demonstrate standard upper limb training movements to patients remotely. The high-speed acquisition of upper limb motion sequences was completed using FPGA, solving the problem of difficult detection of joint motion sequences in the upper limb. Combined with mechanical structure, the movement angles of various joints in the upper limbs have been detected. To achieve the above functions, the main work of the paper is to design a hardware control system for collecting upper limb training data and displaying standard movements. Zhao et al. [16] designed the user interface, training data, and upper limb training data statistics display page for cloud servers using Hypertext Markup Language and Cascading Style Sheets. The classic PID control algorithm is used to control the mechanical structure and achieve the function of displaying standard actions. At the same time, the MYSQL database was used to classify and store the training data.

3 CONSTRUCTION OF SPORTS TRAINING MODEL

Interactive operation is another important aspect of CAD technology. It allows designers to interact with computers through an intuitive user interface and realize the input, modification, and viewing of designs. There are many ways of using interactive operation, including clicking a mouse, dragging and dropping, keyboard input, etc. Through interactive operation, designers can interact with computers more efficiently. CAD technology can play a significant role in constructing sports training models. Traditional models often rely heavily on coaches' experience and athletes' personal feelings, lacking scientific and quantitative analysis methods. CAD technology can build a real sports training model through accurate geometric modelling and data management. These models can simulate different sports scenes and training schemes and quantitatively analyze various parameters in the process of sports. Through the introduction of CAD technology, we can more intuitively understand the effect of sports training, find potential problems, and put forward targeted improvement suggestions. Figure 1 shows the simulation effect of a sports training scene based on CAD.

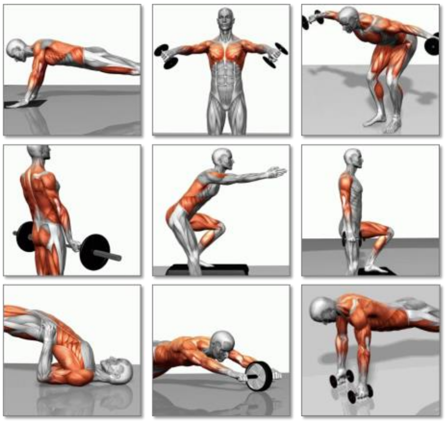

Figure 1: Simulation of sports training scene.

During the construction process, we must leverage the strengths of CAD technology, particularly its accurate measurement capabilities and three-dimensional visualization, to ensure the authenticity of the model.

Moving target detection is concerned with identifying objects in motion relative to the overall scene within a sequence of images. It serves as a fundamental step for further processing, including target recognition, tracking, and understanding and describing target actions, with significant implications for subsequent steps. The focus of target recognition in this context is primarily divided into human and non-human categories. In indoor environments, moving targets often encounter obstruction, but the human shoulder and upper body regions are less susceptible to blockage and exhibit relatively stable shapes.

Establishing the head-shoulder model entails calculating the width-to-height ratio of a moving target:

$$r = \frac{x_{\max} - x_{\min}}{y_{\max} - y_{\min}} \tag{1}$$

If the ratio is within the range of [0.26 to 0.38], it suggests that the entire human body has potentially entered the camera's capture area. Compute the vertical projection histogram of the moving target (as depicted in Figure 2).

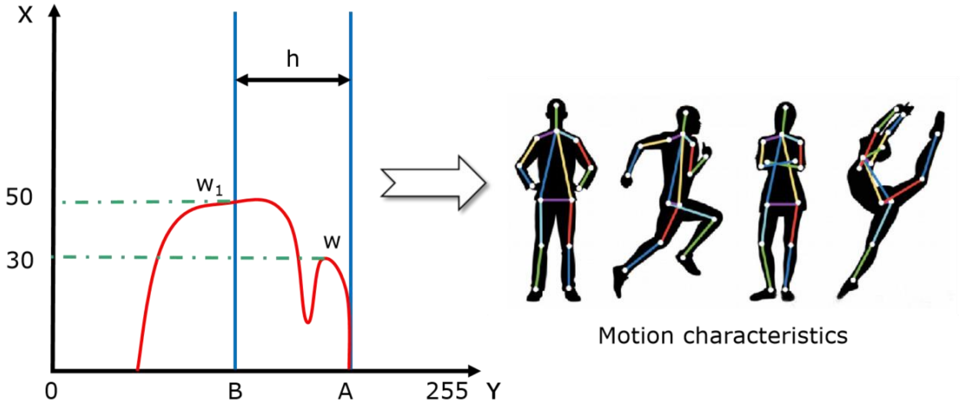

Figure 2: Vertical projection histogram.

Then, using this global maximum point and the width-to-height ratio of an upright human body, estimate the approximate height h of the individual.

$$B(i,j) = \frac{1}{h \times w} \sum_{x=i\cdot h}^{(i+1)\cdot h-1} \sum_{y=i\cdot w}^{(j+1)\cdot w-1} I(x,y) \tag{2}$$

In this article, the radial basis kernel function is chosen based on empirical considerations to model the mapping relationship of the regression machine:

$$f(x) = \langle w, x \rangle + b \tag{3}$$

Here, w represents the weight and b denotes the bias term. Parse this function:

$$\begin{aligned} &\min_{w,b,\xi_i^+,\xi_i^-} \frac{1}{2}\|w\|^2 + C\sum_{i=1}^{l}(\xi_i^+ + \xi_i^-) \\ &s.t. -(\varepsilon + \xi_i^-) \le y_i - \langle w, x_i \rangle - b \le \varepsilon + \xi_i^+ \end{aligned} \tag{4}$$

In this context, ε denotes the insensitive loss function parameter, and the value ε influences the number of support vectors. C acts as a regularization parameter, primarily used to control the penalty for samples that exceed the error threshold.

After the model is built, it needs to be carefully adjusted and optimized. This includes adjusting the athlete's body posture, optimizing the movement track and improving the layout of the training scene. Through continuous adjustment and optimization, the model is more in line with the needs of actual sports training.

(3) Simulation of real motion scene

The ultimate goal of a sports training model based on CAD is to simulate real sports scenes and provide intuitive and accurate training guidance for athletes and coaches. Therefore, after the model is built, it is needed to simulate the real moving scene.

In the process of simulation, it is first needed to import the constructed sports training model into a suitable simulation environment. This environment should have a realistic physical engine, rich environmental elements and real-time rendering ability. By choosing a suitable simulation environment, the scene of sports training can be reproduced more realistically.

Next, according to the actual sports training plan and arrangement, we began to simulate the real sports scene. This includes simulating athletes' training actions, analyzing the movement track and speed, and evaluating the training effect. In the process of simulation, it is needed to make full use of the real-time rendering and interactive functions of CAD technology to ensure the accuracy of the simulation.

$$D_X = \alpha \times O_X \tag{5}$$

Here, a represents a function of the moving target's speed in the horizontal direction, $\alpha = f\ v_k\ \geq 1$. Analogously, for the vertical direction, we have:

$$D_Y = \alpha \times O_Y \tag{6}$$

Through the simulation of real sports scenes, it can provide more intuitive and accurate training guidance for athletes and coaches. They can better understand the essence and law of sports training by observing information such as movement trajectory and speed change in the simulation process. At the same time, they can also use the simulation results to adjust the training plan and improve the training efficiency and effect.

4 OPTIMIZATION OF SPORTS HEALTH ASSESSMENT SYSTEM

Analysis of the existing sports health assessment system

At present, the evaluation system of sports health mostly adopts the methods of physiological index detection, questionnaire survey and coach observation. These methods can reflect the physical condition and training effect of athletes to a certain extent, but they have the following limitations:

The detection of physiological indexes mainly focuses on routine indexes such as heart rate and blood pressure, and the evaluation of key sports qualities such as muscle strength, flexibility and coordination is relatively insufficient.

Questionnaires and coaches' observations mostly rely on subjective judgment and lack objective and quantitative data support, so it is difficult to accurately reflect the actual situation of athletes.

The existing system lacks dynamic monitoring and real-time feedback function, so it can't adjust the training plan in time to cope with the changes in athletes' physical condition.

The use of CAD in sports health assessment systems is reflected in the following aspects:

Accurate modelling and simulation: Using CAD technology, an accurate human motion model can be established to simulate and analyze athletes' movements.

Data analysis and visualization: CAD can process and analyze a large number of sports data and generate an intuitive visual report.

Real-time monitoring and feedback: By integrating the sports health assessment system with CAD technology, the real-time monitoring and feedback of athletes' training stage can be realized.

Before conducting a sports health assessment, it is imperative to identify the sources of potential sports injuries. The connection between each sub-item and the risk source of injury is depicted in Figure 3.

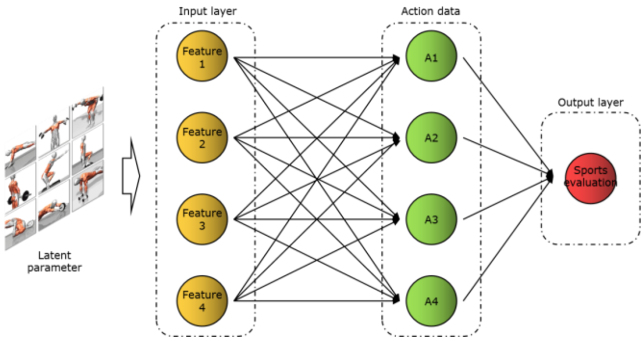

Figure 3: Determination principle of sports injury risk source.

Using multiple linear regression analysis, the prediction model of body parts prone to monitoring problems during strenuous exercise is developed:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_j X_j + \cdots + \beta_k X_k + \varepsilon \tag{7}$$

In the context of scientific training, especially in high-intensity and highly competitive sports such as basketball, it is crucial to have a deep understanding of the differences in sports injuries among athletes in different training programs and the underlying mechanisms. When we talk about the relationship between sports injuries and movement angles, we are exploring a complex biomechanical phenomenon. It involves multiple aspects such as muscles, bones, joints, and sports techniques. e can construct a classifier for the primary factors of athlete injuries using the least squares SVM, employing the following equation:

$$MaxZ_n = p_i x_i * \frac{in - p_{ij}}{y \ x \ * \gamma} * \delta M_\varphi^n \tag{8}$$

This is not just a simple probability problem but requires consideration of different sports events. The distribution of pressure on various parts of the body, the stress state of muscles and joints, and how these factors change with the angle of movement when athletes perform specific movements. For this purpose, we can introduce a multiple regression analysis model, where the injury probability of each injury site (set as Y1, where i represents different injury sites) is used as the dependent variable. The angle of movement (or more specifically, such as movement speed, strength output, duration of movement, etc.) and the individual factors of the athlete are used as independent variables. Among them, j represents different independent variables. Through regression analysis, we can calculate the regression coefficients (β _j) of each independent variable, which reflect the direction and degree of the independent variable's influence on the dependent variable (i.e., damage probability).

By ascertaining the sports health risk grade using BPNN and constructing the hidden layer for damage, the initial damage assessment model can be established. Ensuring the seamless operation of the sports health assessment system requires iterating the free parameters generated during its operation.

$$\frac{\partial \ n}{\partial s_{vu} \ n} = \sum_{u=1}^{n} s_v \ n \ R_u \ x \tag{9}$$

$$s_{vu} \ n+1 = s_{vu} \ n \text{-} \eta \frac{\partial \ n}{\partial_{vu}} \tag{10}$$

Here, $\frac{\partial \ n}{\partial s_{vu} \ n}$ represents an iteration of free parameters; n denotes the value of the input current variable, while $n+1$ signifies the value of the current variable to be adjusted post-iteration; η indicates the overall learning efficiency in this model, which can be both constant and variable.

Functions and characteristics of the sports health assessment system

After integrating CAD technology, the sports health assessment system will have the following functions and characteristics:

Comprehensive health assessment: The optimized system will be able to comprehensively assess athletes' physical condition, sports skills and psychological quality. Through accurate human motion models and simulation analysis, we can more accurately understand the athletes' physical state and potential health risks.

Personalized training guidance: Based on the data analysis and visualization function of CAD technology, the optimized system can provide personalized training guidance for each athlete. According to the report generated by the system, the coach can make a targeted training plan to help athletes improve their sports skills.

Real-time monitoring and dynamic adjustment: The optimized system has real-time monitoring and dynamic adjustment functions. During the training stage, the system can continuously collect athletes' data, and make analysis and feedback. When the athlete's physical condition or sports skills are abnormal, the system can remind the coach and the athlete to make adjustments in time.

Efficient data management and analysis: CAD technology enables the sports health assessment system to manage and analyze a large amount of sports data efficiently. Coaches and athletes can view historical data and analysis reports at any time through the system, which provides strong support for formulating and adjusting training plans.

5 CASE ANALYSIS AND APPLICATION EFFECT DISPLAY

The database for this study comprises 30 groups of basic sports training movements, with each group further subdivided into 4 decomposition movements, resulting in a total of 120 unique movements. This detailed decomposition helps to capture and analyze the key details in the process of movement more accurately. In addition, the system is flexible and can input new standard actions according to the individual needs of trainers, thus continuously expanding and perfecting the contents of the database.

Through Kinect technology, the human skeleton coordinate information can be obtained effectively, as shown in Figure 4. Each action consists of a series of skeleton sequences, which are the basis of action recognition and analysis. When constructing the action template, the system will store the coordinate data of 20 bone points in each frame in the template file. These templates are generated by different individuals performing the same actions according to unified standards, which ensures the diversity and representativeness of the templates.

Two sets of experiments were conducted to validate the effectiveness of the cumulative edge feature algorithm proposed in this article. These experiments extracted the histogram of oriented gradient (HOG) features from both traditional sports action images and cumulative edge feature images generated by the algorithm.

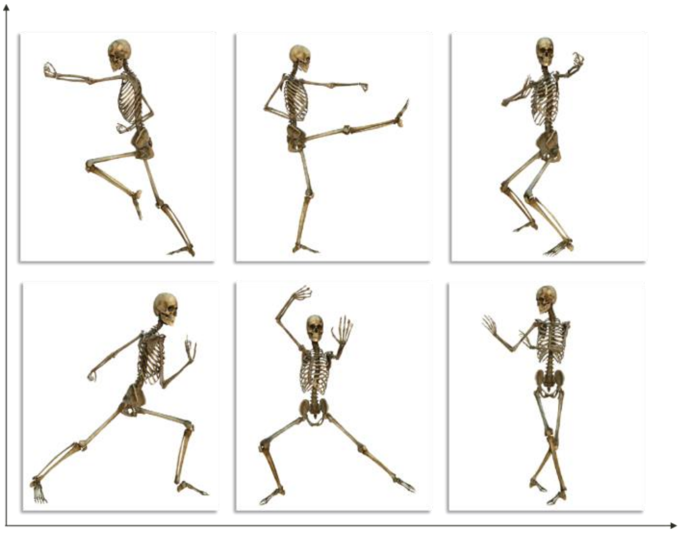

Figure 4: Three-dimensional example of human action skeleton sequence.

The recognition results were then compared between the two datasets. As depicted in Table 1 and Figure 5, the algorithm proposed in this article demonstrates significantly higher recognition rates compared to the traditional method, particularly for multiple sports action numbers, resulting in a notable improvement in recognition accuracy.

Action number	*Our(%)*	*Traditional HOG(%)*
1	91.207	64.321
2	95.355	68.870
3	91.447	76.285
4	91.341	76.688
5	94.810	64.112
6	93.550	69.311
7	88.211	78.385

Table 1: Comparison of experimental results of two kinds of HOG extraction.

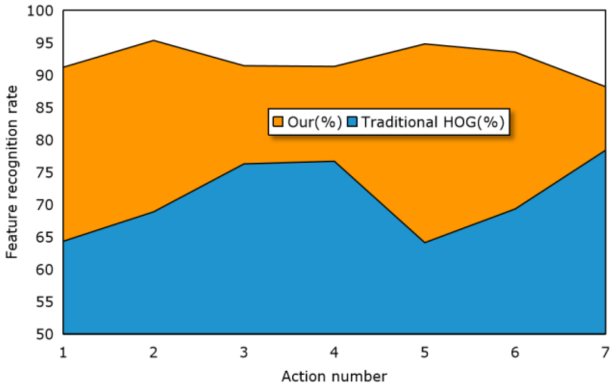

Figure 5: HOG extraction results.

Additionally, the impact of high-dimensional skeleton model characteristics on the recognition performance of time-space HMM is discussed. In the experiment, the number of training samples was set to 25% of the total sample count. Different amounts of joint feature information were used to represent human model characteristics, testing the influence of feature dimensions on the model recognition rate. As depicted in Figure 6, when the number of joint points was increased to 20, the recognition rate of the algorithm significantly improved to 97.69%. This outcome confirms the superiority and robustness of the proposed algorithm in addressing high-dimensional sports action recognition problems.

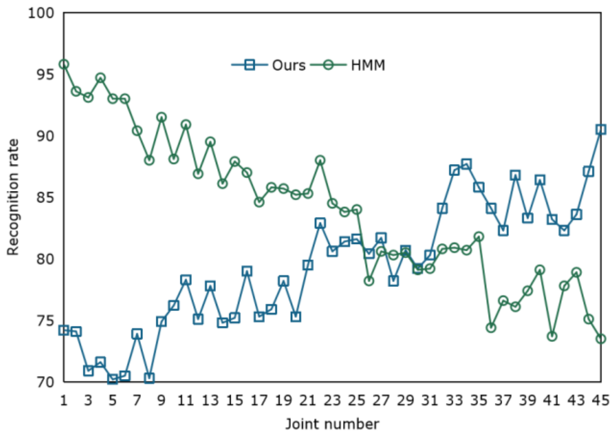

Figure 6: Influence of feature information of joint points on recognition rate.

To assess the trainer's performance, movement information for the three-hand movements of the sports coach is collected. The angles formed by each joint in the decomposition movement are calculated, as illustrated in Figure 7. By comparing the angle curves between the trainer's action and the standard action, the disparity between them becomes evident, offering targeted training guidance for trainers of different levels.

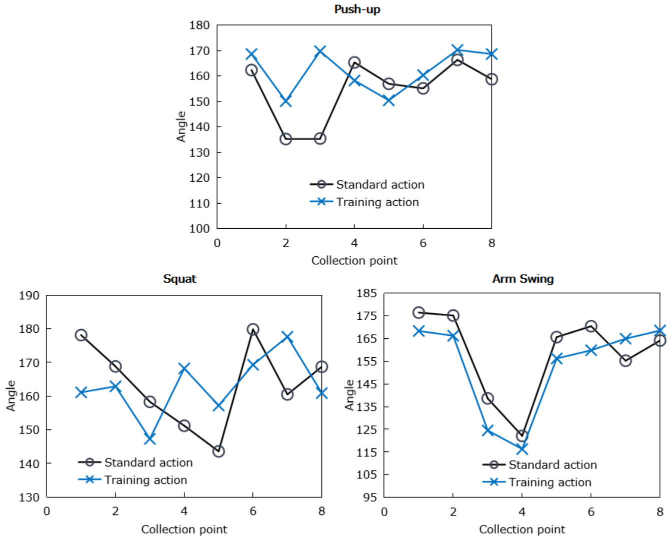

Figure 7: Comparison of key joint angles with standard action curves.

Finally, the accuracy of health risk identification of four sports is tested, and the results are shown in Figure 8. Compared with the other two methods, this method shows higher recognition accuracy and can effectively identify the health risks of four sports. This achievement verifies the effectiveness of this method in health risk assessment, and its application in actual sports training and health management provides strong support.

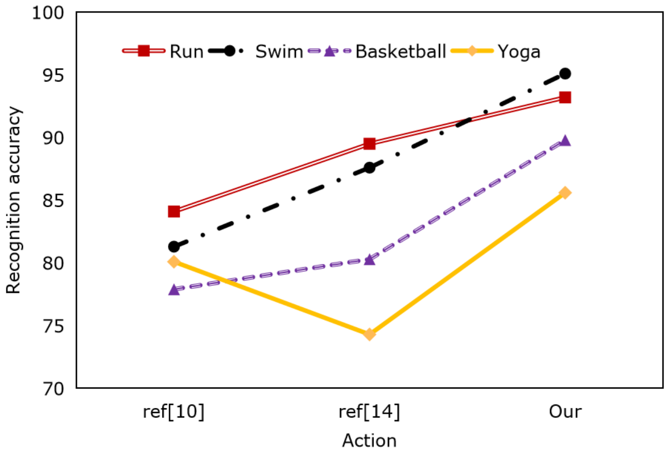

Figure 8: Accuracy of three methods in four sports tests.

To sum up, through a series of rigorous experiments, the obvious advantages of the sports training model and health assessment system based on CAD technology in improving sports training effect and optimizing health risk assessment are fully demonstrated. In the future, we will continue to deepen the research in this field, explore more innovative application scenarios, and contribute more to the development of sports technology and health management.

6 CONCLUSIONS

By introducing CAD technology, this study successfully constructed a more detailed and comprehensive exercise training model and optimized the traditional exercise health assessment system. In the construction of a sports training model, the accurate modelling and simulation ability of CAD technology is fully utilized, and a human motion model with rich details is established. These models can not only accurately reflect athletes' physiological conditions and sports skills, but also help researchers to understand the dynamic changes of athletes in the training stage through simulation analysis. In the optimization of the sports health assessment system, aiming at the limitations of the existing system, the data analysis and visualization functions of CAD technology are introduced. Through the processing and analysis of a large number of sports data, an intuitive visual report can be generated to help coaches and athletes understand the training effect and the changes in physical state more clearly.

The experimental part further verifies the research results. By comparing the performance of different feature extraction algorithms in recognition rate, it is proved that the cumulative edge feature algorithm proposed in this article is superior in extracting HOG features. At the same time, the influence of the characteristics of the high-dimensional skeleton model on the recognition performance of time-space HMM is also discussed, and the effectiveness and robustness of the algorithm in dealing with high-dimensional sports action recognition are verified. Finally, by collecting and analyzing the hand movement information of sports coaches, the application potential of this method in movement analysis and health risk assessment is demonstrated.

To sum up, this article successfully built a sports training model based on CAD and optimized the sports health assessment system. These research results improve the accuracy and effectiveness of sports training and provide more powerful support for athletes' health management.

Zhenzhen Bie, https://orcid.org/0009-0005-9875-3493
Qianqi Zhao, https://orcid.org/0009-0006-1307-350X
Yang Li, https://orcid.org/0000-0002-9397-3906

REFERENCES

[1] Afsar, M.-M.; Saqib, S.; Aladfaj, M.; Alatiyyah, M.-H.; Alnowaiser, K.; Aljuaid, H.; Park, J.: Body-worn sensors for recognizing physical sports activities in Exergaming via deep learning model, IEEE Access, 11(1), 2023, 12460-12473. https://doi.org/10.1109/ACCESS.2023.3239692

[2] Fister, J.-I.; Salcedo, S.-S.; Iglesias, A.; Fister, D.; Gálvez, A.; Fister, I.: New Perspectives in the Development of the Artificial Sport Trainer, Applied Sciences, 11(23), 2021, 11452. https://doi.org/10.3390/app112311452

[3] Ivorra, P.-D.; Vargas, J.-A.-C.; Martinez, G.-P.: Accelerating deep action recognition networks for real-time applications, International Journal of Computer Vision and Image Processing, 9(2), 2019, 16-31. https://doi.org/10.4018/IJCVIP.2019040102

[4] Jiang, Y.: Combination of wearable sensors and Internet of things and its application in sports rehabilitation, Computer Communications, 150(1), 2020, 167-176. https://doi.org/10.1016/j.comcom.2019.11.021

[5] Liu, J.; Che, Y.: Action recognition for sports video analysis using part-attention spatio-temporal graph convolutional network, Journal of Electronic Imaging, 30(3), 2021, 033017. https://doi.org/10.1117/1.JEI.30.3.033017

[6] Marlowe, J.; Tsilomelekis, G.: Accessible and interactive learning of spectroscopic parameterization through computer-aided training, Journal of Chemical Education, 97(12), 2020, 4527-4532. https://doi.org/10.1021/acs.jchemed.0c00925

[7] Nasaoui, H.; Bellamine, I.; Silkan, H.: Action recognition using segmental action network, Revue D'intelligence Artificielle, 37(1), 2023, 185-190. https://doi.org/10.18280/ria.370123

[8] Picco, E.; Antonik, P.; Massar, S.: High-speed human action recognition using a photonic reservoir computer, Neural Networks, 165(1), 2023, 662-675. https://doi.org/10.1016/j.neunet.2023.06.014

[9] Rajšp, A.; Fister, J.-I.: A systematic literature review of intelligent data analysis methods for smart sport training, Applied Sciences, 10(9), 2020, 3013. https://doi.org/10.3390/app10093013

[10] Rashmi, M.; Ashwin, T.-S.; Guddeti, R.-M.-R.: Surveillance video analysis for student action recognition and localization inside computer laboratories of a smart campus, Multimedia Tools and Applications, 80(2), 2021, 2907-2929. https://doi.org/10.1007/s11042-020-09741-5

[11] Wang, D.; Zheng, Y.: Digital and intelligent image processing by artificial intelligence and Internet of things technology in sports fitness detection, IEEE Access, 10(1), 2022, 115996-116003. https://doi.org/10.1109/ACCESS.2022.3218912

[12] Wynters, R.; Liddle, S.-K.; Swann, C.: Qualitative evaluation of a sports-based mental health literacy program for adolescent males, Psychology of Sport and Exercise, 56(4), 2021, 101989. https://doi.org/10.1016/j.psychsport.2021.101989

[13] Yan, X.; Luo, Z.; Wu, L.: Research on the Application of Intelligent Sports Tracking System in Improving the Teaching Effect of University Physical Education, Applied Mathematics and Nonlinear Sciences, 9(1), 2023, 1-15. https://doi.org/10.2478/amns-2024-1516

[14] Yao, X.; Zhang, J.; Zeng, Z.-Y.: Weakly supervised graph learning for action recognition in untrimmed video, The Visual Computer, 39(11), 2023, 5469-5483. https://doi.org/10.1007/s00371-022-02673-1

[15] Zhang, M.; Tang, S.; Wang, C.-J.: ELM-based timing synchronization for OFDM systems by exploiting computer-aided training strategy, IET Communications, 17(15), 2023, 1806-1819. https://doi.org/10.1049/cmu2.12655

[16] Zhao, J.; Chong, S.; Huang, C.-J.-J.: Action recognition based on CSI signal using improved deep residual network model, Computer Modeling in Engineering & Sciences, 130(3), 2022, 1827-1851. https://doi.org/10.32604/cmes.2022.017654