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A Basketball Training System Based on Big Data Technology to Promote Intelligent Physical Education Research

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Abstract: The development of basketball in today's world has organically combined training and competition. However, because it cannot keep up with the development of the times and the advanced training concepts of modern basketball, it cannot keep pace with the times, cannot adapt to the development of modern basketball, and cannot adapt to the training methods and training activities of modern basketball. During the practice phase, single technical movements are repeatedly practiced, as well as lack of confrontation, lack of enthusiasm for skills, tactical practice methods, and no goals without the ball. This not only led to the stagnation of the effectiveness of basketball training, but also restricted the development of physical education. In order to study the online sports training system to promote intelligent sports teaching, this paper has introduced big data analysis technology, established the corresponding big data intelligent sports training system, and compared it with the intelligent sports training system based on visual sensing. Experimental studies have shown that the average packet loss rate of the intelligent sports training system based on big data is 0.21%, the average motion recognition rate is 96.56%, and the average motion recognition time is 0.295s; The packet loss rate is 0.54%, the average motion recognition rate is 90.97%, and the average motion recognition time is 0.304s. Data comparison has shown that the smart sports training system based on big data has higher recognition accuracy, faster recognition speed and less packet loss than the smart sports training system based on visual sensing. The system applies online sports. A better effect in the training system can bring greater improvement to the athlete.

1. Introduction

Regarding the intelligent sports training system, many scholars have made researches related to it in recent years. Nie S studies the construction of a basketball training system based on motion capture technology. Through the processing of motion data, the relevant motion analysis data is fed back to the established motion model to achieve comparative analysis of motion images, so as to obtain better results [1]. Han C studied the basketball training teaching (BTT) method based on intelligent network multimedia technology (NMT) and showed through experiments that the combination of NMT and BTT can improve the efficiency of sports training [2]. Yue T analyzed the requirements and constructed the overall framework of the basketball online sports training system, and designed the corresponding functional modules on this basis. And the student evaluation module based on BP neural network is analyzed. The experimental results show that the method verifies the effectiveness of the system and achieves the experimental purpose [3]. Based on motion perception and computing technology, Hiroki uses d self-organizing mapping technology to visualize high-dimensional time series, indicating that the self-organizing mapping algorithm visualizes human actions, thereby greatly improving the ability to simulate actions, which can be applied to basketball sports training or clinical practice [4]. Many scholars have studied basketball motion systems, but these traditional systems are flawed and cannot handle large amounts of data. To this end, this paper introduces big data analysis technology.

Big data technology has matured through continuous development and improvement over the years, and research on big data is emerging one after another. Online advertisements are accurately placed and the effect of advertisements is evaluated. Ge T has obtained the superiority of the transmission rate based on BD-MQ between 5% and 10% by testing the data transmission system of BD-MQ. It is more stable for a single data transmission rate change of different sizes [5]. Huang X has selected herbal combination methods through probabilistic models and big data technology, pre-processed the formulation with standardized names of all herbs, and proposed the concept of drug candidates. Research results have shown that the use of traditional Chinese medicine can be further optimized by analyzing a wider data sample of various herbal combinations through computational and big data techniques [6]. In order to improve the conventional evaluation method of hydrogenation heat exchanger operation status, LiL proposed a new automatic monitoring algorithm for the operation status of hydrogenation heat exchange equipment based on big data, and verified the application of this method in practical application by examples [7]. Basanta-Val P has proposed an initiative called BOE to process official Spanish government gazettes to reduce computing time and provide the extra speed of big data analysts. The program shows how the infrastructure can improve different simple analytical capabilities when multiple computers are collaborating [8].

In order to improve the traditional basketball training system, this paper establishes an online intelligent basketball training system based on big data analysis technology. And in order to test the practicability of the system, a certain basketball player is selected for experimental analysis, and the effect is compared with the training system based on visual perception. The results show that the packet loss rate of the basketball training system based on big data is more than 0.32% lower than other systems. The average time consumption of the intelligent sports training system is reduced by 0.09s, and the precise control of sports items is increased by 2.74%. It can be seen that the intelligent basketball sports training system based on big data established in this paper is more stable, more efficient and more accurate than the traditional sports training system. It is very suitable for Intelligent sports teaching.

1.1 Basketball sports training system

(1) *Basketball training system based on visual sensing*

Kinect recognition analysis

This article has used a Kinect3D camera developed by Microsoft Corporation. Its main advantages are that it can capture human motion scenes in real time, effectively identify and transmit skeleton information, and recognize the user's personal voice. The Kinect consists of an

RGB camera, an infrared receiver and transmitter for depth images, and a microphone array.

Kinect can capture real-time motion situation, the key is infrared camera, infrared projector and color camera. Kinect's 830 mm wavelength infrared is emitted by an infrared transmitter, and then the receiver receives the red light from the infrared to generate a depth image frame by frame. After the obtained depth image is processed by the human body recognition and background separation algorithm, the corresponding color is extracted from the RGB camera. The image data is transferred to an application by Kinect for processing.

In conclusion, compared with general cameras, KinectV2 has many advantages. The disadvantage of conventional cameras is their over-reliance on color images, making it difficult to eliminate environmental factors from experimental data. KinectV2 relies on depth images to identify and analyze bones. Figure 1 shows the structure of the system.

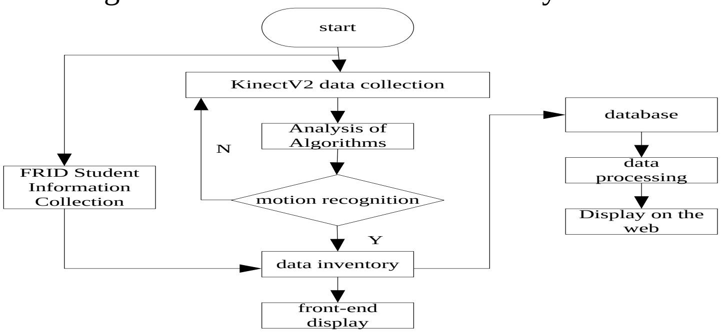

Figure 1. Software system architecture

(2) Video image acquisition module. The main function of this module is to collect sports training images of basketball players. By identifying the nodes for motion training, the motion trajectories of the machine points on the motion joints can be obtained. During the acquisition of basketball players' sports training images, a large amount of noise will be generated due to the imbalance of the system equipment and the influence of the acquisition environment. Therefore, effective recognition can only be performed after preprocessing such as grayscale and noise filtering on the video image. Through the Sobel boundary search algorithm, the outline of the basketball player's training action is extracted from the training video, and the center and radius of each joint in sports training are identified through Hough transform. After obtaining the joint training position of the investigated object, use the image contour method to localize it.

(3) Video image processing module. The first thing to do is to collect training videos, process the collected videos, and then transfer the preprocessed videos to an image processing module to detect erroneous terms in motion videos. The video image processing module includes: a coordinate acquisition sub-module, a video image perception module and an error detection and analysis module. Using the method of computer acquisition, the coordinates of the image point, object point and lens center point of each joint during the basketball player's exercise training process are obtained. According to the measured data, the image sensor module can obtain the spatial position of the athlete's joint in the mechanical spine coordinate system during sports training. Then, after studying the parameter measurement in basketball training, the conduction relationship of sports training error, the error transfer relationship of each link of athlete sports training, the error transfer relationship of sports training nodes in each link of sports training, the results of each link of sports training for athletes are obtained. Athletic training error transfer relationship.

(4) Intelligent assessment process design. After completing physical exercise, evaluating and analyzing the level of basketball training is an important way to improve the quality of physical education. The intelligent test module of basketball sports training of the system uses data mining technology to process the joint positions of athletes, and uses the image processing module to

analyze the movement trajectory in basketball sports training. Reaction time, accuracy, and stability of basketball exercise training were also assessed. Aiming at the current situation of athletes, suggestions are put forward to improve the performance of basketball players.

The architecture can be divided into five levels. The data acquisition layer in Kinect has adopted the Kinect smart camera to collect human skeleton, color and depth images. It is transmitted to the next layer for skeleton algorithm processing, which is filtered by the algorithm processing layer and matched with the DTW template. On this basis, the motion detection results and performance are displayed to the application layer by performing motion recognition on the processed skeleton nodes. The specific framework is shown in Figure 2.

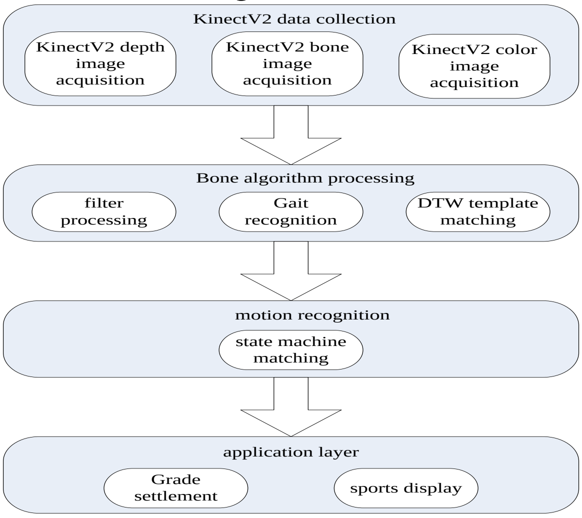

Figure 2. Frame structure of the physical fitness test system

The system adopts the DTW algorithm to complete the matching of skeletal features. In the DTW algorithm, the benchmark template and test template correspond to the standard skeleton and bone feature sequences in the data storage layer, respectively. So the expressions of the benchmark template and the test template are:

$$T = \{T(1), \cdots, T(j), \cdots, T(J)\} \tag{1}$$

$$R = \{R(1), \cdots, R(i), \cdots, R(I)\} \tag{2}$$

T(j), R(i) can be expressed as:

$$T(j) = \{\alpha_{t1}, \alpha_{t2}, \cdots, \alpha_{tx}\} \tag{3}$$

$$R(i) = \{\alpha_{r1}, \alpha_{r2}, \cdots, \alpha_{x}\} \tag{4}$$

Formula (3) represents the composition of the feature vector in the feature sequence T at time j. In the sports training system, the corresponding relationship between the standard value of the skeleton sequence and the eigenvalue is:

$$P = \left\{(k_n, l_m), n, m = 1, \cdots, J: k_1 = l_1 = 1, k_J = l_J = J, k_n \leq k_{n+1}, l_m \leq l_{m+1}\right\} \tag{5}$$

In the formula: kn, lm——the label of any frame corresponding to the standard skeleton sequence and the characteristic skeleton sequence.

According to this, the distance between k_n and l_m can be deduced, as shown in the formula:

$$d[T(l_m), R(k_n)] = \sum_{i=1}^{x} k_i \left\| \alpha_{ri,l_m}, \alpha_{tj,k_m} \right\| \tag{6}$$

In the formula: k_i——the weight of the current angle.

Then the total distance between two feature sequences can be found:

$$D[T, R] = \sum_{(k_n, l_m)} d[T(l_m), R(K_n)] \quad (7)$$

The optimal path of DTW is to minimize the total distance between two feature sequences, and the expression is as follows:

$$DTW[T, R] = \min D[T, R] \quad (8)$$

Using the DTW algorithm, the basic idea of the basketball training system in this paper is "local optimum, global optimum", looking for the closest template matching node, so as to realize the identification of the motion state node.The system can extract all the characteristics of bones in one motion cycle in real time, and the number of reference templates in the system's bone feature sequence is less than the number of test templates. In the case, the system uses the DTW method to analyze a movement of a single cycle.

(5)The realization of warm-up in basketball

Due to the basic principle of gait recognition, the collection and extraction of its eigenvalues is the biggest problem in the whole system. The relative angles of the skeleton points in 3-D are shown in Figure 3. In KinectV2, the motion pose skeleton data points are mapped one by one.

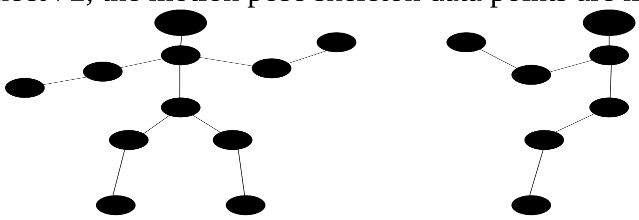

Figure 3. Schematic diagram of feature extraction action

The angle formed between the knee joints in space is required, as long as the angle β between the vectors EW and ER is calculated, and the calculation expression is as follows:

$$\vec{E}W = (w_x - e_x, w_y - e_y, w_z - e_z) \quad (9)$$

$$\vec{E}R = (r_x - e_x, r_y - e_y, r_z - e_z) \quad (10)$$

$$\cos\beta = \frac{\vec{E}W \cdot \vec{E}R}{|\vec{E}W||\vec{E}R|} \quad (11)$$

The rotation angle θ can be obtained in the same way. The rotation angle is the angle between the plane where the vectors EW and ER are located and the XOY plane of the coordinate system. The angle between the normal vectors of these two planes is the rotation angle.

The normal vector of the plane where EW and ER are located:

$$\overrightarrow{N_1} = \vec{E}W \times \vec{E}R \quad (12)$$

The normal vector of the plane where XOY is located is:

$$\vec{N}_2 = (0,1,0) \quad (13)$$

The rotation angle can be obtained from the formula as:

$$\cos\theta = \frac{\vec{N}_1 \cdot \vec{N}_2}{|\vec{N}_1||\vec{N}_2|} \quad (14)$$

During feature extraction, the above-mentioned bone angle calculation method can be used to obtain the corresponding angle, and the characteristic sequence of each type of bone is composed of them. In order to further improve the integrity of motion recognition, this paper classifies and extracts motion features and bone features simultaneously. Sit-ups are a common form of daily exercise. When doing sit-ups, knees are bent at a ninety-degree angle and legs are flat. On a flat surface, do not use feet but allow peers to hold their hands tightly, otherwise the flexors of the thighs and hips will be involved in the work of the movement. The hands are placed on the head, and as the abdominal muscles pull, the closer to the head, the harder the sit-ups become. Using the contraction of the abdominal muscles, the arms quickly assume a sitting position, the upper body continues to bend forward, and then resume the sitting position, and so on. In actual sports training, the feature matrix is extracted, and the matrix expression is as follows:

$$S_R = \begin{bmatrix} a_1 & b_1 & c_1 & d_1 \\ a_2 & b_2 & c_2 & d_2 \\ \vdots & \vdots & \vdots & \vdots \\ a_r & b_r & c_r & d_r \end{bmatrix} \tag{15}$$

In the formula: R——the movement cycle of the squat movement; r - time to complete a squat.

On this basis, the similarity threshold of the general state node in the squat action DTW algorithm is denoted by d_r, and its unit is expressed in degrees. The key to the squat movement is the horizontal forward extension of the arms and the degree to which the squat movement is completed. When in the squat state, the similarity threshold of its nodes is set to d_{rmax}, and its similarity weight can be expressed.

When doing sit-ups, the most important thing is to do a good sit-up posture, in which the score ratio of the sit-ups to the sit-ups is a_1:a_2. Assuming that the subject has done i squats, the final score S is calculated according to the formula:

$$S = \frac{j\sum_{n=1}^{i}(a_1 g_n + a_2 k_n)}{4i^2} \tag{16}$$

In the formula: g——the standing state similarity is; k—sit-up state similarity.

This sport has high demands on the standardization of movements. As prescribed, subjects first lie flat on a mat with feet slightly spread, knees bent at 90 degrees, and hands on their heads. When the subject sits down, the elbows touch or go over the knees once. When lying flat, make sure shoulders touch the mat. If the subject is already sitting up, but the elbows do not touch the knees, the number of times will not be counted. When the subject stood up with his hands in a T-shape, the movement was judged to be complete and the movement was scored.

1.2 Training Intelligent Model Based on Big Data

(1) Intelligent model

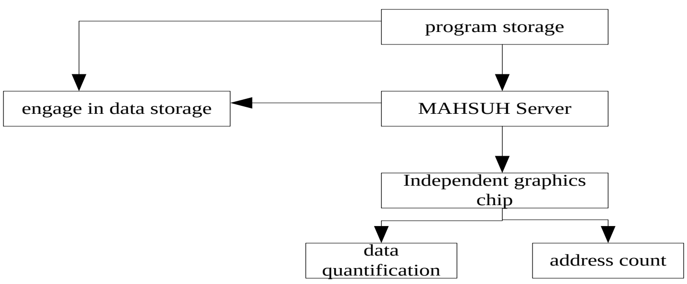

Figure 4. Intelligent model of training progress of sports athletes

This paper introduces MAHSUH server, adopts the overall structure of mesh program, and strengthens the interconnection between components. At the same time, this software provides data of athletes' training needs, the server analyzes the athletes' training needs, analyzes the results, and performs corresponding processing on the server. In Figure 4, the structure of the athlete training intelligent model is described in detail.

Big data models are built on massive data collection and analysis. Therefore, in training, it can be carried out from two main technical links, namely interface and identity system.

(2) Build the Okumura-Hata intelligent model

The most commonly used intelligent model is Okumura-Hata, which has strong anti-interference ability and guarantees the accuracy and stability of the model.The expression is as follows:

$$\frac{Q(r)}{N(r)M(r)} = s_a \left[\frac{Q(r)}{N(r)M(r)}\right]^b \left[\frac{R(r)}{N(r)M(r)}\right]^{1-b-k} - \alpha_h \left[\frac{G(W)}{N(T)} + \frac{Q(r)}{N(r)M(r)}\right] \tag{17}$$

In the formula: Q(r)——data extremely poor; N(r)——base height; M(r)——operating frequency; R(r)——data model dynamics after loss index correction; α_h——transmission distance.

The specific feedback data of this intelligent model can be expressed mathematically as:

$$\mathrm{H}[\mathrm{c}] = \frac{\partial^2 \beta}{\partial \mathrm{v}^2} \tag{18}$$

In the formula: v2——the time-delay parameter of the athlete's training movement characteristics; β - data effective use value.

According to the specific feedback information in the Okumura-Hata intelligent model, it is an important step to intelligently plan the training process of athletes in the future. According to the above process in this paper, the model can be initially modeled.

(3) Training model algorithm optimization

On the basis of the Okumura-Hata intelligent model, from the perspective of big data analysis, the training data of athletes is likely to jump. In order to effectively avoid this situation, the training process needs to be improved, and its expression is:

$$\frac{\partial^2 I_2}{\partial n^2} = \frac{(k - k_j - I_2) W_0(n)}{w_0(n)} > 0 \tag{19}$$

In the formula: $\partial^2 I_2$ ——the model weight mean coefficient; k_j——model data simulation index; ∂n^2- the best operating weight coefficient; W_0 - Big data expression properties.

When modifying the algorithm, the robustness between the modules will become lower and lower, resulting in longer computing time. In the extreme value setting, the maximum and minimum values are adjusted and optimized before the standard can be determined. The formula can be expressed as:

$$G_d = \frac{R_d \cdot V_m}{[g_1, g_2 \cdots\cdots g_q]} E_q \times \frac{Y_m \times g_m \times v_m}{[Y_1, Y_2 \cdots\cdots Y_q]} \tag{20}$$

In the formula: Eq——the maximum critical value of the proposed total amount; $[g_1, g_2 ... g_q]$ - an ordered set that can be collected between the maximum value and the minimum value, which can optimize the bias; $[Y_1, Y_2, \ldots Yq]$——ordered collection of loss data.

After the calculation of Formula (19) and Formula (20), the optimization of the intelligent training model can be completed, so as to have a more applicable guarantee for the reliability of the results formulated by the intelligent training model.

2. Experiment Results of Sports Training Model

In the experimental part of this paper, the sports athletes of a certain school are selected as the experimental objects, and the students' usual physical training is simulated as the experimental samples. The experimental subjects used the intelligent basketball training system based on visual sensing (hereinafter referred to as the VS system) and the intelligent basketball training system based on big data (hereinafter referred to as the BD system). The packet loss rates of the two different systems during the experiment are as follows.

Table 1. Comparison results of packet loss rate of different sports training systems

Training video image time /s	60	120	180	240	300	360	420
Vision Sensing-Based Systems	0.36	0.41	0.47	0.60	0.72	0.83	0.89
big data based system	0.14	0.13	0.15	0.22	0.31	0.40	0.47

From the analysis in Table 1, it can be seen that with the increase of the training video duration, the packet loss rate of the two intelligent basketball sports training systems has increased.On this basis, before 160 seconds, the packet loss rate and change of the BD system are very small. But after 160 seconds, the packet loss rate increased a lot, and the average packet loss rate reached 0.19%. However, for the VS system, the overall loss rate varies greatly, and the packet loss rate is also relatively large. It can be seen that the packet loss rate of the BD system is more than 0.32% lower than that of the VS system, and the stability of the system is better.

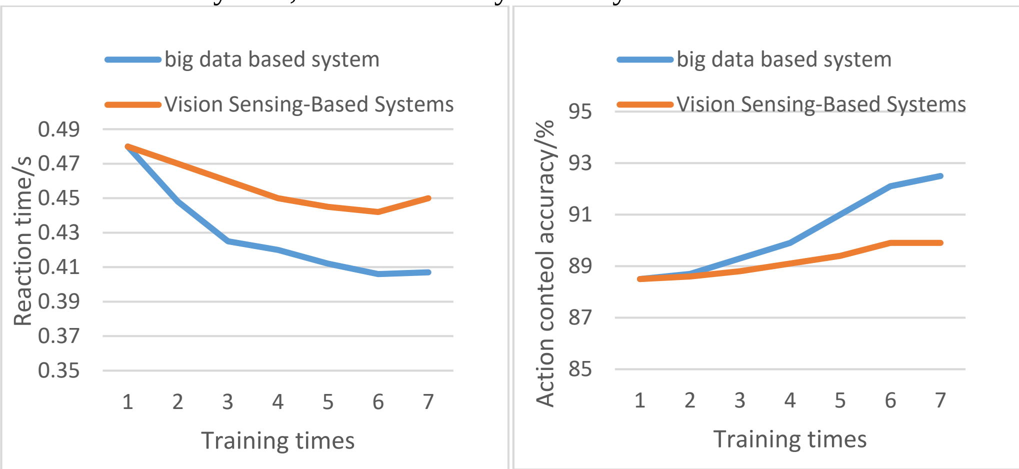

Figure 5. Comparison results of sports training effects

Figure 5 shows the comparison of exercise training effects under the two systems. After analyzing the data graph in Figure 5, it can be concluded that after using the BD system, when the number of training increases, the reaction time of athletes has decreased, from 0.47s to 0.39s. And the precision control of sports has improved, from 87.37% to 91.54%. Compared with the VS system, after using the BD system, the reaction test time of sports athletes decreased by 0.05s, and the precision control of sports items increased by 2.74%. It can be seen that the BD system can train better sports effect, so that athletes can react faster and move more accurately.

In order to ensure the accuracy of the tested intelligent sports training model, and to ensure the accuracy and stability of the process in the experiment, the data is reasonably arranged, and the results are shown in Table 2.

Table 2. Experimental data table

Frequency	1	2	3	4	5	6
Model Feedback Rate (%)	31.3	44.9	56.7	63.6	76.8	89.3
Training intensity	0.14	0.28	0.36	0.47	0.53	0.66

It can be seen from Table 2 that after model optimization, the feedback rate of the model continues to increase with the number of experiments, from 31.3% of the model feedback rate to 89.3% of the model feedback rate. And the training intensity is also increasing, from the initial 0.14 intensity, the final training intensity increases to 0.66.

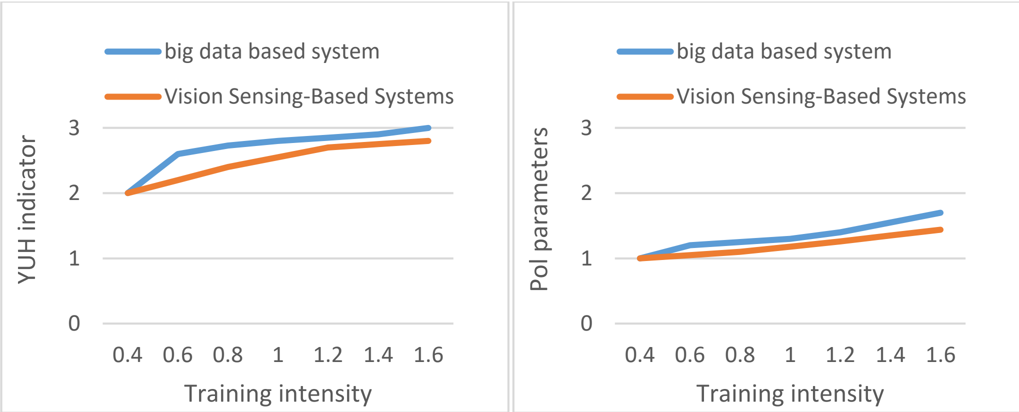

Figure 6. SO test experimental results

Figure 6 shows the result data of the SO test.With the continuous increase of training intensity, the YUH index and Pol parameters of the two models are in a slow upward trend, which has shown that the intelligence of the two intelligent sports training models can reach a high level of fit. And the feedback ability is high. Comparing the two models, the YUH value and Pol parameter value of the BD system are always larger than the YUH value and Pol parameter value of VS system. It has been demonstrated that the BD system has higher intelligence and higher feedback ability.

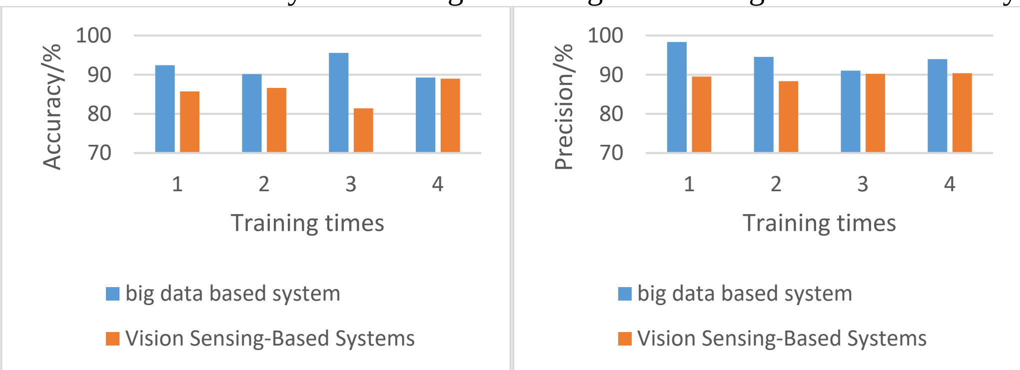

Figure 7. Accuracy and precision of the training system

Figure 7 shows the comparison results of the accuracy and precision metrics of the two basketball sports training systems. It can be seen from the data comparison in the figure that the accuracy rate of the BD system is generally above 89%, and the average accuracy rate of the system reaches 92.17%. The precision rate of the system exceeds 90%, and the average precision rate reaches 94.58%. The accuracy rate of VS system fluctuates greatly, and the value is low, and the average accuracy rate is only 85.76%. The system precision rate of this system is relatively stable, the fluctuation range is small, but the value is low, and the average precision rate reaches 89.63%. In contrast, it can be seen that the system accuracy and precision of the BD system fluctuate greatly but the values are high, indicating that the system has a higher degree of accuracy and more accurate system output results. The BD system has a relatively stable precision rate, but its system accuracy is relatively low.

Figure 8 is a comparison of the motion recognition effects of the two intelligent motion training systems. By analyzing Figure 8, it can be seen that BD system has a high motion recognition rate, the highest recognition rate is 98.64%, the lowest is 93.69%, and its average motion recognition rate is 96.56%. The average motion recognition rate of the other system is 90.97%, which is 5.59% lower than the former. In terms of recognition time, BD system takes an average of 0.09s less than the another system. Therefore, after comparing the data, it is found that the recognition speed of BD system is faster than that of another system. And it has a higher motion recognition rate, which can be well applied to the online intelligent sports training system.

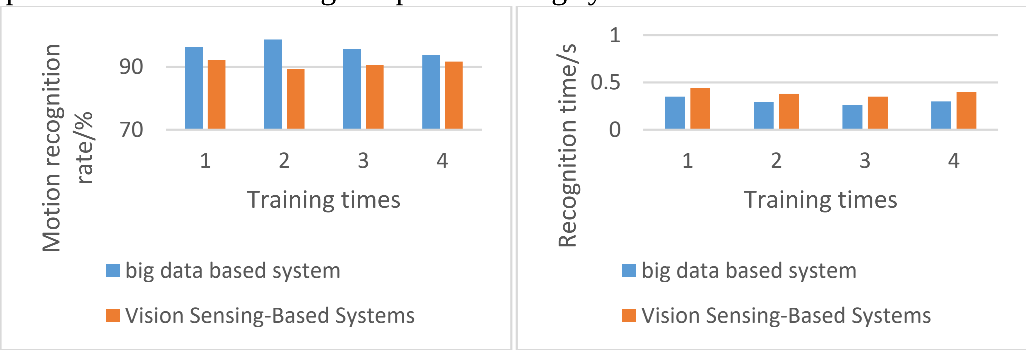

Figure 8. Intelligent motion recognition effect

Table 3. Comparison of operating efficiency of different systems

number of experiments	big data based system		Vision Sensing-Based Systems	
	transfer speed/(Kb/s)	transmission delay/(bit/s)	transfer speed/(Kb/s)	transmission delay/(bit/s)
1	35.70	2.84	29.95	4.78
2	36.31	2.91	28.60	4.95
3	36.08	2.75	27.35	5.20
4	35.43	2.54	29.03	4.91

Table 3 is a data comparison of the operating efficiency of the two systems. The analysis of Table 3 shows that the transmission speed of BD system is higher than that of VS system. And the transmission speed of BD system is more stable, and the transmission delay is the lowest among the two systems. The experimental results have shown that BD system has high operating efficiency.

3. Conclusion

Aiming at the research and analysis of the basketball training system, this paper introduces the big data analysis algorithm and establishes the corresponding basketball training system model. And in order to better verify the superiority of the model, in the experiment, the intelligent basketball training system based on big data and the intelligent basketball training system based on visual perception were used to test and analyse the selected objects. The final test results show that, compared with the traditional basketball training system based on visual perception, the system can perform action recognition more accurately and quickly, and the recognition efficiency is higher than the traditional one. It can improve the shortcomings of the traditional basketball training system, keep up with the pace of modern basketball training, have better performance in intelligent physical education, improve the efficiency of physical education, and ultimately promote the improvement of basketball players' training effects. However, there are still some deficiencies in the research of this paper. This paper focuses on the analysis of the recognition rate of sports training in physical education by big data basketball training, and seldom mentions its more applications in physical education. Therefore, in the future in the research, the basketball training system based on big data needs to be further explored to broaden its application field in physical education.

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