

## Research Article

# Physical Education Teaching Based on Human Model Design and Computer Simulation of Human Two-Dimensional Moving Image

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The traditional gait analysis is mainly used in the research of joint dynamics and electromyography, which is helpful to develop a medical feedback system. The system judges the leg injury by analyzing the patient's gait, so as to provide effective treatment. In order to study how computer technology can be more appropriately introduced into physical education, this paper puts forward a new design method of manikin. The application of some key implementation technologies of computer simulation of two-dimensional motion images of human body is conducive to the scientization of physical education teaching and training. The experiment analyzes the daily movement of human body. MEMS technology is a technology to obtain human inertial data by simulating human motion with one or more computers. By integrating the collected data, different characteristics can be obtained. Then, classify these feature processing algorithms, and finally, identify the actions performed by the human body. Finally, the advantages of this recognition method in recognition accuracy are verified.

## 1. Introduction

The core goal of computer graphics is to create effective visual communication. In the field of science, graphics can display scientific achievements to the public through visualization. In the field of entertainment, such as PC games, mobile games, 3D movies, and movie special effects, computer graphics is playing a more and more important role. Graphics also plays an important basic role in creative or artistic creation, commercial advertising, product design, and other industries. In the field of science, this point was highlighted in the 1987 visual report on scientific computing. The report cites Richard Hamming's classic assertion in 1962: "the purpose of calculation is to gain insight into the nature of things, not to obtain numbers." The report mentioned the important role of computer graphics in helping the human brain understand the essence of things from the perspective of graphics and images, because graphics and images have stronger insight than simple numbers.

"Computer graphics" is a related theory, method, and technique for generating object graphic output based on a model. A computer is used to build, store, and process a

model of an object [1]. Computer graphics has a wide range of applications. One important area is the use of computers to simulate the process of systems or phenomena, for system analysis and process control [2]. There are three geometric models commonly used in computer graphics: wireframe, surface model, and volume model. The single-line model of human body evolved from the wireframe model [3]. Its description method is similar, and the principle is similar. The surface of polygonal surface model is very complex, which can generate various views and realistic graphics. Model information is an ideal model for the two-dimensional spatial wire frame of a simulated object, which can be used to evolve into a single reasoning model of human body [4]. It is scientific and feasible to use computer graphics model to build a suitable model for transfer motion. However, scholars have not done much research on this issue. The design technology of human model simulating two-dimensional human motion on computer has become the focus of research [5]. Taking gymnastics as the research object and computer simulation as the design method, the computer simulation gymnastics graphics movement teaching system was developed in one and a half year.

## 2. The Research Status of Human Body Model

According to Hanna's body model theory and textbook schematic diagram, the human body is understood [6]. Similarly, the human model can be divided into 41 parts. In computer graphics, data structure is essentially a data file, which is used to generate all the graphics that the object describes. These descriptions include geometric information and topology information that defines the shape and size of objects for all components and is used to describe information about objects that are related to the object, such as color and skin quality [7]. The common data structure is a common data file, and its description information is universally applicable. For example, the head consists of four polygons, while the polygon is composed of dozens of vertices [8]. The description of the head link model should include the following information: the general data structure of the joint center (part of the head of the shoulder center ring) coordinates, the link angle joint center (the attachment of the centroid and the active  $X$ -axis) coordinates, the center vertex of the distance (distance) of the vertex, the vertex angle (the vertex distance and the positive angle of the axis), the number of vertices, the color of the filling, and the color of the line [9].

## 3. The Method of Establishing Human Body Model

**3.1. Bilateral Filtering Algorithm Based on Hidden Markov Model.** Two-dimensional human models have broad application prospects in modern medicine, virtual reality, and other fields. Bilateral filtering technology has become a hot research topic. As a nonlinear filter, it plays an important role in solving the pixel values of spatial similarity. This technology also needs to consider the influence of spatial noise to remove gray similarity [10]. In general, the detail protection that can clearly penetrate the blurred edge is not obvious. Research needs models with simple, noniterative, and local characteristics. Second, the bilateral filter can just meet the above characteristics [11]. General Gaussian blur mainly considers the spatial distance relationship between pixels, but does not consider the similarity between pixel values. Therefore, the blur result we get is usually the blur of the whole picture. The improvement of bilateral blur is that when sampling, we not only consider the relationship between pixels in spatial distance, but also consider the similarity between pixels, so that we can maintain the general block of the original image and then maintain the edge. Due to the high frequency of high-frequency human motion signal, the high-frequency noise in color image cannot be completely filtered out. In digital image processing, only low-frequency human motion signals can be filtered better [12]. In digital image processing, bilateral filtering algorithm is often used for image denoising. It is a nonlinear filtering method, which considers the adjacency between pixels and human gray motion signals. The bilateral filters used in digital image processing are

$$L(q) = \frac{\sum_{k \in N(q)} (\|p - k\|) w_s (|L(q) - L(k)|) L(k)}{\sum_{k \in N(q)} (\|q - k\|) w_s (|L(q) - L(k)|) L(k)}, \quad (1)$$

where  $q$  is a pixel,  $k$  is an adjacent pixel of  $q$ ,  $N(q)$  is a set of  $q$  adjacent pixels,  $\|p - k\|$  is the Euclidean distance between  $q$  and  $k$ , and  $L(q)$  is the gray value of  $q$ .  $|L(q) - L(k)|$ . It is the grayscale similarity between  $q$  and  $k$ , and both  $W_c$  and  $W_s$  are weight functions.

In order to introduce the bilateral filtering algorithm from the digital image processing to the scattered point cloud denoising, a visual plane is first defined: for the neighborhood point set  $N(P)$ , the three-dimensional space  $R^3$  is described as  $R^3 = N + S_2$ .  $N$  is a one-dimensional space along the normal direction at the  $P$  point of the neighborhood point.  $S_2$  is a two-dimensional tangent plane over  $P$  points.  $+$  is straight sum operation. In the local scope,  $S_2$  is defined as the visual plane, while the neighborhood point is defined as the projection point on  $S_2$ . The distance from the neighborhood point to the pixel is defined as the gray value of the pixel. The bilateral filtering algorithm is defined as

$$q' = q + \alpha n, \quad (2)$$

where  $q'$  is the filtered point,  $q$  is the point of the original point cloud,  $n$  is the normal vector of point  $q$ , and  $\alpha$  is the bilateral filtering factor. The formula for calculating  $\alpha$  is as follows:

$$\alpha = \frac{\sum_{k_{ij} \in N(q_i)} W_c(\|q_i - k_{ij}\|) W_s(\langle n_i, q_i - k_{ij} \rangle) (\langle n_i, q_i - k_{ij} \rangle)}{\sum_{k_{ij} \in N(q_i)} W_c(\|q_i - k_{ij}\|) W_s(\langle n_i, q_i - k_{ij} \rangle)}. \quad (3)$$

The definition of the smoothing filter function  $W_c(x)$  and the feature-preserving weight function  $W_s(y)$  is

$$\begin{aligned} W_c(x) &= e^{-x^2/2\sigma_c^2}, \\ W_s(y) &= e^{-y^2/2\sigma_s^2}. \end{aligned} \quad (4)$$

$\sigma_c$  and  $\sigma_s$  are the Gauss filtering coefficients of the plane of view, namely, the weight of the spatial domain and the weight of the feature domain.  $\sigma_c$  describes the effect of distance from point  $q_i$  to neighborhood point on this point.  $\sigma_s$  describes the influence of projection from point  $q_i$  to neighborhood points on the normal  $n_i$  of  $q_i$  to point  $q_i$ . The larger the  $\sigma_c$ , the better the filtering effect. The larger the  $\sigma_s$ , the better the cloud motion characteristics of the human body. The two influence each other. K-nearest neighboring point culling algorithm and K-nearest neighbor-based outlier culling algorithm are selected. The algorithm actually takes the idea: for any point in the point cloud, that is, the average distance between the point and the corresponding nearest neighbor points, if the average distance from the whole point to the K-nearest neighbor is in accordance with the Gauss distribution, the average distance to the K-nearest neighbor point at the point of  $M + D$  is treated as the outlier

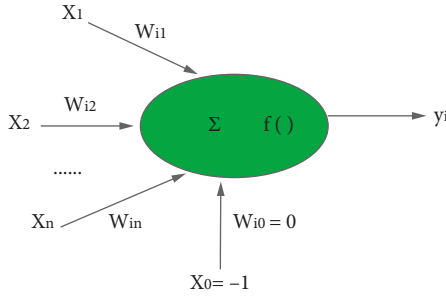


FIGURE 1: Neuronal structure.

point and is removed. The first step is to properly initialize the network structure so that each weight  $w_{ij}$  and threshold  $\theta_j$  of the neural network are initialized between 0 and 1 (Figure 1).

Then, the square error SSE of the network error and the maximum number of iterations are set to 0, and the number of iterations is calculated one by one. The second step is to extract an input vector  $X$  and its corresponding output vector  $T$  from the training set randomly. The third step is the forward propagation input process. The net input vector  $I_j$  of each neuron is calculated relative to the previous layer, and a continuous derivable function is selected as a transfer function (such as logistic or sigmoid function). Then, the output vector  $O_j$  of neuron  $J$  is mapped to 0 and 1 according to

$$I_j = \sum_i w_{ij} O_j + \theta_j I, \quad (5)$$

$$O_j = \frac{1}{(1 + e^{-I_j})}. \quad (6)$$

The fourth step is to calculate the error squared sum SSE of the neural network, as shown in

$$SSE = \text{sumsq}(T_j - O_j). \quad (7)$$

The fifth step is the reverse propagation process. The error vector  $ERR_j$  of each neuron is calculated according to the expected output value  $O_j$ , as shown in

$$ERR_j = O_j(1 - O_j) \sum_k (ERR_k w_{jk}). \quad (8)$$

The sixth step is to dynamically adjust the weights and thresholds of the vectors in the neural network according to the formulas (9) and (10), in which  $\alpha$  is the learning rate.

$$w_{ij} = w_{ij} + \alpha ERR_j O_j, \quad (9)$$

$$\theta_j = \theta_j + \alpha ERR_j. \quad (10)$$

The seventh step is that if SSE is less than or equal to the target error, it means that the network is convergent. If  $t = M$ , it indicates that the network is not convergent. When these cases occur, the iteration process ends. Otherwise, it will continue to be executed from the second step. BP network adopts a guided learning method, and its learning includes the following four processes. (1) The input mode consists of the “mode forward propagation” process from the input

layer through the hidden layer to the output layer. (2) The error signal of the difference between the expected output and the actual output of the network is the “error back propagation” process of rounding the connection weight layer by layer from the output layer through the hidden layer. (Reverse calculation process) (3) network “memory training” process is repeated by “mode forward propagation” and “error inverse propagation.” (4) The network tends to converge, that is, the “learning convergence” process in which the overall error of the network tends to the minimum. In the training phase, the training instance repeatedly passes through the network, modifies each weight, and changes the connection. The initial set of corresponding points is predicted. Reasonable calculation of the characterization factor is implemented correspondingly to the important points obtained. Its position in point cloud is discussed in detail. Based on their characteristics and location similarity, the relationship between them is predicted. A preliminary estimate of the response point pair is implemented, and the initial corresponding point set is clarified. The error point must be reasonably removed.

**3.2. Model Correction Method.** The commonly used data mining techniques include statistical analysis class and knowledge discovery class. One is statistical analysis. The data mining models used by statistical analysis technology include linear analysis and nonlinear analysis, regression and logistic regression analysis, single variable and multi-variable analysis, cluster analysis, time series analysis, and so on [13]. First of all, these technologies can be used to check which human model information is abnormal human model information. Then, a statistical model or a mathematical model can be established to analyze the information of these human models so that the rules and information hidden between the information of the human body model are found. Photos and videos based on or containing real human bodies are used as objects of data input and postprocessing. We choose the existing models in the human model library of the existing human modeling commercial software PR as our analysis. The reconstructed and adjusted object is used to replace the digital model obtained by scanning the real human body. The main purpose of this is to make a compromise between the cost of building the system and the authenticity of the system results. For example, in order to increase market share and profit, general statistical analysis tools can be used to seek the best business opportunities. A comprehensive quality management system is utilized to improve the quality of products or services, and customer satisfaction and user experience are improved. Or by restructuring business processes or reshaping the pipeline structure, the profits of enterprises can be increased accordingly. The data mining technology of statistical analysis is one of the most mature data mining technologies at present, which has been widely applied [14].

The two is knowledge discovery technology. Knowledge discovery class technology is based on human model information driven, which can discover business patterns from human model information in human model information

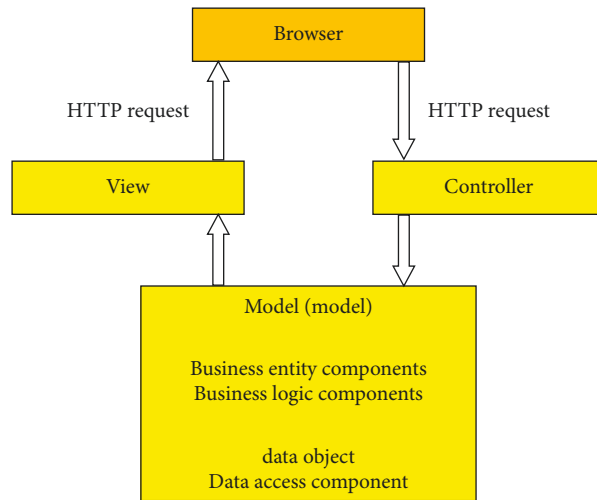


FIGURE 2: MVC three-layer architecture.

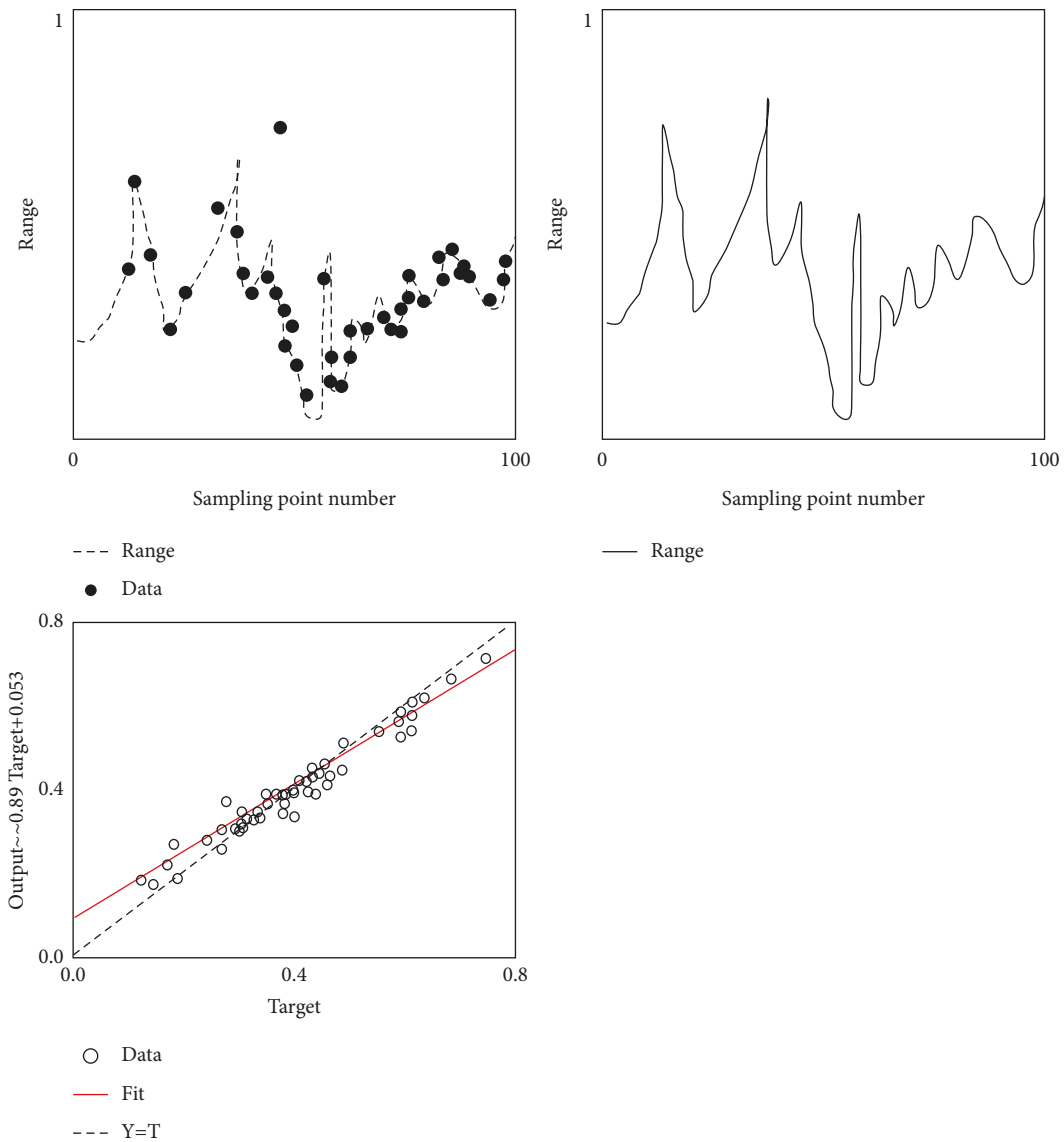


FIGURE 3: The data distribution.

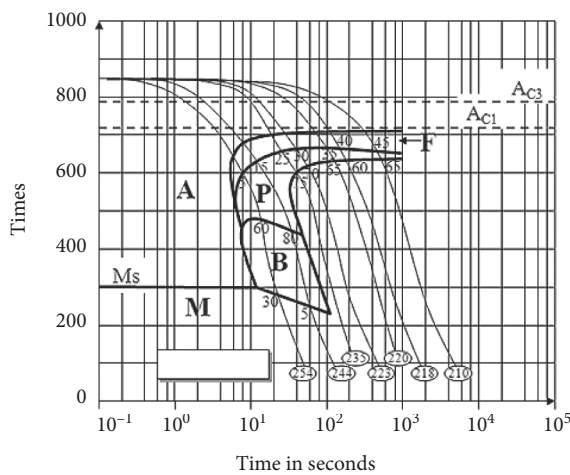
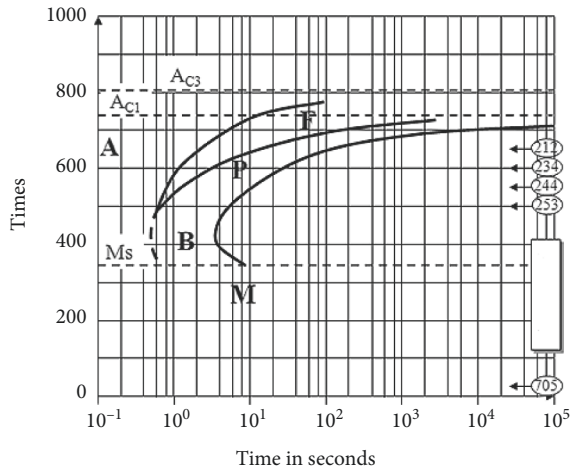


FIGURE 4: Action data normalization processing.

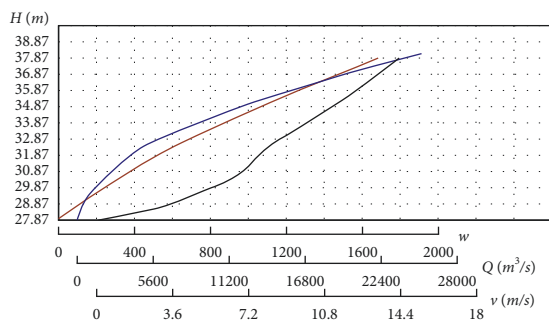


FIGURE 5: Principal component analysis results.

warehouse. This kind of data mining technology does not need to be like the statistical analysis data mining technology in the analysis of human body model information. What is the target variable before starting the analysis, and what information needs to be mined must be clearly known; otherwise, it is difficult to successfully mine. Knowledge discovery technology mainly includes neural network, decision tree, association rules, and so on [15].

In order to apply the knowledge of data mining in practice to improve production, the model generation management subsystem in the human model building

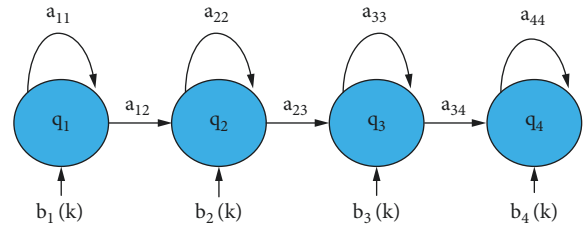


FIGURE 6: State Markov model.

system has been optimized. New modules have been added, and the corresponding functions are realized. The production management system adopts B/S (browser/server) mode. Based on the MVC three-tier architecture developed in ASP.NET environment, SQL SERVER 2008 is used as the background human model information base management system. The functional implementation of the system is implemented on the server side. The client can get the result of server-side operation through browser, so as to provide convenient and quick interaction. MVC (model view control) divides the software system into three parts: model, view, and control, as shown in Figure 2.

The view layer is the interface between the user and the whole system to complete the interaction between the system and the user, for example, data entry, deletion, modification, or query result display and summary of various kinds of data.

#### 4. The Application of Human Body Model in Physical Education

4.1. Action Signal Acquisition. In this paper, the analog circuit is designed to collect the surface EMG signals on human arms and legs, and filter the signals, including low pass and high pass. After amplification, the analog-to-digital conversion is realized through the A/D of American Delsys EMG processor, and then simple digital filtering and processing, drawing surface EMG (sEMG), feature extraction, pattern recognition, and so on. Identify the simple actions of a part of the human body. As shown in Figure 3, different testers have different actions and different test results.

After data normalization is processed, Figure 4 is obtained. The ordinate of Figure 4 is the number of times, and the abscissa is the time of each action, which lists several time curves to get the action, such as the BPF curve and the M curve. Figure 5 shows the relationship between the residual energy and the number of principal components in the principal component analysis.

In the actual system, the signal extracted by means of signal preprocessing often has small amplitude and large noise, which is easy to be disturbed. Therefore, it is necessary to isolate and filter impedance transform and other means to extract and amplify the signal because the human motion signals collected by motion capture system are doped with some noise during the experiment. The number of extracted features is large. Therefore, in order to ensure the accuracy of the research results, it is necessary to process the original signal accurately, feature extraction and selection, so as to

TABLE 1: When the number of states is 4, the recognition result.

Classification	Identify the right	Recognition error	Unrecognized	Sum of samples	Recognition rate (%)
Halt	71	5	3	200	93
Bend	70	6	3	200	89
Sit	86	6	8	200	91
Left turn	87	7	2	200	91
Right turn	87	9	3	200	92
Sideslip	85	8	3	200	87
Bow step	83	6	7	200	89
Normal walking	87	7	3	200	90
Up the steps	71	3	6	200	88

TABLE 2: When the number of states is 7, the recognition result.

Classification	Identify the right	Recognition error	Unrecognized	Sum of samples	Recognition rate (%)
Halt	73	5	3	200	93
Bend	75	3	2	200	95
Sit	73	6	2	200	93
Left turn	72	7	2	200	92
Right turn	87	8	3	200	89
Sideslip	70	8	2	200	90
Bow step	87	7	5	200	89
Normal walking	74	5	2	200	94
Up the steps	75	3	2	200	95

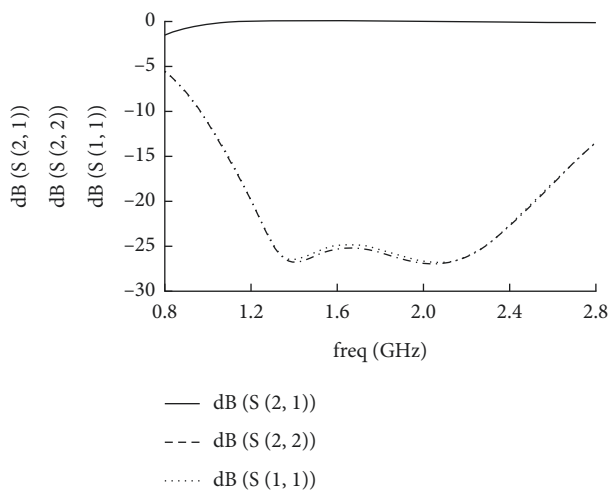


FIGURE 7: Recognition rate for different states.

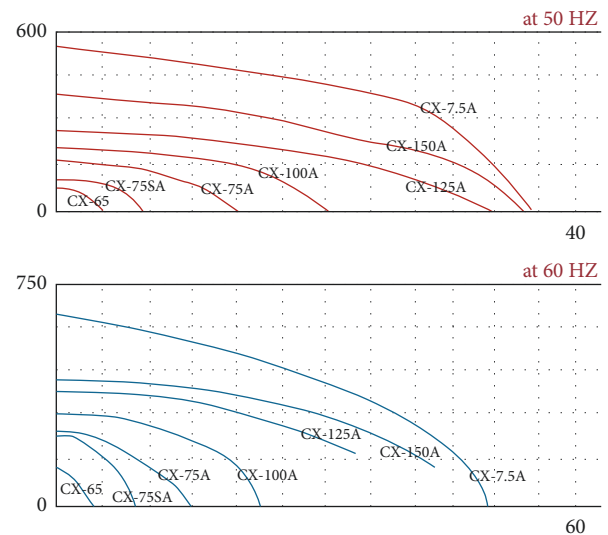


FIGURE 8: The operation of the system.

reduce the noise and reduce the recognition rate on the basis of reducing the number of features. First, the noise contained in the original action data is analyzed. By using principal component analysis, one-dimensional features are selected and merged into high-dimensional features. In the specific operation, the classifier's feature vectors are trained according to the formula stochastic gradient descent algorithm. The loss function is calculated according to the formula, and the classifier is trained if the stopping condition is reached; otherwise, the procedure is transferred. In traditional Taiji movements, there are many repetitions of movements, complicated routes, and emphasis on the right

frame. The practice time is about one minute for a routine, which is not conducive to popularization and other drawbacks. The Tai Chi movement is simplified, the arrangement is refined, and nearly half of the repetitive movements are reduced. The route is two back and forth on the two point one line. There are four ways: straightforward, backward, sideways, and turning.

Hidden Markov model (HMM) is a statistical model, which is used to describe a Markov process with hidden unknown parameters. The difficulty is to determine the hidden parameters of the process from the observable parameters. Then, these parameters are used for further

TABLE 3: Factor analysis using EM algorithm.

Serial number	Code of formula	Index name	Factor1	Factor2	Factor3	Factor4
1	U111	Completeness of lesson preparation	0.6338			
3	U113	After-school situation	0.6816			
4	U12	Attitude of educating people	0.7225			
13	U42	The situation of blackboard				0.6704
17	U6	Personality characteristics				

analysis, such as pattern recognition. In the modeled system, it is considered as a Markov process and unobserved (hidden) state statistical Markov model.

In Figure 6,  $q_i$  represents a possible gesture.  $b_i(k)$  is the probability of a specific gesture. The number  $a_{ij}$  marked on the path of the state transfer is the probability of the occurrence of a possible movement attitude  $q_i$  to another possible action attitude  $q_j$ . When the pose number is  $N$ , the gesture transfer probability can be expressed by the matrix  $A = \{a_{ij}\}$  of  $N \times N$ .

**4.2. The Analysis and Application of the Data Set of the Action.** In order to ensure the accuracy of the recognition results, the research needs to test everyone's physical education teaching mode behavior. The study used 20 different teaching behaviors and collected 10 groups of different data. The collected teaching behavior of each person is cross verified, and the state parameters are distinguished by principal component analysis and vectorization. Due to the limited number of training, the TV value in the experiment is too large. When the item value corresponding to parameter  $a$  is 0 or 1, the complexity state coefficient is fixed to 3 to 8. Tables 1 and 2 show the identification results when the number of states is 4 and 7, respectively. The effects of different state numbers on the recognition rate of physical education teaching were compared.

Figure 7 shows the recognition rate of the number of states when the number of states is taken. It can be seen that with the increase of the number of states, the recognition rate is on the rise as a whole. When the number of states increased from 3 to 7, the recognition rate increased significantly, and after 7, there was little change. At the same time, the system runs as shown in Figure 8:

Then, based on the index system of algorithm and construction, the situation of university sports teaching informatization is evaluated. First, the algorithm is analyzed by factor. After processing the original data of 15 people's physical education teaching actions, they are programmed by MATLAB. The results are as shown in Table 3.

As can be seen from Tables 1–3, HMM can achieve good recognition results. The algorithm design is reasonable and feasible. At the same time, it shows that the pretreatment method and feature selection method are effective. It shows that the information collection of these physical education movements is better, and the extracted feature parameters can better reflect the teaching results. Although the Markov model has obtained good test results, there are still many problems to be further improved. After extracting the parameters of physical education teaching model, dimension reduction will result in the loss of some original information.

In order to train a good hidden Markov model, a lot of data training is needed. Because the training data are not enough, the hidden Markov model cannot accurately represent the characteristics of a certain sport teaching action. In the training and testing of the hidden Markov model, many parameters are selected by manual setting, and the results are not very good.

## 5. Conclusion

Computer technology is increasingly being introduced into physical education. On this basis, this paper puts forward a new design method of human model and some key implementation technologies of computer simulation of human two-dimensional motion image, which is helpful to the scientization of physical education teaching and training. The experiment analyzes the daily movement of human body. According to the number of vulnerable parts with the best identification effect, 10 different actions are summarized. Different characteristics can be obtained by integrating the collected data. Then, these feature processing algorithms are classified, and finally, the actions performed by the human body are recognized. Finally, the advantages of the recognition method in recognition accuracy are verified. However, due to the lack of training data in this paper, hidden Markov model cannot accurately reflect the characteristics of a physical education teaching behavior. In the training and testing of hidden Markov model, many parameters are selected manually, and the results are not very good. Therefore, after extracting the parameters of physical education teaching model, dimensionality reduction will lead to the loss of some original information. In order to train a good hidden Markov model, a lot of data training is needed for further research.

## Data Availability

The data used to support the findings of this study are included within the article.

## Conflicts of Interest

The authors declare that they have no conflicts of interest.

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