

Retraction

Retracted: Optimization and Simulation of Virtual Experiment System of Human Sports Science Based on VR

Complexity

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

- (1) Discrepancies in scope
- (2) Discrepancies in the description of the research reported
- (3) Discrepancies between the availability of data and the research described
- (4) Inappropriate citations
- (5) Incoherent, meaningless and/or irrelevant content included in the article
- (6) Manipulated or compromised peer review

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

- [1] G. Li, "Optimization and Simulation of Virtual Experiment System of Human Sports Science Based on VR," *Complexity*, vol. 2021, Article ID 3872881, 10 pages, 2021.

Research Article

Optimization and Simulation of Virtual Experiment System of Human Sports Science Based on VR

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Virtual reality technology is an emerging technology developed on the basis of information technology. It is widely used in military, medical, mining, entertainment, and other fields. Therefore, many countries have been vigorously conducting research in recent years. As one of the important components of the virtual reality system, the three-dimensional human motion tracking system is of great significance to the research of practical virtual reality systems. It introduces the measurement principle of the spatial three-dimensional coordinate dynamic measurement device and discusses in detail the ultrasonic transmission, reception, amplification, filtering, comparison, shaping circuit, and single-chip interface circuit. This paper introduces the working principle and characteristics of the virtual experiment system and gives the structure diagram, hardware schematic diagram, and software flow diagram of the system. We mainly study the method of tracking human motion by measuring the three-dimensional coordinates of the space point, which lays a good foundation for the research of the actual three-dimensional motion tracking system. At the same time, the three-dimensional human body modeling is discussed, and the interactive movement policy of the human arm is briefly introduced. It has a certain effect on the actual virtual reality human-computer interaction system.

1. Introduction

Virtual reality (Virtual Reality abbreviated as VR) is a comprehensive view with computer technology as the core. Hearing and touch are integrated, imitating the reproduction technology of the real three-dimensional space [1]. The goal of VR technology is to use a computer to generate a simulated environment that can highly realistically simulate the various characteristics of the user in the natural environment (including multiperception, immersion, interactivity, and autonomy). It can realize the direct natural interaction between the user and the environment [2]. With the continuous development of VR technology, computer graphics, and network technology, three-dimensional space has been introduced into the Internet, transforming the web from a page-centric model to interaction with three-dimensional, dynamic, and realistic world. Then, we form the second generation of web (multimedia + virtual reality + Internet) technology [3]. With the development of Web

technology, a new education model in which students can learn in virtual universities on the Internet has become the trend and direction of current education reform. Distance teaching based on virtual environment is becoming more and more popular [4]. In recent years, many countries, including countries, have carried out research and popularization work in this area. Mainly they focus on how to achieve realistic effects under virtual conditions to provide students with a broader learning experience.

Sports human science covers sports physiology, sports anatomy, sports health science, sports biological power, and so on. In sports science to study the human body shape and structure, the effect of functional sports on shape and function, and the law of change [5], its important feature is laying on science and complexity. Virtual experiment refers to various virtual experiment environments realized by virtual reality technology in computer system [6]. The experimenter can complete various predetermined experimental projects as in the real environment, and the learning

effect obtained is equivalent to or even better than the effect obtained in the real environment [7]. Therefore, experiment is a very important teaching content of this subject. In view of the current lack of physical resources (including experimental equipment and faculty and staff), which restricts the experimental needs of students, in order to adapt to the new educational model, the virtual experiment system Visual Experiment System for Amleci Human Science (VESAHS) has been developed using VR technology. Aiming at the abstraction and complexity of the human exercise science curriculum and the shortcomings of traditional laboratories, this paper uses virtual reality, intemel, and other technologies to develop a human exercise science virtual experiment system. It can express the unique interactive three-dimensional dynamics of phenomena or complex structures that are difficult to observe and experimentally verify in the real environment and express the intuitive virtual world for students to learn and explore and provide a way for multiperson cooperation to experience. It uses geometric constraints to express the shape characteristics of the human body model, thereby obtaining a cluster of similar design schemes in shape or function. Parametric modeling is a more abstract modeling method based on traditional geometric modeling methods. It expresses the external geometric features of a complex human body with abstract feature parameters. It relies on conventional geometric modeling methods to make the design personnel carry out human body design at a higher and more abstract level. The article discusses in detail the system's fluorometer and implementation technology. It is to establish a shared sports L-body scientific virtual experiment system, allowing experimenters to operate the experimental equipment in the virtual environment through the man-machine interface and realize the collaboration of multiple experimenters and work together to complete the whole process of the experiment.

2. Related Work

As an emerging technology, virtual reality has been widely used in many fields. The goal of VR technology is to use a computer to generate a simulated environment so that users can directly interact with the environment. With the continuous development of social productivity and the continuous improvement of people's living standards, the requirements for entertainment life are more abundant, and the requirements for timeliness are higher. There is more and more demand for high-tech products such as virtual reality, and their applications are also increasing. Virtual reality products will occupy an important position in news, entertainment, digital production, and other fields and will surely form an industry that is widely used in these fields. It is foreseeable that VR technology will be one of the technologies with the most development potential and the greatest impact on human life in the 21st century [8]. At present, countries all over the world have invested a lot of money in research, and new products are coming out constantly. The relevant state departments also attach great

importance to the research and application of this technology and have done a lot of work.

In the 90s, during the overall development stage of virtual reality, the dialogue system was developed. Zang [9] proposed a software architecture for multiprocess communication through an event-driven mid-drive user interface management system (UMIS), which solved the problem of virtual reality. The problem of dynamic flexibility has promoted the development of the software support environment. In terms of hardware architecture, DIVISON company proposed a basic parallel model in the Super Vision system. Dunn [10] developed related parallel processing devices and DVS operating system, which enabled the full development of virtual reality and many application software emerged. In the virtual environment, the real-time tracking of moving objects is only a short time ago. With the deepening of human body research and the development of advanced human-computer interaction and immersive technology research, the interaction between humans and the virtual environment should not only stop at the keyboard and flat mouse to reproduce and get feedback in the virtual environment for research. VhNet (virtual life network) system is a distributed collaborative virtual environment developed by Gorghiu [11] of MiraLab Laboratory at the University of Geneva, Switzerland, and the Computer Graphics Laboratory of the Swiss Federal Institute of Technology (EPI.F). VLNet uses a multiprocess structure. The process is divided into two types: core process and extern driver process. The core process completes the main simulation tasks and provides the underlying interface for external drivers (such as display and database operations). The core process has 4 engines, including object behavior engine, navigation engine, facial expression engine, and body posture engine. They divide the main functions of VE into independent modules and are responsible for resource management. The virtual human modeling and virtual human control design are carried out in this system. The system can construct a large-scale virtual environment. Users can enter the virtual environment in the form of virtual man-machines and interact with other users in remote places. In addition to real-time interaction with the virtual environment, users can also ask each other to feel each other's facial expressions and postures. Virtual human (virtual human), also known as humanoid, has a similar meaning to avatar (substitute, avatar). There are two main groups about virtual human research, namely, SNHC in MPEG4 and Humanoid in VRML. The former focuses on how to describe the human body and various actions and uses it as knowledge to model real people to produce model-based video compression; the latter focuses on virtual space, especially Web-based virtual space In, increasing virtual participants. Both of them need to model various postures, expressions, and actions of the human body to produce a virtual person with strong sense of reality. The FreeWalk system was developed by Liao [12] of Kyoto University, Japan, and its purpose is to communicate at any time in a public 3D virtual space in a community constructed by a computer network. FreeWalk constructs a virtual 3D

environment for people to communicate. Participants use the mouse to roam in the environment and choose different people to talk, which can effectively control the visual orientation, distance, and sound distance in the interaction. However, it does not have the function of constructing a three-dimensional stand-in for participants, nor can it extract participants from the background, so it is relatively weak in the construction and synthesis of virtual venues.

Kleczkowski [13] of NPS (The Naval Postgraduate Sch001) in the United States is also engaged in the research of human tracking technology in order to provide a natural immersive integration with the network virtual environment, including joint-based body motion research, inertial motion tracking research, and mobile device research, research of human body modeling in virtual environment, and so on. Li [14] used inertial sensors and omnidirectional treadmills to simulate human movement into a juice computer. Starting in 2018, DVENET, supported by the National 863 Program, is a distributed virtual environment basic information platform developed by Li [15] of the Software Institute of the Chinese Academy of Sciences. Based on the distributed virtual battlefield environment of DVENET, several real simulators and virtual simulators distributed in different regions can be combined together to carry out simulation exercises of coordinated and confrontational tactics in different places. VST-1 is a VST prototype system successfully developed by the Multimedia Technology Room of the Department of Management Science and Engineering, National University of Defense Technology [16]. It can construct a three-dimensional virtual meeting space and can synthesize all participants into the same virtual meeting place and realize the spatial synthesis of participants' video and audio in the virtual meeting place; support natural interaction methods between participants, such as gaze and body language; it can provide participants with a variety of three-dimensional input devices (such as data gloves and three-dimensional mouse) and the ability to interact with virtual space objects [17]. In short, with the support of "863" high technology, the state has carried out research on virtual reality, but there are few studies on virtual human behavior interaction (especially hardware interface), and the "863" high technology has supported it. Multimode interfaces such as virtual warfare are in great need of support from this aspect [18].

3. Construction of a Scientific Virtual Experiment System for Human Sports Based on VR

3.1. Basic Theory of the Virtual Experiment System. Virtual experiments refer to various virtual experimental environments realized by using virtual reality technology in a computer system. Experimenters can complete various predetermined experimental projects as in a real environment, and the learning effects obtained are equivalent to or even better than those in the real environment. The effect was achieved in the environment [19]. The virtual

experiment system realizes "software as instrument" and "software as components." Instruments and components have unlimited reproducibility. Especially through networking, the resource sharing of large scientific instruments can be realized, avoiding the repeated purchase and purchase of large instruments and equipment.

The inverse kinematics problem of sports kinematics is the process of knowing the posture of the end effector of the moving human body and solving the motion speed and acceleration of each joint [20–23]. The process of finding inverse solutions in sports kinematics is a multisolution problem. The greater the degree of freedom is, the stronger the multisolution is. Due to the high real-time operation requirements in this assembly line automatic loading and unloading system, the speed of the inverse kinematics solution will directly affect the planning and handling efficiency of the motion path; even for general operation requirements, research on how to improve the inverse kinematics solution efficiency is also very important. Generally speaking, the methods of finding inverse solutions for moving human bodies are mainly divided into analytical methods, also known as pseudoinverse methods (including algebraic and geometric methods), iterative methods (represented as least squares), inverse transformation methods, and so on [24–26]. The inverse kinematics equation of a moving human body with a degree of freedom greater than or equal to six has the characteristics of complexity and nonlinearity, which makes the solution process very complicated, and it is necessary to choose a suitable method to find the optimal solution of the inverse solution. V-REP supports the pseudoinverse method and the damped least square method to solve the inverse solution of the moving human body. Some scholars propose a semisupervised prediction model, which exploits the improved unsupervised clustering algorithm to establish the fuzzy partition function, and then utilize the neural network model to build the information prediction function [27, 28]. After comparing and analyzing the two inverse solutions, the system uses the damped least square method to find the inverse solution. The moving human body used in this loading and unloading system includes a KUKA KR6 R900 six-axis moving human body and a KUKA LBR IIWA seven-axis moving human body. Since the inverse kinematics problem of the six-axis moving human body is relatively mature, this chapter will analyze and discuss the method of solving the inverse problem of the KUKA LBR IIWA seven-axis moving human body. Use the pseudoinverse method to solve KUKA LBR IIWA. When the value of it is known, you can use the following equations to solve for x in turn:

$$T(x_1, x_2, \dots, x_n) = T(x_1) \cdot T(x_2) \cdots T(x_n). \quad (1)$$

Check the connecting rod parameters of the KUKA LBR IIWA moving human body and use positive kinematics to get the transformation matrix of each connecting rod:

$$T^{-1} \cdot d(t) = \begin{bmatrix} c_1 & 0 \\ 0 & c_n \end{bmatrix}. \quad (2)$$

And because the end coordinate system is expressed in the world coordinate system as follows:

$$d(r) = j^t (i \cdot j + t^2 \cdot I)^{-1}. \quad (3)$$

The elements on the left and right sides of (3) are equal to each other, and c can be solved in turn. It can be seen that the whole calculation process is cumbersome and the amount of calculation is very large. It is necessary to calculate the inverse of different 4×4 homogeneous transformation matrices and multiply the 4×4 dimensional matrix. Here, i , j , and r represent the four sets of measurement values stored in OA, OB, and OC, respectively. The whole solution process is very difficult. Therefore, for a moving human body with multiple degrees of freedom, the pseudoinverse method is not suitable for finding the inverse solution of the moving human body.

Use Damped Least Squares to find the inverse solution of the moving human body. This is the most widely used nonlinear least squares method. It has the advantages of short convergence time and strong anti-interference ability. When the damping coefficient is relatively small, the step length of this method is the same as that of the Newton method. When it is very large, the step length is approximately equal to the step length of the gradient descent method. The following formula can be used to solve

$$d(r) = (j^t \cdot j + t^2 \cdot I)^{-1} \cdot j^t, \quad (4)$$

where $d(r)$ is the smallest difference from the best inverse solution and is a nonzero damping constant, which is equivalent to minimizing the number:

$$(j + t \cdot i) \cdot j^t \cdot d(t) = (j \cdot i \cdot I)^{-1}. \quad (5)$$

It can be proved that when the damping coefficient is selected appropriately, it is nonsingular. Therefore, the damped least squares solution is equal to

$$\|j \cdot d(t) - e\|^2 + t^2 \|d(t)\|^{-1}. \quad (6)$$

The advantage of this equation is that the matrix to be inverted is only 3×3 , where $t=3k$ is the size of the target location space, and m is usually less than n . And you can calculate equations and use row operations without calculating matrix inversion. When the damping coefficient is large, the damped least squares solution performs well near the singular point; but once it is selected too large, the convergence speed will slow down and the number of iterations will increase. Therefore, the selection of the damping coefficient should consider the optimal solution and the number of iterations.

After repeated experiments, it is concluded that when two moving human bodies use the damped least square method, the optimal damping coefficient is 0.01, and the number of iterations is 3. When the damping coefficient is selected as 0.01, the whole system has a better convergence speed, and the number of iterations is 3. The setting process is as follows: (1) First, open V-REP and then click on the $f(x)$ icon on the left; (2) select Kinematic, click "Add new IK group," and add the desired moving human body; (3) then

set the robot upper limit of the damping coefficient and the number of iterations, where it is the damping coefficient, and max-iterations is the number of iterations. At the same time, configure the parameters of the inverse solution using the damped least square method for two moving human bodies.

3.2. Three-Dimensional Human Body Tracking Technology Algorithm. The three-dimensional position tracker is one of the key sensing devices of the virtual reality system. Its task is to detect the position and orientation of the relevant object and report the position and orientation information to the virtual reality system. The most common application in the virtual reality system is to track the user's head position and hand position. By tracking the position information of key points of the human body such as head, hands, and feet, the position and orientation changes of the person in the space are obtained, thereby simulate human behavior posture and motion trajectory in the computer. In order to obtain the position information of the key parts of the three-dimensional human body in space, a spatial coordinate measuring device is needed. The space coordinate measuring device is a device that inputs the dynamic space coordinate (X , Y , Z) information of an object freely moving in a certain space area into a computer.

For this device, the algorithm flow is shown in Figure 1. Through uninterrupted high-speed detection of the changes in the three-dimensional coordinates of the object in the space in which it is located, the trajectory and instant displacement of the tracked object in space can be obtained, so as to achieve the purpose of tracking the object. In VRML, the creation of a virtual environment is a virtual scene described by a VRML file, which is interpreted by a browser with a VRML plug-in and displayed to the operator. The virtual environment generator stores the VRML files of the main experimental items of the sports human science course.

For the near-field characteristics of electromagnetic wave signals, someone has done research and pointed out that in the near-field range, the amplitude of the electromagnetic wave signal received by the receiving device has a logarithmic relationship with the distance of the transmitting device. The functional relationship is shown in paper. The so-called near-field refers to the distance range where the transmitting and receiving device cannot be regarded as a point, and the shape and size of the transmitting and receiving device have an effect on the received signal. Based on this principle, someone proposed the realization of a DC six-degree-of-freedom tracking system using electromagnetic coils. This electromagnetic azimuth tracking system uses a 3-axis Hall coil time-sharing emission of low-frequency magnetic field and then uses a 3-axis magnetic receiver fixed on the measured object as a sensor to receive the transmitted signal, and the system then bases on the phase and intensity of the received signal. The feature value calculates the attitude information of the receiver. The electromagnetic wave signal is emitted in an orderly manner from 4 directions. The electromagnetic wave signal emitted in each direction can be received by the receiving coil

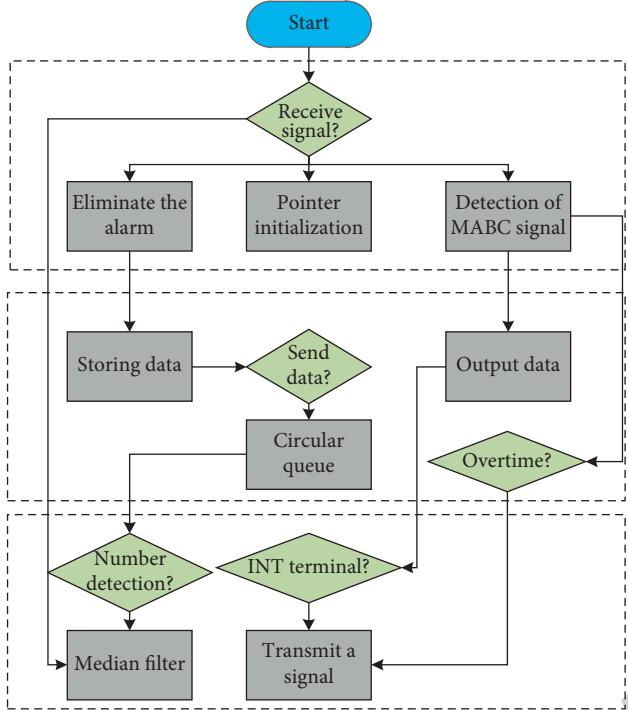


FIGURE 1: Algorithm flow of 3D human tracking technology.

installed on the human head, hands, feet, center of gravity, and so on. At the same time, due to the difference in the position and distance of the receiving coil from this direction, the received signal amplitude of the values is also different. The parameters of the human virtual experiment system are shown in Table 1. When each receiving point obtains the amplitude of the transmitted signal in 4 directions in turn, the three-dimensional coordinate position of the point at the moment can be calculated.

The position of the measured object in the electromagnetic tracking system can be described as the result of matrix transformation of the measured object relative to the coordinates of the emission source. Regarding the relative relationship between the measured object (fixed to the receiver) and the coordinates of the emission source, a coordinate system $Oxyz$ is established based on the emission source at point 0, the receiver is located at point $0'$, and its position coordinates in the $Oxyz$ system are (x, Y, z) or spherical coordinate system, and the coordinate system $0'XYZ'$ is parallel to the reference coordinate system. The attitude of the receiver is expressed as three successive corners, poison, and jealousy relative to $0'x'Y'z'$. The three rotation angles are defined as follows: first, perform the azimuth rotation around the z -axis to reach the new coordinate system $O'X'Y'z'$; then perform the poisonous angle rotation around the y -axis in this coordinate system of elevation rotation to reach the coordinate system $O'xyz$. Finally, the roll rotation around the x -axis is performed to reach the $O-XY-Z$ coordinate system. The sign of the angle is according to the rule: look at the positive direction of the coordinate axis that it is rotating around. If the direction of rotation is clockwise, the angle is positive; otherwise it is negative. The spatial orientation of the receiver uses position

TABLE 1: Parameters of the human virtual experiment system.

Number	Human joint angle	Angle range	Specified load
1	R1	$[-170, 170]$	80
2	R2	$[-150, 150]$	100
3	R3	$[-120, 120]$	120
4	R4	$[-100, 100]$	140

coordinates $(x'y'z)$ or (p,r) and the corner coordinate direction. Based on this coordinate relationship, a mathematical model is established, and the value in the receiving device is amplified by the amplifier circuit, and then A/D conversion is input to the C51 single-chip microcomputer. Time sharing is performed by the single-chip microcomputer. Drive the emission source and receiver, process the received values, and input the data into the system machine.

3.3. Optimization of the Human Science System. Reinforcement learning is a kind of trial-and-error learning, which requires continuous exploration and experimentation in the environment. It is through the rewards given by the environment to continuously optimize its own actions and explore the best control strategy through learning. It mainly includes five elements: agent, environment, reward, action, and state. In the fixed-point motion control of the moving human body, after each movement of the moving human body, the reinforcement learning algorithm gives the reward value through the set reward function. If the reward value is positive, the action is strengthened; if it is negative, the action is weakened. Through continuous learning, the moving human body will have a greater chance of choosing a good action when it encounters this state again. After continuous training and learning, in the same state, the moving human body has tried many actions; knowing which action to perform in this state can get the largest reward value. A virtual 3D human anatomy scene is established using real human data. In order to vividly display the anatomical structure, various experimental scenes are stored in the virtual scene model. The object involved in the scene is a 3D avatar, which is a representative of a person in the real world in a virtual environment. If the optimal action in each state is learned, combining all the optimal actions is the optimal path for fixed-point motion control.

In the fixed-point motion control of the moving human body, the main strong chemical learning algorithms include DQN (Deep Q-Learning) algorithm, PPO (Proximal Policy Optimization) algorithm, and DDPG (Deep Deterministic Policy Gradient) algorithm. The DQN algorithm was proposed by Deep Mind in 2013. This is the first learning strategy that combines reinforcement learning with deep learning and successfully applied to a high-dimensional state space. The DQN algorithm uses a neural network instead of Q-table to approximate the optimal Q-value function and successfully solves the problem of storing actions in a high-dimensional continuous state. The DQN algorithm adopts the sampling method of experience replay, conducts reinforcement learning training by randomly sampling from the previous state, and uses the reward value reward in the Q-

learning algorithm to construct the label. The system framework is shown in Figure 2. By constructing two convolutional neural networks to represent the current Q value and the target Q value, respectively, the algorithm fluctuation problem that occurs when the neural network represents the value function is solved. Using the sampling method of experience, it can accurately deal with the correlation between sample data and nonstatic distribution. Calculate the value through the neural network and then use the SGD stochastic gradient descent method to update the network parameters to obtain the optimal Q value of the network. However, the DQN algorithm selects the next action by obtaining all the executable actions in the current state and can only obtain a discrete dataset, which makes it unsuitable for high-dimensional continuous action space. Many physical control tasks require continuous (real-valued) and high-dimensional operating space. DQN cannot work directly in the continuous domain because it needs to find the behavior that maximizes the behavior value function. The solution is to discretize the action space, but this will lead to a multidimensional disaster. The DQN algorithm is used in the fixed-point motion control of discontinuous motion. Because the motion trajectory of the moving human body in the machine motion control is continuous, the DQN algorithm is not applicable. The PPO algorithm is a deep reinforcement learning algorithm proposed by OpenAI in 2017, which solves the shortcomings of the DQN algorithm for continuous motion control.

The PPO algorithm uses Gaussian decision-making. This decision-making method can perform continuous actions. The output of the decision-making model is the mean and the logarithmic variance log. The specific distribution is shown in Figure 3. Gaussian decision is a kind of random decision. The output of the decision model is the general distribution of actions. DDPG is a deep deterministic strategy gradient algorithm, which uses an actor-critic framework. It can be applied to the continuous motion control of the moving human body and can ensure the motion of the robot arm continuity and smoothness. The DDPG algorithm uses two identical actor-critic network architectures in order to avoid the uncertainty when the neural network parameters are updated. The parameter update process of the DDPG algorithm after introducing the target network is to take out m (m is a fixed parameter greater than zero) training samples from the sample storage space R and pass the training samples into the critic network to obtain the action state value function. Generally, the value of m is relatively large. The purpose is to reduce the impact of a single error sample on the direction of policy gradient descent, improve the stability of the algorithm, and make the calculated result closer to the actual situation, and the neural network parameters will reach convergence faster when they are updated. Finally, the neural network parameters in critic network and actor network are updated through backpropagation. When the number of training rounds reaches the predetermined round or the error is less than a certain fixed threshold, this

round is ended and the actor neural network parameters in the target network are output.

4. Application and Analysis of the Virtual Experiment System of Human Sports Science Based on VR

4.1. Application Simulation of the Virtual Experiment System. The browser uses Microsoft's Internet Explorer to browse device. In order to browse the VRML virtual environment, a VRML browser plug-in is also required. This system uses the most commonly used browser plug-in, the VRML 2.0 Viewer that comes with Windows 98. The application server platform uses Microsoft's IIS (Internet Information Services) 3.0, and the database server uses the SQL server 7.0 large-scale database system. System resources include ROM, RAM, timer/counter, and interrupt source. During task analysis, resources such as timers/counters and interrupt sources have actually been allocated. Therefore, the main task of resource allocation is the allocation of RAM resources. If there is an off-chip RAM, its capacity is larger than that of RAM, and it is usually used to store large quantities of data, such as sampled data series. What really needs serious consideration is the allocation of internal RAM. The internal RAM is addressed in units of 00H~7FH. It is composed of working register area, bit addressing area, and data buffer area. In different address areas, the functions are not completely the same. The FH of the internal RAM is the working register area, which is divided into 4 areas. Each area has 8 working registers R0~R7 and includes a total of 32 internal RAM units. Among them, 00H~0FH can be used as area 0 and area 1 working registers. If 4 working register areas are not needed in the program, the units corresponding to the remaining working register areas can also be used as general data buffers. The 20H~2FH of the internal RAM are bit addressing areas. Each bit of these 16 units has an 8-bit address, and the bit address range is 00H~7FH. Each bit in the bit addressing area can be used as a software trigger, and the program is actually connected for bit processing. During program design, various program status flags and bit control variables are usually set in bits. Similarly, the RAM unit in the bit addressing area can also be used as a general data buffer. The hardware parameter allocation is shown in Figure 4. 30H~7FH are general purpose registers, which can only store whole bytes of information. Usually used to store various parameters, pointers, intermediate results, or as a data buffer. The stack is often placed at the high end of the on-chip RAM, such as 68H~7FH.

The human body can only and must be in one of the two-foot-on-ground state and the one-foot-on-ground state in the process of walking. The walking speed of the human body determines the speed of the human body motion change period per second. The speed of walking is to be broadcasted at a voltage of 24 frames, as the unit, to obtain the joint motion value in each unit time. The direction of the human body's walking forward is the x -axis direction. The height direction of the human body is the Y -axis direction,

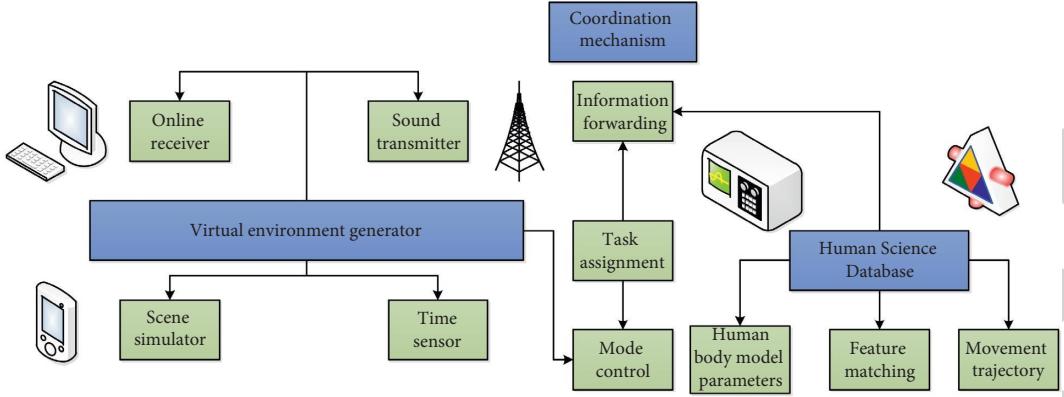


FIGURE 2: Human body science system framework based on VR.

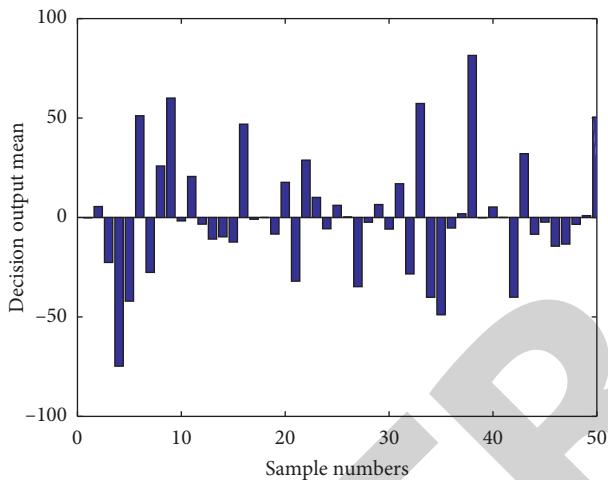


FIGURE 3: The output histogram of the decision model of the human science system.

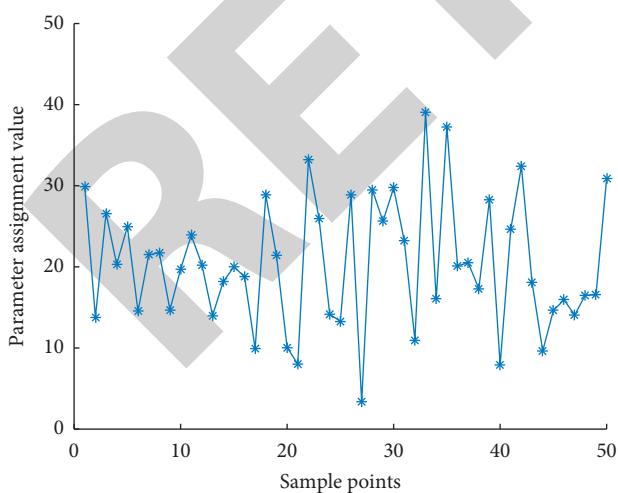


FIGURE 4: Line chart of hardware parameter allocation of the VR system.

and the XOY rectangular coordinate system is established, as shown in paper. In the article, the motion trajectory curves of some joint points obtained by the camera are drawn. The

points on the curve, respectively, represent the coordinate positions of the corresponding joints at time T_0, T_1, \dots, T_{23} , where the subscript i in T_i is the frame number of the picture. The continuous walking action is the periodic forward movement of the joint trajectory curve, and the displacement is 2 steps. Introduce the parameter T , use the travel distance X and the joint height Y as the vertical axis, and the time T as the horizontal axis to establish the T - x coordinate system and the T - Y coordinate system. The scatter points of the virtual walking motion joint trajectory are shown in Figure 5.

The function curve of the joint X coordinate and Y coordinate relative to T in the figure is called an animation curve. Usually, the motion of the joints during walking is periodic. Trigonometric functions can be used to fit the animation curve. According to the Fourier expansion, the following motion equation can be obtained. It is determined according to the height, stride length, walking speed, joints, and the position in the initial frame of the walker. For example, if the step frequency increases, b and b_7 should be smaller, and the step frequency becomes slower, so b and b_7 should be larger. Once the parameters in the action equation are determined, we have the x and Y coordinate values when T is T_0, T_1, T_2, \dots , which can be calculated. If the coordinate values of the joints on the left side of the human body are obtained, since the movement law of the joints on the right side is similar to that of the left side during walking, the difference is only half a cycle, so it is easy to obtain the coordinate values of the joints on the right side.

The processing of the inheritance relationship of human arms can be divided into the processing of single-branch inheritance relationship and the processing of multibranch inheritance relationship. The human arm can be decomposed into upper arm, forearm (elbow), palm, and fingers. Then, we divide the thumb into the first and second fingers and divide the remaining 4 fingers into the first, second, and third fingers. In order to facilitate the analysis, in this example, each component of the arm 3D model adopts wedge-shaped modeling. Select the coordinate system as shown in the figure and use OpenGL to build a three-dimensional scene. World coordinate system ($X, -Y, -Z$) takes a coordinate system consistent with the OpenGL world coordinate system, which is used to describe the position of each part of

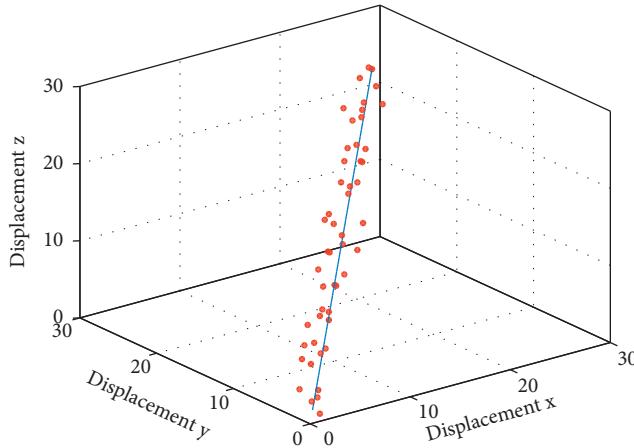


FIGURE 5: Fitting of the scattered points of the joint trajectory of the virtual walking motion.

the hand at any time and local coordinate system ($x.Y.z$). It attached to each part of the human hand model, we use the corner oX, MY, CpZ. Describe each part separately about the coordinate axis x , y , z . The specific simulation effect is shown in Figure 6.

4.2. Example Results and Analysis. This chapter uses a two-link moving human body built on the Python language for fixed-point motion control teaching. On the basis of the traditional DDPG algorithm for intensive learning training, constraints are set; that is, the reward in the circle is added and the memory is custom initialized. After the standard interface is adopted, various computers, external equipment, and measuring instruments can be easily and organically connected to form a measurement and control system. The 232°C interface is a serial bus standard promulgated by the American Electronics Industry Association. It is also the most commonly used serial interface at present. It is used to realize digital communication between computers and between computers and peripherals. The 232 serial interface bus is suitable for the following: the communication distance between devices is not more than 15 m, and the maximum transmission rate is 20 kb/s. According to the requirements of system design, we choose RS-232°C interface: electrical characteristics: RS. 232°C adopts negative logic, namely, logic “1”: $-5 \text{ V} \sim -15 \text{ V}$, logic “0”: $+5 \text{ V} \sim +15 \text{ V}$. When using the RS-232°C bus to connect the system, there are short-range communication methods and remote communication methods. Short-range communication refers to the communication with a transmission distance of less than 15 meters. In this case, RS can be used. 23°C cable is directly connected; long-distance communication over 15 meters, called remote communication, requires a modem. We use a 9-core socket to connect the single-chip microcomputer with the upper computer (PC), and the transmission medium is a two-core shielded cable. The two methods have been trained for multiple sets of training experiments, and the training results are shown in Figure 7. Set the memory capacity of the experience replay pool to 10000 and set the

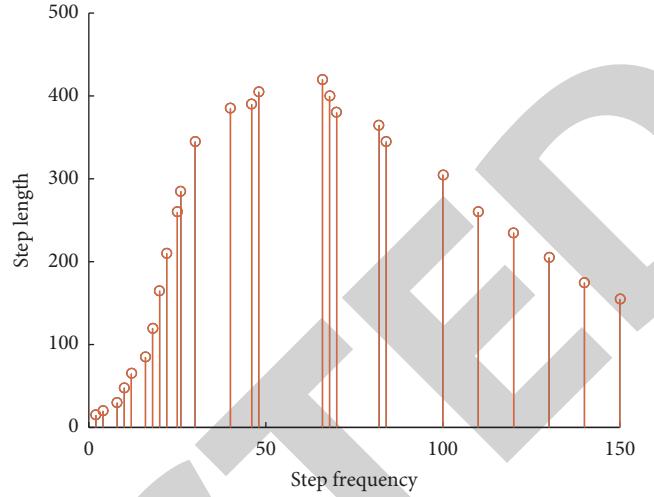


FIGURE 6: Human walking step length and step frequency simulation.

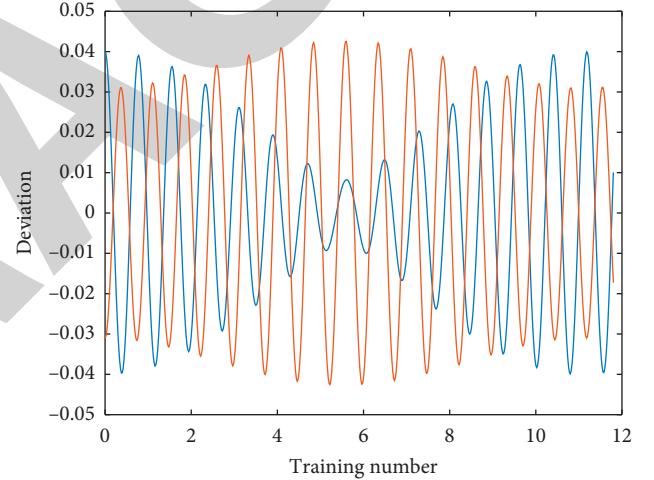


FIGURE 7: Deviation curve of VR training steps.

bonus discount factor gamma to 0.9. In Figure 7, the red and blue colors, respectively, represent the data before and after the model optimization. In comparison, the optimized model performs better in the statistical analysis of the data than before the optimization.

Figure 8 shows the convergence value of each round when the number of training steps is 10 fixed. When the number of training rounds is 300, the unconstrained training experiment cannot find the target point, and the training after adding the constraint can find the target point, but the jitter is large, because the number of training rounds and training steps are small; DDPG randomness of the algorithm is magnified, causing the experimental results to fail to converge stably. However, it can be seen that keeping the number of training steps in each round unchanged at 100, as the number of training rounds increases, the jitter becomes smaller and smaller. Therefore, as long as the number of training rounds and training steps are sufficient, the moving human body can stably find the target point in the space.

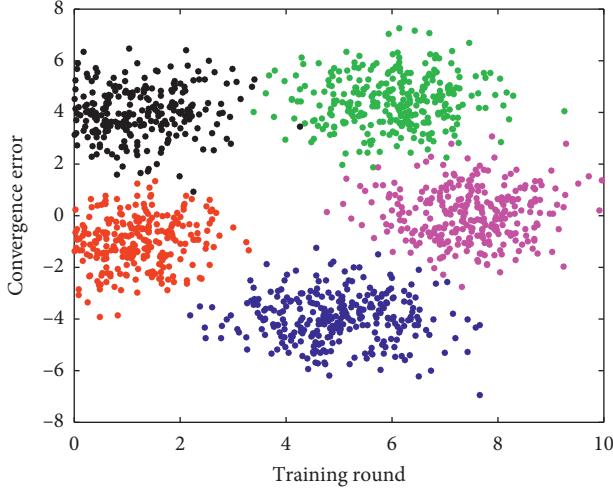


FIGURE 8: The convergence of the virtual system after optimization.

When the fixed number of training steps is 300, it can be seen that the training with the increase of the number of training rounds and the constraint condition has achieved a good convergence effect, and there is a large jitter when the constraint is not added, but compared with no optimization, the convergence of the effect has been significantly improved. The experimental data uses real human body data to establish a virtual 3D human anatomical scene in order to display the anatomical structure realistically. Various experimental scenes are stored in the virtual scene model in Table 2. The object involved in the scene is the 3D avatar, which is the representative of the person in the virtual environment. In this virtual experiment environment, a substitute with a username is used to represent an experimenter, and multiple forms of substitutes are provided for the experimenter to choose, and the editing function can also be used to construct their favorite substitutes.

Because the level of the RS-232 signal is inconsistent with the level of the serial port signal of the single-chip microcomputer, it is necessary to perform a level conversion between the two. The integrated level conversion chip MAX232 is used here as an RS-232°C/TTL level conversion chip. It only uses a single +5 V for its work and can be connected to four 1 μ F electrolytic capacitors to complete the conversion between RS-232 level and TTL level. The converted serial port signals TXD and RXD are directly connected to the serial port of ATMEL 89C2051. The number of training steps per round is kept unchanged at 300. As the number of training rounds increases, the effect of unconstrained training improves more obviously, which means that when no constraints are imposed, the randomness of the DDPG algorithm is amplified when the number of training rounds is small. It can be seen that when the sample points are in the 0-20 interval, the deviation statistics are relatively large, and the average is around 150. When the sample points are in the 20-40 interval, the deviations are mainly distributed around 100, which is relatively stable. When the number of training rounds reaches 1000 and the number of training steps per round is 300, the DDPG algorithm can already find the target point in the space stably. It can be seen from Figure 9 that when the DDPG reinforcement learning algorithm is used to train a sports

TABLE 2: Changes in stroke frequency and stroke width of athletes swimming under the VR model.

	15–20 m	20–25 m	25–30 m
Stroke frequency	51	50	49
Stroke aptitude	1.7	1.6	1.6

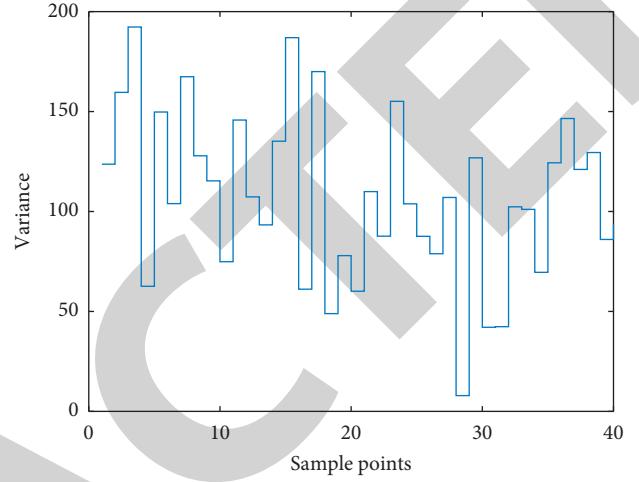


FIGURE 9: Data stability after multiround training of the system.

human body to find a target point in space, when the training round is 100 and the number of training steps per round is 30, the sports human body can already find the target point stably.

5. Conclusion

This paper mainly conducts research on the tracking of human motion based on VR by measuring the three-dimensional coordinates of points in space, as well as the research on the computer processing method of the three-dimensional human motion tracking information based on VR, in order to lay a good foundation for the research of practical three-dimensional human motion tracking system basis. Based on the introduction of the concept and characteristics of virtual reality, this paper expounds the principles of several main methods for three-dimensional human body tracking and provides a theoretical basis for the three-dimensional human body coordinate measurement of the VR method and analyzes the feasibility. At the same time, the hardware design of the VR method for three-dimensional human body coordinate measurement was completed, including the ultrasonic transmitter circuit, signal amplification, filtering, comparison and shaping circuit, and the hardware interface circuit design of the single-chip microcomputer. The main program of MCU control and serial communication program were written in assembly language, and software debugging was carried out. Finally, the 3D human body modeling method based on VR is studied, and the walking model of the 3D human body is given. Taking the interactive motion simulation of human hand as an example, the OpenOL implementation of 3D human motion simulation is introduced. In this paper, a certain amount of

research work has been done on the VR method for three-dimensional human body tracking, and a set of practical and feasible ultrasonic coordinate human body positioning system has been designed. The system has a wide application prospect in the pose extraction of basketball players, which will be the direction of the author's future research.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares no conflicts of interest.

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