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DESIGN OF A SIMULATION AND EVALUATION SYSTEM FOR ATHLETE TECHNICAL AND TACTICAL TRAINING BASED ON VIRTUAL REALITY TECHNOLOGY

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Abstract. In order to avoid the influence of external environmental factors on athletes' physical fitness and technical tactics, the author proposes the design and research of an integrated simulation training system for athletes' physical fitness and technical tactics based on virtual reality. The hardware unit of the design system includes a 3D scanner module, VR glasses module, locator module, tracker module, and wireless transceiver device. The software module introduces virtual reality technology and designs a visual simulation module, trained object detection module, trained object tracking module, and overall control module. The simulation experiment results show that compared with existing systems, the training scene output clarity and frame rate of the designed system are better, and the thread switching time and signal mixing time are shorter, which fully proves that the designed system has higher operating efficiency and better application performance.

Key words: Virtual reality technology, Athletes, Technical and tactical training, Physical fitness

1. Introduction. In recent years, the rapid development of virtual reality technology has given rise to this idea. The so-called virtual reality (VR) technology mainly refers to the general application of computer technology, computer simulation technology, multimedia, intelligence, computer network, social networking technology, and multi-sensor technology [1].

This technology simulates the function of human visual system, such as vision, hearing, and touch, enables human beings in computer to create virtual environment and interact with them in real time by means such as language and gesture, generating multi-dimensional personal information. With the development of competitive sports and the increasing importance to the competitive environment, it has become a decisive factor in the success. In order to improve the men's athletics quality, many coaches have decided how to build a training center that satisfies the actual competition, which is the problem solved by VRT [2,3]. It can achieve interaction between real environment, virtual environment, and real environment. In the heat exchanger, training is more accurate, injury is lower, investment is reduced, and operation efficiency is improved. Another characteristic of VRT is the creation of virtual competitors whose structure and technology are based on analyzing their videos and other data, just like real competitors. Athletes enter the area through 3D helmets, jacket materials, and other outdoor equipment. This is an example of sports, where athletes can see the boxes.

Fight in front of him, dodge, and involuntarily counterattack with a three-dimensional helmet. This is beneficial for athletes to achieve greater ability of winning through mechanical, tactical, emotional, and technical means. The combination of VRT and physical education has important training effect. In sports, there are many uncertainties, uncertainties, and dangerous situations or behaviors which can only be seen and analyzed from the three-dimensional view using multimedia technology.The three-dimensional data of individual is the motion information of the three-dimensional system of each joint, which is the key and basis for identifying the individual's three-dimensional sport.

VRT displays three-dimensional information of athletes, captures the main points and characteristics of movement. The evaluation of training effectiveness is of great importance for teachers to change training plans in time and evaluate sports performance. After collecting the daily training data, we can simulate the application of the training system of computer simulation training, evaluate the training effectiveness, and compare it with the previous training methods to analyze the progress and shortcomings of the athletes. According to the effects of training evaluation and the characteristics of athletes, a comprehensive analysis of their behaviors

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can be made, and a better training plan can be prepared for the next stage of training.VRT has a wide range of applications, especially its integrated network communication system. This has become a useful tool. As a technology, the widespread use of VRT will change people's feelings, and even their attitude towards the world, individuals, and time [4]. Friends from all over the world can learn, chat, and play games together as in real life.

With the application of computer network and other 3D devices, our work, life, and entertainment will become increasingly prevalent. It not only has important implications, but also changes people's scientific and digital thinking of today's sports competition. Virtual reality technology combines computer, software, and virtual world technology, which can adapt the real world. The dynamic environment can respond to real-time according to factors such as human form and language, thus achieving the communication between human and the virtual world.Virtual reality (VR) is the abbreviation for virtual reality technology, also called Jilin technology. By using computer image, simulation technology, computer technology, artificial intelligence, network technology, dynamic simulation, and multi- sensor environment, we simulate human body such as vision, hearing, and touch, absorbing people in the virtual world. In addition to creating a wide range of data sources for people with a wide range of applications from real-time interaction through language and gesture, virtual reality technology also includes three main aspects: manipulation, interaction, and visualization. With the rapid development of VRT technology, it has been widely used in fields such as CAD and simulation. Modeling, visualization, remote control, computer architecture, computer technology and teaching techniques, education and teaching, information visualization and modeling, entertainment and drawing, design and planning, remote operation, etc. In recent years, countries around the world have been given much attention and investment, and have been integrated into major sports such as Olympic competitions.

Sports training is very critical to both ordinary people and athletes, and it assumes the responsibility of improving the comprehensive physical quality of the human body. The traditional single sports training has been unable to meet the diversified needs of modern people, so we must innovate the training methods and introduce the computer virtual technology into it. First of all, the use of this technology to conduct high-intensity sports training early guidance can effectively reduce the accidental injuries in the training, such as boxing, cross-country running, taekwondo, etc. This kind of sports often produce all kinds of accidental injuries, to bring psychological shadow to the early stage of training, and then give up sports training. Virtual technology, on the other hand, can simulate the real movement scene through the computer, and the athletes can open their hands and feet without having to worry about accidental injury, and can understand the specific details of each technical action through the simulation technology, and correct the subtle errors in their movement.Secondly, the technology can decompose difficult movements in more detail, and demonstrate through simulation to understand how to avoid damage when performing difficult movements. Third, the current situation can improve the lack of material conditions, especially some athletes or sports institutions with limited funds, unable to purchase more sports equipment. But through virtual technology can change this situation, so that people can better do physical training through computers.

Sports training and sports have always been the key livelihood issues in China, and they are also the basic activities carried out by various sports groups. With the continuous development of modern computer technology, the major domestic sports institutions and folk sports people have begun to pay attention to the application of computer technology in sports training, but it has little effect at present. First of all, the capital of modern computer virtual technology equipment is relatively expensive, so it is necessary to capture the technical movements through multiple sensors, and use professional analysis software to detect them. Although this analysis software is more common, the requirements for professional technology are higher in the process of use.Secondly, many athletes blindly believe in their sports experience during training and ignore scientific computer software analysis, which leads to people to ignore the application of this technology and the promotion efficiency is low. Thirdly, people lack the cognition of virtual sports training technology, and think that the physical training of virtual computer can not achieve the effect of real body movement, thus ignoring the important role of virtual sports training.

In the process of sports training, due to different students have different physical quality, when part of the physical quality of low students in difficult sports training activities, is prone to accidental injury, cause them in danger, this will undoubtedly hit their learning confidence, at the same time is not conducive to their physical and mental health development. For this, PE teachers can through the practice training teaching classroom reasonable introduction of virtual reality technology, science for students to create surreal sports training environment, guide them to contact with the virtual environment, which not only can improve various sensory experience of students in class, stimulate students to sports professional knowledge content and skills of learning interest and desire, can also reduce the difficult sports training of accidental injury.Under the virtual reality technology application, sports teachers can use virtual professional athletes to demonstrate a variety of professional technology with certain risk action, let the students to the technology has intuitive clear understanding, and then teachers lead them to safe and reliable practice, so as to effectively reduce the safety risk of sports training. In the virtual environment for physical training, each student can completely open their hands and feet, not too concerned about whether it will hurt the people around, so as to greatly improve the safety factor and training efficiency of sports training.

The "physical fitness+technical tactics" training of athletes is influenced by many factors, such as weather, terrain, time, etc., which cannot meet the professional needs of today's athletes. Therefore, a virtual reality based integrated simulation training system design and research on "physical fitness+technical tactics" for athletes is proposed. Introducing virtual reality technology to break through the limitations of conventional training time and space, providing assistance for athlete physical fitness and tactical training, and providing effective assistance for social security [5,6].

2. Methods.

2.1. Concept, composition, and characteristic analysis of virtual reality technology.

(1) Concepts of Virtual Reality Technology. Virtual reality (VR), also called spiritual realm or visual realm. The research topics include artificial intelligence, computer science, electronics, sensors, computer graphics, control intelligence, psychology, and so on. the It uses computer simulation to create a three-dimensional virtual world, provide users with experimental visual, auditory, tactile, and other senses, thus creating a visual system that allows direct observation, processing, and touch upon changes in the internal environment, and can interact with them, . integrated with people and computers, put people's minds there.

(2) Classification of Virtual Reality Systems. Immersive virtual reality system is a complex system. Users need to wear helmets, data gloves, and other intrusion and tracking tools to immerse themselves in the virtual world and interact with it. A simple virtual reality system is composed of ordinary computer systems [7]. the Users can interact with the virtual environment by keyboard and mouse. Users can recognize virtual scenes on a regular computer using mouse and keyboard.

(3) The composition of virtual interactive devices. In order to achieve sufficient information exchange between people and machines, it is necessary to develop a special consulting tool and a demonstration tool to realize various information feedback from others and to provide guidance to complete the practical experiments. Achieving virtual reality consists of a virtual address system, a virtual environment generator with high-performance computers as the core, a visual system with helmets shown as the core, a hearing system with speech signals, audio links, and a local voice as the core, body positioning and body tracking devices with positioning trackers, configuration information, and clothing information as the main body, as well as feedback for functional requirements such as taste, smell, touch, and force.

(4) Analysis of the Characteristics of Virtual Reality Technology. Multiple cognition: Multiple cognition refers not only to the visual perception possessed by computer technology, but also to the auditory perception, emotional force, tactile understanding, visual movements, and even the taste and smell of the senses[8,9]. The best virtual reality technology requires a comprehensive understanding that everyone has. Because of the limitations of related technologies, especially computer technology, the cognitive function of virtual reality technology is mainly applied to visual, auditory, visual force, tactile sound, etc.

Immersive: Immersive, also known as existential, refers to the degree to which the user feels the protagonist is present in the simulated environment [10]. The best simulation environment should make it more difficult for users to distinguish between true and false, allowing them to complete themselves in the three-dimensional virtual environment created by computer. the Everything in the environment seems real, sound real, moving real, even smelly and really delicious, just like the feeling in the real world.

Interaction: refers to the degree to which users can control objects in a simulated environment, as well as the natural level of feedback received from the environment (including the actual operation). For example,

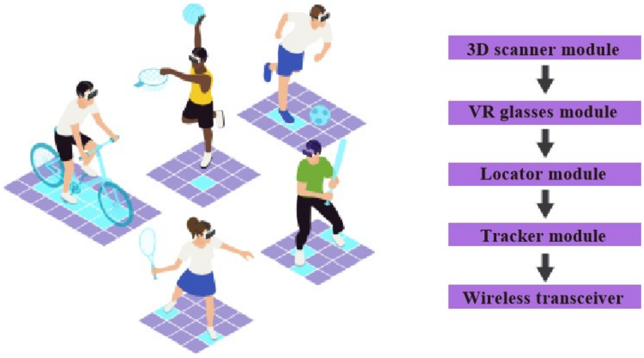

Fig. 2.1: Overall schematic diagram of the system hardware unit

users can directly grab virtual objects in a simulated environment with their hands. At this point, they have the desire to hold something and are able to feel the weight of the object. The objects captured in the viewfinder can also be moved immediately with the movements of the hand.

Thought: Emphasize that virtual reality technology should have a broad space and reflect space, broaden human understanding. It can not only produce real existing products, but also be free to imagine the goal of no or even impossible environment [11,12].

2.2. Hardware Unit Design of Integrated Simulation Training System for "Physical Fitness+Technical Tactics". The hardware unit of virtual reality technology is the foundation and prerequisite for the stable operation of the athlete's "physical fitness+technical and tactical" integrated simulation training system. Based on the requirements of physical fitness and technical and tactical training, the system hardware unit is selected and designed, including the 3D scanner selection unit, VR glasses selection unit, locator selection unit, tracker selection unit, and wireless transceiver selection unit. The overall schematic diagram of the system hardware unit is shown in Figure 2.1 [13].

The specific selection and design process is as follows: The 3D scanner is one of the key hardware devices in the design system, and its essence is a device for detecting objects, environment, and other data. One of the key hardware components in the design system is to perform virtual reconstruction of the integrated simulation training scene of athletes' physical fitness+technical tactics based on data collected by 3D scanners [14,15]. However, the scanning range of 3D scanners is limited, and in specific applications, their positions need to be transformed to comprehensively obtain target data, laying a solid foundation for virtual reconstruction of training scenes. VR glasses can help trained athletes watch the entire virtual scene, providing them with an immersive feeling. VR glasses are a key hardware support in virtual reality technology, which can provide a large amount of VR video information, allowing users to truly experience the virtual world by selecting VR glasses of the VRPark model as the design system hardware.

Positioners can locate the body position and movable space of trained athletes. Under normal circumstances, a locator is used in conjunction with a regulator. After receiving the output signal from the regulator, the locator adjusts the position of the trained athlete accordingly and feeds back the adjusted position information to the locator. The valve locator is selected as one of the hardware units for designing the system. The tracker can track key body position information of trained athletes in real-time and send interactive instructions to them through a professional controller, increasing the realism of simulation training. Based on the design system requirements, select the NF-308 tracker as the hardware device. The NF-308 tracker is mainly composed of a main tester, a receiver, and a remote recognizer. It has advantages such as smooth appearance, user-friendly design, speed, and accuracy, and is widely used in various fields.

Wireless transceiver refers to a wireless signal receiver that is connected to the system computer host to facilitate unified control of the integrated simulation training process of athletes' physical fitness+technical tactics. According to the design system requirements, select a single wireless transceiver chip as the wireless transceiver device. The single-chip wireless transceiver chip operates in full duplex transmission mode, with a

Table 2.1: Code table for adding operation behavior in visual simulation

Code	Operation Description
SDK development toolkit	Provide some files for application program interface APIs
vgScene*scene;	Declare various Vega class instance pointers required
Dg= vgNewDS;	Create a new instance of the vgDataset class
VgName (ds,esprit.ft");	Specify the file for reading the model dataset
VgLoadDS(ds);	Load the corresponding dataset
Obj=vgNewObj;	Create a new model object instance
VgName (obj, " police") ;	Name the instance policy
Pos =vgNewPos() ;	Create a new instance of the vgPosition class
VgObjDS (obj,ds) ;	Place model objects based on their initial position
Scene = vgGetScene(0) ;	Get the first instance of the vgScene class object

transmission distance of about tens of meters and a communication speed of about 2Mb/s. In addition, the chip also has dedicated data channels, frequency hopping technology, and data encryption technology, which can stably transmit system data and provide effective support for the smooth operation of the athlete's "physical fitness+technical and tactical" integrated simulation training system.

2.3. Software module design for the integrated simulation training system of "physical fitness+technical tactics" . The design system software module includes a visual simulation module, a trained object detection module, a trained object tracking module, and an overall control module. The specific design process is as follows [16].

(1) Visual simulation module. The visual simulation module is the foundation and prerequisite for the virtual modeling of the integrated simulation training scenario of athletes' physical fitness+technical tactics. The three-dimensional structure of the athlete's "physical fitness+technical tactics" training scene is relatively complex, and the scene range is also relatively large, which brings significant difficulties to visual simulation. Athletes' "physical strength+technical and tactical" integration scene training scene includes static objects, buildings, trees, dynamic objects, trainees, suspect, police cars, etc. In the process of constructing a 3D scene, static object modeling is relatively simple. Only the corresponding 3D data needs to be read from the database and processed by texture mapping to be displayed. For dynamic objects, real-time control and real-time acquisition of their position information are required during the 3D scene process. Due to space limitations, only partial display of the operation behavior of the trained athlete model is added to the visual simulation, as shown in Table 2.1.

(2) Trained object detection module. The main purpose of designing the system is to provide integrated physical and tactical training for athletes. Therefore, during the operation of the system, it is necessary to detect the training targets, clarify their positions and relevant information. According to the design system requirements, the background difference method is selected to detect the trained target, and its principle expression is:

$$D_k(x, y) = |f_k(x, y) - f_b(x, y)| \tag{2.1}$$

In equation 2.1, Dk (x, y) represents the training target; Fk (x, y) represents the image to be processed; Fb (x, y) represents the background image. For the background difference method, the key step is to obtain background images with high reference value. Generally, Gaussian background modeling method is used to model the dynamic background of the training scene. Gaussian background modeling mainly involves transforming the background into a function that follows a Gaussian distribution, expressed as:

$$I(x, y) \sim N(\mu(x, y), \delta(x, y)) \tag{2.2}$$

In equation 2.2, I(x, y) represents the pixel grayscale value corresponding to the coordinate (x, y); $\mu(x, y)$ represents the mean of the Gaussian function; $\delta(x, y)$ represents the variance of the Gaussian function [17]. When detecting trained moving targets, if the background is stationary, in order to adapt to the dynamic changes of various factors such as lighting, the background is dynamically updated. The update method is as follows:

$$\begin{cases} \mu(x, y) = (1 - \alpha) \cdot \mu_{k-1}(x, y) + \alpha \cdot I_k(x, y) \\ \delta_k(x, y) = (1 - \alpha) \cdot \delta_{k-1}(x, y) + \alpha \cdot d_k(x, y) \cdot d_k^T(x, y) \end{cases} \tag{2.3}$$

In equation 2.3, a represents the update coefficient, and the larger the value of a, the faster the update speed; Dk (x, y) represents the difference in grayscale values. Using the difference between the current image and the pre stored background image, and then using a threshold to detect the trained moving target, the calculation formula is as follows:

$$R(x, y) = \begin{cases} D_k(x, y), \mu(x, y) > T \\ 0, other \end{cases} \tag{2.4}$$

In equation 2.4, when the background area of the image is greater than the threshold T, the detected target is the target to be extracted. Through the above process, real-time detection of trained targets can be achieved, providing relevant data for target tasks for simulation training, and ensuring the smooth progress of simulation training [18].

(3) Trained target tracking module. Training target tracking is also one of the key links in designing a stable system operation. In order to integrate physical fitness and tactical training for athletes, it is necessary to grasp the real-time location information of the training target. This study is based on color histograms for training target tracking, and the specific process is as follows: Transform the image of the training area into the HSV color space, quantify it, and perform statistical analysis on its color histogram. The expression is:

$$q_u = \sum \delta[b(x(i, j) - u)] \tag{2.5}$$

In equation 2.5, qu represents the statistical value of the quantized boundary u. Under normal circumstances, there may be a small amount of background elements in a specific area that can interfere with it. Therefore, it is necessary to process it to obtain a more accurate histogram. The processing formula is:

$$q_u = \sum \delta[b(x(i, j) - u)] \cdot D(i, j) \tag{2.6}$$

In equation 2.6, D(i,j) represents the differential parameter. After processing the color histogram in a specific area, setting a threshold can obtain the color features that highlight the trained target. The Kalman filtering algorithm is used to separate the image background and achieve target tracking. The formula is:

$$h(i) = sep(q_n) \tag{2.7}$$

In equation 2.7, sep (*) represents the separation function. By using the above formula to separate the background area and achieve tracking of the trained target.

(4) Overall control module. The overall control module is mainly responsible for managing and coordinating all modules, such as program entry, module startup, idle processing, event processing, I/O control, command issuance, etc. In addition, the overall control module also requires internal updates to provide real-time data support for 3D scene construction, and timely store valuable data in the system database for convenient subsequent applications and queries. According to the design system requirements, the overall control module is mainly implemented through functions such as Win Main() and vgSystem. Due to space and character limitations, this will not be elaborated too much. Through the design of the hardware units and software modules mentioned above, the integrated simulation training system of "physical fitness+technical tactics" for athletes has been implemented. Under the premise of motion target detection, tracking and control, it helps athletes improve their physical fitness and technical tactics, and helps them play a role in maintaining social security.

Table 3.1: Application Performance Data Table

Number of experiments	Output frame rate/fps
1	60
2	59
3	58
4	61
5	62
6	61
7	60
8	60
9	59
10	60

3. Result analysis. In order to verify the difference in application performance between the designed system and the existing system, experiments were designed based on a simulation platform. The specific experimental process is shown below [19].

3.1. Experimental Platform Construction. Based on the integrated simulation training requirements of athletes' physical fitness and technical tactics, an experimental platform is built, with hardware including a PC, camera, wireless receiving device, projector, ID card reader, etc. The camera needs to have good night vision function, which can maintain the clarity of the picture in low light environments and also adapt to strong light environments.

3.2. Analysis of experimental results. Based on the experimental platform built above and the displayed experimental scenario, conduct an integrated simulation training experiment on athletes' physical fitness+technical tactics. Test the image resolution and output frame rate of the training scene output by the system, as shown in Table 3.1.

Using this system for integrated simulation training of athletes' physical fitness+technical tactics, the system outputs images of training scenes with high resolution and clarity; According to Table 3.1, the average frame rate of the training scene image output of the system is 60fps. From this, it can be seen that the output image quality and resolution of the designed system are good, and can achieve smooth display of training scenes. On this basis, obtain data on system thread switching time and semaphore mixing time to reflect the application performance of the system. Among them, thread switching time refers to the time required between CPU task transitions; The signal mixing time refers to the time between the release and reception of a signal. The smaller the value of thread switching time and semaphore mixing time, the higher the efficiency of system operation and the better the application performance. The specific analysis process of experimental results is as follows: The application performance data obtained through experiments are shown in Table 3.2, Figures 3.1 and 3.2 [20].

As shown in Table 3.2, under different experimental frequencies, the designed system thread switching time data range is 10.02ms 14.20ms, and the signal mixing time data range is 100.23ms$\sim$111.10ms. The above data proves that the designed system has high operational efficiency and good application performance.

4. Conclusion. The author introduced virtual reality technology to design a new integrated simulation training system for athletes, which greatly reduces the system thread switching time and signal mixing time. This provides better assistance for the integrated training of athletes, and also provides certain reference value for simulation training research. Using this system for integrated simulation training of athletes' physical fitness+technical tactics, the system outputs images of training scenes with high resolution and clarity; Under different experimental frequencies, the designed system thread switching time data range is 10.02ms 14.20ms, and the signal mixing time data range is 100.23ms 111.10ms. The above data proves that the designed system has high operational efficiency and good application performance.

Table 3.2: Application Performance Data Table

Number of experiments	Thread switches the time data	Signal mixing time data
1	10.21	100.23
2	10.03	110.46
3	10.7	105.41
4	11.46	103.26
5	12.36	102.46
6	12.15	106.49
7	11.09	104.26
8	11.93	110.33
9	14.21	111.11
10	10.33	106.51

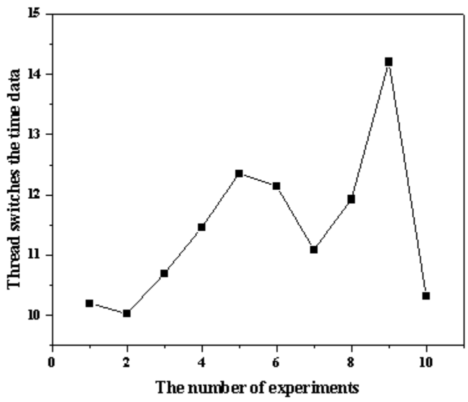

Fig. 3.1: Thread Switching Time Data

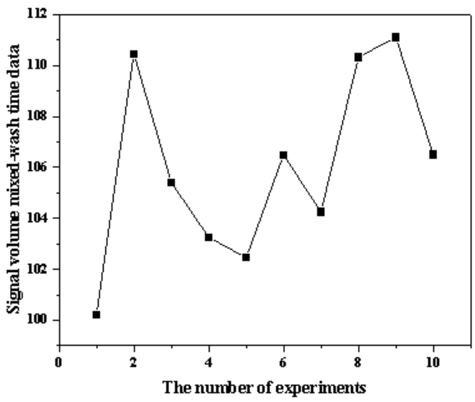

Fig. 3.2: Signal Mixing Time Data

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