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Research Article
Analysis of the Application of Virtual Reality Technology in Football Training

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As computer science and information technology develop rapidly, virtual reality (VR) technology has evolved from theory to application. As a key technology in modern society, VR technology is increasingly influencing more and more aspects of people's daily lives, including sports training. VR technology can be seen as an assistive technology that provides specific support for athletes' sports training through various means such as simulating training scenarios and conducting data analysis. This paper focuses on exploring the application of VR technology in football training and the combination of sports training and VR technology. In addition, a feasibility analysis of the application of VR technology in football is carried out, and software such as Poser 8.0, 3ds MAX, and EON Studio in the virtual football training system are introduced. The aim is to further provide theoretical support for the development and research of virtual football sports system software and to study virtual systems that are not disturbed by external natural conditions. It will break through the limitations of sports training due to factors such as weather, player injuries, lack of training space, and funding. This is conducive to improving teaching and training methods, promoting the mastery of technical movement essentials and the improvement of football skills.

1. Introduction

As technology continues to develop and advance, virtual reality (VR), sometimes called virtual environments (VE), has become a trendy topic in recent years. The core concept of VR technology has been around dating back to 1965 [1]. However, the expensive cost of the device is a hurdle to its widespread deployment [2]. Also, due to the overhype and hype surrounding VR for a long time, the adoption of VR technology had hit a low point [3]. Thus, many experts had not been optimistic that VR technology would be widely used in the world. Nevertheless, VR technology has become increasingly popular with the advent of inexpensive consumer-grade VR headsets for gaming and entertainment in recent years [4]. Nowadays, it can be seen that VR has been extensively applied in a great variety of fields such as game [5–7], sport [8–10], film [11, 12], education [13], and construction [14] and brings great commercial value to soci-

ety. Therefore, research into the application of VR technology is very promising in the future.

VR is an advanced, human-computer interface that simulates a realistic environment where participants can move around in a virtual world, and they can see it from different perspectives and make the computer do things [15]. This emerging technology includes a wide range of fields such as computer science, engineering, and the social sciences [16]. Specifically, VR combines the contradictory aspects of the virtual and the real to create an immersive experience through the use of computer technology to create realistic three-dimensional animations. Then it is combined with sensor technology to give a realistic experience in terms of sight, sound, touch, and even smell, creating a simulated space like the real world. In other words, VR is a technology that normally provides interaction and immerses the senses of the users [17]. Hence, through the computer-generated images or animated characters and avatars, the users can

move around the virtual world and pick up and interact with virtual objects as they do so [18].

Interactivity is the essential part in VR technology because the users play a role in the media, and their actions can influence the experience or scenario unfolding in real time [19]. In this process, the users can better interact with the VR devices with the aid of computers and the corresponding devices. The other key element of VR technology is its immersion. In the environment of immersive VR, the users are perceptually encircled by the virtual environment, and their consciousness of the real world is minimised [20]. Therefore, since the sensory feeling from the real world is blocked, this could create the impression that a person has actually entered the virtual environment and construct an illusion of participation in the artificial world [21].

The fundamental purpose of VR technology is to ensure that participants can interact naturally with the virtual environment and achieve a realistic experience. Immersive VR systems allow users to be fully immersed in a computer-generated environment to create an immersive effect, but the hardware required is demanding and expensive, and not conducive to commercial development. The desktop VR systems use a computer screen or projection screen as the viewing window for the virtual environment and require the use of a handheld input device or position tracker to manipulate objects in the virtual environment, such as a "physical game console," which is low cost and simple to use.

With the rapid development of technology, the market for VR technology has been growing, and sport is one of the areas where VR is developing rapidly. As the world of sport continues to grow and improve, countries around the world are investing more in sport, and virtual reality is becoming more prominent in sports teaching, simulation training, stadium construction, and event broadcasting. The recent Olympic Games, for example, are the clearest example of the use of VR technology to enhance sports technology. The modern competitive sport is rapidly developing to a high level of difficulty, standard, and precision, and the use of modern technology to assist physical education and training has become a favourable tool for improving the standard of competitive sport. The unpredictable and unexpected events in sports training, the disproportionate investment and output of training funds, and the unreasonable structure of investment all have an impact on the level of competition. There has been a lot of research into the use of VR technology in sports. Becker and Pentland built a Tai Chi trainer within a modified version of the Alive system [22]. Yang and Kim designed an immersive virtual training system based on VR technology known as "ghosts" [23]. Baek et al. designed a movement system that adjusts a given reference for the trainee, providing an analysis of the effect of the trainee's movement following the reference [24]. Meng examined how VR technology can be used to build virtual physical education environments [25]. Tsai et al. proposed a VR-based basketball training system that can be used to help the athletes to get better tactics [26]. In China, VR technology is widely used in the fields of football, bed-vaulting, gymnastics, diving, and sailing. This suggests that VR technology, with its low cost and zero risk advantages,

has a wide range of application prospects in various fields. The combination of VR technology and sports can not only improve the training level of athletes and promote their athletic performance but also facilitate the development of national fitness sports with its low investment cost, small floor space, and ease of operation.

Football is one of the most popular sports in the world and attracts millions of spectators. However, the intense physical confrontation, the difficult manoeuvres, and the risky tackling of the ball in football can cause various degrees of physical injury. Therefore, it is essential to develop a training environment that is free from outside interference, avoids sports injuries, and gives the athletes a sense of immersion. The interactive, immersive, and imaginative nature of VR technology in sport means that VR has an important role to play in facilitating football training. Nowadays, in the globalised contemporary society, technology drives the progress of the society, and this is also reflected in professional football [27, 28]. The competitive environment of football has built a marketplace for technology-based innovation for coaches who are seeking to create a sustainable competitive advantage [29]. As VR technology can assist players to better train in football without the constraints of time and space, it has a broad application prospect in football training. After all, VR technology can be valuable enough to accurately measure the body movements with athletes during sports and subsequently for coaches and players to be able to perform data analysis.

In order to better explore the application of VR technology in football training, this paper focuses on researching various applications of VR technology in football training and analyzing the essential technologies that should be adopted in the VR training system. Also, this study suggests some positive effects of the VR training system.

2. Analysis of the Application of VR Technology in Football Training

VR technology in football training offers significant training efficiency and low training risk. At the same time, VR technology can reduce the distraction of the real environment for the players. As a result, VR technology is being widely used in football training.

Figure 1 shows an example of football training through VR devices. It can be seen that the athlete can train on the simulated real court with the headgear and wearables. The advantages of training football using VR technology are that it is convenient and can be done anywhere and that the computer can analyse data about the players, thus supporting them in getting better training.

2.1. Basic Functions of Virtual Football Training System.
In order to meet the requirements of football training, there are several basic functions that the virtual football training system should meet with.

2.1.1. A Football Training Ground with a Realistic Feel.
A virtual football training ground with a realistic feel needs
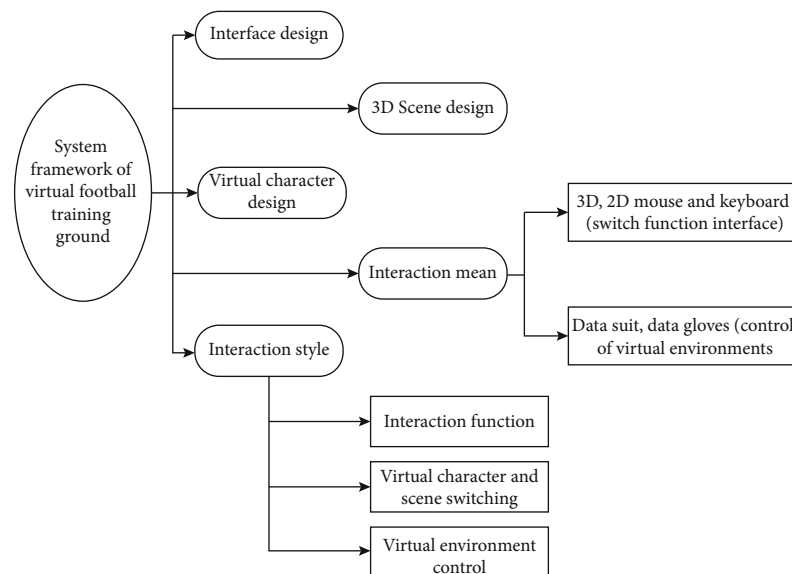
FIGURE 1: VR football training.

FIGURE 2: System framework of virtual football training ground.

to be created, so models of the goal, the football, the grass, and the surrounding trees and sky need to produce a vivid and realistic virtual training scene.

2.1.2. Collect Athlete Physiological Data. Athlete physiological and psychological health data is an important reference for evaluating the effectiveness of athletic training, and athletes' physiological data is mainly obtained through heart rate, electrocardiogram, and blood pressure.

2.1.3. Movement Reenactment and Demonstration. The virtual system should be able to record and represent the user's (athlete's or coach's) technical movements and clearly indicate the deficiencies between the two movements, which facilitates the correction of errors and the demonstration of technical skills.

2.1.4. Graphical Analysis of Training Results. The graphical display of the athletes' training effects and the results of

the error analysis can visually reflect the athletes' training effects and the degree of standardization of their movements, aiding teaching and training.

2.2. Virtual Simulated Training Ground. VR technology can be used to build a simulated training ground with the help of a three-dimensional image library to build a realistic training environment for football trainers and increase the realism of the clinical game. The virtual environment includes the background of the football field, the configuration of the field, the football game scenario, and the modelling of the virtual players. The virtual football training ground is created using multiple images, data, and pictures to create a three-dimensional environment almost similar to the real training ground. The trainer can experience many game situations and contingencies in advance in this environment, thus reducing the probability of friction and injury in the real game. The main system framework of the virtual football training ground is shown in Figure 2.
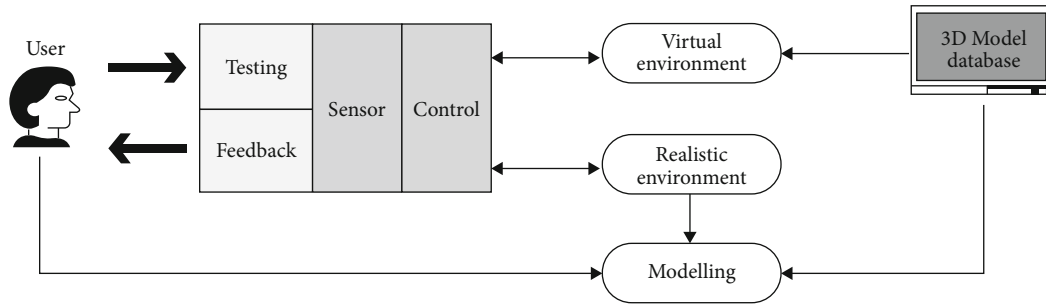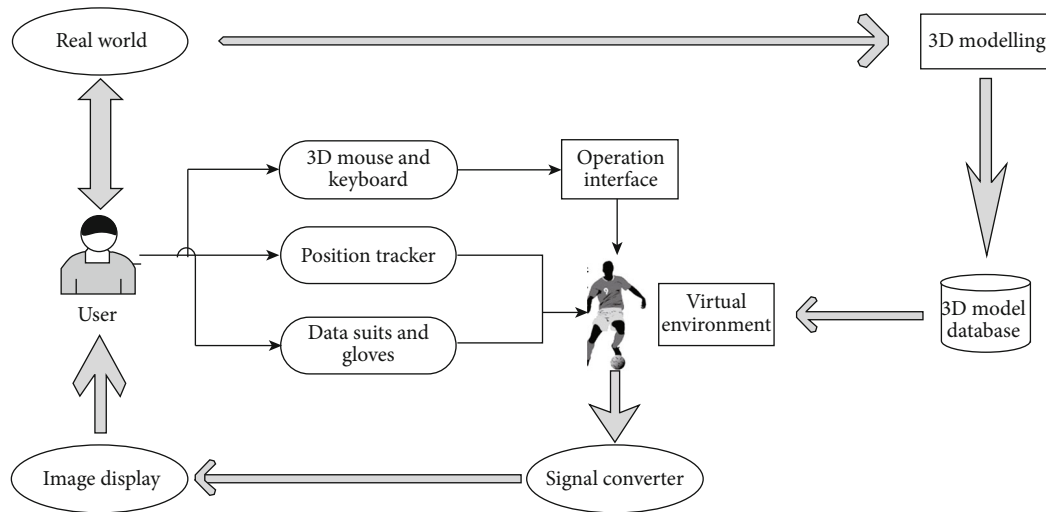
FIGURE 3: Basic framework of the VR system.

FIGURE 4: Principle of desktop virtual football training system.

From Figure 1, it can be seen that the system framework of the virtual football training ground mainly includes interface design, 3D scene design, virtual character design, interaction mean, and interaction style. The interface design is the home page of the system that the user sees when opening the system. The 3D scene design and virtual character design are the core parts of the whole system, and they are also the most complex technology in the system design, mainly including scene modelling technology, virtual human modelling technology, and collision detection technology. The virtual environment is controlled by the user, and the sensing device acquires the motion data through data suits, data gloves, position trackers, and other devices to control the virtual environment. In the interaction means, there are two different aspects. The first one is a 3D and 2D mouse and keyboard, which are used to switch function interfaces. The other one is a data suit and gloves which can be applied to control the virtual environments. These two means are quite essential to this whole framework because they can be regarded as the core parts of VR technology. In addition, there are three different interaction styles, that is, the interaction function, the virtual character and scene switching, and the virtual environment control. These functions can help the whole training system to achieve the interaction between users and computers. By these means, the athletes can better train in the virtual environment instead of the true environment. Thus, through building a virtual simulated training ground, the football athletes can obtain better training without going to the true ground.

2.3. Desktop Virtual Football Training System. The basic framework of the VR system is shown in Figure 3. The system is based on the real world as the ontology, which is built into a 3D model and transformed into a virtual world. The virtual world forms a closed feedback control loop with the internal system through displays, sensors, etc., to achieve interaction between the virtual environment and the real world under the control of the user. It should be noticed that the 3D model database can store the 3D models and use them in various scenarios in order to meet the requirements of different true cases.

Based on the basic framework of the VR system, the principle of the desktop virtual football training system can be designed according to Figure 4.

The virtual environment is formed by first acquiring 3D data from the real world, creating a 3D model, and then integrating the individual 3D models to form the same virtual environment as the real world. The computer acquires the user's movement information through hardware devices such as data gloves, data suits, and position trackers and inputs the acquired movement information into the computer's virtual environment through 3D sensors. At the same
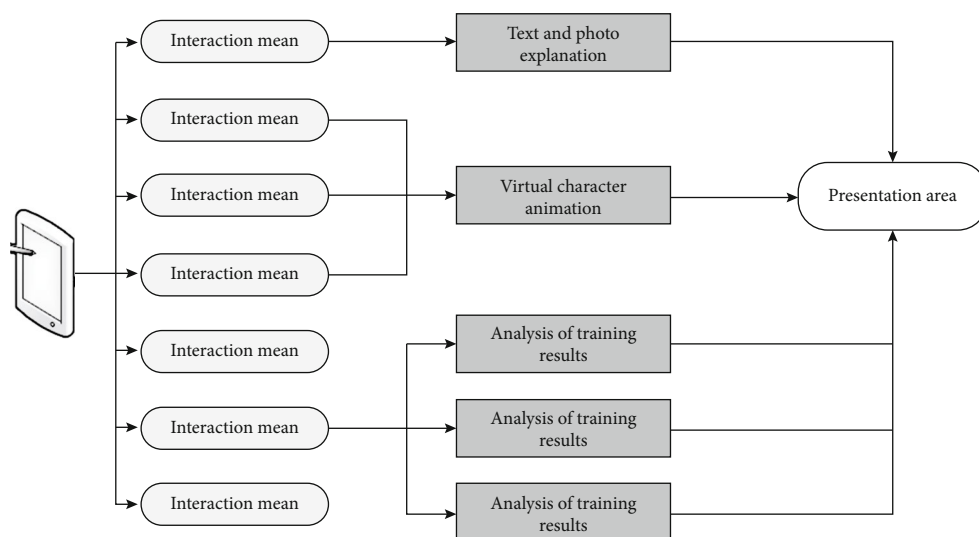
FIGURE 5: Function of interaction.

FIGURE 6: Virtual human modelling.

time, auxiliary tools such as the mouse and keyboard can help the user to switch and control the interface and interactive functions.

2.4. Design of Interaction Function. The football training system should also have certain interactive functions in its application as shown in Figure 5. Integrating football theory with technical and tactical teaching, together with virtual human animation demonstrations, is both convenient for teaching and conducive to the mastery of technical essentials and the improvement of the sport. At the same time, during the interaction between the computer and the athlete, data analysis can provide analytical support to the athlete in order to help them identify their strengths and weaknesses in training. Actually, data analytics are quite essential for both athletes and coaches. For athletes, they can clearly know their status during their training. For coaches, they can conduct greater strategies according to the data analysis function for the athletes.

VR technology makes use of many leading high technologies in the interaction process. Examples of such technologies are 3D image visualization generation systems, graphics workstations, 3D interactive compositors, headset displays, and many more. The 3D image visualization system is able to synthesize the natural environment such as wind direction, wind strength, temperature, and humidity to create a highly simulated virtual training environment. In the training of athletes, it can help to detect and analyse the reality of the athletes during solo training. For example, the system's sensors for physiological and biochemical testing allow for the analysis of physical injuries during exercise and the analysis and advice of athletes who are overloaded. In addition, the basic conditions of individually trained football players are tested in a timely manner, and the training content and duration are arranged according to their physical condition.

3. Key Technology in VR Football Training System

3.1. Virtual Human Modelling. Human modelling (e.g., Figure 6) is at the heart of virtual human motion simulation and uses a hierarchical modelling approach where movement of higher-level components changes the spatial position of lower-level components. For example, the movement of the knee joint changes the position of the lower leg and foot, and movement of the shoulder joint affects the position of the large and small arm. The muscle layer can be used to change the shape and posture of the body as required; the skin layer includes the texture and color of the skin, which gives the virtual character a vivid and realistic appearance.

There are many tools commonly used for modelling the human body, such as Maya, 3ds MAX, Make Human, and Poser 8.0. Poser 8.0 is a professional software for 3D design from Metacreations. It is simple to use, has a simple interface, and is flexible compared to similar 3D production
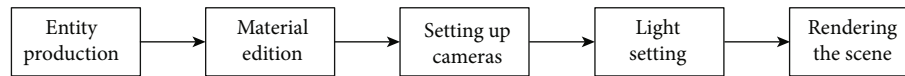
| Entity production | → | Material edition | → | Setting up cameras | → | Light setting | → | Rendering the scene |

FIGURE 7: Process of modelling in football scenes.

software. Poser 8.0 allows for easy and intuitive skeletal construction of human models.

3.2. Motion Data Information Capture. Traditional methods of acquiring sports data are mainly based on the "active tracking method." This technique requires the application of marker points to key areas of the subject's body, but the requirements of athletes' clothing in formal athletic competition limit the use of this technique. A common method of motion tracking without contact with the human body is "contactless tracking," which involves setting up multiple sets of video capture devices at the site of a training or competition to capture the whole process of the athlete's movement from all angles, using the main joints of the human body as nodes, and after postprocessing with specialized software to obtain 3D joint rotations in different postures. The main joints of the human body are used as nodes, which are then processed by specialized software to obtain 3D coordinate data of joint rotation in different postures.

3.3. Virtual Football Ground Design. There are many software tools used for virtual reality modelling, CAD is mostly used in mechanical engineering and manufacturing, and its graphics are highly accurate, but its lighting and animation functions are weak, and there is a gap with 3ds MAX. 3ds MAX is the tool of choice for modelling 3D scenes because of its powerful modelling capabilities and easy and fast production process. The application of 3ds MAX software for the modelling of football scenes and the animation of football movements mainly includes several processes as shown in Figure 7. Through these processes, the virtual football ground in the VR football training system can be designed for use.

3.4. Virtual Football Training System Interaction Based on EON Studio. EON Studio is a full-featured development tool designed for the integrated production of 3D/VR content and the development of interactive 3D applications. EON Studio can be easily combined with other 3D software to turn them into virtual reality objects and scenes without remodelling. First, select a frame function node in the EON simulation tree window and import it into the virtual scene and avatar file, convert it into the internal database, create the EON simulation tree structure in the database, form a tree hierarchy of frame function nodes, then drag the nodes set in the simulation tree window to the logic window, and set the logical relationship path between the nodes by connecting them. The model animation is set up and interacted with in the virtual environment.

4. Effects of VR Football Training System

4.1. Improve Teamwork. The effective playing formations can help teams to be comfortable in the game and help to improve the coordination between players. The VR system is unique in its ability to organize formations in advance of a football match by organizing the formation to be used and the stage of the match at which it will be played. By inputting data on the various formations used in a football match, the system allows for the organization of special training sessions for a variety of formations designed to suit the opponent of the match. What is more, this system also allows for the design of multiple formations to enhance the coordination of training between players, maximising the coordination of training habits and individual levels. After all, this system can use emerging technologies such as big data analytics to analyse the motion data of athletes in order to improve the training results of the team. The VR football training system is therefore essential for improving the team's coordination skills.

4.2. Inspire Athletes' Potential. VR technology can not only reduce the risk to the athletes when training but also enable the design of a training programme that is tailored to the trainee's training and stimulates the potential of the trainee. The technology can be used to test and analyse the abilities of coaches and trainees. Based on the data provided by the VR system, the user can identify their own strengths and weaknesses, thus targeting their weaknesses for improvement. At the same time, the VR system can accurately test the athletes' skeletal growth and development and monitor, analyse, and regulate them continuously, thus helping them to adjust their game form and posture in time to achieve good results. Therefore, the VR training system allows for the full range of athlete training to be monitored and scientifically analysed from the preparation to the conduct of the competition. It is of great importance to the athletes and allows them to develop their potential to a great extent.

4.3. Strengthen Core Athletes. Although football is a collective game played by a team, each footballer plays a different role and is in a different position during the game. An excellent football team must have core players to perform difficult tackles, passes, etc. VR technology is different from the actual training of core players, mainly using stereoscopic glasses and data gloves to confront the opponent and find the right tactics. The simulation is not fundamentally different from a real football match because the atmosphere of the game and the audio-visual effects of the players are based on the actual game. The core athletes are able not only to train realistically but also to use the system to adapt their tactics and find the best way to train.

5. Conclusion

This paper provides a brief introduction to VR technology and an in-depth analysis of its use in football training.

Firstly, it analyses the basic functions that a virtual football training system needs to have. Based on these functions, it then introduces the virtual simulated training ground, the desktop virtual football training system, and the design of the interaction function. After that, this paper states some key technologies in the VR football training system, such as virtual human modelling, motion data information capture, virtual football ground design, and virtual football training system interaction based on EON Studio. All of these technologies are quite important to the VR training system because they can provide a solid foundation for football training. Through the VR training system, the athletes can get better training effects. For example, they can improve teamwork, inspire their potential, and strengthen the core athletes. Overall, VR technology has made a breakthrough in football training by virtue of its superiority and a high degree of simulation, and the VR system has been a key guide to the physical and tactical training of the players, greatly improving their psychological and teamwork during matches. Also, VR technology has an essential influence on both athletes and coaches. In this paper, the analyses suggest that VR technology will become a trend in the development of sports and provide solid technical support to enhance sports technology.

In order to promote better development of VR technology, this paper gives the following suggestions. Firstly, there is a need to strengthen the application of VR technology in sport, to promote cross-fertilization of disciplines and to use VR technology to solve the problems of poor teaching conditions, inadequate teacher reserves, and limited coaches. Through the advantages of VR technology, the athletes and coaches should get better training to improve their abilities. In addition, the relationship between virtual reality and football teaching and training needs to be properly addressed. The environment on the field is highly variable, and good results require not only skill and stamina but also the ability to quickly adjust to the player's competitive state, which cannot be simulated by many unexpected events in a virtual training system. Last but not least, it is necessary to encourage interdisciplinary research among PE teachers or students to improve the quality of their research and to develop excellent research talent.

Data Availability

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

Conflicts of Interest

The author declares no competing interests.

Acknowledgments

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