Application of Virtual Reality Technology in Rehabilitation Training of Middle-aged and Elderly

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Abstract. Virtual reality technology plays an important role in improving the rehabilitation ability of the middle-aged and the elderly. It can train the reaction speed of the middle-aged and the elderly, improve their physical quality and help them improve their quality level. Therefore, this paper probes into the application of virtual reality technology in improving the rehabilitation ability of middle-aged and old people, constructs a rehabilitation training platform based on virtual reality technology, and carries out experiments, it is expected to provide some reference for the practical application of virtual reality technology.

Keywords: virtual reality technology; middle-aged and elderly; rehabilitation training platform

1. Introduction

Virtual Reality (VR) is a kind of technology that enables users to interact and immerse themselves in a computer-generated simulation environment. By synthesizing visual, auditory and tactile information, virtual reality can simulate real-world scenes and objects, and respond to user's actions and interactions in real time. The application of virtual reality technology in the rehabilitation training of middle-aged and elderly can provide them with personalized training, make them gain immersive training experience and improve their overall performance. The purpose of this paper is to study the application of virtual reality technology in improving the rehabilitation ability of the middle-aged and the elderly, and hope to provide a better rehabilitation training environment for the middle-aged and the elderly in the future.

2. The general framework of rehabilitation training platform based on VR technology

The framework of rehabilitation training platform based on virtual reality technology can be divided into four parts, they are the collection of training information, the storage of rehabilitation training resources, the classification and integration of sports information data and the intelligent rehabilitation training. The general framework of the rehabilitation training platform based on virtual reality technology is shown in Figure 1.

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The collection of rehabilitation training information is the initial collection of the user's movement data, body posture and speed, and the quality control of the data, for subsequent analysis and assessment of their skill levels and training needs.

Rehabilitation training resource storage is used to store training videos, teaching materials, training plans and other rehabilitation-related resources, while ensuring the efficiency of resource transmission and security of resource use.

Classification and integration of sports information data is to process and analyze the data, extract the key features and patterns of sports, help users understand the advantages of sports skills, and make personalized training plans based on these information.

Intelligent rehabilitation training is to provide intelligent training experience with virtual reality technology. Through virtual reality equipment, users can conduct virtual rehabilitation training, simulation of real scenes and a variety of training scenarios. The platform provides feedback and guidance based on users' real-time performance to help them improve their technology and training results.

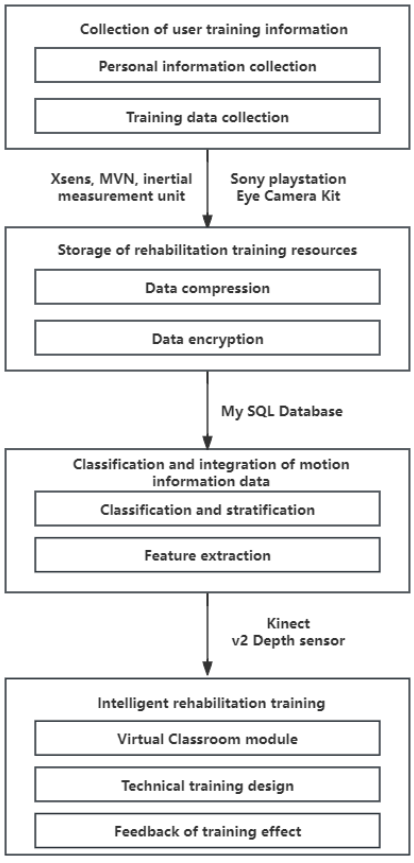

Figure 1. The general framework of rehabilitation training platform based on virtual reality technology

3. Collection of user training information

Through the user interface, provide user registration, login and personal information management functions, the name, age, height and weight of the basic information collection. During the training, use the API Application Wizard to quickly create the basic information structure. Using MFC Basic class library, processing windows, messages and controls, simplified procedures for the development of procedures. 3DS MAX was used to build 3D model of athletes and training environment, then the model was imported into Visual C + + Project, OpenGL environment was configured to improve the generality of the system and the ease of modeling [1] . After building the user model, the user motion is captured and collected by the motion capture device, and then calibrated to ensure the accuracy of the collected training data. The real-time motion data is collected, and the captured motion data is applied to the user model to realize motion reproduction and recording.

To clean and correct the collected motion data, to check the problem of the loss, repetition and abnormality of the original data, to correct or delete the abnormal data, to normalize the checked data and to unify the date format, and carry out data quality control. Carry on the intelligent analysis to the movement data, extract the key movement, the posture and the target, provides the data foundation for the following intelligent training. At this point, the user training information collection process is over.

4. Storage of rehabilitation training resources

The use of dynamic resource loading technology can reduce the storage space and the bandwidth consumption of network transmission, and store the training resources in the cloud, and can achieve cross-device access and sharing. Git version control is used to manage the training resources, track the resources of different versions, record the modification history, and facilitate the recovery and rollback operations. The metadata index system is established to search, classify and filter training resources quickly by means of index and label, and the Data Warehouse of training resources is established to improve the retrieval efficiency of resources [2] . In order to protect training resources from data loss or damage, backup data and take disaster-tolerant measures to back up stored training resources on a regular basis, backup data is stored in different locations or storage media to prevent single point of failure. In the event of unexpected data loss or system failure, the backup data is used for data recovery, restoring the data to the state of the last backup.

At the same time, considering the security and privacy protection of data, AES data encryption algorithm is used to replace and replace the 128-bit key continuously to get the output of cipher text, encrypt user's personal information and training data to prevent data leakage. Combined with RBAC technology, different roles such as administrator, doctor and user in user data system are determined, and each role represents different user identity and authority level. Administrators can access and modify all data, doctors can view and edit data for specific users, and users can only view their own data. By restricting access to user data, only authorized users can access sensitive data, and effectively store and manage training resources.

5. Classification and integration of motion information data

Through the rehabilitation training platform, using the information transmission link to realize the multi-information seamless docking, and finally in the node integration. The platform integrates the training information resources by using the technology of classification and hierarchy, which is convenient for users to extract the information resources. Suppose the training information resource to be integrated is C, which is calculated as shown in Formula (1) .

$$P = \sum_{n=1} C_n/n \tag{1}$$

In the formula: P is the feature of rehabilitation training information, n is the feature quantity of training information, and C_n is the n single feature of training information.

The characteristic deviation of the training information to be calculated is set to m_v, and its calculation is shown in the Formula (2) .

$$R_p = H - H' \tag{2}$$

In the formula: R_p is the feature deviation of training information, H is the vertical fine-tuning coefficient of training information, and H' is the horizontal fine-tuning coefficient of training information.

By calculating the c-adjacent feature deviation of training information resources, the training information resources are sorted according to the order of deviation values from large to small, and resource layering is performed according to their coding, and the data catalog is generated, and then realize the integration of training information resources.

6. To realize intelligent rehabilitation training

6.1 Virtual Classroom module

In the virtual classroom based on virtual reality technology, virtual reality technology is used to create realistic training scenes and situations, and to provide online rehabilitation training courses and teaching resources for athletes. Real-time transmission of video and audio using WebRTC streaming, Media Transfer Protocol media data into small chunks and delivering it over the network with low latency. To improve the transmission efficiency, the original video and audio data are compressed and decompressed using H. 264(AVC) video codec and Opus Audio Codec. By dynamically adjusting the frame rate to ensure smooth video playback and to avoid the Cottonwood phenomenon, to provide users with the best viewing experience [3] . After logging in through the VR user interface, users can choose their own training courses. The user's virtual images are integrated into the online virtual classroom, two or more virtual images are linearly mixed, and the coupling is calculated, as shown in Formula (3) .

$$M = \frac{P_A P_B S_A S_B}{V_A + V_B} \tag{3}$$

In the formula: M is the image coefficient after coupling; P_A and P_B are the virtual positions of two different images; S_A and S_B are the action similarity of two different images; V_A and V_B are the motion velocity of two different images.

By constructing interactive function of virtual classroom module, users and virtual doctors can interact at any time, receive and feedback real-time guidance. Also, using the HTML5 Canvas,

an interactive whiteboard is created that allows users to draw, write, and annotate. Through the canvas API, the brush, eraser and shape drawing functions. In addition, intelligent Q & A engine is combined to match questions with RDF Knowledge Map and provide personalized responses to provide users with an immersive training classroom experience.

6.2 Rehabilitation training design

According to the characteristics of the training content and dynamic display of the users, three main first-level program navigation and 20 second-level coordination buttons are designed for posture and rehabilitation skills, visual and reactive ability and training switching, and configure frame-by-frame forward and backward playback, full view switching and other functions. Use a physics engine to simulate the physical behavior of a device, including its elasticity, strength, and friction. Through the program design, the rehabilitation training is simulated in the virtual environment, and the training mode of the user in the virtual scene is designed to show the continuous and dynamic training attitude of the user from multiple angles [4] .

The main functions of the rehabilitation training design are as follows:

1) in the virtual environment, the Doctor can set various movement exercises and training tasks and present them to the users in a dynamic way.

2) doctors can show the changes and characteristics of virtual training by using realistic 3D animation simulation technology, so that users can understand and respond to the simulation of different actions according to the action characteristics of the virtual model.

3) doctors and users can record and replay the arrangement of different training methods to help training analysis and recovery.

The training time of each user can be displayed on the time data stream module at the same time by setting up Special Time Data Stream Module Command and Motion Track Module Command, each user's training trajectory will be recorded on the same training trajectory, and can identify and distinguish each user's movement trajectory. The command and training track module of the time data stream module can make many people move synchronously, and the information can be recognized, recognized and stored by the database, enable the user to receive the appropriate instructions and review the training process at any time.

6.3 Feedback of training effect

Based on the convolutional neural network architecture, a pre-trained POSENET model is loaded, and the user image that needs to be attitude estimated is used as input through the forward propagation process, feature extraction and pose estimation of user's motion image are carried out, and the position information of key points such as head, shoulder, elbow and foot is obtained [5-7] . According to the position of the key points of the output, the key points are filtered, connected and matched to further improve the accuracy of the attitude estimation, and finally get the coordinate position of each key point in the image, the training attitude estimation and movement analysis are implemented[8-10].

Based on motion capture data, the user's motion was identified, and the user's motion trajectory during training was analyzed. SVM is used to classify the indexes and determine the relative

importance of each index in the whole evaluation process, and the calculation is shown in Formula (4) .

$$T(x) = sign(Zx + F) \tag{4}$$

In the formula: T is the class sign, Z is the normal vector, x is the characteristic vector, F is the characteristic deviation.

According to the pre-set Evaluation Index, the training effect of the user is evaluated automatically. The multivariate linear regression model U is established, and its calculation is shown in Formula (5) .

$$U = \lambda_0 + \lambda_1 X_1 + \lambda_2 X_2 + \cdots \lambda_n X_n + \alpha \tag{5}$$

Through the best fitting curve, the estimated value of the regression coefficient is obtained, as shown in Formula (6) .

$$\eta = (\varphi'\varphi) - 1\varphi' H \tag{6}$$

In the formula: η is the coefficient vector of the regression model, φ is the characteristic matrix, φ' is the transposition of the characteristic matrix, and H is the objective variable vector.

Finally, we import the scikit-learn Library in Python environment, perform the model fitting and get the result output. According to the analysis results, to provide users with real-time feedback and suggestions to help users improve their training skills.

7 Contrast test

7.1 Test preparation

In order to test the application effect of the platform on the training of users' rehabilitation ability, Windows 7 was chosen as the development platform to meet the requirements of the operating system[11-13]. Using 2TB Kingston KC2500 hard disk, data information read. The Web server uses Apache, and the network bandwidth is 10 Gbit/s Ethernet. To provide data processing support, the AMD Ryzen 95950X processor was used with a memory frequency of DDR4-4000MT/s and a main frequency of 3.6 ghz. Select MySQL database for the storage and management of data in the experiment, to support the analysis of the results of the task.

7.2 Test results

Five users with different rehabilitation ability were tested for 10 minutes every day, and the data were analyzed according to their training actions, reaction time, body displacement speed and action acceleration. By comparing the effects of traditional training methods and virtual reality technology on the defensive ability of athletes, the paper verifies the enhancement effect of virtual reality technology on the training skills of users.

According to the experimental data, after the training with virtual reality technology, the reaction time and body displacement speed of 5 users were improved, and the average reaction time was shortened by 0.028 seconds, the average body displacement speed increased by 0.27 m/s. Compared with the traditional training method, the virtual reality technology performs better in the rehabilitation ability training, and has certain application value.

The results compared with the traditional training methods are shown in Table 1.

Table 1 Results of the user's rehabilitation ability test

User ID	After using the traditional rehabilitation training method to carry on the training each target promotion value		
	Reaction Time (s)	*body displacement velocity (m / s)*	*Acceleration of motion (m/s^2)*
1	0.02	0.18	0.07
2	0.03	0.21	0.11
3	0.02	0.09	0.12
4	0.02	0.18	0.16
5	0.01	0.16	0.15
User ID	Using the virtual reality rehabilitation training method to improve the value of various indicators after training		
	Reaction Time (s)	*body displacement velocity (m / s)*	*Acceleration of motion (m/s^2)*
1	0.03	0.20	0.09
2	0.03	0.21	0.14
3	0.02	0.13	0.13
4	0.02	0.19	0.18
5	0.02	0.20	0.15

8 Conclusions

The integration of virtual reality technology into rehabilitation ability training can help users understand their own physical function performance, provide a safer training environment, and improve the level of user training, it has a beneficial effect on the training reaction time, body displacement speed and acceleration of the user. With the support of virtual reality technology, the construction of rehabilitation training platform is not only the trend of the times, but also can further enhance the user's rehabilitation training ability and provide a new path for the rehabilitation training field.

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