A Movement Training Platform for Old Patients Suffering from Type II Diabetes Based on Human Computer Interaction

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ABSTRACT

This research put forward a low-cost movement training platform for the old suffering from type II diabetes based on Kinect sensor. The platform uses Kai Mai Tai Chi as the main training routine, somatosensory interaction technology as human-machine interactive method, Berg Balance Scale as filtrating technology, and Kinect sensor as application apparatus. The platform can provide users with rational movement training plan and assess the effect of training according to the users’ physical condition. The comparison tests show that this platform can reach the demand in terms of accuracy and possess preferable availability and promotional value.

INTRODUCTION

In [1], the patients of DM were tested by a two-month period of aerobic exercise. The insulin sensitivity of the subjects was increased by 46%. Related research was did on rats [2]. The rats were divided into three groups, two were DM and the other is normal group. The subjects were trained by swimming in six weeks. The results showed that the insulin resistance of the rats of all groups was reduced by movement training. In [3], Mingzi Li considered that continuous exercises could promote the absorption and transformation of blood glucose efficiently and enhance the activity of insulin. Exercise therapy can promote the body metabolism and reduce blood glucose and blood lipid, which has benefit to the health of patients with type II DM. However, exercise therapy method is confined with low compliance and irrational exercise intention. The reasons are as follows: firstly, professional guide and costly special experimental area are needed for normal

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training, which constitutes great load to those who are not so rich. Secondly, this method is limited by weather, training field. Finally, this method is hard to assess continuously and adjusted in real time. Therefore, it’s essential to develop a low-cost movement training platform with high adaptation, high enjoyment, and exercise function assessment system [4-6].

Virtual reality (VR) technology promotes the rapid development of movement training [7]. Movement training requires the classification of the patient's condition to determine the best amount of exercise and to meet the patient's habits.

VR can provide accurate testing, training, guidance and other technologies to movement training. The application of VR in the field of movement training mainly includes four aspects: balance and posture training, walking training, upper and lower limb training and daily behavior training. The defects of VR are also obvious. High costs, control difficulty and intrusive instrument have serious restrict on the popularity of this technology [8]. Kinect, as a rising computer hardware units which can achieve image capture, human body motion trail capture, automatic speech recognition, remote interaction and other functions, is showing fantastic ability [9]. As present, the HCI technique using Kinect sensor has a broad application in healthcare field [10-12]. In this research, a movement exercise platform is constructed for the old suffering from type II DM based on somatosensory technology.

Kai Mai Tai Chi routine is used as the main training routine combining with somatosensory technology to find rational and effective exercise intension suiting the old with type II DM and to observe the exercise effect and the patients’ tolerance. The somatosensory technology using Kinect sensor allows patients to manipulate virtual substitute’s motion in a virtual 3D environment. This research intends to formulate rational and personal movement training plans and reducing potential problems during exercise planning, which offer new technology to solve the aging tendency and generate economic benefits.

METHODS

Description of the Movement Training Platform

The movement training platform consists of three modules, namely, filtering, learning and interactive module. The framework is as shown in figure 1.

![Figure 1. Framework of movement training platform.](image-url)
Construction of Movement Training Platform

Filter module uses Berg Balance Scale as the filter method. BBS [13] is a comprehensive functional examination scale, which evaluates the patients’ capacity of gravity shifting center proactively by observing a variety of functional activities to conduct a comprehensive inspection of the patients sitting, stance of the dynamic and static balance. Learning module provides trajectory training, motion track training and proficiency evaluation to the users. According to the basic trajectory methods of Kinect, trajectory training sets some specific irregular action into established route to let patients connect the movements from low to high difficulty according to digital display and exercise the basic movements and get familiar with the basic movements of Kai Mai Tai Chi. Motion track training divides the various operations of the Kinect into different modules. Patients move hands to the specified location to start the game, then complete the required action according to the indicating lamp, which provide guidance of text and video. Patients can start the video guide through speech recognition or click “start” indicates playing the video while "stop" means a pause and "restart" indicates video playback, all of which ensures that patients can control the video playing through speech recognition, so that they can train alone at home. After completing all the action, patients will get a evaluating score. As shown in Figure 2.

Figure 2. The motion track training of Kai Mai Tai Chi.

In order to further improve the accuracy of action, patients can exercise the next proficiency evaluation training which is established on the basic of trajectory training. After importing the characteristic model into Unity 3D, we can bound model skeleton to patient skeleton which entails patients drive model’s motion to achieve human-machine interaction. A skeleton model with chart let and one without chart let are provided to indicate two users, which allow two patients interact in one environment.

Approach Algorithm of Human Motion Assessment

Before assessing the motion of patients, a coordinate axis is needed to establish to adapt the user's current environment. A list of reasons will affect the accuracy of coordinate axis, such as the out of level of Kinect place position. Therefore, before the assessment, patients are asked to stand in front of Kinect for 5 seconds so that the procedures can set up the appropriate relative coordinate axis based on the human
skeleton. Kinect sensor captures the coordinate data of 20 joint points at a speed of 30 frames per second. The skeleton points calculating by the depth data will generate amplitude because of the camera’s performance. In order to improve the accuracy of evaluation, the collected data was intercepted and processed with median filter method. The filter program written by MATLAB language can effectively eliminate the volatile data part so that the data is more stable and accurate.

The motion evaluation is divided into two dimensions to recognize and evaluate the motions of patients, called angle dimension and distance dimension. Thus, 4 groups of angle measurement and 4 groups of distance measurement are set up to describe the motion’s accuracy. Assume that contrast coordinate point is spine point k, the space angle is evaluated using vector comparison. Firstly, the angles from shoulder to the elbow and the angles from leg to knee are measured whether they are up to the standard. Aiming at the limb movements of Kai Mai Tai Chi, four standard direction vectors \( \alpha_1, \alpha_2, \alpha_3, \alpha_4 \) are set up. In the angle group, four vectors \( \overrightarrow{cb}, \overrightarrow{cb}, \overrightarrow{fe}, \overrightarrow{fe} \) are set up and the connection vectors of the skeletal points and the standard vectors are compared to calculate the angle value. Then, the angles from wrist to elbow and from knee to ankle bone are calculated and four space vectors \( \overrightarrow{ba}, \overrightarrow{ba}, \overrightarrow{ed}, \overrightarrow{ed} \) are introduced which are compared with \( \overrightarrow{ba}, \overrightarrow{ba}, \overrightarrow{ed}, \overrightarrow{ed} \) to calculate the angle value. The angle range of the skeleton vectors and the standard direction vectors is less than 5 degrees, 10 points are assigned. 5 degrees to 10 degrees is assigned for 8 points, 10 degrees to 15 degrees for 6 points, 15 degrees to 20 degrees for 4 points, and over 20 degrees for 2 points. Angle calculation formulas are as follows:

\[
\theta_1 = \arccos \left( \frac{\overrightarrow{cb} \cdot \overrightarrow{a_1}}{||\overrightarrow{cb}|| \cdot ||\overrightarrow{a_1}||} \right)
\]

\[
\theta_2 = \arccos \left( \frac{\overrightarrow{cb} \cdot \overrightarrow{a_2}}{||\overrightarrow{cb}|| \cdot ||\overrightarrow{a_2}||} \right)
\]

\[
\theta_3 = \arccos \left( \frac{\overrightarrow{fe} \cdot \overrightarrow{a_3}}{||\overrightarrow{fe}|| \cdot ||\overrightarrow{a_3}||} \right)
\]

\[
\theta_4 = \arccos \left( \frac{\overrightarrow{fe} \cdot \overrightarrow{a_4}}{||\overrightarrow{fe}|| \cdot ||\overrightarrow{a_4}||} \right)
\]

Next, By calculating the moving distance from the left to the right hand and from the left to right feet, the standardized distance can be evaluated. Static data is collected when the axis is set up used to calculate the moving distance of chest, hands, legs, etc. Static indexes include: left and right wrist, left elbow, elbow, left shoulder, right shoulder, left ankle, right ankle, left knee, left knee, left hip, right hip, spine, left, right, left, right. Dynamic value: left hand, right hand, left foot, right foot, spine. We take the left hand as an example. The standard position coordinates are calculated as follows:
CONCLUSION

To test the effect and availability, inviting 10 old people who never start exercising Kai Mai Tai Chi for a contrast test and setting 10 point as the highest score for proficiency and 100 for accuracy, the effect of this platform is compared with professionals’ on-the-spot teaching. In conclusion, the average score for proficiency of platform is 8.2 and for accuracy is 70.8. The average score for proficiency of on-the-spot teaching and for accuracy is 82.9. Conclusion can be drawn that there is no obvious difference between them. Given environment and conditions, this platform gets advantages over cost and freedom. The innovation of this paper is to provide a new training test system, which combines distance and angle, and a dynamic evaluation method is proposed. The platform can provide with a system combining teaching, training, assessment and interaction. The old can train Kai Mai Tai Chi at home depending on their own time, physical condition and hobbies. The patients can master Kai Mai Tai Chi rapidly and conveniently though teaching training and assessment training by this platform. The results show good interest and compliance.

REFERENCES


