

Design and Implementation study of Remote Home Rehabilitation Training Operating System based on Internet

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Abstract. The proportion of rehabilitation doctors and patients mismatch is very grim in the context of social aging. The Family Rehabilitation System captures the profound information of the trainer's movements through the kinect bone tracing technique, allowing the doctor to remotely master the patient's training progress. With the help of computers and the Internet, the patient can consult a physician, while the physician can remotely guide and launch the training "prescription" through the Internet according to the training effect. Patients can have rehabilitated training at home. The results of the test showed that the system has a positive effect on the rehabilitation of the patient.

1. Introduction

The number of patients with motor dysfunction caused by hemiplegia and stroke increased. In order to promote better recovery of their body muscles, patients are still required to perform rehabilitation exercises in the community or family after the treatment of discharge. However, there are still some difficulties in community rehabilitation for patients with motor dysfunction: (1) The number of therapists on-site services is scarce and expensive; (2) In the absence of standard and systematic action guidance, the patients' own training is not only the science is not high and the effect is limited. (3) Patients need to be trained in special environments such as rehabilitation centers, and wearing complex training equipment is inconvenient for them. The family rehabilitation system collects the depth information of the trainer's movements through the Kinect skeletal tracking technique; With the help of computers and the Internet, patients can consult physicians, and the doctor through the Internet remote guidance and open training action "prescription" according to the training effect so that patients at home can be rehabilitation training. This liberated the physician's labour force and formed a network community that was closely linked to the hospital and regularly received "training prescriptions" to improve patient rehabilitation.

2. The foundation of rehabilitation theory

Exercise therapy is the use of physiological stimulation to regulate the function of multiple systems and organs, promote the body remodelling and regulate the organization function to adapt to the needs of the treatment of movement. The basic mechanism is to improve body metabolism, nervous system, heart and respiratory capacity, so as to maintain or restore the patient's original motor function, thereby helping the body to form a new compensation mechanism. Exercise therapy is the foundation and core of physiotherapy and it is also the obvious method of effect. It combines the disciplines of



biomechanics, kinematics and neuroscience. Active motion refers to the active use of their own strength to complete rehabilitation training rather than using external forces for training. It is in the recovery period of the body, the muscles have a certain strength based on the use of human active movement to improve muscle strength and control of muscle movement. Training program from simple to complex, power from small to large, gradually improve the difficulty.

3. Design and implementation of the system

The system hardware consists of a driving vehicle, a Kinect camera and a computer. Display of the rehabilitation action to guide the disabled system to complete rehabilitation training. The Kinect sensor is installed in the range of 0.4m~8 m, which is used to capture limb and body tilt angles in patients with limb rehabilitation movements. The computer receives the automatic capture data obtained by the Kinect sensor and contrasts with the standard rehabilitative action, giving the correct voice reward and incorrect voice prompts. The computer is transmitted to the external computer through the network, and the doctor can judge the training completion condition according to the data, then through the computer remote instruction (figure 1). When the patient is standing in training, the hydraulic spring will lift the human body to relieve the lower extremity endurance. When the patient stands up, the elastic reduction band and the folding reduction structure will lift the seat vertically, increasing the space of the patient's walking training. When the patient is tired in training, they can turn the seat 90 degrees horizontally and rest on it. At the end of the training, the car will be folded to reduce the space occupied. This system is especially suitable for the training of patients with lower extremity strength.

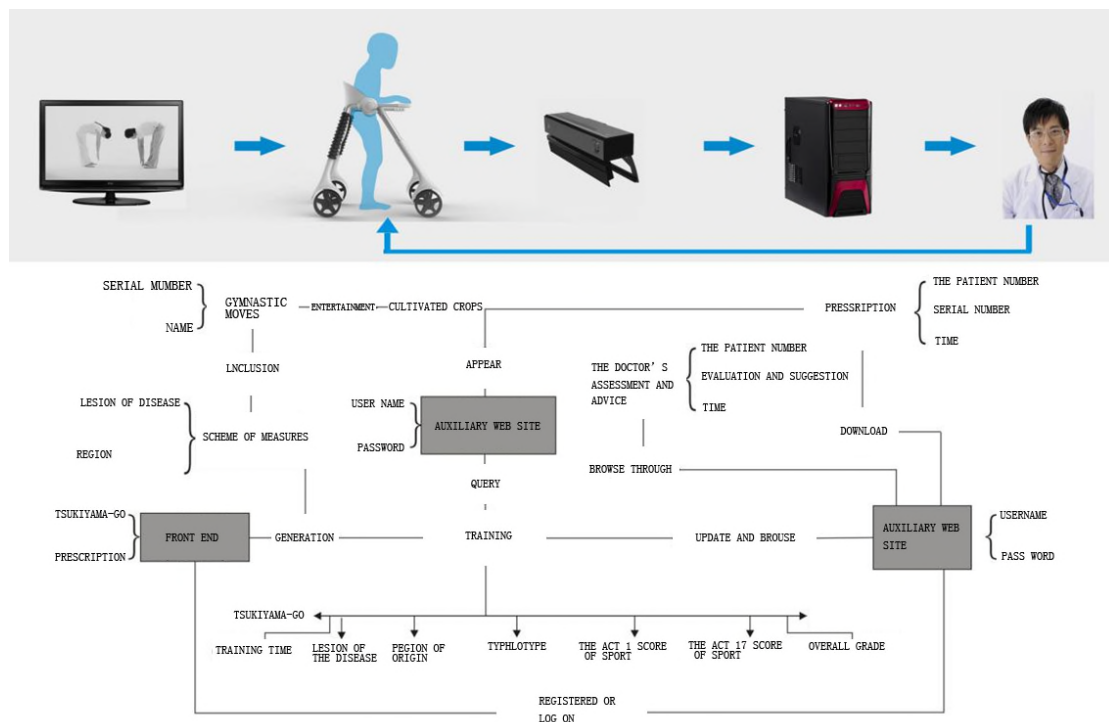


Figure 1. Design and implementation of the system.

The system solves the following problems: 1, through the extraction of Kinect depth information guidance training. The equipment and environment without any high requirements. So the patient was freed from the limitations of training equipment and environment. 2. It is more scientific to design training action according to medical principle. 3, unlike other game training or only a few methods of training action, the system has multiple action, multiple mode of training. 4, this system has the

rehabilitation training front-end module, the Center website module, the Network Exchange module, forms a network of community which patients and hospitals are closely linked.

4. The system structure and workflow

4.1. Front-end system

The front-end system consists mainly of Kinect sensors and monitors. Kinect is a highly-performing sensor launched by Microsoft. Its core components include four parts of infrared projector, color camera, infrared depth camera and chip, and capture range of 1 to 8 meters. The data information that Kinect sensors can provide is: depth information, video, and audio three kinds. The functions of Kinect in the system are as follows: the input and storage of patient data, the setting up of rehabilitation plan and the voice reminder during training according to the side of sports obstacle, rehabilitation part and training mode. The monitor mainly displays the action template and the real-time display patient training picture and result appraisal after the training completes through the Chat window and the PDF document feedback training.

4.2. Background real-time data processing module

After the data acquisition and initial processing, the system carries on the real-time score to the patient's movement data according to the angle value and the position range value of the corresponding joint connection. In the Data acquisition module, the angle between the 3 joint dots is calculated by using formula, such as formula (1):

$$\theta = \arccos \left(\frac{D(M, N)^2 + D(N, P)^2 - D(P, M)^2}{2 \cdot D(M, N) \cdot D(N, P)} \right) \quad (1)$$

Through the formula (2), when the Kinect captures the joint motion, the system can obtain the relative angle between the nodes at any time, thus calculating the angle change $\Delta\theta$ of the joint point and the center joint point of the motion in the range of Δt , and suppose that the motion joint point corresponds to the angle range of the variable K, K determined through the formula (2):

$$K = \begin{cases} 1, & |\Delta\theta| \geq \theta_t \\ 0, & |\Delta\theta| < \theta_t \end{cases} \quad (2)$$

In each data acquisition process, the system calculates the angle change $\Delta\theta$ between current time and the front Δt moment, then obtains the data of K to calculates. When the $k = \text{false}$, continue to capture the position of the joint point of movement information, when the $k = \text{true}$ really display the corresponding audio information and text message reminder, end and start the next action of information collection.

4.3. Design of system action template library

Action Template Library consists of action template and scoring algorithm, which is not only an important part of the whole system, but also the core of the rehabilitation training front. The action template and scoring algorithm have the function of providing training guidance for patients and provide the basis to evaluate the user training. According to the characteristics of each action to select the points of grading, such as the angle of the key position, the range value of the joint position and the relationship between different joint points and so on. The action template gallery as shown in table 1

Table 1. The action template gallery as shown.

Type of action	Action Name	Action explanation
First joint action	Flexion of the shoulder joint	Arm straight forward slowly up, Motion range $0^{\circ}\sim 180^{\circ}$
	Shoulder joint stretching	Arm straight back slowly up, Motion range $0^{\circ}\sim 50^{\circ}$
	Shoulder Joint Outreach	Arm unbend along the midline side of the body slowly up, motion range $0^{\circ}\sim 180^{\circ}$
	Flexion of elbow joint	A small arm bends along the elbow, and the range of motion $0^{\circ}\sim 180^{\circ}$
	Palmar flexion of wrist joint	The forearm is horizontally straightened and the palms rotate downward along the wrist joint, ranging $0^{\circ}\sim 90^{\circ}$
	Dorsal flexion of wrist joint	The forearm is horizontally straightened, and the palms rotate upwards along the wrist joint, ranging $0^{\circ}\sim 70^{\circ}$
Compound action	Flexion of the shoulder joint+Palmar flexion of wrist joint	flexion of shoulder joint 90° , rotate palms downward
	Translation+Palmar flexion of wrist joint	The palms move horizontally and then rotate downward.
	Translation+Flexion of the shoulder joint	flexion of shoulder joint 90° , then do the horizontal move
	Shoulder Joint Outreach+Flexion of elbow joint	Shoulder joint outreach 90° , then do elbow flexion movement

4.4. Patient dynamic real-time match person display module

The system set the Kinect collection information for 30 frames/sec, and in the monitor dynamic real-time playback contains 20 of the human body joint point of the match person's screen, patients can refer to the match person's screen to know their training action is standard and timely adjustments. A total of 20 joint points were collected by the Kinect bone tracking technique.

4.5. Center website and Network communication module

The purpose of the development center website is to facilitate patients' access to personal training, physician advice, download new "rehabilitation prescriptions" and doctors can check patient information and distance guidance training. The site consists of three parts: (1) Public section, including home page, landing pages and registration page. (2) The patient user part, including the patient after landing the total page and each function page set on the page, as shown in figure 4. (3) The Doctor User section, including the total page after the doctor landed and the collection on the page's various functional pages.

4.6. Assisted driving

It is mainly used to assist the patients to rise, walk and rest in situ. When the patient is standing in training, the hydraulic spring will lift the human body to relieve the lower extremity endurance. When the patient stands up, the elastic reduction band and the folding reduction structure will lift the seat vertically, increasing the space of the patient's walking training. When the patient is tired in training, they can turn the seat 90 degrees horizontally and rest on it. At the end of the training, the car will be folded to reduce the space occupied.

5. System testing

In order to test the stability and reliability of the system, the elbow flexion, the combination of two hands, the flexion kapyong shift of elbow joint, the 360-degree rotation of the head were selected and 4 actions were tested 100 times. Then compare the correctness of the actual action and the system recognition. The results show that the system can fully recognize the flexion of elbow joint and the movement of both hands, and the flexion kapyong shift of the elbow and the rotation of the head 360 degrees 5 times are not recognized. The reason is that the tester moves faster and causes the system recognition error. Overall, the stability and reliability of the system can meet the needs of patients.

6. Concluding

In the background of the aging of the Society, the increase of the patients with motor dysfunction and the shortage of the medical staff, the family rehabilitation training system can liberate the doctor's labor force and improve the patients' rehabilitation effect. It has a positive effect on the rehabilitation of patients on the basis of good interaction between human and computer and doctor and patient. The test results show that the stability and reliability of the system conform to the design requirements and have certain application value.

Reference

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